فسيولوجيا الأحياء الدقيقة
Microbial Physiology

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مكتب ٢ ب ٤٥

Energy And Metabolism
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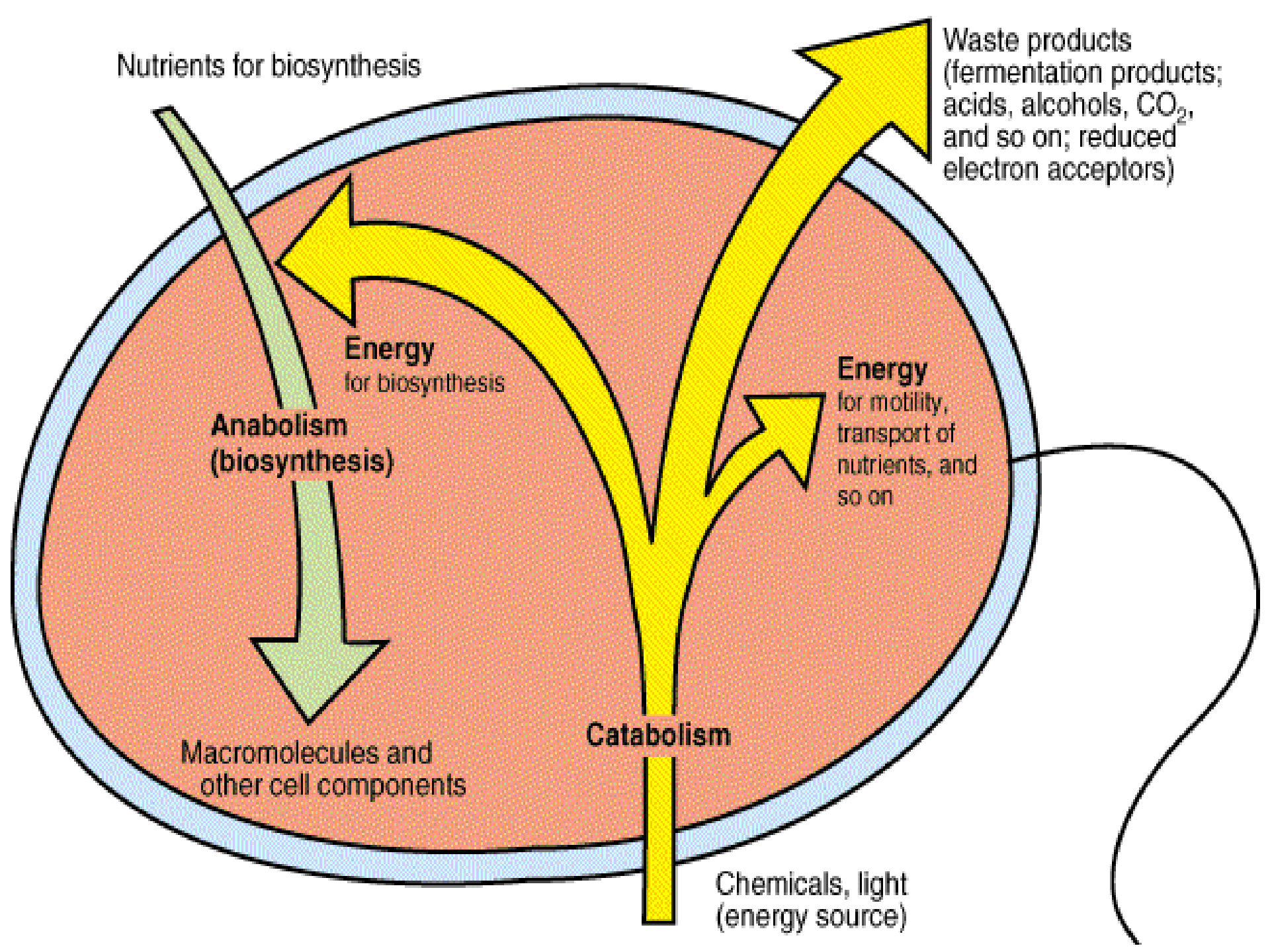
Energy And Metabolism

- Cellular metabolism consists of a complex network of chemical reactions.
- Capture energy and raw materials and process them into forms that can be utilized by the cell.
- The generation of ATP and the proton-motive force are key elements in energy transformation.
- Energy for cellular processes is stored in the form of **ATP** (adenosine triphosphate) as it has high-energy bonds that can be released quickly and easily.


Nutrients for biosynthesis
Waste products (fermentation products; acids, alcohols, CO_2, and so on; reduced electron acceptors)
Energy for biosynthesis
Anabolism (biosynthesis)
Energy for motility, transport of nutrients, and so on
Macromolecules and other cell components
Catabolism
Chemicals, light (energy source)

Generation of ATP

❖ ATP is formed by adding an inorganic phosphate group (**P_i**) to **ADP** (adenosine diphosphate).

❖ The removal of the phosphate group that releases the energy.

❖ **There are three general mechanisms:**

- Substrate-level phosphorylation.
- Oxidative phosphorylation.
- Photophosphorylation.

Oxidation and Reduction reactions

- **Substrate-level Phosphorylation** is the direct transfer of high-energy phosphate groups from a substrate to ADP. The phosphate group has generally acquired its energy during a previous oxidation step.

- **Oxidative Phosphorylation:** Electrons are transferred from an organic compound to an electron carrier (usually NAD^+). These electrons are then passed through a series of different electron carriers to molecules of **oxygen** or other **inorganic molecules**.

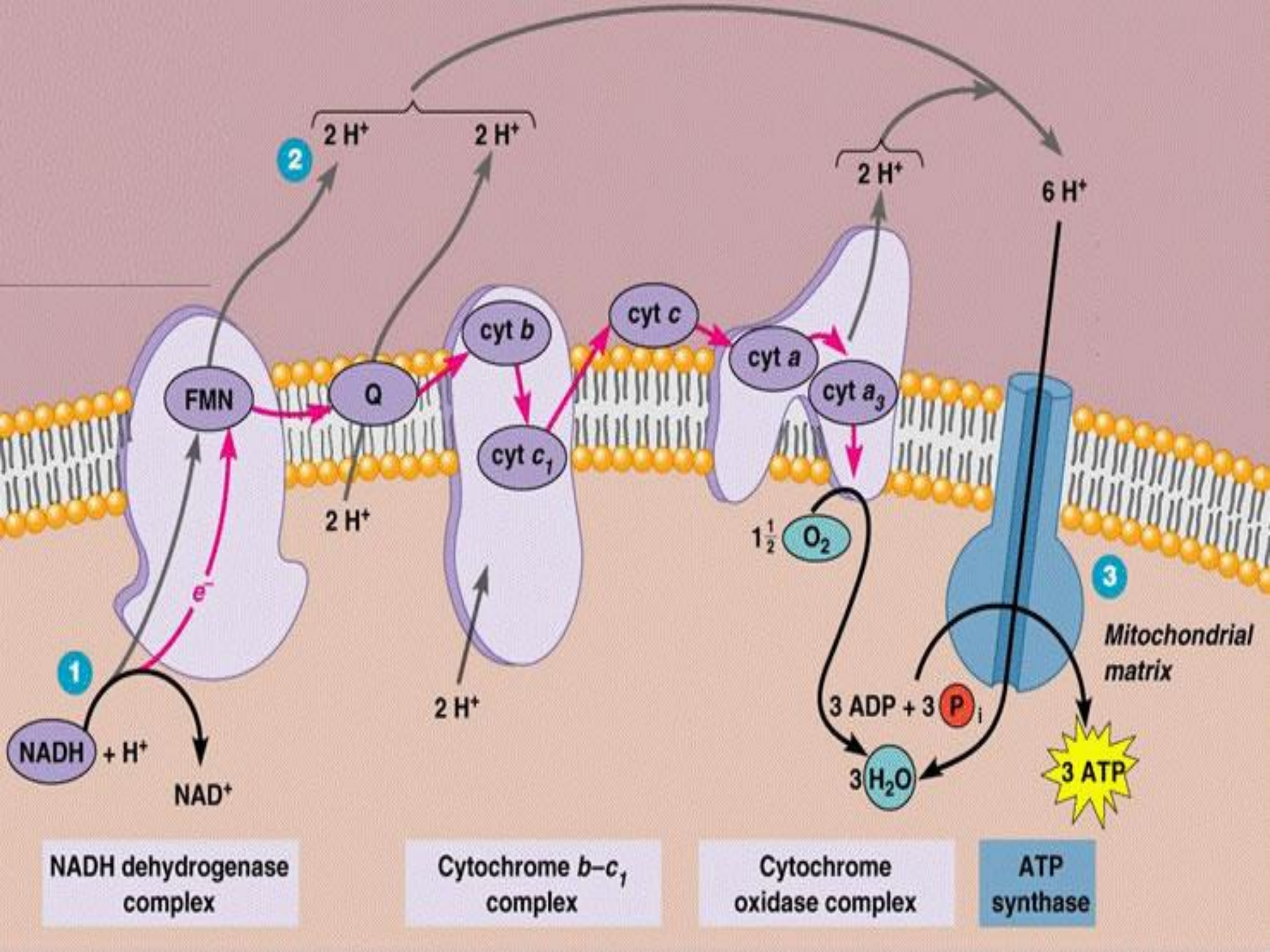
- This series of carriers is called an **Electron Transport Chain (ETC)**. It is the energy released during the transfer of electrons from one carrier to the next that is used to generate ATP from ADP and inorganic phosphate through a process known as "**chemiosmosis**".

- ***Chemiosmosis*** **-** the energy of the protons moving through the channel energizes the ATP synthase and drives phosphorylation of ADP to make ATP.

Oxidation and Reduction reactions

- **Photophosphorylation**

  Only occurs in photosynthetic cells. In these cells, light trapping pigments such as chlorophyll convert light energy into chemical energy stored as ATP and NADPH; yet, requires an electron transport chain.


2 H+
2 H+
2
2 H+
6 H+
FMN
Q
cyt b
cyt c
cyt a
cyt a3
cyt c1
2 H+
2 H+
1½ O2
e−
1
3
Mitochondrial matrix
NADH + H+
NAD+
3 ADP + 3 Pi
3 H2O
3 ATP
NADH dehydrogenase complex
Cytochrome b–c1 complex
Cytochrome oxidase complex
ATP synthase

- The **processes** that use the mechanisms are:

- ***Cellular respiration*** – ATP is generated by oxidation of organic molecules, the passage of electrons down an electron transport chain, and chemiosmosis. The final electron acceptor is almost always inorganic.

- ***Aerobic*** – the final electron acceptor is O_2.
- ***Anaerobic*** – the final electron acceptor is some inorganic molecule other than O_2.

- ***Fermentation*** – ATP is generated by oxidation of organic molecules and the final electron acceptor is an organic molecule. The electrons produced by oxidation are not used to make ATP. ATP production is accomplished by substrate-level phosphorylation.

- ***Photosynthesis*** – ATP is generated by photophosphorylation.
  - ***Cyclic reactions*** produce ATP. The electrons come from chlorophyll, pass down an electron transport chain, and return to chlorophyll.
  - ***Non-cyclic reactions*** produce ATP and NADPH. The electrons come from chlorophyll, travel down an electron transport chain, and are passed to NADP to form NADPH. Chlorophyll is then reduced by H_2O or some other oxidizable compound like H_2S to replace the lost electrons.

QUESTIONS??