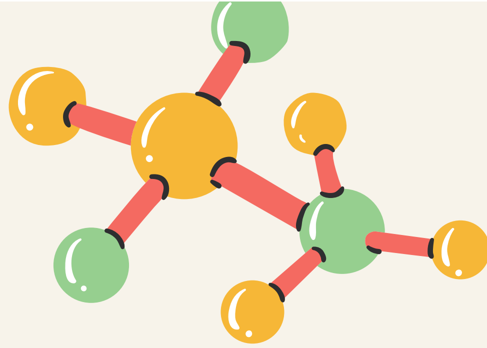
تشابتر ١

ملخص جين ١٠٩

شهد



Cells join smaller organic molecules (**Monomers**) together to form larger molecules (**macromolecules**) (**Polymers**), which may be composed of thousands of molecules

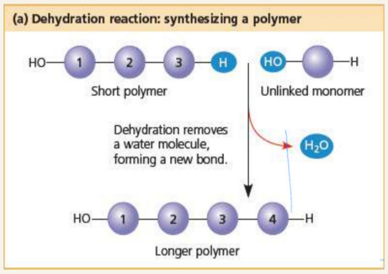
Macromolecules are organic molecules that weigh more than **100,000** daltons (**ATOMIC MASS UNIT**).

The four major classes of macromolecules are:
a) - Carbohydrates,
b) - Lipids,
c) - Proteins,
d) - Nucleic acids

Monomers are connected by covalent bonds through a dehydration reaction

– One monomer provides a hydroxyl group and the other provides a hydrogen atom to form water (H2O).

– This process requires energy and is aided by enzymes

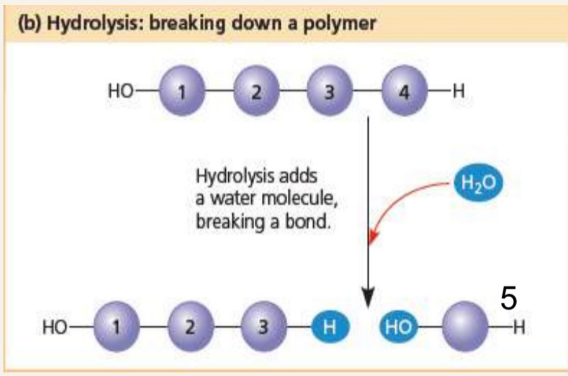

(a) Dehydration reaction: synthesizing a polymer

The covalent bonds connecting monomers in a polymer can be disassembled by hydration (hydrolysis) reaction

– In hydrolysis as the covalent bond is broken, a hydrogen atom and a hydroxyl group from a split water molecule attaches where the covalent bond used to be.

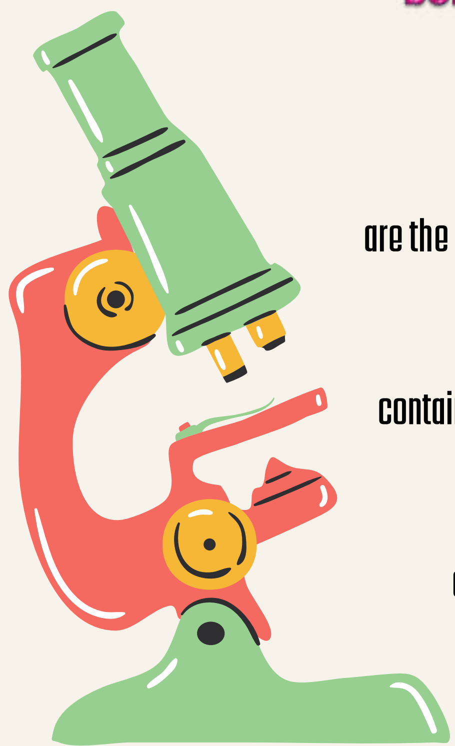
– Hydrolysis reactions dominate the digestive

– process, guided by specific enzymes.

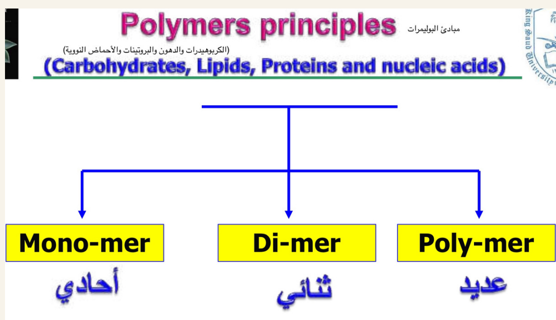

(b) Hydrolysis: breaking down a polymer

A Polymer: is a long molecule consists of a chain of similar building molecules (monomers) covalently bonded together.

Carbohydrates



1. Monosaccharides:
are the simplest form of carbohydrates (simple sugars).
contain a single sugar molecule.
2. Disaccharides:
contain two monosaccharides joined via dehydration synthesis
3. Polysaccharides:
are polymers of many monosaccharides.



Carbohydrates is suga

Carbo = carbon

hydrate = water

Used as an immediate energy source

The molecular formula is CnH2nOn means that, carbon, hydrogen and oxygen are found in the ratio = 1:2:1

Monosaccharides:

- are the simplest form of carbohydrates (simple sugars).
- contain a single sugar molecule.

Classification of monosaccharides:

- Based on the location of the carbonyl group, C=O

1) Aldoses: are the monosaccharides with the carbonyl group (C=O) at the end of Carbon chain (e.g. Glucose, Galactose)

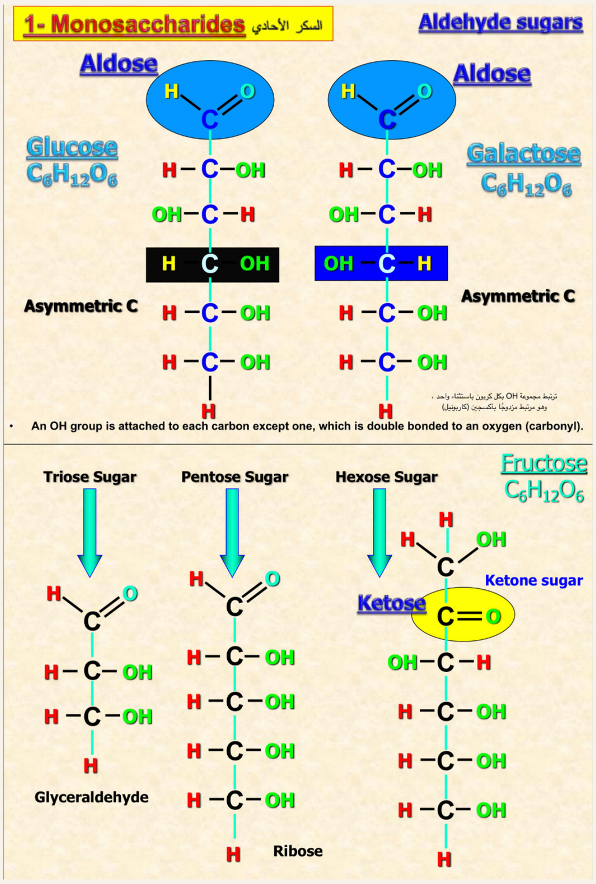
2) Ketoses: are the monosaccharides with the C=O carbonyl group within the Carbon chain (e.g. Fructose)

Based on the number of C in the skeleton

1) Triose (3C): e.g. Glyceraldehyde.

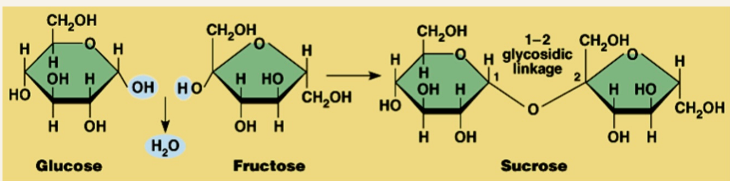
2) Pentose (5C): e.g. Ribose.

3) Hexose (6c): eg. Glucose, Fructose and Galactose



Disaccharides

- contain two monosaccharides joined via dehydration synthesis.
- consist of two monosaccharide molecules joined during a dehydration reaction.
- Sucrose (table sugar): consists of Glucose + Fructose.
- The covalent bond formed between Glucose & Fructose is called "glycosidic linkage".



Polysaccharides

- are polymers of many monosaccharides.
- they consist of few hundreds to few thousands of monosaccharides joined by a dehydration reaction.
- Two types of polysaccharides:

:Storage*

Provide sugar for cell by hydrolysis.

1) Starch (Source is plants) :

• A storage polysaccharide of plants (within plastids).

• It consists of thousands of α glucose molecules.

• It gives glucose when hydrolysed by special enzymes in humans.

• Potatoes and grains are the major sources of starch.

2) Glycogen (in animals) :

• Stored in animal cells (e.g. liver and muscle cells in Human).

• It is consisted of thousands of glucose molecules.

• It gives glucose when hydrolysed.

*Structural:

Serve as building materials for the organism.

1) Cellulose :

• It is the building material of plant cell wall.

• Forms the micro-fibrils and cell wall in plants.

• It is consisted of thousands of β glucose molecules.

• Humans cannot digest it, but some bacteria and protozoa can (e.g. in Termites and Cows

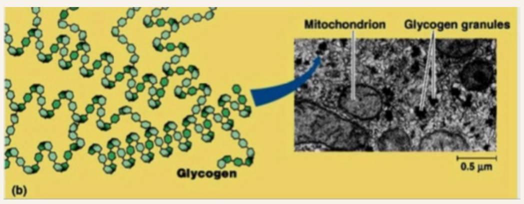
stomach).

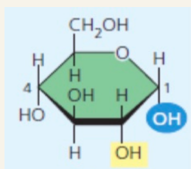
2) Chitin :

• It is the building material of the cuticle in insects.

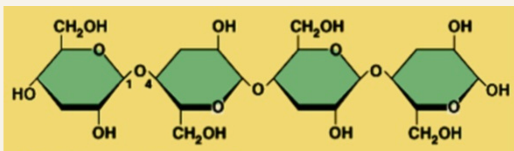
• It is consisted of thousands of glucose molecules with a N atom at one end.

• It is used to manufacture the surgical threads.

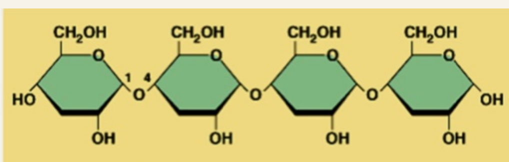




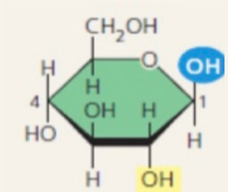
α Glucose



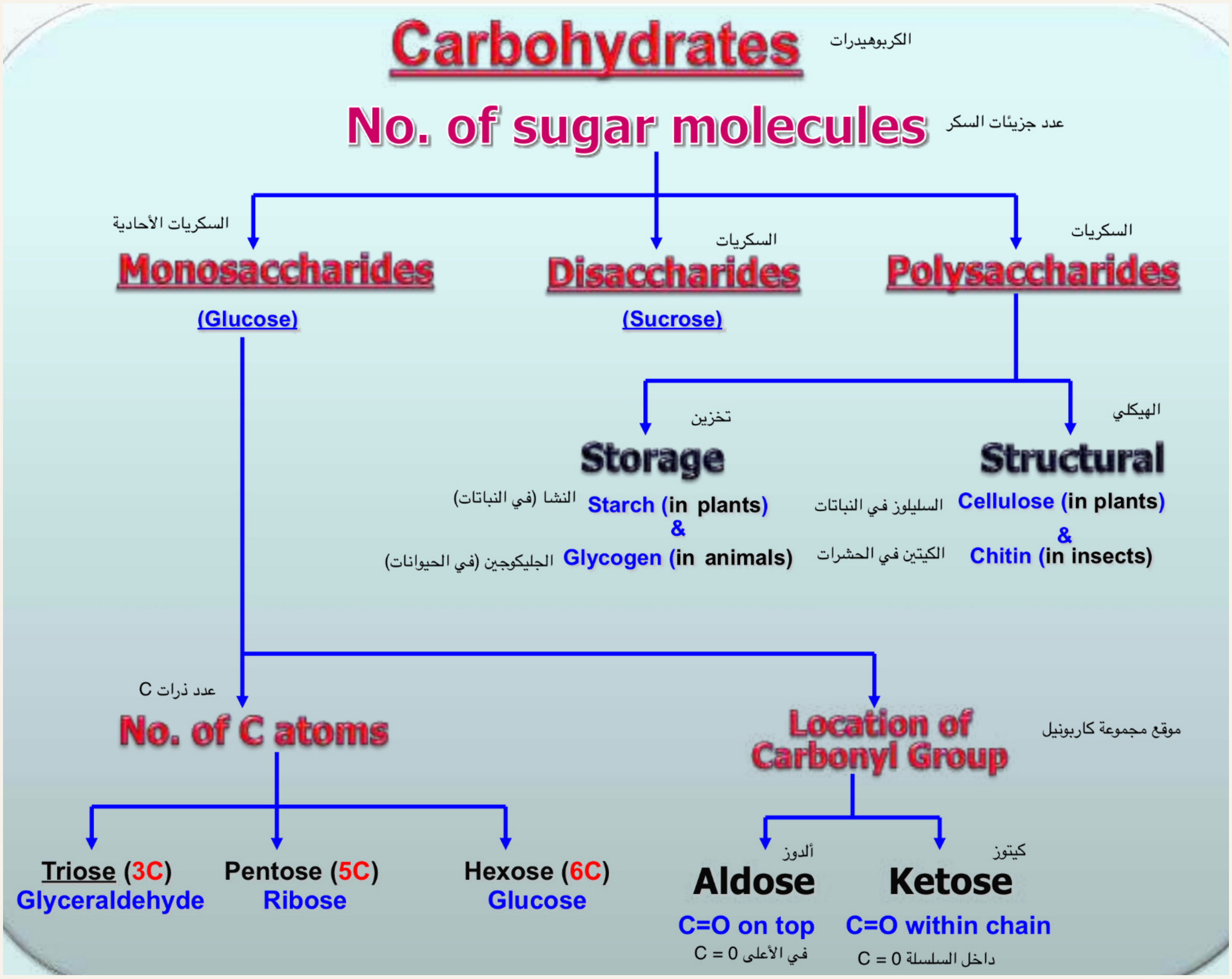
(c) Cellulose: 1–4 linkage of β glucose monomers



(b) Starch: 1–4 linkage of α glucose monomers



β Glucose


Carbohydrates
الكربوهيدرات
No. of sugar molecules
عدد جزيئات السكر
السكريات الأحادية
Monosaccharides
(Glucose)
السكريات
Disaccharides
(Sucrose)
السكريات
Polysaccharides
تخزين
Storage
النشا (في النباتات)
Starch (in plants)
&
الجليكوجين (في الحيوانات)
Glycogen (in animals)
الهيكلي
Structural
السليلوز في النباتات
Cellulose (in plants)
&
الكيتين في الحشرات
Chitin (in insects)
عدد ذرات C
No. of C atoms
Location of Carbonyl Group
موقع مجموعة كاربونيل
Triose (3C)
Glyceraldehyde
Pentose (5C)
Ribose
Hexose (6C)
Glucose
ألدوز
Aldose
C=O on top
في الأعلى C = 0
كيتوز
Ketose
C=O within chain
داخل السلسلة C = 0

تشابتر ٢

حين ١٠٩

شهد

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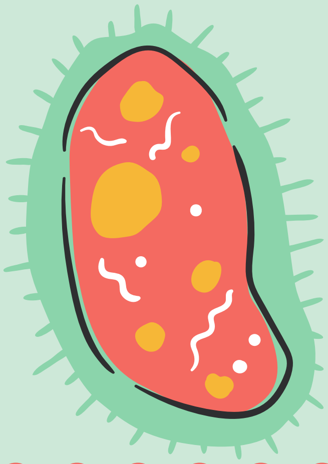
Proteins are polymers of amino acids (constructed from 20 amino acids



There are six functions of proteins:

1. **Storage:** albumin (egg white)
2. **Transport:** hemoglobin
3. **Regulatory:** some hormones
4. **Movement:** muscles
5. **Structural:** membranes, hair, nails
6. **Enzymes:** cellular reactions

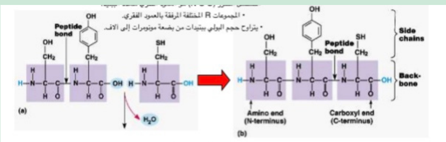
Tyapes of Amino acids

Differences in the R groups produce the 20 different amino acids.

- Hydrophobic: the amino acids that have hydrophobic R groups (non-polar).
- Hydrophilic: the amino acids that have polar R groups, making them hydrophilic.
- Ionized: the amino acids with functional groups that are charged (ionized) at cellular pH (7). So, some R groups are bases, others are acids

Amino acids are joined together when a dehydration reaction removes a hydroxyl group from the carboxyl end of one amino acid and a hydrogen from the amino group of the other. The resulting covalent bond is called "peptide bond".

- The repeated sequence (N-C-C) is the polypeptide backbone.
- Attached to the backbone are the various R groups.
- Polypeptides range in size from a few monomers to thousands



Lipids : It is the general term for compounds which are not soluble in water.

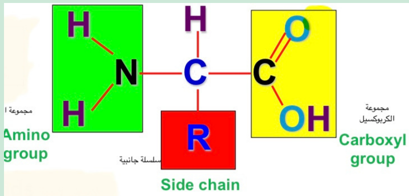
1. Fats: store large amounts of energy
2. Phospholipids: are major components of cell membranes
3. Steroids: include cholesterol and certain hormones

Functions and structure of lipids:

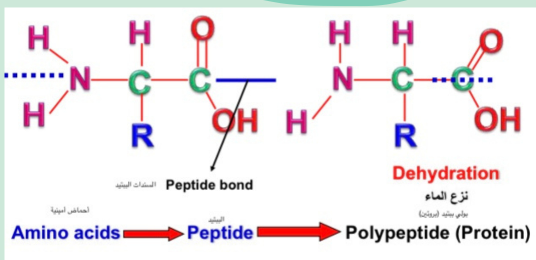
1. **Long term energy storage**
2. **Protection against heat loss (insulation)**
3. **Protection against physical shock**
4. **Protection against water loss**
5. **Chemical messengers (hormones)**
6. **Major component of membranes (phospholipids)**

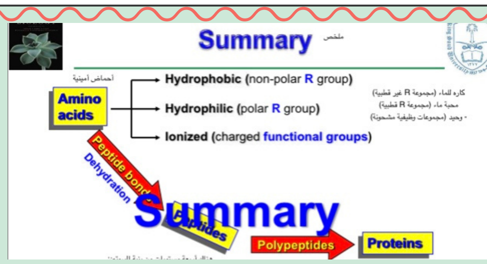
The components of amino acid include a hydrogen atom, a carboxyl group, an amino group, and a variable R group (or side chain)

General Formula of the Amino Acid:



The peptide bond is formed between the carboxyl group of one amino acid and the amino group of the other by dehydration





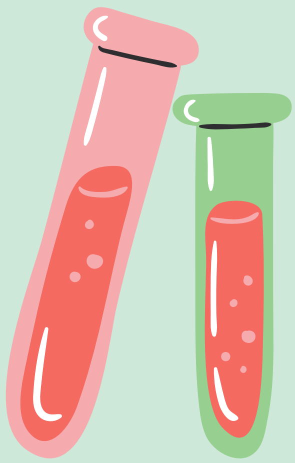
There are four levels of protein structure:

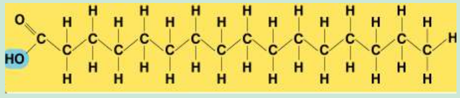
a. Primary Structure (

b. Secondary Structure

c. Tertiary Structure

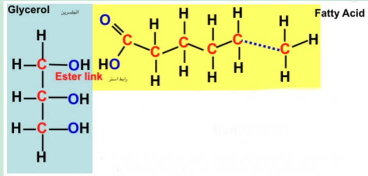
d. Quaternary Structure

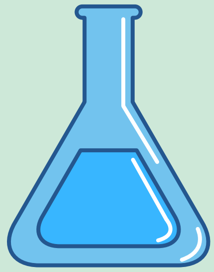




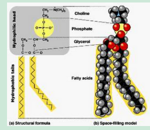
Structure of fatty acids

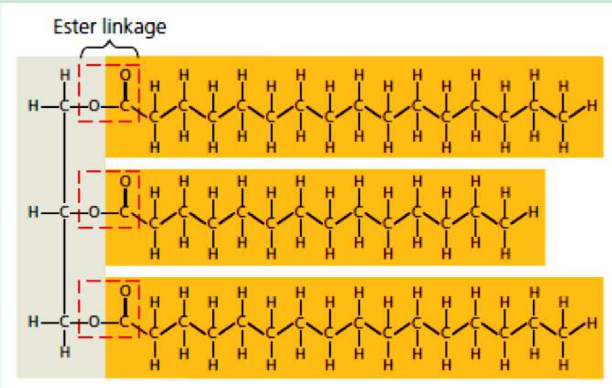
- Long chains of mostly carbon and hydrogen atoms with a -COOH group at one end.
- When they are part of lipids, the fatty acids resemble long flexible tails



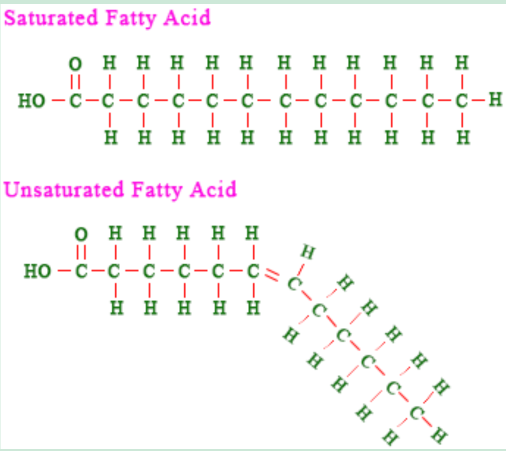


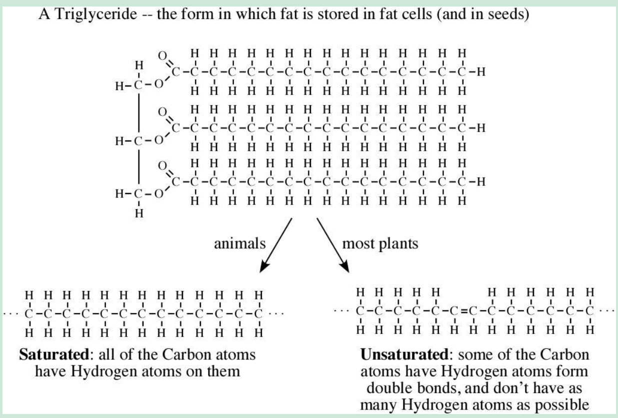
- In a fat, three fatty acids are joined to a single glycerol by an ester linkage, creating a triacylglycerol.
- Thus, the fat molecule is constructed from two kinds of smaller molecules: glycerol and fatty acids (so, it is not a true polymer)
- Hence, lipids are the one class of large biological molecules that does not include true polymers.





(b) Fat molecule (triacylglycerol)





B)- Other lipids: have structural, hormonal, or protective functions

Phospholipids have two fatty acids attached to a glycerol molecule and a

- phosphate group at the third position.

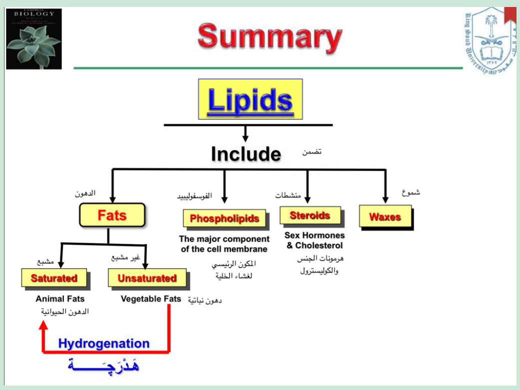
– The phosphate group carries a negative charge.

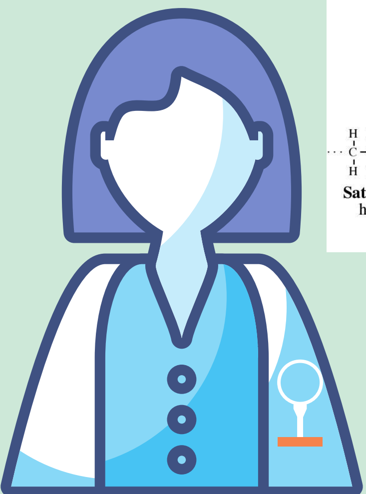
1- Phospholipids: are the major components of cell membranes

- The 2 fatty acid tails are HYDROPHOBIC, but the phosphate group and its attachments form a HYDROPHILIC head.
- Thus, it is AMPHIPATHIC: has both hydrophobic and hydrophilic regions

2. Steroids: (e.g. Cholesterol) are hydrophobic molecules. Some of them are forming hormones (Sex Hormones)

3. Waxes: are hydrophobic molecules used for waterproofing (protection).





تشابتر ٣

حين ١٠٩

شهد

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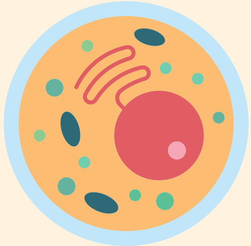


What are viruses?

- At the boundary of life, between the macromolecules (which are not alive) and the prokaryotic cells (which are alive), lie the viruses and bacteriophages (phages).
- These creatures are parasites responsible for causing many diseases in living things (HIV in humans, as an example).
- Viruses are found everywhere.
- Viruses consist of a core of nucleic acid, either DNA or RNA, and a protective coat of protein.
- Viruses do not show any of the expected signs of life.
- Viruses do not respond to stimuli, do not grow, do not do any of the things we normally associate with life.
- Viruses are not considered "living" organisms. However,they do show one of the most important signs of life: the ability to reproduce in a host cell.

What are viruses?

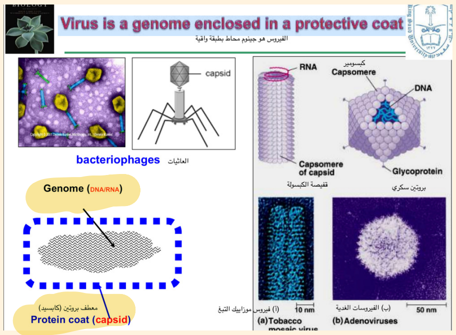
1- Viruses are much smaller than bacteria

4- A virus is a genome a in enclosed coat protective

3- Viruses are not cells

2- Virus is about 20nm in diameter

Virus is a genome enclosed in a protective coat



Viral Capsid and Envelope

A- Capsid

A protein shell that encloses the viral genome.

- It is rode-shaped, helical, polyhedral or more complex.
- Capsomeres: Are the protein units that form capsid.

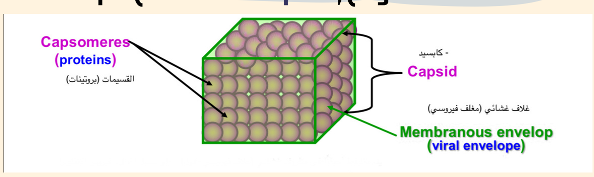
Capsomeres

(proteins) Capsid

Sometimes further wrapped

in a membranous

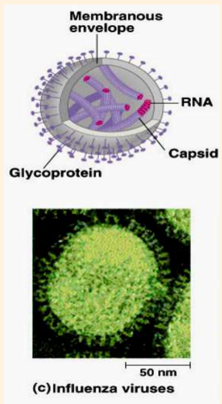
envelope (Viral envelope ,(eg. Influenza virus



B- Envelope الغطاء الفيروسي

Some viruses have viral envelopes, membranes cloaking their capsids.

- These envelopes are derived from the membrane of the host cell.

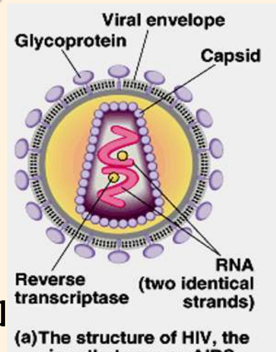


Types of Viral Genome:
(Hereditary material المادة الوراثية)

Viral genomes may consist of:

- double-stranded DNA (dsDNA),
- single-stranded DNA (ssDNA),
- double-stranded RNA (dsRNA),
- single-stranded RNA (ssRNA).

depending on the specific type of a virus.

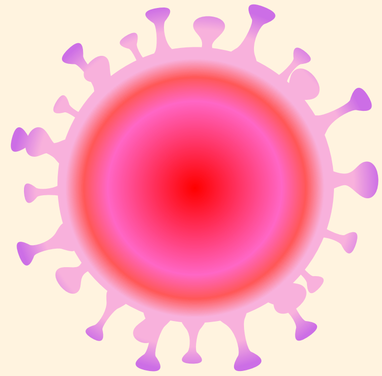


(a)The structure of HIV, the virus that causes AIDS

The viral genome is usually organized as a single linear or circular molecule of nucleic acid.

The smallest viruses have only four genes, while the largest have several hundred.

Bacteria infecting Viruses



- Viruses that infect bacteria, are called bacteriophages or phages
- It has a 20-sided capsid-head that encloses their DNA and protein tail piece that attaches the phage to the host and injects the phage DNA inside.
- Phages reproduce by Lytic Cycle) and/or Lysogenic cycle

Bacteriophages (on E. coli)

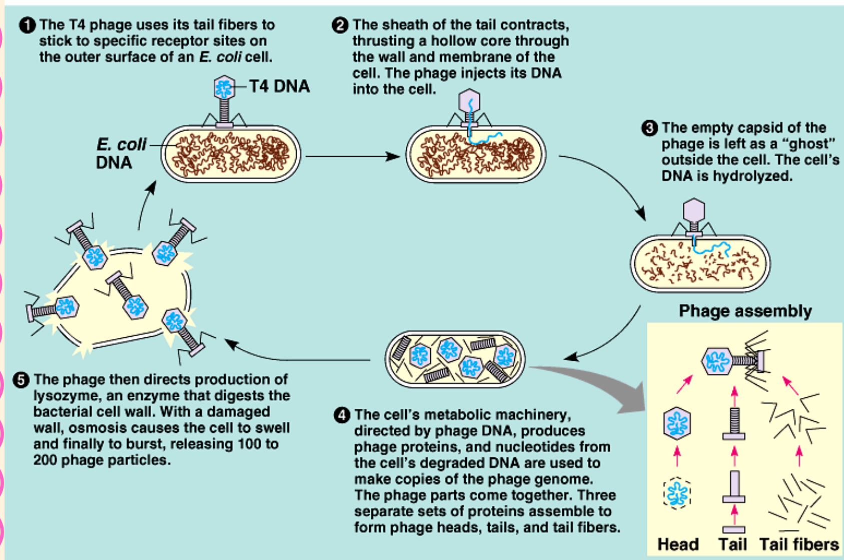
Phages reproductive cycles within bacteria:

lytic cycle -(1

The phage reproductive cycle results in the death of the host.

– In the last stage, the bacterium lyses (breaks open) and releases the phages produced within the cell to infect others.

- Virulent phages reproduce only by a lytic cycle.



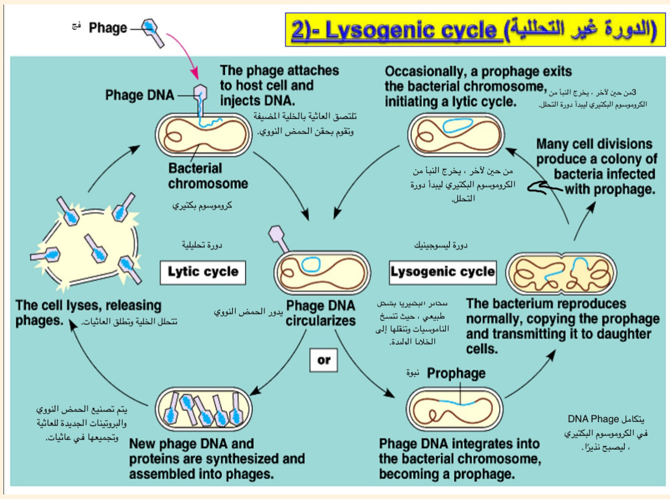
2)- lysogenic cycle (الدورة غير التحللية)

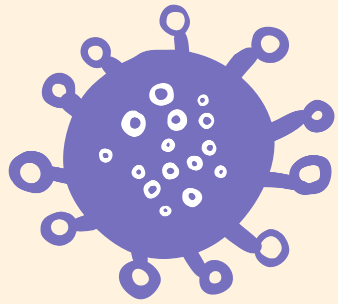
Phage lambda (λ)

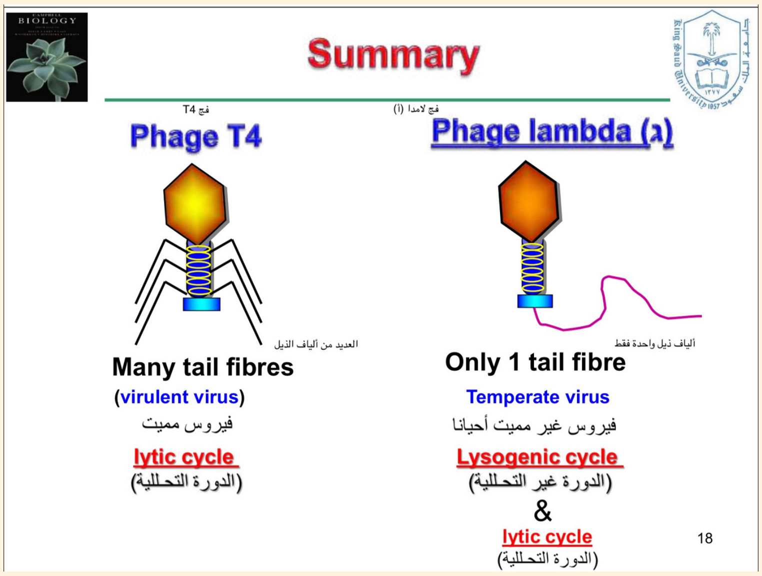
The phage genome replicates without destroying the host cell.

- Temperate phages, like phage lambda (إلامبدو رمز لمدا), λ may use both lytic and lysogenic cycles.
- Within the host, the virus' circular DNA engages in either the lytic or lysogenic cycle.
- During a lytic cycle, the viral genome immediately turns the host cell into a virus-producing factory, and the cell soon lyses and releases its viral products

2)- Lysogenic cycle (الدورة غير التحللية)







ملخص: شخصيات الفيروسات

Summary: Characters of viruses

تهاجم معظم فيروسات حقيقيات النوى أنسجة معينة. على سبيل المثال تصيب فيروسات البرد البشرية فقط الخلايا المبطنة للجهاز التنفسي العلوي ، وفيروس الإيدز يرتبط فقط بخلايا دم بيضاء معينة (جهاز المناعة).

Most viruses of eukaryotes attack specific tissues. eg. Human cold viruses infect only the cells lining the upper respiratory tract, and AIDS virus binds only to certain white blood cells (Immune system).

محاط بغلاف بروتيني (أحيانًا ، غلاف غشائي أيضًا) DNA

- **DNA enclosed in a protein coat** (sometimes, membranous envelope also)
- **Can be crystallised يتبلور** - يمكن أن تتبلور
- **They lack يفتقد enzymes for metabolism** يفتقرون إلى الإنزيمات لعملية التمثيل الغذائي
- **Have no ribosomes for making their own proteins** ليس لديهم ريبوسومات لصنع البروتينات الخاصة بهم

  تكاثر فقط داخل خلية مضيفة حية (تلزم التطفل)
- **Reproduce only within a living host cell** (obligate parasitism **تطفل إجباري**).

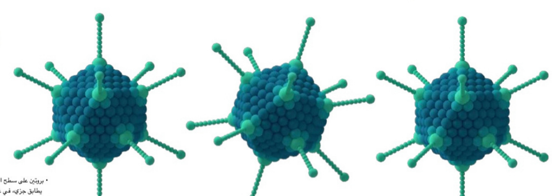
  - يصيب كل نوع من الفيروسات نطاقًا محدودًا من الخلايا المضيفة (نطاق المضيف)
- **Each type of a virus infects a limited range of host cells (host range مدى الإصابة)**

الفيروسات مضيفة معينة

Viruses are host specific

- **a protein on the surface of the virus has a shape that matches a molecule in the plasma membrane of its host, allowing the virus recognize the host cell.**

• بروتين على سطح الفيروس له شكل يطابق جزيء في غشاء البلازما لمضيفه ، مما يسمح للفيروس بالتعرف على الخلية المضيفة.



شهد

تشابتر ٤

حين ١٠٩

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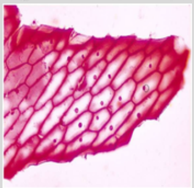
The Cell: Discovery of the Cell



- The first person to see cells was Robert Hooke in 1665.
- He was looking at a thin slice of cork through a microscope
- He found what he described as "tiny rooms" that he called cells

The Cell Theory

- In 1838, the German botanist Matthias Schleiden concluded that all plants were composed of cells
- In 1839, Theodor Schwann concluded the same thing for animals
- In 1855, Rudolf Virchow noted that all cells come from other cells

The cell theory states that:

1) all living organisms are made of one or more cells,
2) cells are the basic units of structure and function, and
3) cells come only from pre-existing cells.

A cell is the smallest unit that can carry on all of the processes of life

Types of cells

Prokaryotic
Bacteria and related micro-organisms

Eukaryotic
All other forms of life

Domains of life

A)- Prokaryota

Contains 2 Kingdoms:

1. Archaea,
2. Bacteria (Eubacteria),

B)- Eukaryota

Contains 4 Kingdoms:

1. Fungi
2. Protista
3. Plantae
4. Animalia

Prokaryotic and eukaryotic cells differ in size and complexity

Similarities أوجه التشابه

l All cells are surrounded by a . plasma membrane

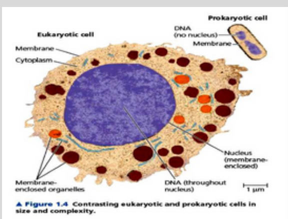
l The semi-fluid substance within the cell is called "cytosol", containing the cell organelles . .

l All cells contain chromosomes which have genes in the form of DNA.

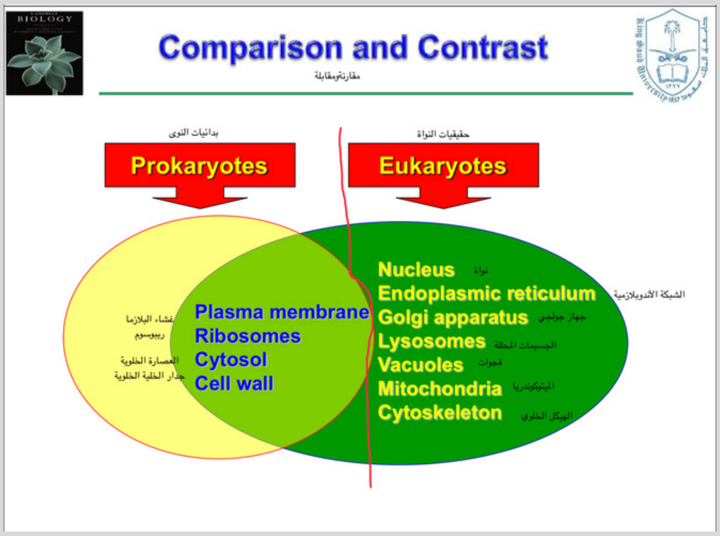
l All cells have tiny organelles called "Ribosomes" that make proteins.

Differences أوجه الإختلاف

1. Eukaryotes have a nucleus, while prokaryotes do not.
2. Eukaryotes have membrane-bound organelles, while prokaryotes do not.
3. Eukaryotic cells are, on average, ten times the size of prokaryotic cells.
4. The DNA of eukaryotes is much more complex and therefore much more extensive than the DNA of prokaryotes.
5. Prokaryotes have a cell wall composed of peptidoglycan. Many types of eukaryotic cells also have cell walls, but none made of peptidoglycan.
6. The DNA of prokaryotes floats freely inside the cell; the DNA of eukaryotes is held within its nucleus and associated with histones (proteins)
7. Eukaryotes undergo mitosis and meiosis; prokaryotes divide by binary fission (simple cell division)



▲ Figure 1.4 Contrasting eukaryotic and prokaryotic cells in size and complexity.

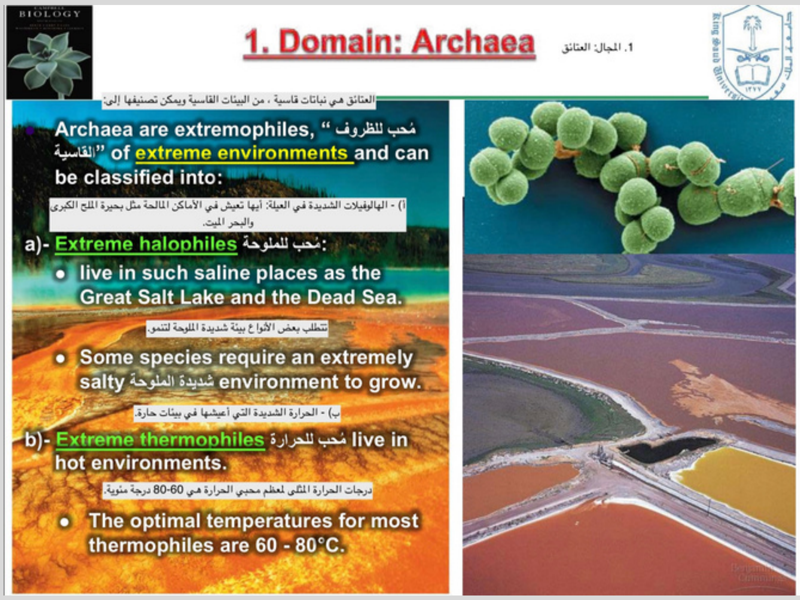


A)- Prokaryotes:

l Prokaryotes are single-celled (Unicellular) organisms that do not have a membrane-bound true nucleus, and can live in nearly every environment on earth.

l Although tiny, prokaryotes differ greatly in their genetic traits, their modes of nutrition, however, their habitats are similar.

l Based on genetic differences, prokaryotes are grouped into two Major Domains: Domain Archaea and Domain Bacteria.



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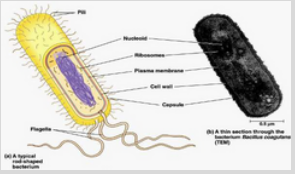
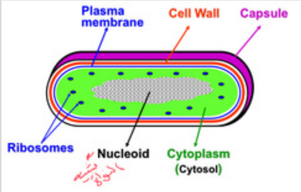
تشابتر ٥

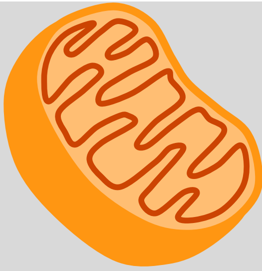
2. Domain: Bacteria

Bacteria occur in many shapes and sizes. Bacteria are of four shapes: rod-shaped, sphere-shaped, spiral-shaped, or filamentous-shaped



Prokaryotic Cell





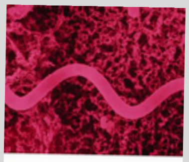
Shapes of Bacteria

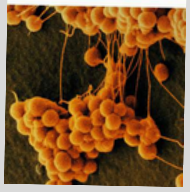
*Bacteria have one of three basic shapes:

A. Spiral shaped bacteria in the form of spirilla (singular, spirillum) or vibrio (comma like).

B. Sphere-shaped bacteria are called cocci (singular, coccus). An example of cocci is Micrococcus luteus. Cocci are single or aggregate cells in different shapes.

C. Rod-shaped bacteria are called bacilli (singular, bacillus). An example of bacilli is Escherichia coli. Bacilli are single or aggregate cells in different shapes also



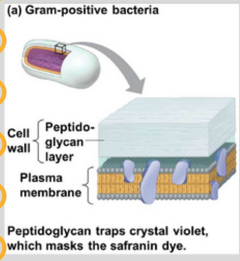


The Gram's stain: صبغة جرام

Developed by the Danish physician "Hans Christian Gram" in 19th-century

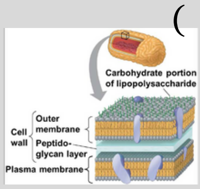
l It is a tool for identifying bacteria, based on differences in their cell walls.

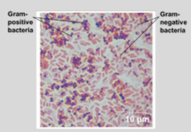
- A)- Gram-positive (Gram +ve) bacteria:
- Their cell walls have large amounts of peptidoglycans that react with Gram's stain (appear violet-stained)



B)- Gram-negative (Gram -ve) bacteria:

l their cell walls have small amount of peptidoglycan. So, they do not react (or very weakly react) with Gram's stain (appear (stained-red





Summary of Gram's stain: صبغة جرام

Gram Stain

- Most species of bacteria are classified into two categories based on the structure of their cell walls as determined by a technique called the Gram stain.
- Gram-positive bacteria have a thick layer of peptidoglycan in their cell wall, and they appear violet under a microscope after the Gram-staining procedure.
- Gram-negative bacteria have a thin layer of peptidoglycan in their cell wall, and they appear reddish- pink under a microscope after the Gram-staining procedure

Summary of Gram's stain: صبغة جرام

- Gram +ve bacteria: have Large amount of peptidoglycan that stained violet.
- Gram –ve bacteria: Have small amount of peptidoglycan stained red

Most Gram-negative species are pathogenic (more
- threatening (than gram-positive species.
- Gram-negative bacteria are commonly more resistant than gram-positive ones to antibiotics

I - Bacterial capsule

*Many prokaryotes (bacteria) secrete a sticky protective layer called capsule outside the cell wall.

*Capsule has the following functions:

. bacterial cells to their substratum تيبثت Adhere .1

. Increase bacterial resistance to host defenses .2

.Stick ((bacterial cells together when live in colonies .3

.Protect bacterial cell .4

II - The bacterial cell wall

l In all prokaryotes, the functions of the cell wall are as follow:

1. maintains the shape of the cell,
2. affords physical protection
3. prevents the cell from bursting (in a hypotonic . environment

*Most bacterial cell walls contain peptidoglycan (a polymer of modified sugars cross-linked by short polypeptides).

*The walls of Archaea lack (peptidoglycan

Reproduction of Bacteria

Prokaryotes *) reproduce only asexually by fission binary

*A single cell produces a colony of offspring

Nutrition of Prokaryotes

التغذية في بدائيات النواة

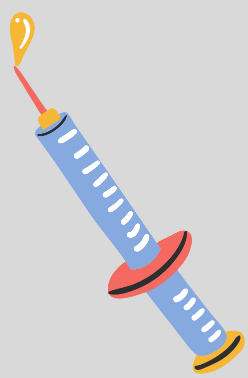
*Nutrition refers to how an organism obtains energy and a carbon from the environment to build the organic molecules of its cells.

Nutrition of Prokaryotes

التغذية في بدائيات النواة

- Phototrophs: Organisms that obtain energy from light
- Chemotrophs: Organisms that obtain energy from chemicals in their environment..
- Autotrophs: Organisms that use CO2 as a carbon source.
- Heterotrophs: Organisms that use organic nutrients as a carbon source

- Photoautotrophs: use light energy as an energy source, and CO2 as a carbon source to synthesizeuse light energy as an energy source, and CO2 as a carbon source to synthesize
- Chemoautotrophs: use chemical inorganic substances as an energy source, and CO2 as a carbon source
- Photoheterotrophs: use light as an energy source, and organic substances as carbon sources
- Chemoheterotrophs use organic substances as a source for both energy and carbon.



أحياء ١٠٩

تشابتر ٦

B- The Eukaryotic Cell

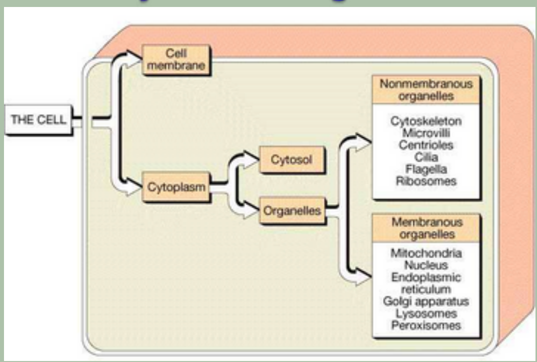
Eu = True

Karyon = Nucleus

Animal Cell | **Plant Cell**

Compare Animal and Plant cell
What are the functions of cell organelles ?

Eukaryotic Cell Organization



Introduction

• An eukaryotic cell has internal membranes, which partition the cell into compartments.

• These membranes also participate in metabolism as many enzymes are built into membranes.

• The general structure of a biological membrane is a double layer of phospholipids and diverse proteins.

• Each type of membrane has a unique combination of lipids and proteins for its specific functions.

– For example, those in the membranes of mitochondria function in cellular respiration.

Comparison: Plant & Animal Cells

• Similarities

– Both are eukaryotic cells

– Both contain similar organelles

– Both are surrounded by cell membrane

*Differences

– Plants have

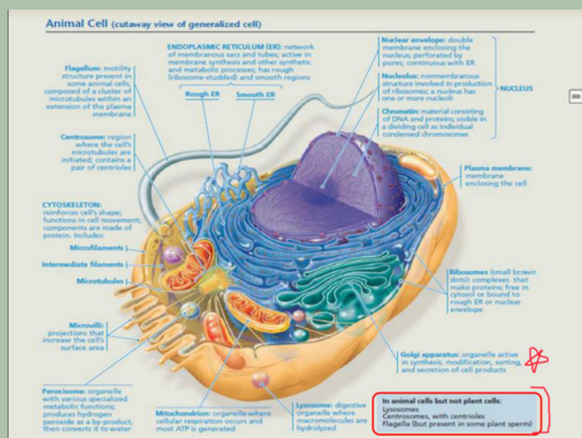
Cell wall – provides strength & rigidity and is not found in animal cells.

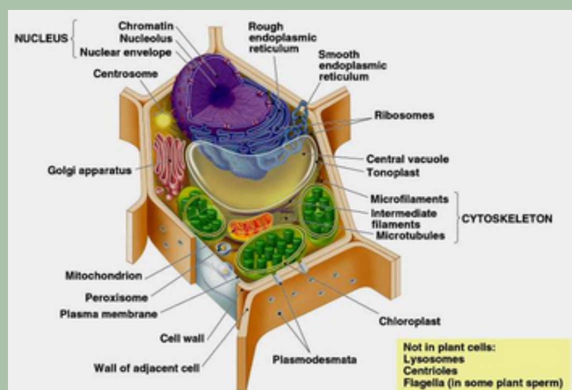
• Have chloroplasts that is photosynthetic and are not found in animal cells.

– Animals have

• Lysosomes, centrioles and flagella are not found in plants.

• Centrioles have important role in cell division.





1)- The nucleus:
Contains the cell's genetic library

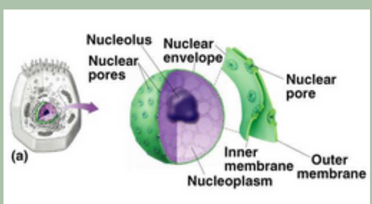
The nucleus contains most of the genes in an eukaryotic cell as it is the repository for genetic material.

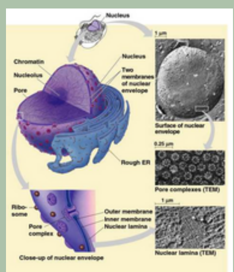
• The nucleus is separated from the cytoplasm by a double membrane called nuclear envelope.

• It directs activities of the cell.

• The nuclear membrane contains pores that allow macromolecules and particles to pass through.

• The nuclear membrane is maintaining the shape of the nucleus.





The nucleus contains the "chromatin fibers" which are mad
up
of DNA and proteins.

• When the cell prepares to divide, the chromatin fibers coil u
and condensed to be seen as "chromosomes".

• Each eukaryotic species has a characteristic number of chromosomes.

- A typical human cell has 46 chromosomes, but sex cells or
gametes (eggs
and sperms) have only 23 chromosomes.

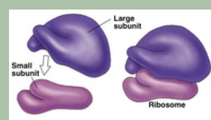
• The nucleus directs protein synthesis by synthesizing messenger RNA (mRNA).

– The mRNA travels to the cytoplasm and combines with ribosomes
to translate its genetic message into the primary structure of
specific protein.

• Nucleolus is a dark region and produces ribosomes.

2)- Ribosomes:
The protein-making machine

• Ribosomes: are RNA-protein complexes, and composed of two subunits (large and small) that joi
and attach to mRNA to carry out protein synthesis.



• So, it is the site of protein synthesis.

• Ribosome assembly begins in the nucleolus and is completed in the cytoplasm

*In the nucleus, rRNA is transcribed, then binds to special proteins to form the ribosomal subunit
in the nucleolus.

• The subunits pass out through the nuclear pores to the cytoplasm where they combine to form Functional Ribosomes when they attach to an mRNA molecule.

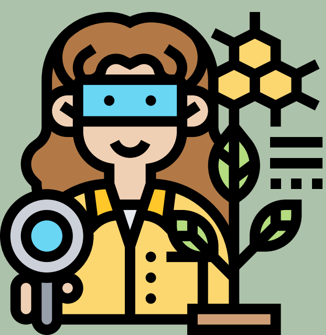
• Cells that synthesize large quantities of proteins (e.g., pancreas) have large numbers of ribosome

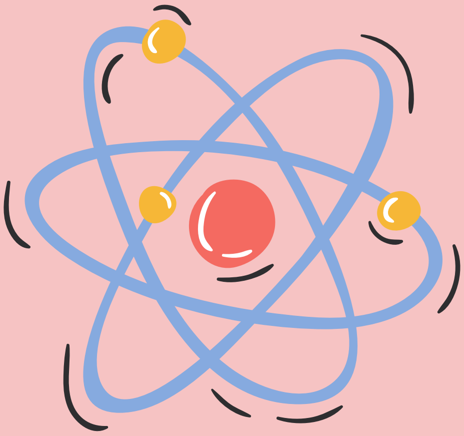
• Types of Ribosomes:-

1) Free ribosomes are suspended in the cytosol and synthesize proteins that function within the cytosol.

2) Bound ribosomes are attached to the outside of the endoplasmic reticulum.

– These synthesize proteins that are either included into membranes or for secretion outside the cell.





حين ١٠٩
ملخص تشابتر٧

A)- The endoplasmic reticulum (ER)

(intracellular highway)

• Largest internal membrane, composed of lipid bilayer

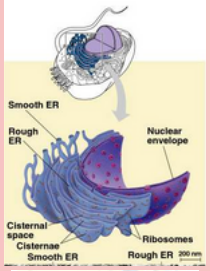
• Serves as a system of channels from the nucleus

• Functions in storage and secretion

• There are two types of ER those are different in structure and function.

1. Smooth ER looks smooth because it lacks (does not have) ribosomes.

2. Rough ER looks rough because ribosomes (bound ribosomes) are attached to its outside.



The endoplasmic reticulum

*The smooth ER:

• It is smooth as it lacks the associated ribosomes.

• It is rich in enzymes and plays a role in metabolic processes.

• Its enzymes synthesize lipids (oils, phospholipids and steroids).
including the sex hormones.

• Extensive in the liver, it helps in detoxifying drugs and poisons.

*The rough ER:

• It is "rough" because of the associated ribosomes (sites of protein synthesis)

• It is especially abundant in those cells that secrete proteins such as digestive glands and antibody-producing cells.

• These secretory proteins are packaged in transport vesicles that carry them to their next stage.

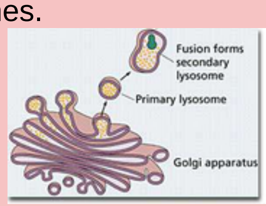
C)- Lysosomes:

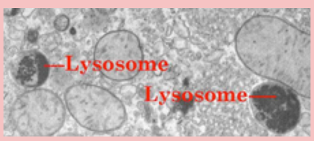
are digestive components

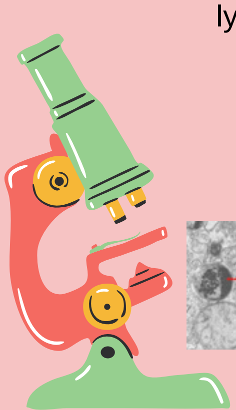
• The lysosome is a membrane-bounded sac of enzymes that digests macromolecules.

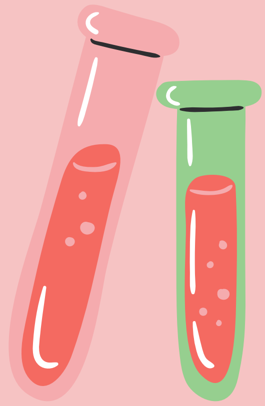
• Lysosomal enzymes work best at pH = 5 (acidic).

• The lysosomal enzymes are synthesized by rough ER and then transferred to the Golgi then to lysosomes.









B)- Golgi apparatus:

finishes, sorts, packages and ships cell pr

• Collect, package, and distribute molecules synthesized at one location in the cell and utilized at another location

• Many transport vesicles from the ER travel to the Golgi apparatus for modification of their contents.

• The Golgi body's function is manufacturing, warehousing, sorting (Packaging), and shipping materials to outside the cell.

• The Golgi also manufactures polysaccharides.

• It correctly send proteins to their respective address.

• If the Golgi makes a mistake in shipping the proteins to the right address,
certain functions in the cell may stop.

• The Golgi apparatus is more abundant in secretory cells.

Functions of Lysosomal enzymes

1) They hydrolyse proteins, fats, polysaccharides, and nucleic acids.

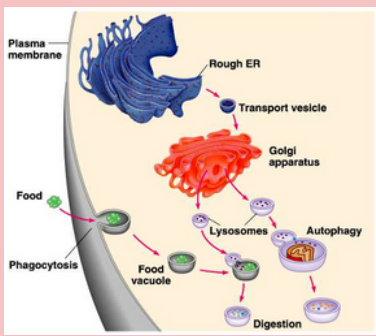
2) Can destroy the cell by auto-digestion (autophagy).

3) Can fuse with food vacuoles to digest food, (when a
food item is brought into the cell by Phagocytosis).

4) Can also fuse with and digest another organelle or part of the cytosol. This process is called recycling which renews the organelle and/or the cell.

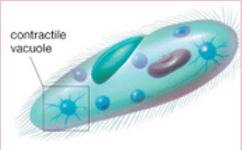
5. They digest unwanted particles.

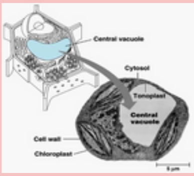
6. They help white blood cells to destroy bacteria.

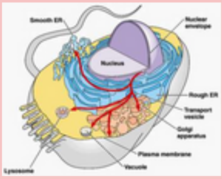


D)- Vacuoles:

have diverse functions in cell maintenanc







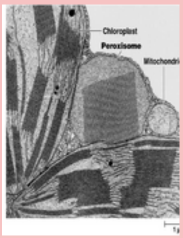
- They are membrane-bound sacs with varied functions such as storage, digestion, and waste removal.
- Contain water solution and help plants maintain shape.

There are different types of vacuoles including:

1. Food vacuoles, from phagocytosis, fuse with lysosomes for digestion.
2. Contractile vacuoles, found in freshwater protists (e.g. Paramecium) to maintain water balance (osmoregulation) by pumping excess water out of the cell.
3. Central vacuoles (in mature plants) store wastes, maintain the cell shape.

Other Membranous Organelles

A)- Peroxisomes



- Peroxisomes are similar in appearance to lysosomes, but the two have different origins:
- Lysosomes are generally formed in the Golgi complex,
- Whereas peroxisomes are self-replicating themselves.
- Contain enzymes for degrading amino acids and fatty acids. These reactions produce a toxic hydrogen peroxide; (H_2O_2) as a byproduct of cellular metabolism

Functions of peroxisomes

1- Hydrogen peroxide (H_2O_2) is a poison, but the peroxisome has enzymes that converts H_2O_2 to water (H_2O).

2- Some peroxisomes break fatty acids down to smaller molecules that are transported to mitochondria as fuel (cellular respiration).

3- They detoxify alcohol and other harmful compounds. Thus, it exists extensively in the liver cells.

4- Initiate the production of phospholipids, which are typically used in the formation of membranes.

Other Membranous Organelles

B)- Mitochondria:

They are rod-shaped organelles that convert oxygen and nutrients into ATP (adenosine triphosphate) during aerobic respiration.

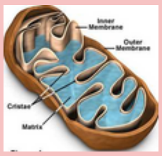
- ***Mitochondria are the sites of cellular respiration,***
- Generating ATP from the catabolism of sugars, fats, and other fuels in the presence of oxygen.
- Almost all eukaryotic cells have mitochondria.
- Mitochondria are mobile and move around the cell along tracks in the cytoskeleton .

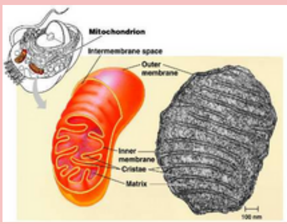
*Mitochondria have a smooth outer membrane and a highly folded inner membrane forming the cristae.

- The inner membrane encloses the mitochondrial matrix, a fluid-filled space with the mitochondrial DNA, ribosomes, and enzymes.

The number of mitochondria present in a cell depends upon the metabolic requirements of that cell, and may range from a single large mitochondrion to thousands.

The mitochondrion is different from most other organelles because it has its own circular DNA (similar to the DNA of prokaryotes) and reproduces independently of the cell in which it is found.





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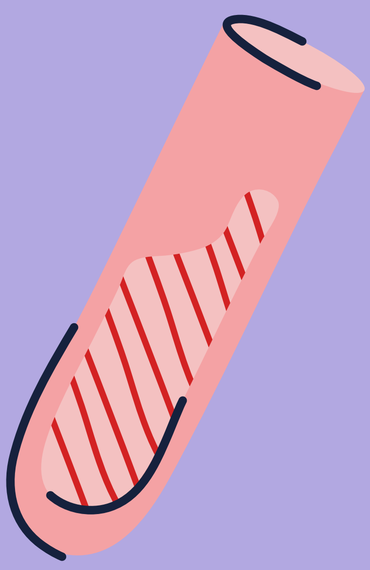
ملخص تشابتر ٨

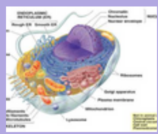


The Cytoskeleton الهيكل الخلوي

Microtubules and filaments

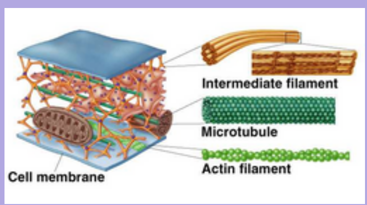
A network of fibres that provides structural support to the cell. The cytoskeleton also functions in cell motility and regulation.

- It is made up of 3 types of fibers
  1. Microfilaments
  2. Microtubules
  3. Intermediate filaments

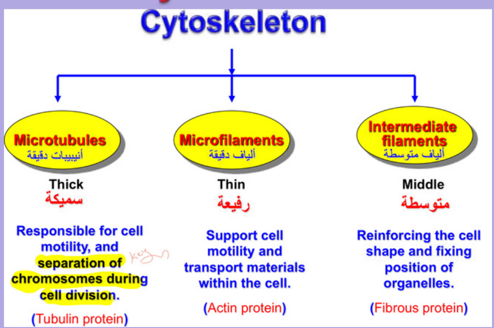


- It has 3 main functions:
  1. Provides mechanical support of the cell and keeps organelles in their fixed locations.
  2. Helps moving materials within the cell
  3. Plays a major role in cell motility

Cytoskeleton



Cytoskeleton



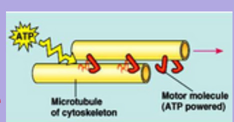
The cytoskeleton is dynamic, dismantling in one part • and reassembling in another to change cell shape.

- The cytoskeleton plays a major role in cell motility by interacting with motor proteins. .
- Motor proteins are able to move along the surface of a suitable substrate (powered by ATP).
- Motor proteins are the driving force behind most active transport of proteins and vesicles in the cytoplasm.

Cell Movement

– In cilia and flagella motor proteins pull components of the cytoskeleton past other each

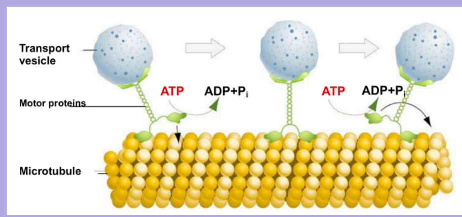
– This is also true in muscle cells.



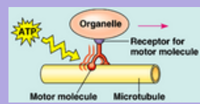
Motor proteins

Motor proteins are a class of molecular motors that are able to move along the surface of a suitable substrate. They are powered by the hydrolysis of ATP and convert chemical energy into mechanical work.

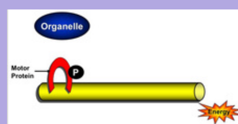
MOTOR PROTEINS "WALKS" ALONG A MICROTUBULE TRACK



Motor proteins



- Interactions of motor proteins and the cytoskeleton circulates materials within the cell.
- The cytoskeleton may transmit mechanical signals that rearrange the nucleoli and other structures.
- Motor molecules also carry **vesicles** or **organelles** to various destinations the by provided cytoskeleton.



Microtubules functions as tracks that guide motor proteins carrying organelles to their destination.

*They move chromosomes during cell division

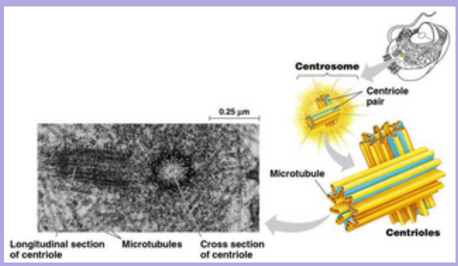
Motor proteins and movement of organelles

Centrosome

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

Centrosome

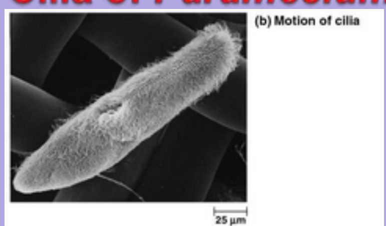
• In animal cells, the centrosome has a pair of centrioles, each
with 9 triplets of microtubules 9 + 0 pattern)
arranged in a ring .
• During cell division the centrioles replicate .



Cilia and Flagella

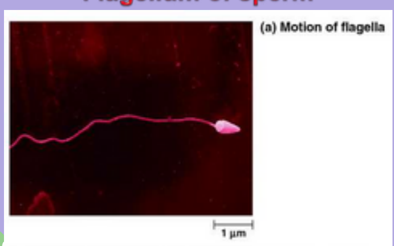
• Microtubules are the central structural supporting both cilia and flagella.
– Both can move unicellular and small multicellular organisms by propelling water outside the organism.
• Cilia usually occur in large numbers on the cell surface.
• Flagella usually occur in just one or a few per cell.
• Cilia move more like oars with alternating power and recovery strokes.
• Flagella have an undulatory movement .
• So, they differ in their beating pattern

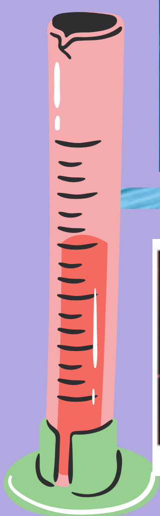
Cilia of Paramecium



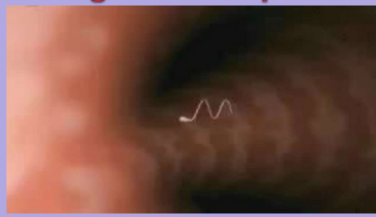
Cilia of Paramecium

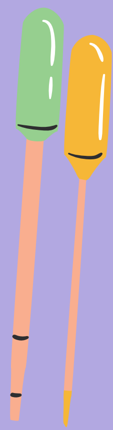
Flagellum of sperm



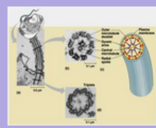


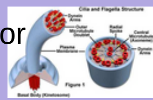
Flagellum of sperm





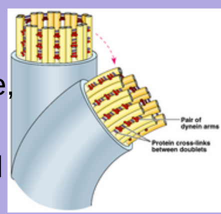
v Both cilia and flagella have the ultrastructure same
v Both have a core of microtubules sheathed by the plasma membrane.
v 9-doublets (9 + 2 pattern) arranged microtubules of around a pair at the center.
v Flexible “wheels” of proteins connect outer doublets to each other and to the core.
v The outer doublets are also connected by motor proteins.
v Thus, the structure of the cilium and flagellum is different from that of the centriole.





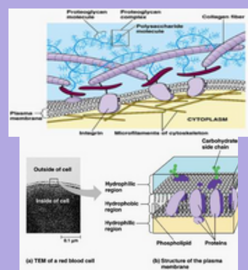
Movement of Cilia and Flagella

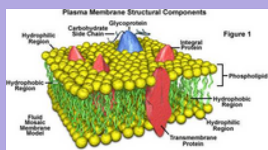
• Cilia and flagella have arms of a motor protein .(dynein(
– Dynein arms alternately grab, move, and release the outer microtubules.
– Protein cross-links limit sliding and the force is expressed as bending



Cell membrane

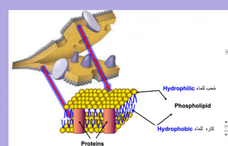
The plasma membrane functions as a selective barrier that allowspassage of oxygen,nutrients, and wastes for the whole volume of the cell.

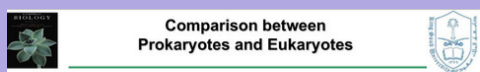




Cell membrane

Composed of a kind of lipids (phospholipids) and proteins
Lipid layer contains hydrophilic and hydrophobic regions



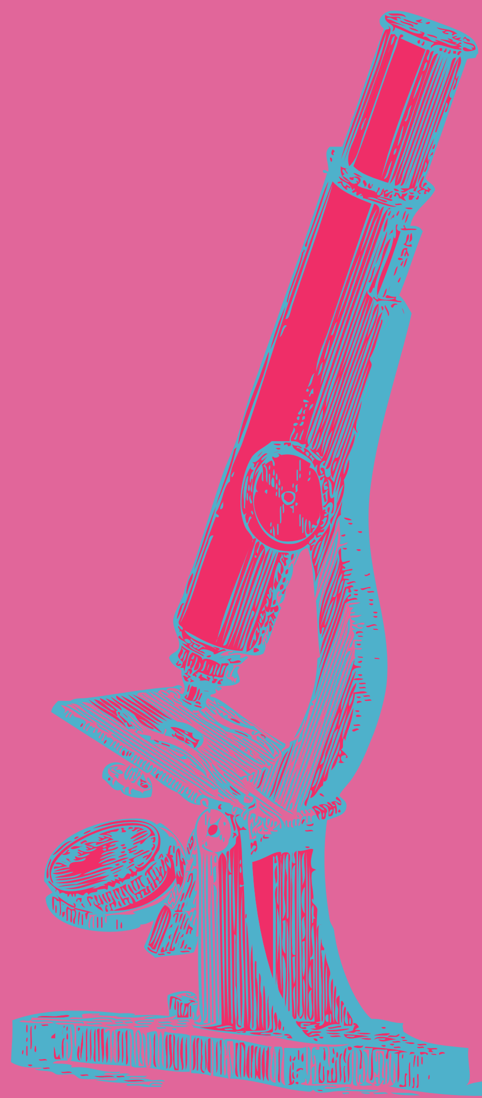


Comparison between
Prokaryotes and Eukaryotes

Term	Prokaryotes	Eukaryotes
Size	1-10 µm in diameter	10-100 µm in diameter
Cell wall	Existed	In plant cell (not animal cell)
nucleus	No nuclear envelope but Nucleoid	True nucleus exists with nuclear envelope
DNA	As fibre in the nucleoid region (plasmids in some cases)	As Chromatin (DNA and protein)
Specialized Organells	Most of them are absent	All are existed
Cell division	By Binary Fission	Meiotic and/or Mitotic

حين ١٠٩

ملخص تشابتر ٩



A) Structure of Cell Membrane

v The plasma membrane separates the living cell from its nonliving surroundings.

v This thin barrier, 8 nm thick, controls traffic into and out of the cell.

v Like other membranes, the plasma membrane is selectively permeable , allowing some substances to cross more easily than others.

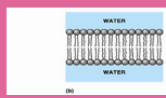
v The most abundant lipids in the cell membrane are phospholipids.

v **Phospholipids** and most other membrane constituents are amphipathic molecules.

v Amphipathic molecules have both hydrophobic regions and hydrophilic regions

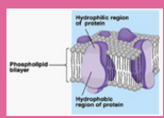
Membrane Structure

v The lipid molecules in the bilayer are arranged as hydrophobic fatty acid tails that are sheltered from water while the hydrophilic phosphate groups interact with water.



v Some membrane proteins are amphipathic, with hydrophobic and hydrophilic regions.

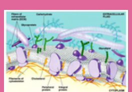
v If at the surface, the hydrophilic regions would be in contact with water.



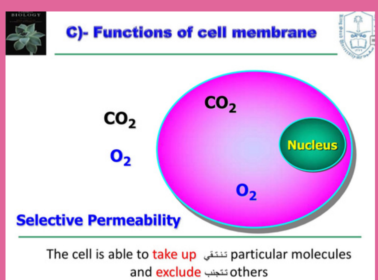
v In this fluid mosaic model, the hydrophilic regions of proteins and heads phospholipids are in contact with water, while the hydrophobic regions are in a non-aqueous environment.

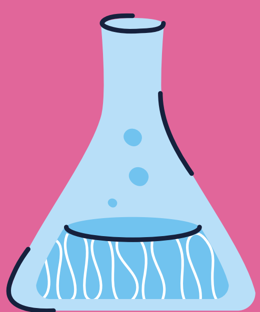
Cell membrane is mosaic of structure and function

A membrane is a collage of different proteins • embedded in the fluid matrix of the lipid .bilayer



*To work properly with permeability, membrane must be fluid about as fluid as oil.



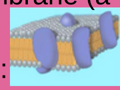


B)- The plasma membrane has a unique collection of proteins.

There are two populations of MEMBRANE PROTEINS.

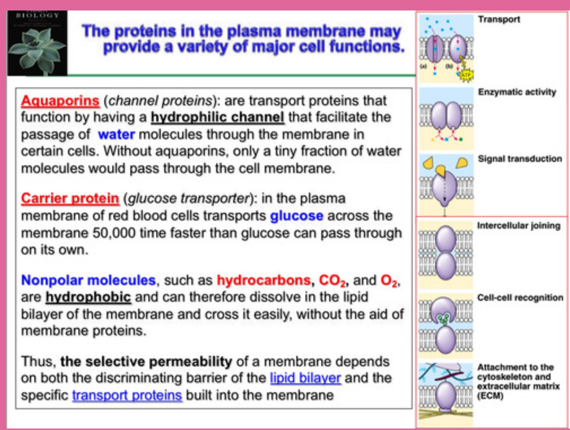
1. Peripheral protein) hydrophilic) is not embedded in the lipid bilayer at all. Instead, it is loosely bounded to the surface of the protein, often connected to the other population of membrane proteins.

2. Integral protein penetrates the hydrophobic core of the lipid bilayer, often completely spanning the membrane (a transmembrane protein). It is amphipathic, because:



• Where it is in contact with the core, it has a hydrophobic region.

• Where it is in contact with the aqueous environment outside the membrane, it has a hydrophilic region.



The proteins in the plasma membrane may provide a variety of major cell functions.

Aquaporins (*channel proteins*): are transport proteins that function by having a **hydrophilic channel** that facilitate the passage of **water** molecules through the membrane in certain cells. Without aquaporins, only a tiny fraction of water molecules would pass through the cell membrane.

Carrier protein (*glucose transporter*): in the plasma membrane of red blood cells transports **glucose** across the membrane 50,000 time faster than glucose can pass through on its own.

Nonpolar molecules, such as **hydrocarbons**, CO_2, and O_2, are **hydrophobic** and can therefore dissolve in the lipid bilayer of the membrane and cross it easily, without the aid of membrane proteins.

Thus, **the selective permeability** of a membrane depends on both the discriminating barrier of the lipid bilayer and the specific transport proteins built into the membrane

)- Functions of cell membrar

Selective permeability -1

A steady traffic of small molecules and ions moves across .the plasma membrane in both directions

v For example, sugars, amino acids, and other nutrients enter a muscle cell and metabolic waste products leave it.

v The cell absorbs O_2 and expels CO_2.

v It also regulates concentrations of inorganic ions, like Na^+, K^+, Ca^{2+}, and Cl^-, by passing them across the membrane.

v However, substances do not move across the barrier indiscriminately as membrane is selectively permeable.

v Hydrophobic molecules, like hydrocarbons, CO_2, and O_2, can dissolve in the lipid bilayer and cross easily as described in the previous slide.

v Ions and polar molecules like H_2O and glucose pass through channel proteins as described in the previous slide.

v Thus membrane proteins assist and regulate the transport of ions and polar molecules.

C)- Functions of cell membrane

transport Passive- 2

Involves the movement of molecules across the cell membrane
without the need of energy by the cell.

No ENERGY is required to move substances across membrane
(water, lipids, and other lipid soluble substances).
Rather, the CONCENTRATION GRADIENT represents

Types of Passive transport:

I. Diffusion
II. Osmosis
III. Facilitated Diffusion

I)- Diffusion:

(The passive transport of solutes molecules)
Is the tendency of molecules of any substance to spread out in the available space randomly.

- For example, a permeable membrane separating a solution with sugar molecules from pure water, sugar molecules will cross the barrier randomly.
- The sugar molecules will cross the membrane until both solutions have equal concentrations of the sugar (dynamic equilibrium

- A substance will diffuse from where it is more concentrated to where it is less concentrated, down its concentration gradient

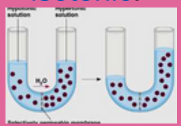
Osmosis الأسموزية : the passive transport of w
(Principal of water movement)

- Osmosis:

It is the passive transport in which water diffuses across a selectively permeable membrane from the hypotonic solution to the hypertonic solution until the solutions become isotonic.

Types of solutions.

- The solution with the higher concentration of solutes is hypertonic.
- The solution with the lower concentration of solutes is hypotonic.
- Solutions with equal solute concentrations are isotonic.



ummary:
pes of solutions and Osmosis

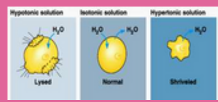
*Hypertonic solutio:
ccontains high concentration of solute molecules.

*Hypotonias solutio:
contains low concentration of solute molecules

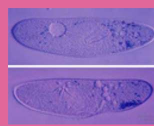
*isotonic solution:
contain equal concentrations of solute molecules.

Osmoregulation التوازن الأسموزي

- The cell in a hypertonic environment will loose water, shrivel , and die.
- A cell in a hypotonic solution will gain water, swell, and burst.
- Nothing will happen for a cell in an isotonic solution
- Organisms without rigid walls have osmotic problems in either a hypertonic or hypotonic environment and must have adaptations for osmoregulation to maintain their internal environment.

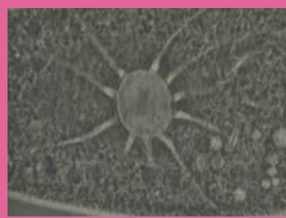


- Example, Paramecium has a specialized organelle (the contractile vacuole), that functions as a pump to force water out of the cell.



Osmoregulation: in Paramecium

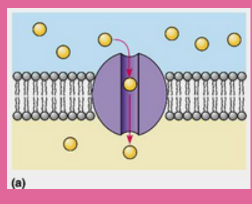
The contractile vacuole



III)- Facilitated Diffusion:

Specific proteins facilitate تسهيل passive transport

- Many polar molecules and ions diffuse passively through the lipid bilayer with the help of transport proteins (gated channels .(
- The passive movement of molecules down its concentration gradient via a transport protein is called facilitated diffusion.
- Many transport proteins simply provide channelsallowing a specific molecule or ion to cross the membrane.



حين ١٠٩

تشابتر ١٠

Active transport: pumping ضخ of solutes against their concentration gradient الإنحدار التركيزي

• Some facilitated transport proteins can move solutes against their concentration gradient, from the side where they are less concentrated to the side where they are more concentrated.

• This active transport requires metabolic energy via ATP.

• Active transport is critical for a cell to maintain its internalconcentrations of small molecules.

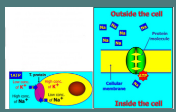
• Active transport is performed by specific proteins embedded in the membranes called transport protein (T. protein).

1)- Transport of small molecules (Ions)

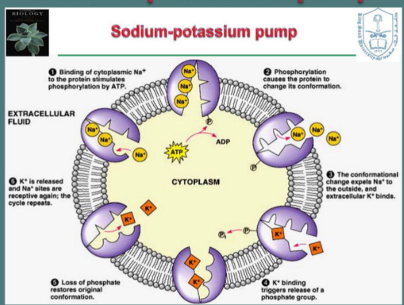
• The sodium-potassium pump actively maintains the gradient of sodium (Na+) and potassium ions (K+) across the membrane.

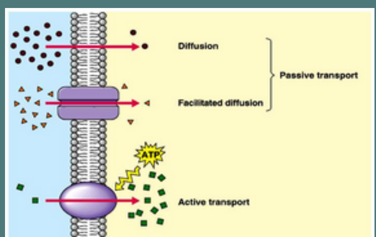
– The animal cell has higher concentrations of K+ and lower concentrations of Na+ inside the cell.

– The sodium-potassium pump (T. protein) uses the energy of one ATP to pump 3 Na+ ions out and 2 K+ ions in.

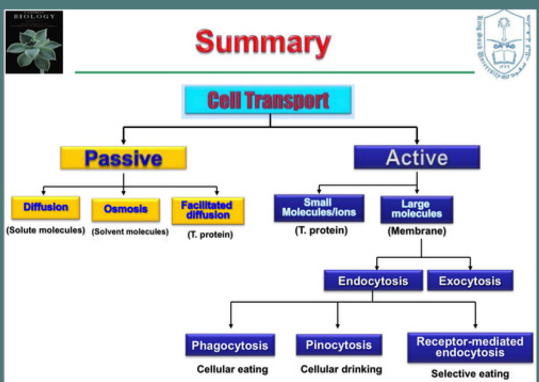


Sodium-potassium pump





Both diffusion and facilitated diffusion are forms of passive transport of molecules down their concentration gradient, while active transport requires an investment of energy to move molecules against their concentration gradient



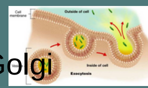
2)- Transport of large molecules (macromolecules)

*Large molecules are transported by Exocytosis and endocytosis

*Small molecules and water enter or leave the cell through the lipid bilayer or by transport proteins.

*Large molecules, such as polysaccharides, proteins and lipoprotein particles cross the membrane by vesicles .

1-Exocytosis.



*A transport vesicle budded from the Golgi apparatus is moved by the cytoskeleton to the plasma membrane.

*When the two membranes come in contact , the bilayers fuse and spill the contents to the outside

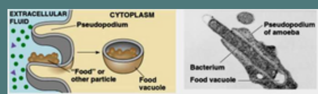
2-Endocytosis

A cell brings in macromolecules and particulate matter by forming new vesicles from the plasma membrane and include the following:

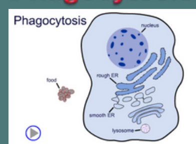
A-Phagocytosis

Called "cellular eating". The cell engulfs a • particle by extending pseudopodia around it and packaging it in a large vacuole.

• The contents of the vacuole are digested when the vacuole fuses with a lysosome.



Phagocytosis



."B)- Pinocytosis, " cellular drinking

A cell creates a vesicle around droplets of extracellular fluid

– This is a non-specific process

C)- recepto-mediated endocytosis:

*It Is called (Selective eating) which is very specific in what substances are being transported.

• It is triggered when extracellular substances bind to special receptors , on the membrane surface. This triggers the formation of a vesicle

• It enables a cell to take large quantities of specific materials that may be in low concentrations in the environment.

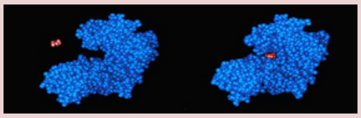
حين ١٠٩

تشابتر ١١

AN INTRODUCTION TO METABOLISM

Enzymes

Protein molecules with catalytic properties due to their power of specific activation



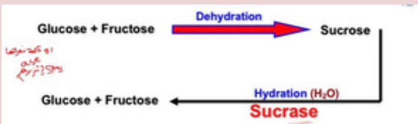
Hydrolysis of sucrose (table sugar)

Hydrolysis of sucrose in the presence of Sucrase results in its two monosaccharide components. This process include:

1- Breaking the bond between Glucose and Fructose;

2- Then, forming new bonds with H+ and OH- to from water.

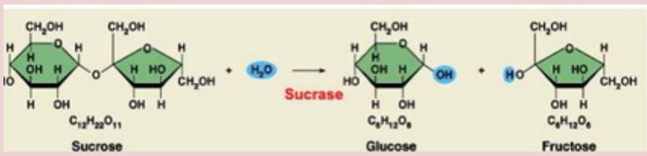
This process consumes energy (Activation Energy; EA)



Enzymes speed up metabolic reactions by lowering energy barriers حواجز الطاقة

*Chemical reactions between molecules involve both bond breaking and bond forming.

*To hydrolyze (hydration) sucrose, the bond between glucose and fructose must be broken via hydrolysis in the presence of sucrase (the catalyst)



Enzymes and Activation Energy

Activation Energy:

It is the minimum amount of energy needed to start a reaction. It is the amount of energy needed for the reaction (between enzyme & substrate) to complete (to break the bonds).

Raising the temperature for these reactions to complete will either denature the compounds or kill the cell.

Thus, organisms must therefore use a catalyst

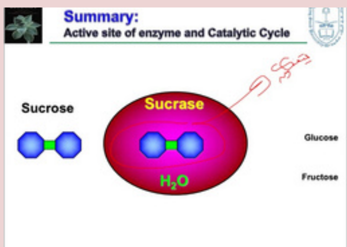
Catalyst:

It is a chemical agent that accelerate the reaction without being

Enzyme is a catalytic protein بروتين مساعد/محفز

consumed by the reaction.

An enzyme is a specific catalyst for specific reactants at any time in the cell (e.g. Sucrase for only Sucrose)



Activation energy

Activation energy: is the amount of energy necessary to push the reactants over an energy barrier.

At the transition state, the molecules are at an unstable point.

The difference between free energy of the products and the free energy of the reactants is the delta G.

Enzyme can increase the rate of reactions by lowering EA.

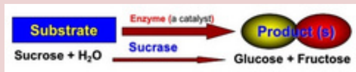
The transition state can then be reached even at moderate temperatures.

Enzymes are substrate specific

The substrate is a reactant which binds to • .an enzyme

• When a substrate binds to an enzyme, the enzyme catalyzes the conversion of the substrate to the product.

– Sucrase (catalyst) is an enzyme that binds to sucrose (substrate) and breaks the disaccharide into fructose and glucose (products).



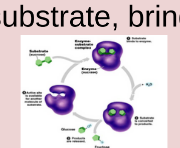
Specificity of enzyme refers to the shape of its

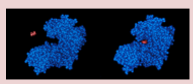
Active Site into which fits the surface of the substrate.

The active site is an enzyme's catalytic center

the active site of an enzymes is the groove** on the surface of the enzyme into which the substrate fits.

- The specificity of an enzyme is due to the fit between the active site and that of the substrate.
- As the substrate binds, the enzyme changes shape to fit the substrate, bringing chemical groups in position to catalyze the reaction.





Summary:

Active site of enzyme and Catalytic Cycle

1- The substrate binds to the active site of enzyme.

2- This forms an Enzyme-Substrate complex (via weak hydrogen bonds).

3- The active site catalyzes the conversion of the substrate to final products (to its original components) by breaking bonds.

4- The resulting products release from the enzyme.

5- The enzyme starts another reaction over and over again.

6- Thus, the enzyme can have a huge metabolic effect in the catalytic cycle.

7- An enzymes has catalytic properties due to its power of hydrolytic activities

Summary:

Some characters of enzyme

- A single enzyme molecule can catalyze thousands or more reactions a second.
- Enzymes are un-affected by the reaction and are reusable
- Most metabolic enzymes can catalyze a reaction in both the forward and reverse directions.

*The actual direction depends on the relative concentrations of products and reactants.

*Enzymes catalyze reactions in the direction of equilibrium.

- The enzyme lowers the activation energy and speed up the reaction.
- The rate that a specific number of enzymes converts substrates to products depends in part on substrate concentrations.
- At some substrate concentrations, the active sites on all enzymes are saturation enzyme called , engaged

Cellular factors affecting enzyme activity

• Changes in shape of the enzyme molecule influence the reaction rate.

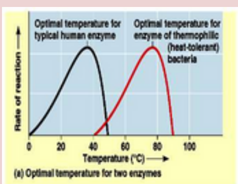
• Some conditions lead to the most active conformation and lead to optimal rate of reaction. These factors are:

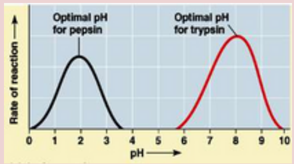
1. Temperature: has a major impact on reaction rate.

v As temperature increases, reaction between substrate and active sites occur faster.

v However, at some point thermal increase begins to denature the enzyme.

v Each enzyme has an optimal temperature





Cellular factors affecting enzyme activity

2. pH also influences the reaction rate, each enzyme has an optimal pH falls between pH 6 - 8 for most enzymes.

• However, digestive enzymes in the stomach are designed to work best at pH 2 while those in the intestine are optimal at pH 8, both matching their working environments.

Cofactors. 3

A non-protein helpers for catalytic activity of enzymes. They bind permanently to the enzyme and include two types:-

a)- Inorganic cofactors, include zinc, iron, and copper.

b)- Organic cofactors, include vitamins or molecules derived from vitamins (coenzymes).

Enzyme inhibitors: مُثبِّطات الإنزيمات

• Inhibitors are chemicals that reduce the rate of enzymatic reactions.

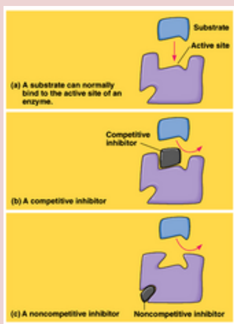
• The are usually specific and work at low concentrations.

• They block the enzyme but they do not usually destroy it.

• Many drugs and poisons are inhibitors of enzymes in the nervous system.

Competitive inhibition: the inhibitor binds to the same • site as the substrate, thus prevent the enzymatic reactions.

Non-competitive inhibition• the inhibitor binds somewhere other than the active site, resulting in changing enzyme shape. Finally, deactivate the active site



Some benefits of enzyme inhibitors

The insecticide **DDT** is an inhibitor for key enzymes of nervous system in insects results in death.

Many antibiotics (e.g. **Penicillin**) inhibits enzymes that help bacteria to make their cell walls.

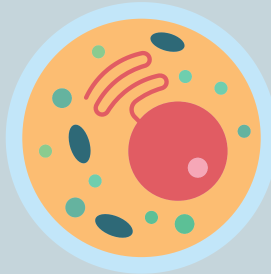
In the next lecture we will explain that:

Activation and Inhibition of enzymes are essential for metabolic control

حين ١٠٩

تشابتر ١٢

The Control of Metabolism



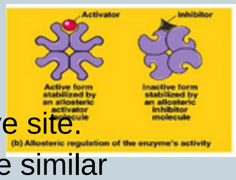
• In many cases, the molecules that naturally regulate enzyme activity behave like reversible noncompetitive inhibitors.
• These molecules often bind weakly to an allosteric site which is a specific receptor on the enzyme that is not the active site.
• These molecules can either inhibit or stimulate enzyme activity.

:Regulation Allosteric)- 1

• Most allosterically regulated enzymes are constructed of two or more polypeptide chains.
• Each subunit has its own active site.
The allosteric sites are often located where subunits are joined.
• The whole protein exists in two conformational shapes, The active form, and the inactive form.

: a)- Allosteric activators

It stabilizes the conformation that has a functional active site.



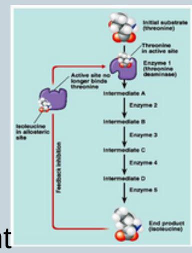
b)- Allosteric inhibitors:

It stabilizes the conformation that lacks an active site.
• In many cases, both inhibitors and activators are similar enough in shape that they compete for the same allosteric sites.
• These molecules may be products and substrates of a metabolic pathway.

c): inhibition Feedback-

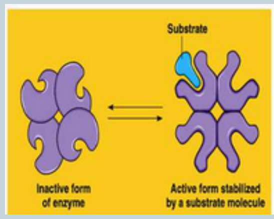
It is one of the common methods of metabolic control in which a metabolic pathway is turned off by its end product .

• Example:
The production of Isoleucine from Thereonine by Thereonine deaminase:
• The end product acts as an inhibitor of an enzyme in the pathway.
• When the product is abundant , the pathway is turned off, when rare the pathway is active.



regulation Cooperativity)- 2

• It occurs in enzymes with multiple catalytic subunits. Lending a substrate to one active site stabilizes favorable conformational changes at all other subunits, a process called cooperativity
• This mechanism amplifies the response of enzymes to substrates, making the enzymes accept .substrates additional



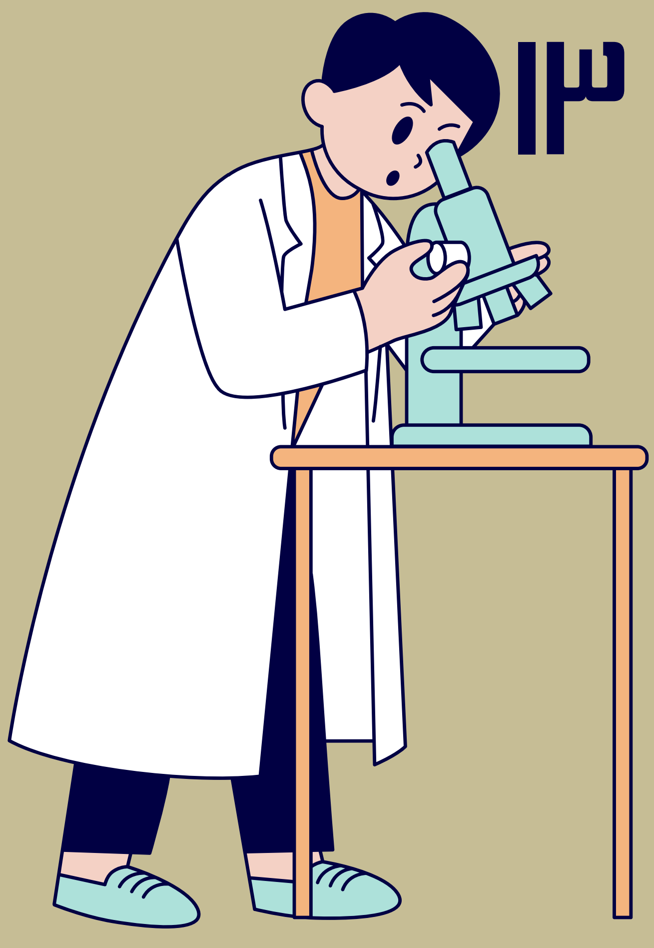
Summary of metabolic control
The cell is controlling its metabolism by regulating enzyme activity:

1)- Allosteric Regulation
Regulatory molecules that bind weakly to an Alosteric site of the enzyme (Allosteric Enzymes) in order to inhibit or stimulate the enzyme activity
A)- Allosteric activation.
B)- Allosteric inhibition
C)- Feedback inhibition.

2- Cooperativity
Stabilizes favorable conformational changes at all other subunits to make the enzyme more efficient

حين ١٠٩

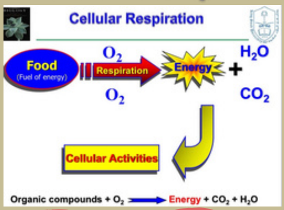
ملخص تشابتر ١٣



Overall process

a) Organic compounds + $O_2 \rightarrow CO_2 + H_2O$ + energy
b) Food is the fuel for cellular respiration.
c) Cellular respiration is a catabolic pathway: it releases energy by breaking down complex molecules.
d) Cellular respiration involves movement of electrons (gain or loss).
e) We will study the breakdown of glucose as an example.

Cellular Respiration



Importance of ATP

The transfer of the terminal phosphate group from ATP to is molecule another phosphorylation

This changes the shape of the receiving molecule in order to work (transport, mechanical, or chemical).

• When the phosphate group leaves the protein molecule, it returns to its original shape.

Redox reactions release energy when electrons move closer to electronegative atoms

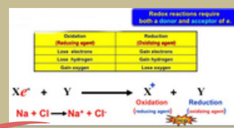
Catabolic pathways relocate the electrons stored in food molecules, releasing energy • .that is used to synthesize ATP

• Reduction-Oxidation reactions (Redox reactions):

Are reactions that result in the transfer of one or more electrons from one reactant to another

• Oxidation: Is the loss of electrons.

• Reduction: Is the addition of electrons.



Cells recycle the ATP they use for work

• ATP (Adenosine Tri-Phosphate) is the important molecule in cellular energetics .

– The attachment of three negatively-charged phosphate groups (P) is unstable an , energy-storing arrangement.

– Loss of the end phosphate group release energy.

– Thus, it can diffuse to any part of the cell and release energy.

• The price of most cellular work is the conversion of ATP to ADP and phosphate (P).

• An animal cell regenerates ATP from ADP by adding P via the catabolism of organic molecules.

Electrons “fall” from organic molecules to oxygen during cellular respiration

• In cellular respiration, glucose and other fuel molecules are oxidized, releasing energ

• Glucose is oxidized, oxygen is reduced, and electrons lose potential energy.

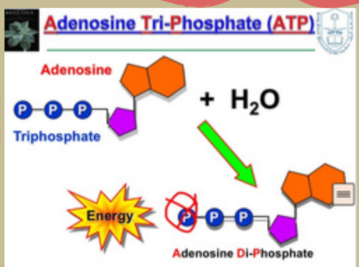
• H is the source of electrons that transfers to O.

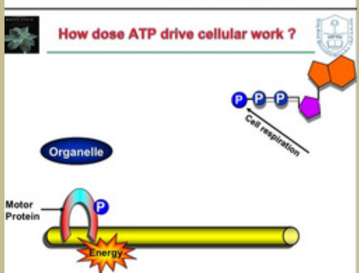
• Thus, molecules that have an abundance of hydrogen are excellent fuels because their bonds are a source of electrons that “fall” closer to oxygen.

• Enzymes lower the barrier of activation energy, allowing these fuels to be oxidized slowly.

• When H moves to O, it leaves bonds which degenerated to release energy.

• The resulting energy is used by the cell to synthesis ATP .





The “fall” of electrons during respiration is stepwise by NAD+ and an electron transport chain

• Cellular respiration does not oxidize glucose in a single step that transfers all the hydrogen in glucose to oxygen at one time.

• Rather, glucose and other fuels are broken down gradually in a series of steps, each catalyzed by a specific enzyme.

• At key steps, hydrogen atoms move from glucose and passed first to the coenzyme NAD+ (Nicotinamide Adenine Dinucleotide).

• Dehydrogenase enzymes strip two hydrogen atoms from the fuel (e.g., glucose), pass two electrons to NAD+ and release H+.

• This changes the oxidized form, NAD+, to the reduced formNADH. Thus, NAD+ is oxidizing agent as it accepts electrons.

– NAD+ functions as the oxidizing agent in many of the redox steps during the catabolism of glucose.

$$H\text{-}C\text{-}OH + NAD^+ \xrightarrow{\text{Dehydrogenase}} C{=}O + NADH + H^+$$

As electrons “fall” from NADH to oxygen, their energy is used to synthesize ATP.

Electron transport chain

. Cellular respiration uses an electron transport chain to break the fall of electrons to O2 into several steps •

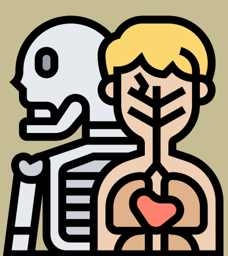
• The electron transport chain, consisting of several molecules (primarily proteins), is built into the inner membrane of a mitochondrion.

• NADH takes electrons from food to the “top” of the chain.

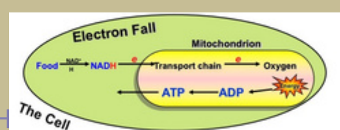
• At the “bottom”, oxygen captures the electrons and H+ to form water.

• Electrons are passed by the chain until they are caught by oxygen (the most electronegative)

Summary of electron “Fall” steps



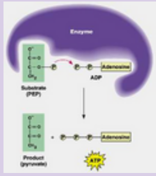
- Falling of all H atoms from glucose to O is gradually not at once.
- It occurs in steps, each step is catalyzed by an enzyme.
- H atoms of glucose pass first to the co-enzyme NAD+ to form NADH
- Then from NADH to electron transport chain, and finally to O and releases energy to form ATP.



حين ١٠٩

ملخص تشابتر ١٤

Phosphorylation



I- Substrate-level phosphorylation:

• Some ATP is generated in glycolysis and in Krebs cycle by Substrate-level phosphorylation. Phosphate group is transferred from
an organic molecule (the substrate) to ADP, forming 10% of the total ATP (4 ATP).

Ultimately, 38 ATP are produced per each glucose molecule that is degraded to CO_2 and H_2O by respiration.

II- Oxidative phosphorylation:

• As electrons passed along the chain,
their energy stored in the mitochondrion
in a form that can be used to synthesize
the rest 90% of the ATP (34 ATP).
• via Oxidative phosphorylation.

1- Glycolysis (splitting glucose): harvests chemical energy by oxidizing glucose to **2-pyruvate molecules**

• During glycolysis, glucose (a six carbon-sugar) is split into two molecules (each is three-carbon sugar).
• These smaller sugars are oxidized and rearranged to form two molecules of pyruvate.
• Each of the 10 steps in glycolysis is catalyzed by a specific enzyme.
• These steps can be divided into two phases:

1)- Energy investment phase:

ATP is consumed to provide activation energy by phosphorylating glucose (this requires 2 ATP per glucose).

2)- Energy payoff phase:

ATP is produced by substrate-level phosphorylation and NAD+ is reduced to NADH.
• 4 ATP and 2NADH are produced per glucose.
• Thus, the net yield from glycolysis is 2 ATP and 2 NADH per glucose.

Oxygen is not required for glycolysis

Summary of Glycolysis (Splitting of glucose)

It is the process of breaking a glucose into 2 Pyruvates.
It is a source for some ATP & NADH.
It occurs in the CYTOSOL (cytoplasm).
It has two phases

A)- Energy investment phase

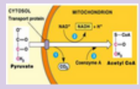
1)- Glucose is phosphorylated twice by adding 2 P coming from 2 ATP (substrate-level phosphorylation). It has two phases
2)- Thus, Glucose (6-C) splits into two small sugar molecules (each with 3-C).

B)- Energy pay-off phase

4ATP are formed by adding 4P to 4ADP molecules.
The net yield of this process is the formation of 2 NADH, 2 ATP and 2 pyruvate molecules.

2. The Krebs cycle completes the energy-yielding oxidation of organic molecules (in mitochondrial matrix
It is the process of producing some of the remaining energy (ATP) from the Pyruvate molecules. It occurs mainly in mitochondrial matrix if oxygen is present.
• If O2 is present, pyruvate enters the mitochondrion where enzymes of the
Krebs cycle complete the oxidation of this organic fuel to CO2.
• As pyruvate enters the mitochondrion which modifies pyruvate to
acetyl-CoA which enters the Krebs cycle in the matrix.
– A carboxyl group is removed as CO2.
– A pair of electrons is transferred from the remaining two-carbon fragments to NAD+ to form NADH.
– The oxidized fragment, acetate, combines with coenzyme A to form acetyl-CoA.

cycle is called Pre-Krebs cycle الدورة التحضيرية لدورة كربس



The Krebs cycle Occurs in 2 steps:
It is the main source for preparing most of the cellular NADH (storing
energy molecule), and for producing some more of the cellular ATP.
It includes two cycles :
The Pyruvate is the substrate for this cycle

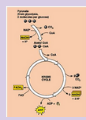
Pre-Krebs cycle المرحلة التحضيرية

The acetyl-CoA is the substrate for this cycle

Krebs cycle

A)- Pre-Krebs cycle

Pyruvate is converted into acetyle CoA in the presence of O2 through 3 steps.
a)- C=O- group of pyruvate is released as CO2.
b)- The remaining two-C fragments are oxidized (releasing **e-**) into
acetate and the resulting e- transform NAD+ into NADH.
c)- The coenzyme-A (CoA) transform acetate compound into
acetyle-CoA, which will be ready for Krebs Cycle for further
oxidation.

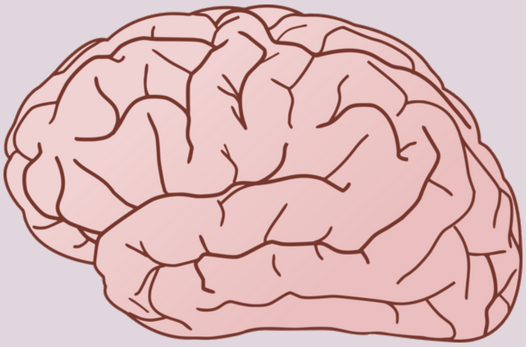


B)- Krebs cycle

It has eight steps starting with 2 acetyle-CoA compunds. They are summarized as shown in the figur
This cycle begins when acetate from each acetyl-CoA combines with oxaloacetate (4 C atoms) to form citrat (citric acid).
• Ultimately, the oxaloacetate is recycled and the acetate i broken down to CO2.
• Each cycle produces one ATP by substrate-level phosphorylation, three NADH, and one FADH2 (another electron carrier) per acetyl CoA. Thus, the outcome of the tw cycles is
(for the 2 Acetyle-CoA molecules):

Output { 2 ATP, 6 NADH, 2 $FADH_2$

Flavin Adenine Dinucleotide



حين ١٠٩

ملخص تشابتر ١٥

وأخيرًا اخر تشابتر للميد

3- Electron transport chain:

(oxidative phosphorelation)

• Only 4 of 38 ATP ultimately produced by respiration of glucose are derived from substrate-level phosphorylation (2 from glycolysis and 2 from Krebs Cycle).

• The vast majority of the ATP (90%) comes from the energy in the electrons carried by NADH and FADH2.

• The energy in these electrons is used in the electron transport chain to power ATP synthesis

• Thousands of copies of the electron transport chain are found in the extensive surface of the cristae (the inner membrane of the mitochondrion).

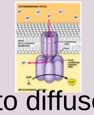
• Electrons drop in free energy as they pass down the electron transport chain.

Electron transport chain

• ATP-synthase, in the cristae actually makes ATP from ADP and Pi.

• ATP used the energy of an existing proton gradient to power ATP synthesis.

– This proton gradient develops between the inter-membrane space and the matrix.



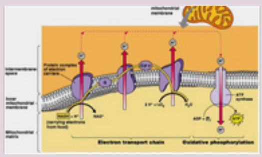
– This concentration of H+ is the proton-motive force.

• The ATP synthase molecules are the only place that will allow H+ to diffuse back to the matrix (exergonic flow of H+).

• This flow of H+ is used by the enzyme to generate ATP in a process called “Chemiosmosis”.

• **Chemiosmosis**: (osmos = puch)It is the oxidative phosphorelation that results in ATP production in the inner membrane of mitochondria

Energy carried by NADH and FADH2 give a maximum yield of 34 ATP is produced by oxidative phosphorylation.



Cellular respiration generates many ATP molecules for each sugar molecule it oxidize

• During respiration, most energy flows from glucose >NADH >electron transport chain> proton-motive force> ATP.

• Some ATP is produced by substrate-level phosphorylation during glycolysis and the Krebs cycle, but most ATP comes from oxidative phosphorylation (through electron transport chain).

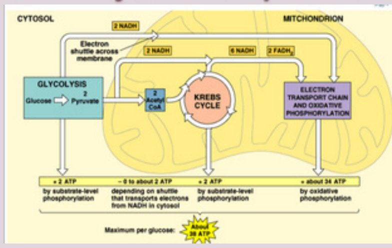
• Energy produced in Glycolysis and Krebs cycle gives a maximum yield of 4 ATP by substrate-level phosphorylation.

• Energy produced in electron transport chain gives a maximum yield of 34 ATP by oxidative phosphorylation via ATP-synthase.

• Substrate-level phosphorylation and oxidative phosphorylation give a bottom line of 38 ATP

- Glycolysis occurs in the cytosol and breaks glucose into two pyruvates
- Krebs Cycle takes place within the mitochondrial matrix, and breaks a pyruvate into CO2 and produce some ATP and NADH.
- Some steps of Glycolysis and Krebs Cycle are Redox in which dehydrogenase enzyme reduces NAD+ into NADH.
- Electron Transport Chain accepts e- from NADH and passes these e- from one protein molecule to another.
- At the end of the chain, e- combine with both H+ and O2 to form H2O and release energy.
- These energy are used by mitochondria to synthesis 90% of the cellular ATP via ATP-synthase, a process called Oxidative Phosphorylation, in the inner membrane of mitochondria.

Summary of cell respiration



Definitions: تعريفات

Chemiosmosis: a process via which oxidative phosphorylation takes place at the end of the Electron Transport Chain to produce 90% of ATP via ATP-synthase.

• Or, is the process in which ATP synthesis powered by the flow of H+ back across ATP synthase.

• ATP-synthase: an enzyme presents in the inner mitochondrial membrane and used in making ATP by using H+ (protons).

• NAD+: Nicotinamide adenine dinucleotide, which is a co-enzyme that helps electron transfer during redox reactions in cellular respiration.

• FAD: Flavin adenine dinucleotide, which is an electron acceptor that helps electron transfer during Krebs Cycle and Electron Transport Chain in cellular respiration.

Fermentation: Enables بعض some cells to produce ATP without the help of oxygen

• Oxidation refers to the loss of electrons to any electron acceptor, not just to oxygen.

– In glycolysis, glucose is oxidized to 2 pyruvate molecules with NAD+ as the oxidizing agent (not O2).

– Some energy from this oxidation produce 2 ATP.

– If oxygen is present, additional ATP can be generated when NADH delivers its electrons to the electron transport chain.

• Glycolysis generates 2 ATP when oxygen is absent (anaerobic .(

• Anaerobic catabolism of sugars can occur by fermentation.

• Fermentation can generate ATP from glucose by substrate-level phosphorylation as long as there is a supply of NAD+ (the oxidizing agent) to accept electrons.

– If the NAD+ pool is exhausted , glycolysis shuts down.

– Under aerobic conditions, NADH transfers its electrons to the electron transfer chain, recycling NAD+.

• Under anaerobic conditions, various fermentation pathways generate ATP by glycolysis and recycle NAD+ by transferring electrons from NADH to pyruvate

Fermentation

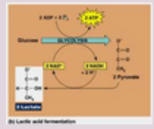
• Alcohol fermentation:

the pyruvate is converted to ethanol in two steps.

– First, pyruvate is converted to acetaldehyde by the removal of CO2.

– Second, acetaldehyde is reduced by NADH to ethanol.

– Alcohol fermentation by yeast is used in wine-making.

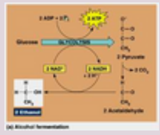


• Lactic acid fermentation:

the pyruvate is reduced directly by NADH to form lactate (ionized form of lactic acid).

– Lactic acid fermentation by some fungi and bacteria is used to make cheese and yogurt.

– Muscle cells switch from aerobic respiration to lactic acid fermentation to generate ATP when lack of O2 (O2 is scarce(



• The waste product, lactate, may cause muscle fatigue, but ultimately it is converted back to pyruvate in the liver.

Examples of anaerobic respiration:

A)- During exercise our bodies require a lot of energy

• The body can only supply a limited amount of oxygen for cellular respiration.

• Energy is not produced at the rate required.

• Cells will use anaerobic respiration to release extra energy

• This produces lactic acid (a waste product).

B)- We use yeast to make bread

• CO2 produced causes bread to rise by creating air pockets

• The ethanol (alcohol) produced is evaporating during baking

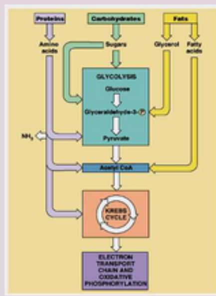
Fat and Protein Breakdown

A. Fats

• have more energy per gram than carbohydrates or proteins.

• fatty acid chains are oxidized and broken into smaller 2 carbon chains.

• the 2 carbon chains are converted into acetyl CoA to enter the Kreb's cycle.



B. Proteins

• must be converted into individual amino acids.

• excess amino acids are converted by enzymes into intermediated of glycolysis and Krebs cycle.

• amino acids go through deamination (amino groups are removed)

• nitrogenous wastes from the amino groups are released as wastes.

• new compounds enter glycolysis or Krebs