Introduction to Microbiology

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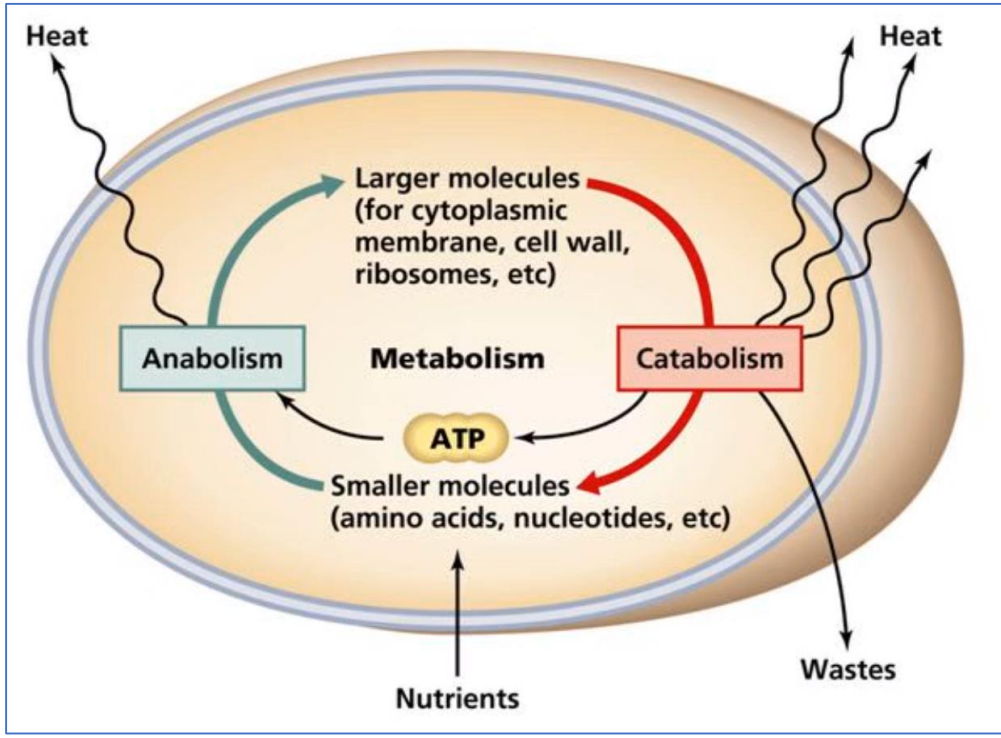
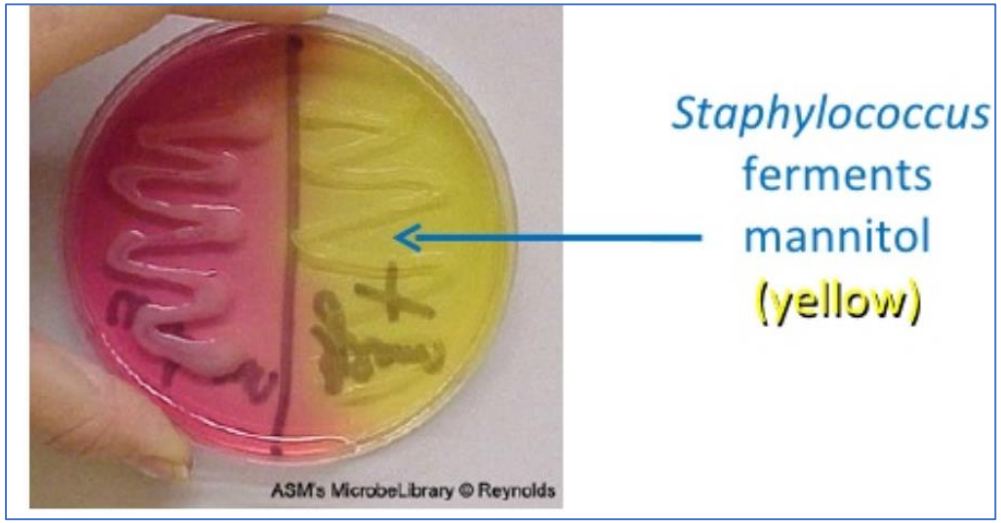
Lecture 5

Bacterial metabolism

- All cells require energy to survive and grow, and it can be obtained from breakdown of molecules (catabolism).
- The energy can then be used to build cellular constituents (anabolism).
- Different bacteria use different metabolic pathways depending on the nutrients available in its environment.
- Growth requirements and metabolic byproducts may be used in classifying and identifying different bacteria.

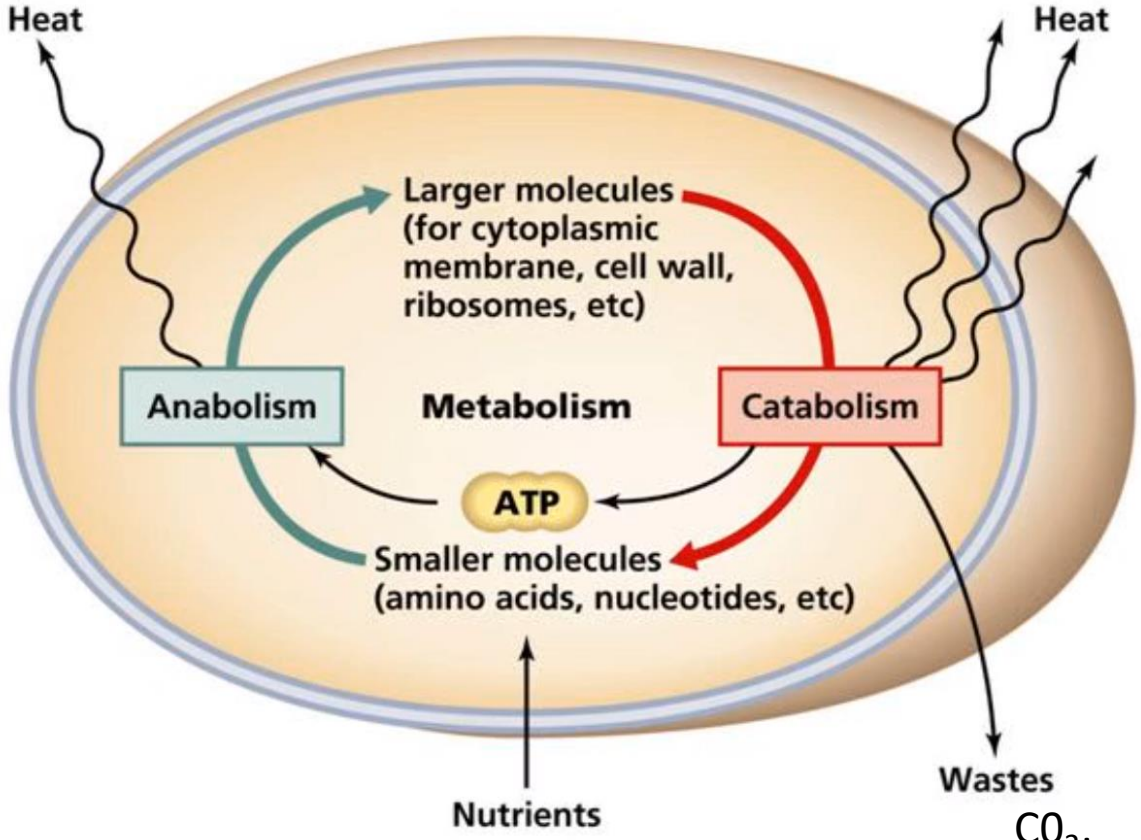




Bacterial metabolism

- Before entry to the cell, macromolecules should be broken down first.

- Metabolic pathways can be regulated through enzyme activity which depends on enzyme and substrate concentration. Or through metabolites binding to enzymes and affecting their activity.

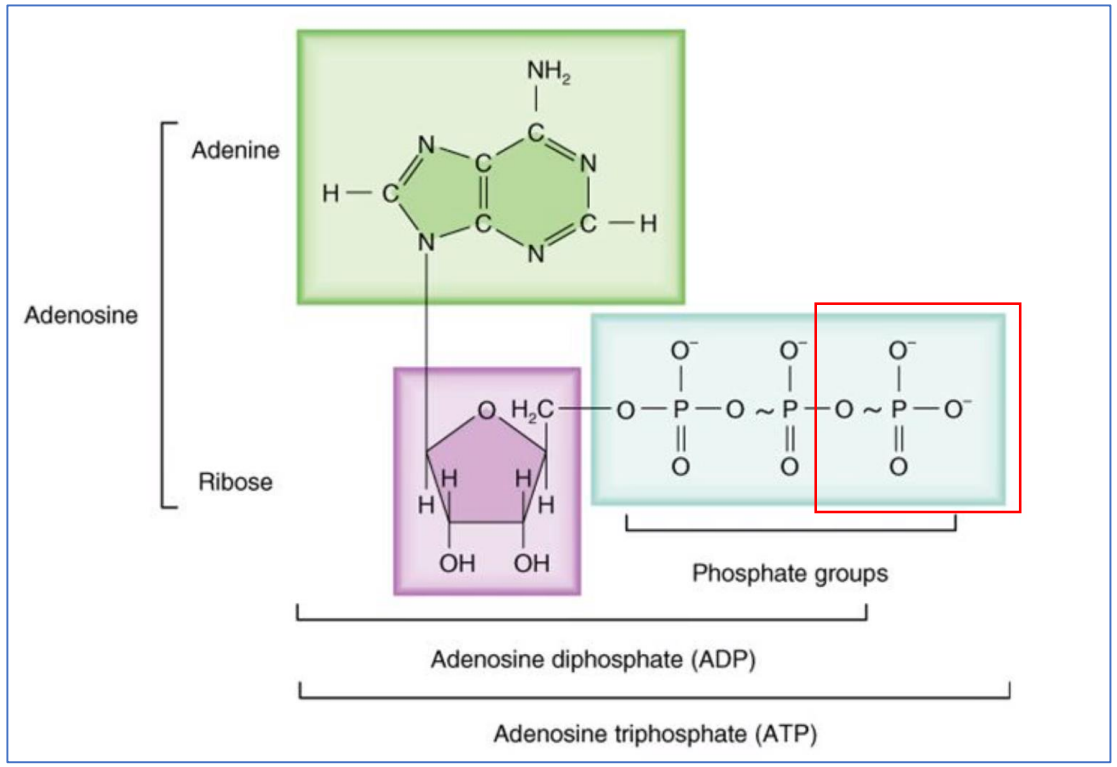


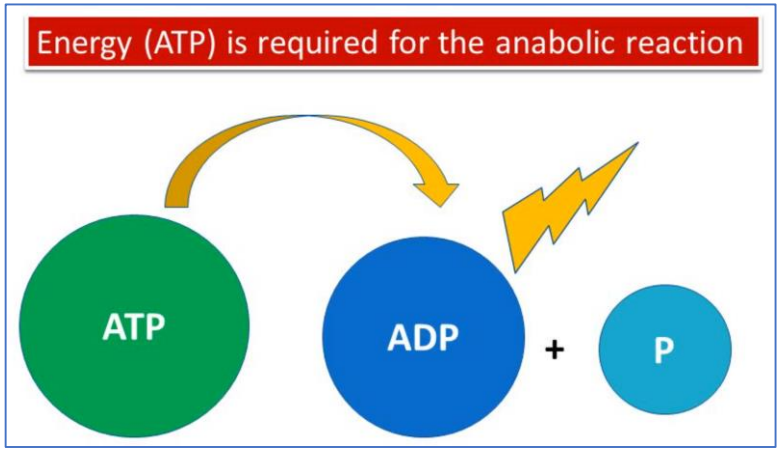
Are sources of essential elements including the components of proteins, lipids, and nucleic acids (C, O, H, N, S, P), important ions (K, Na, Mg, Ca, Cl), and components of enzymes (Fe, Zn, Mn, Mo, Se, Co, Cu, Ni)

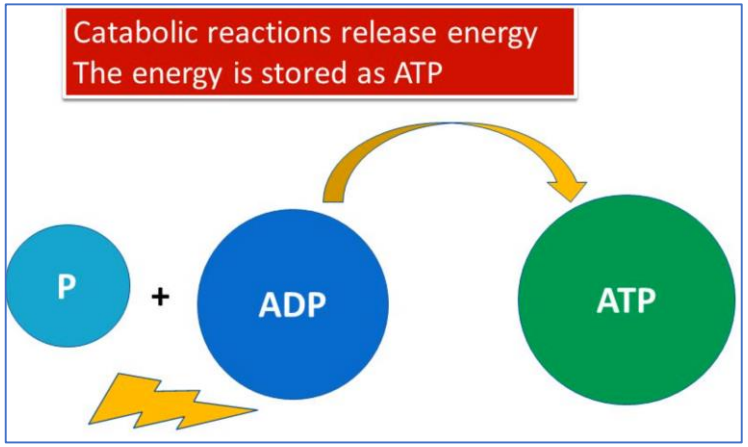
ATP at the heart of metabolism

Generated through several mechanisms:

- Oxidative phosphorylation
- Substrate level phosphorylation
- Chemiosmosis
- Photophosphorylation



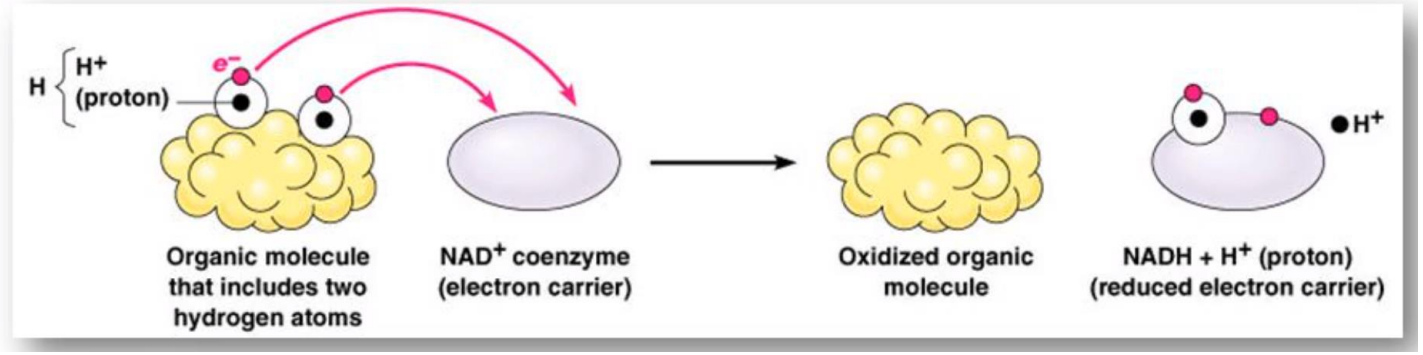


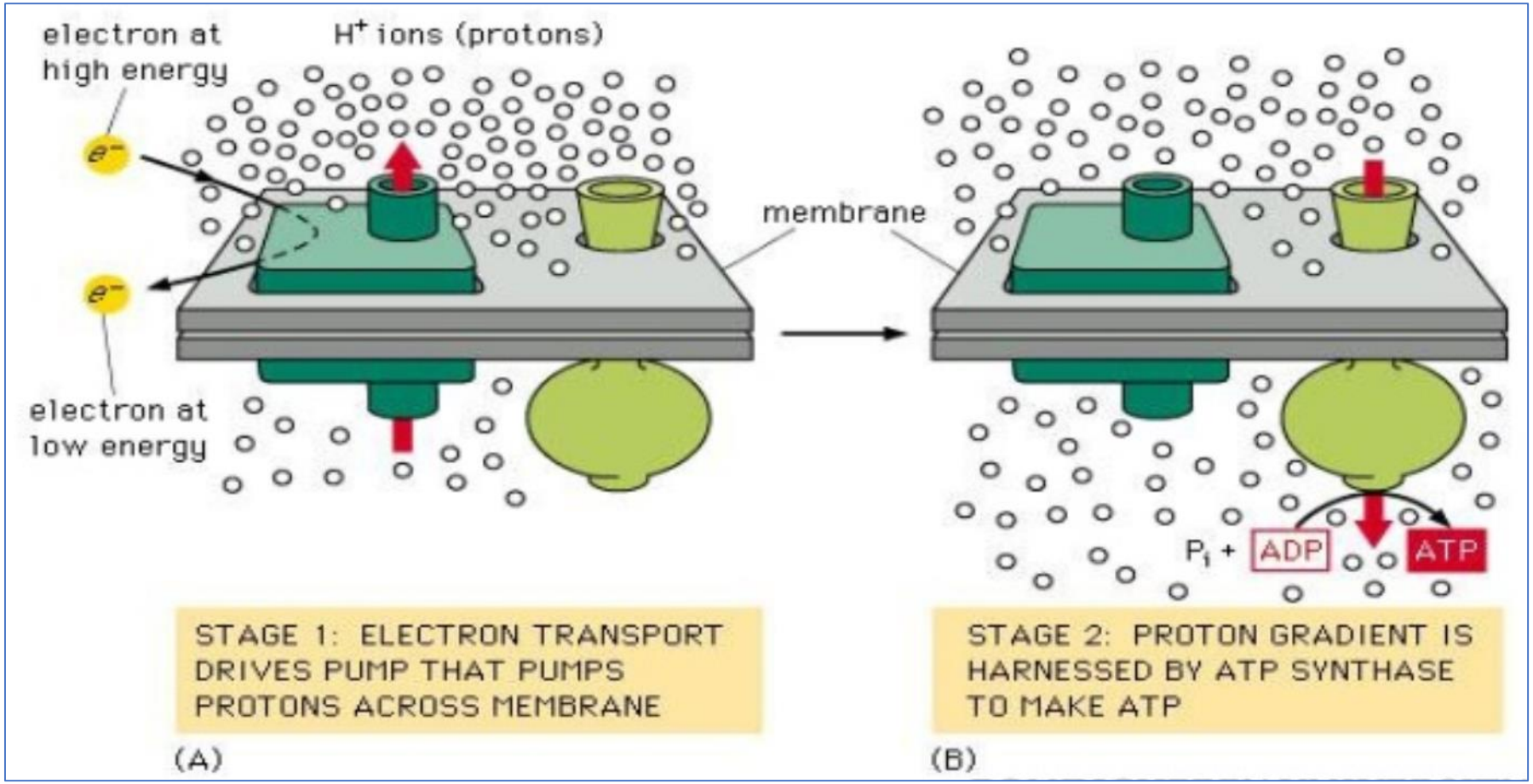


Oxidative phosphorylation

- Energy released as electrons pass through an <u>electron transport chain</u>, to finally O2 as an electron acceptor.

- ATP is then made by <u>chemiosmosis</u>.





Substrate level phosphorylation

- High energy phosphates added from a substrate during catabolism to ADP forming ATP.

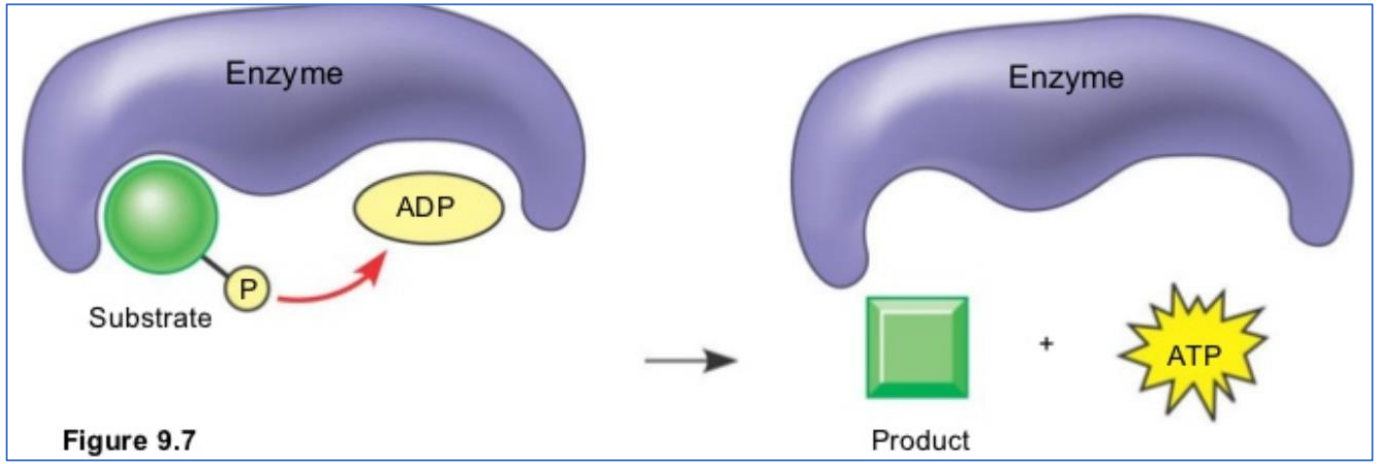
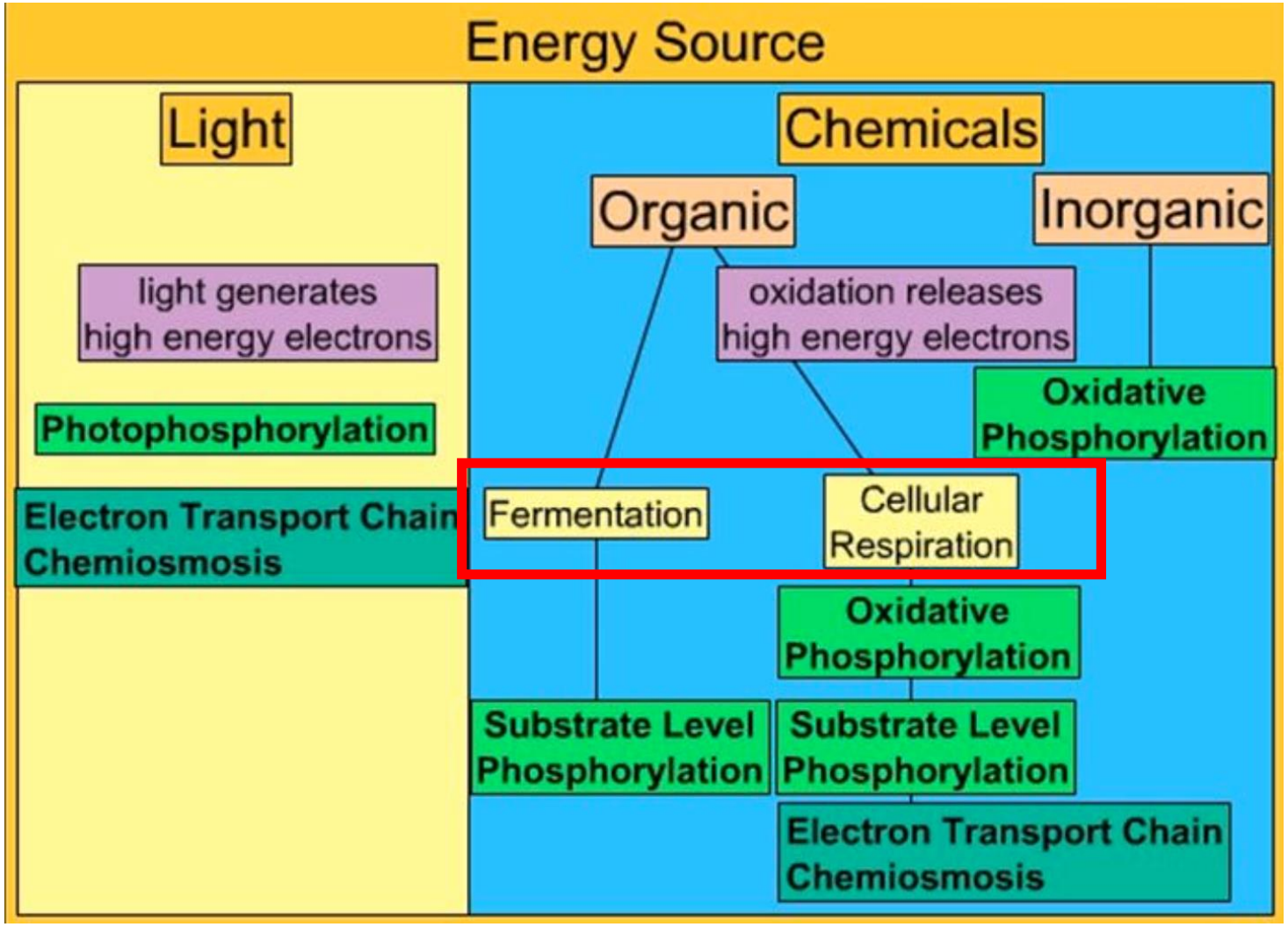


Figure 9.7

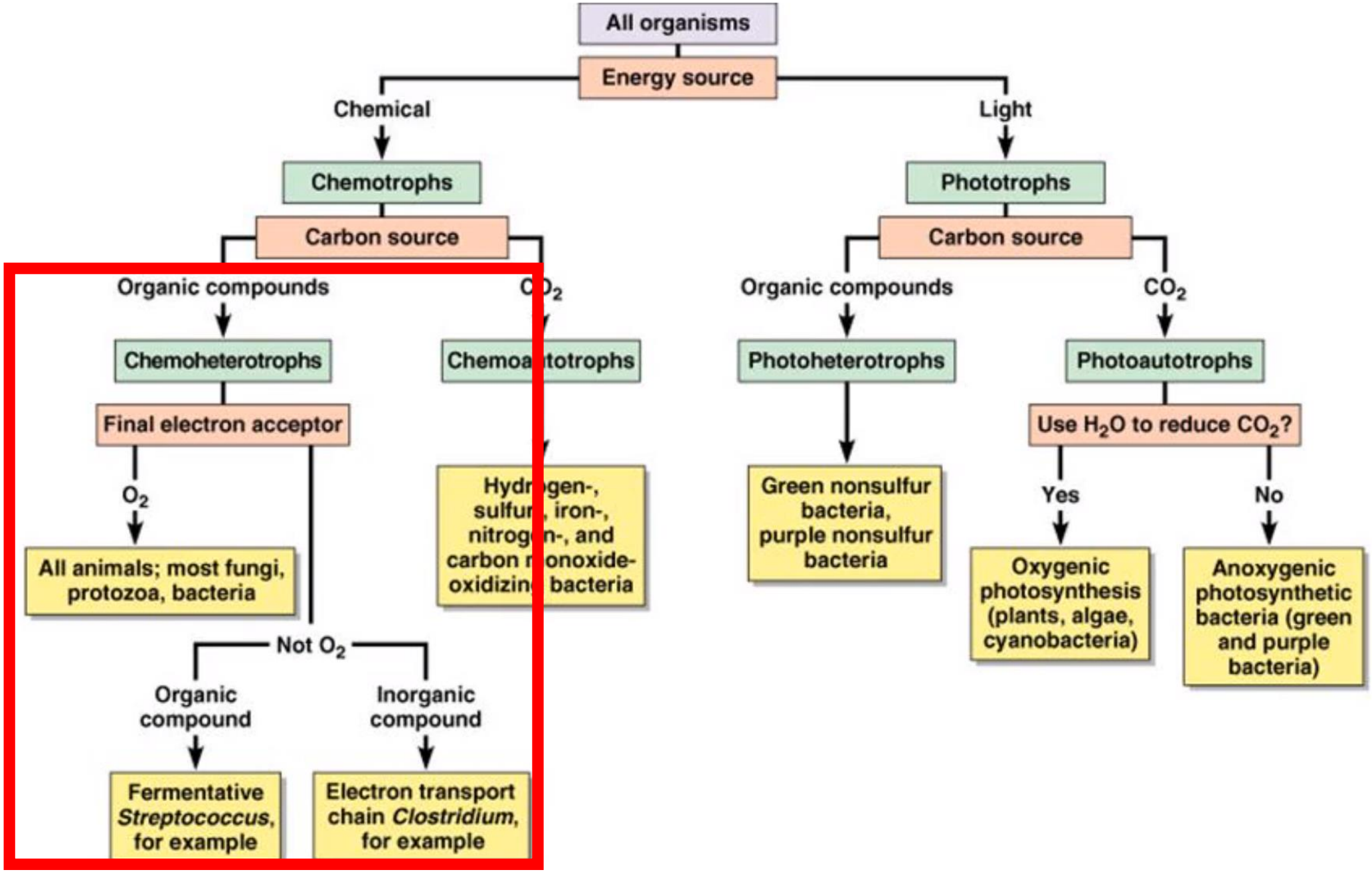
ATP generation processes

- Cellular respiration generates ATP by oxidation of organic molecules. Final electron acceptor is O_2 in aerobic respiration, or other receptors (NO_3^-, SO_4^-) in anaerobic respiration with less ATP yield.

- Fermentation has organic molecules as final electron acceptors.



Metabolic diversity in prokaryotes

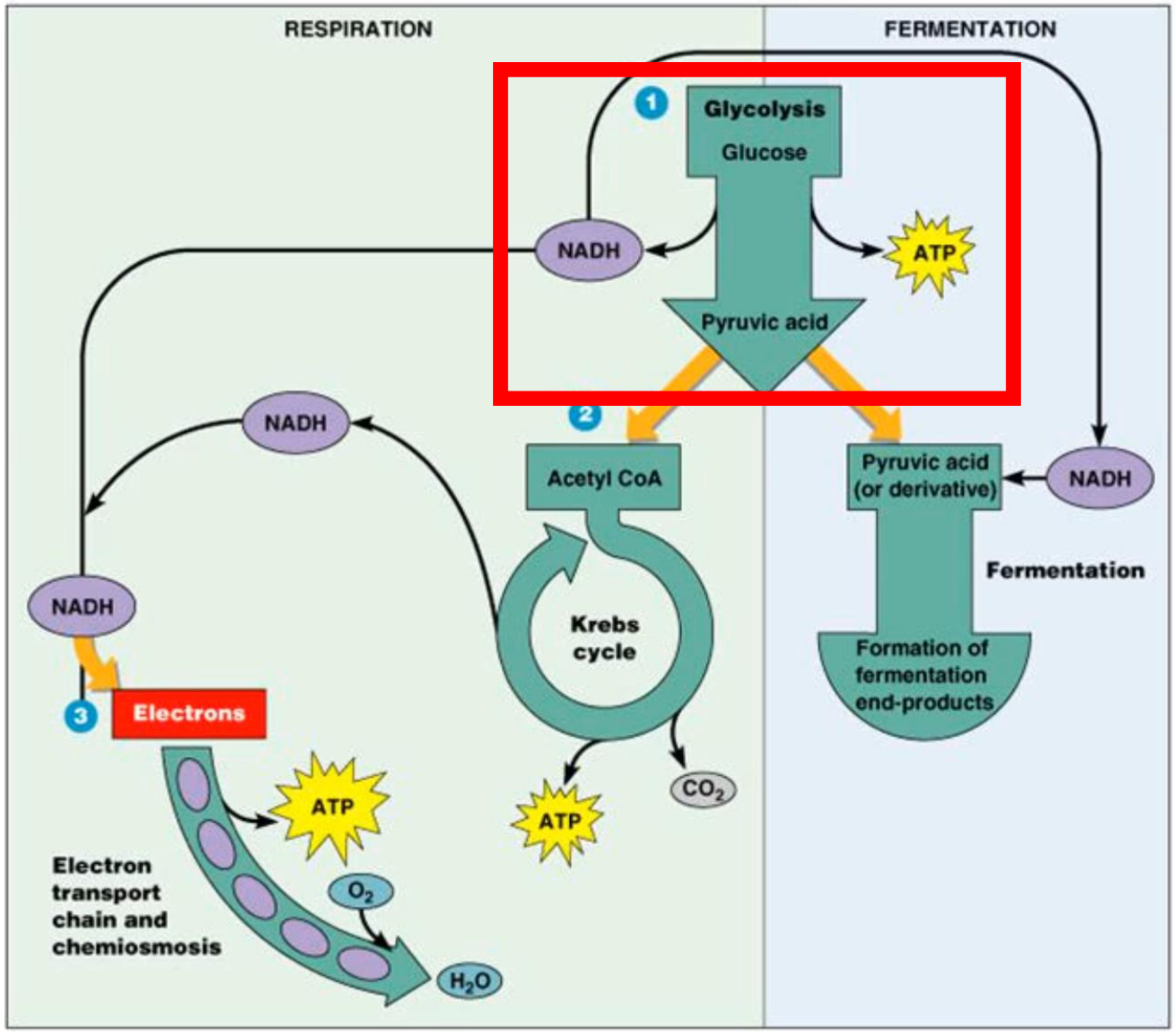


Carbohydrates are a major energy source

- Glucose is the most common, others include lactose and mannitol.

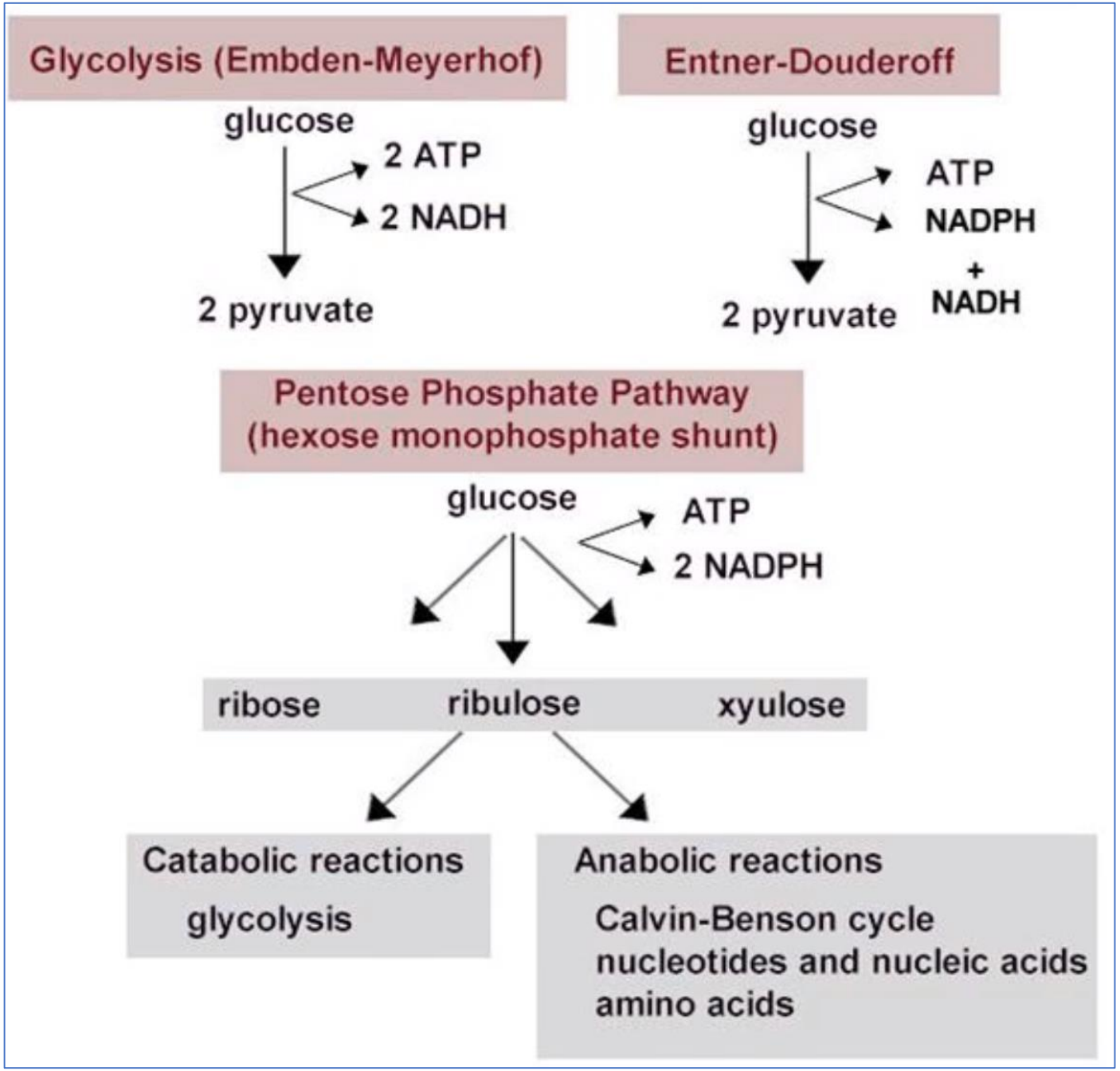
- Glycolysis in the cytoplasm generates pyruvic acid.

- Takes place though:
  - Embden-Meyerhof-Parnas (EMP) pathway
  - Pentose phosphate pathway
  - Entner–Doudoroff pathway (ED pathway)



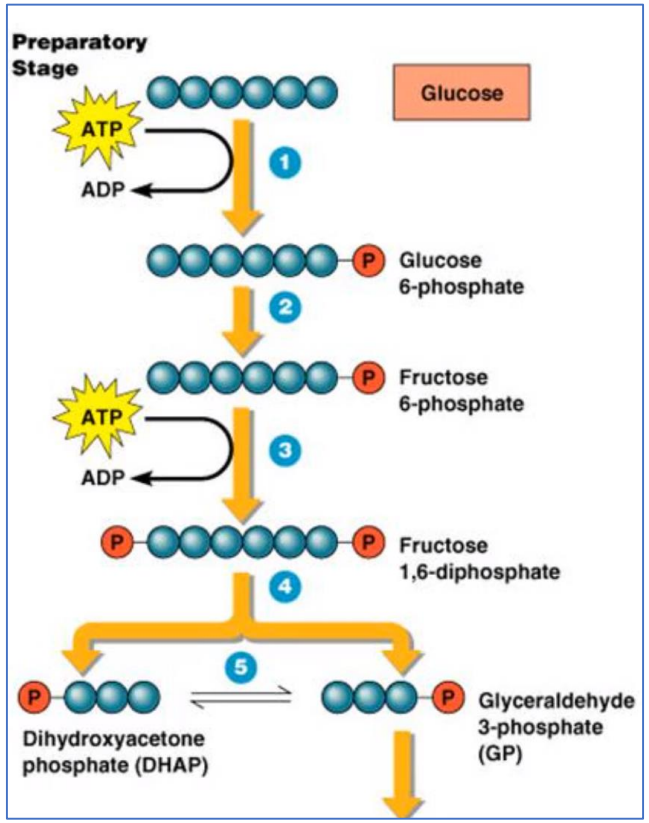
Glycolysis

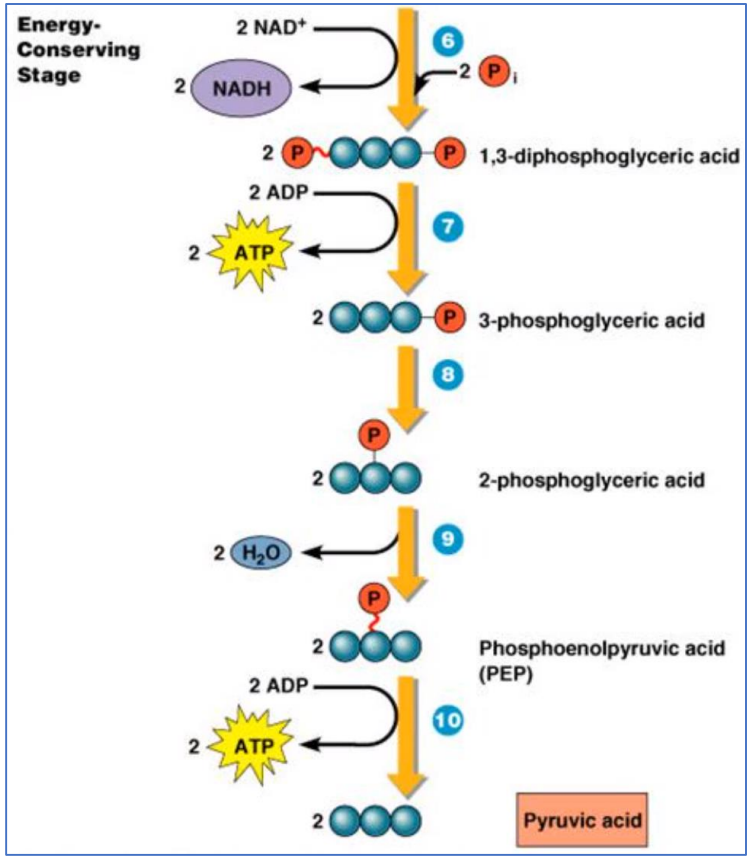
- Each pathway would use different enzymes and generate different metabolites that will be used in various anabolic and catabolic processes later on. (ex. PPP generates ribulose important in nucleic acid synthesis).



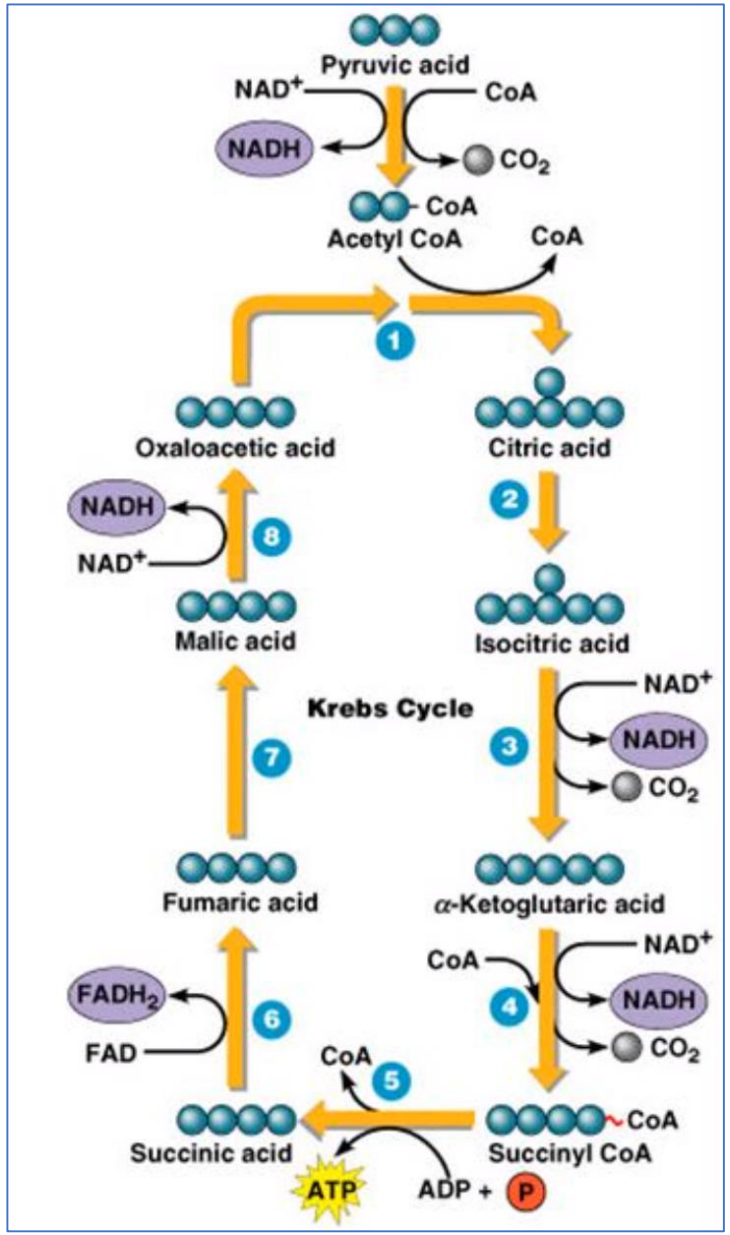
Glycolysis (EMP)

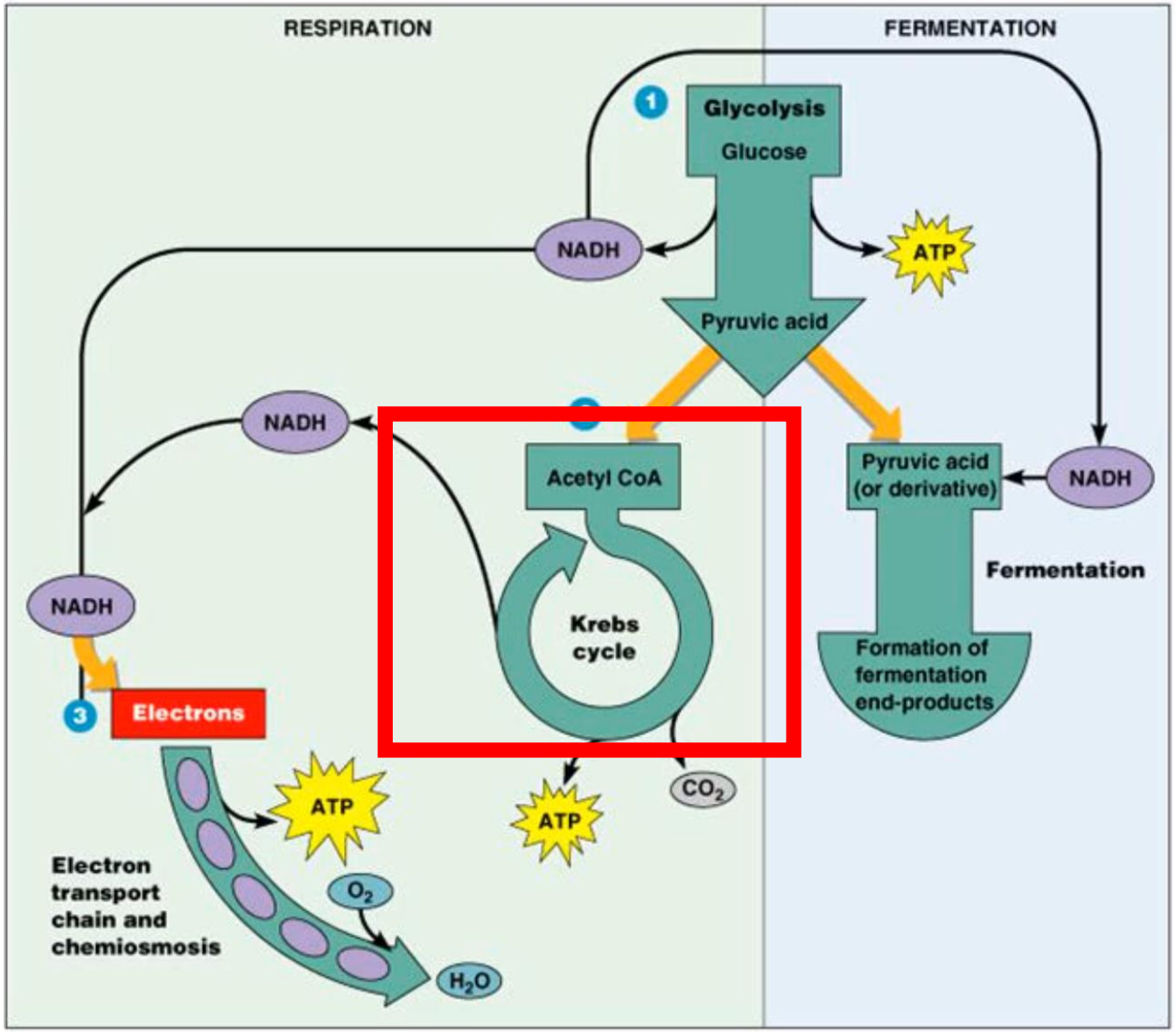
- Most common pathway for glycolysis.
- Generates 2ATP, 2NADH from one glucose.
- Pyruvic acid is the end product.





Aerobic respiration/ Krebs cycle





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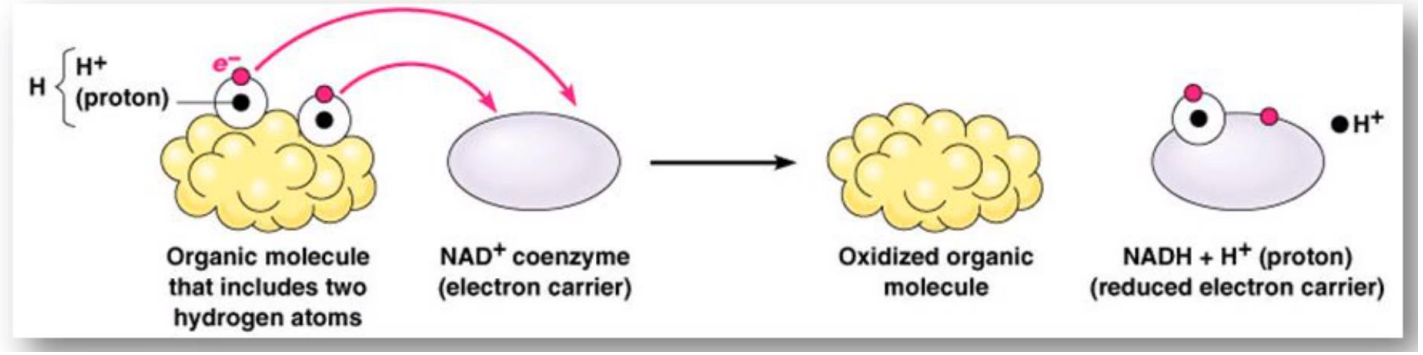
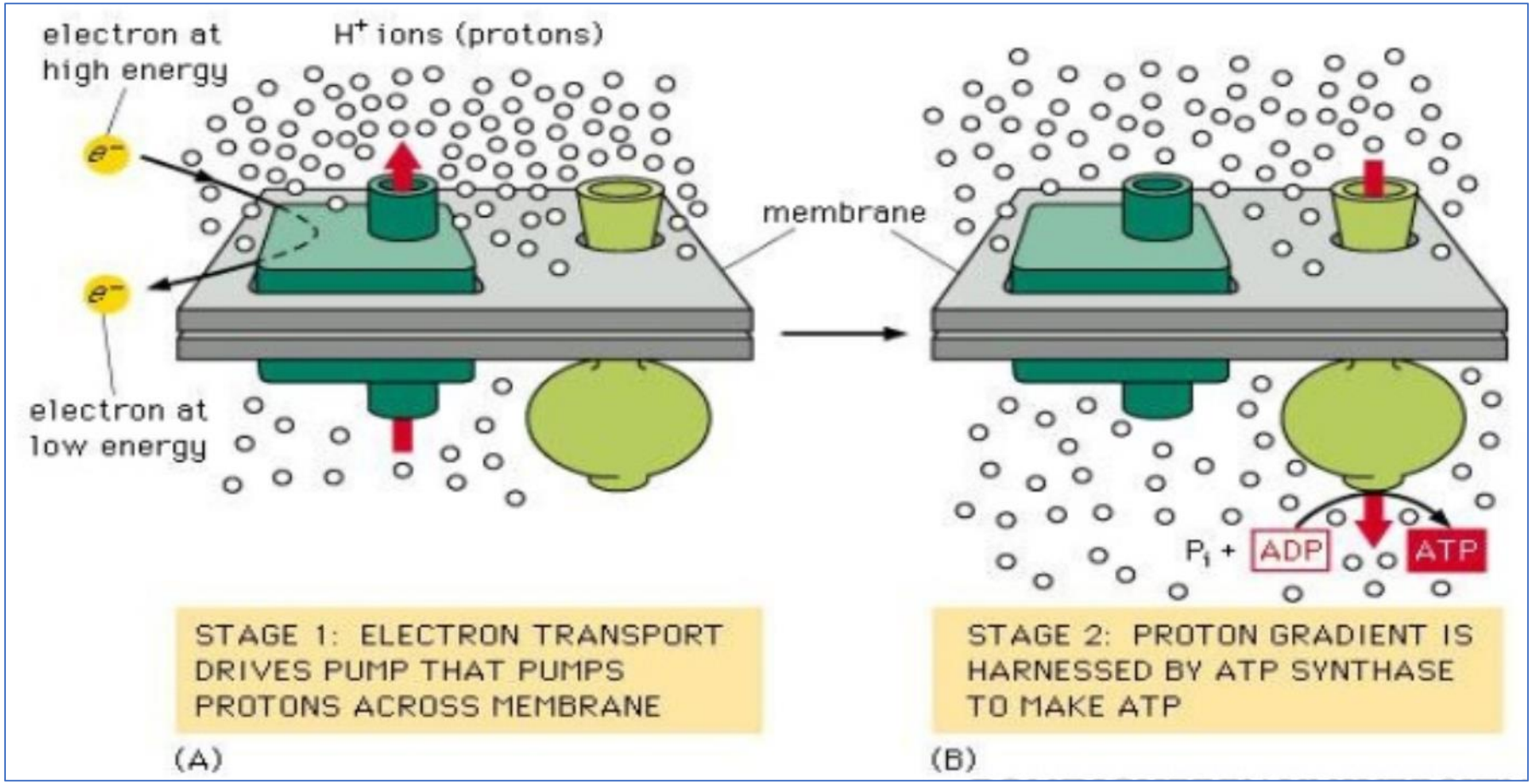
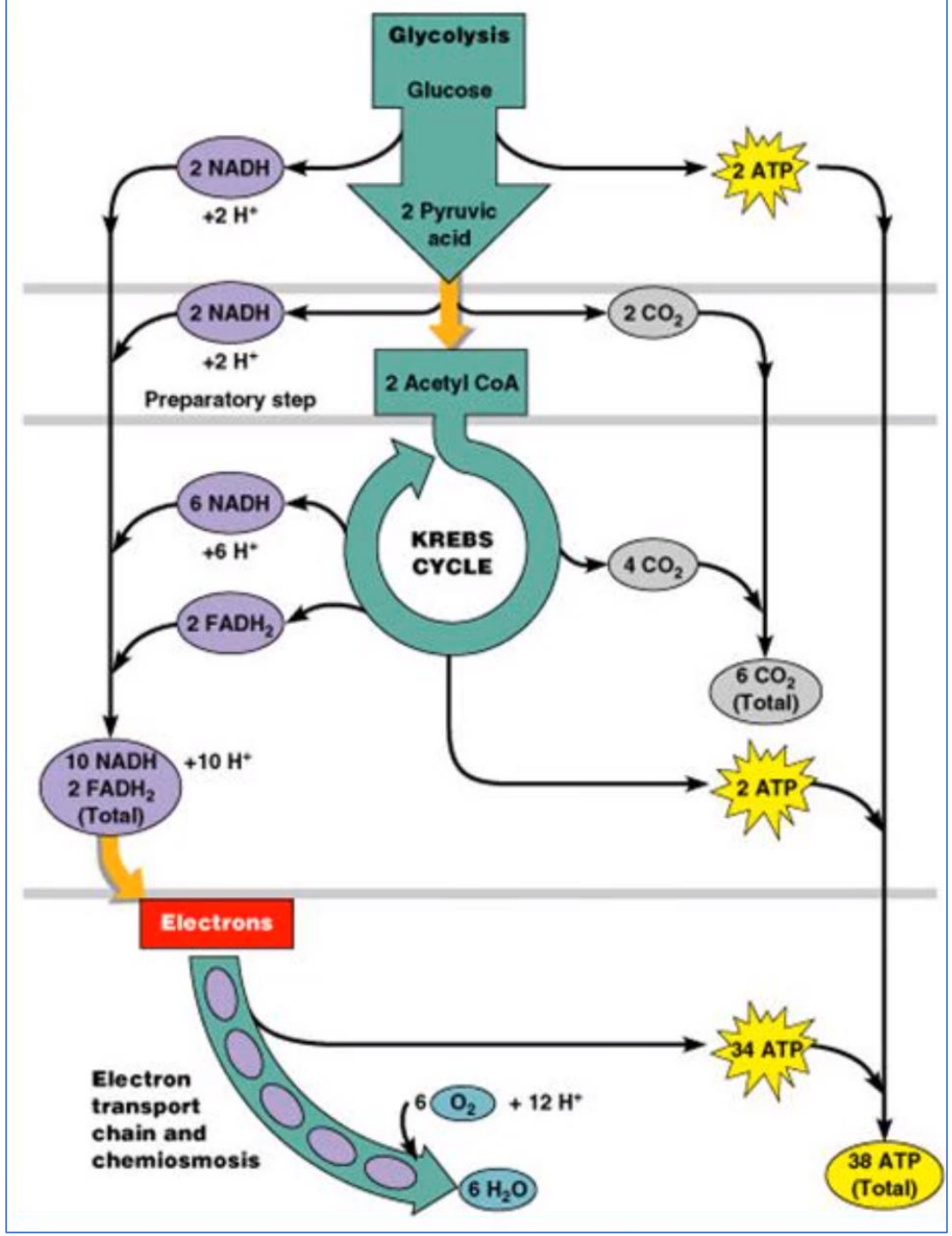


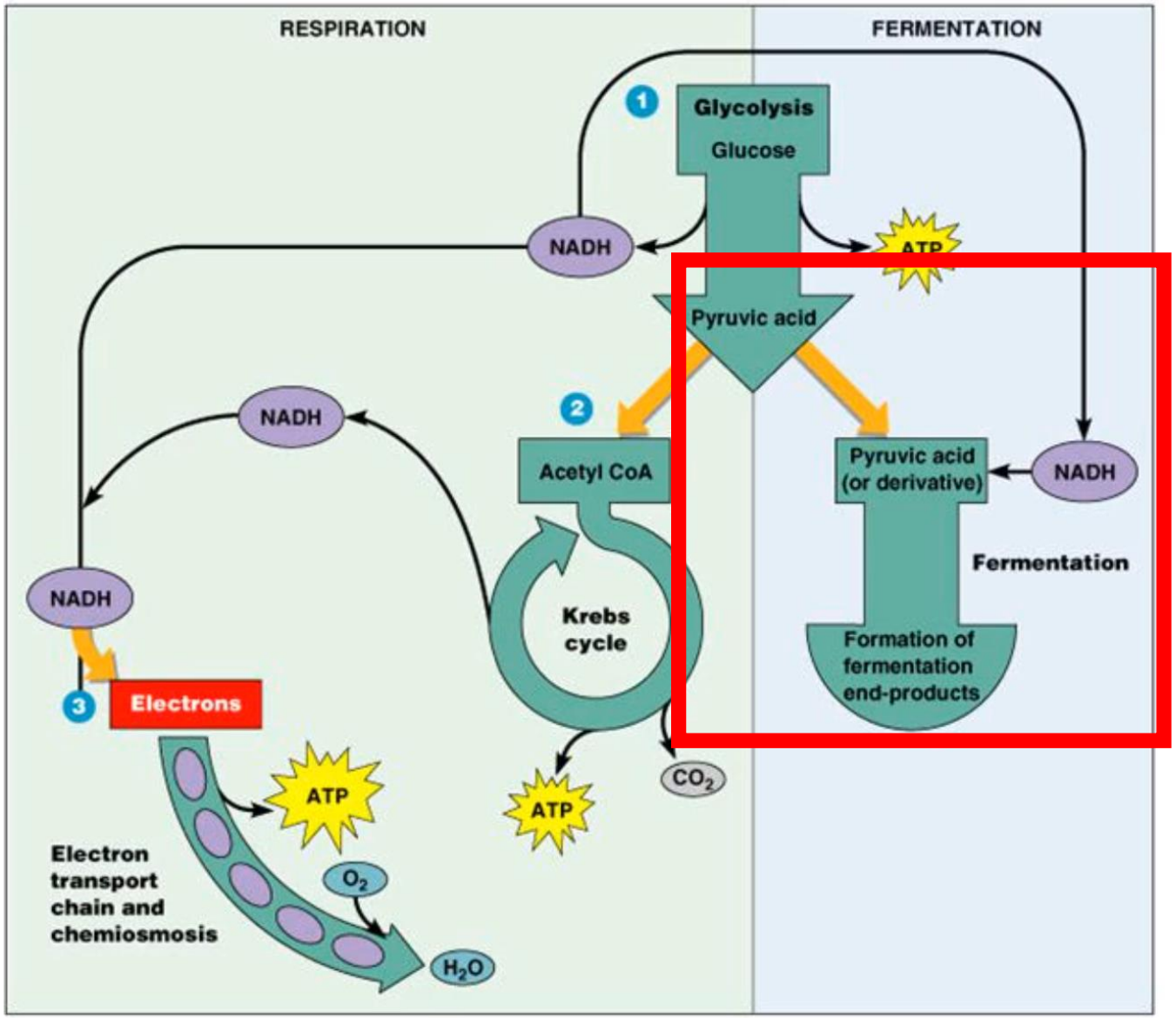


Aerobic respiration summary

- 2 ATP, 2 NADH from glycolysis.
- 2 NADH from formation of Acetyl-CoA
- 6 NADH, 2 FADH from Krebs cycle
- NADH= 3 ATP
- FADH= 2 ATP
- **Total = 38 ATP**

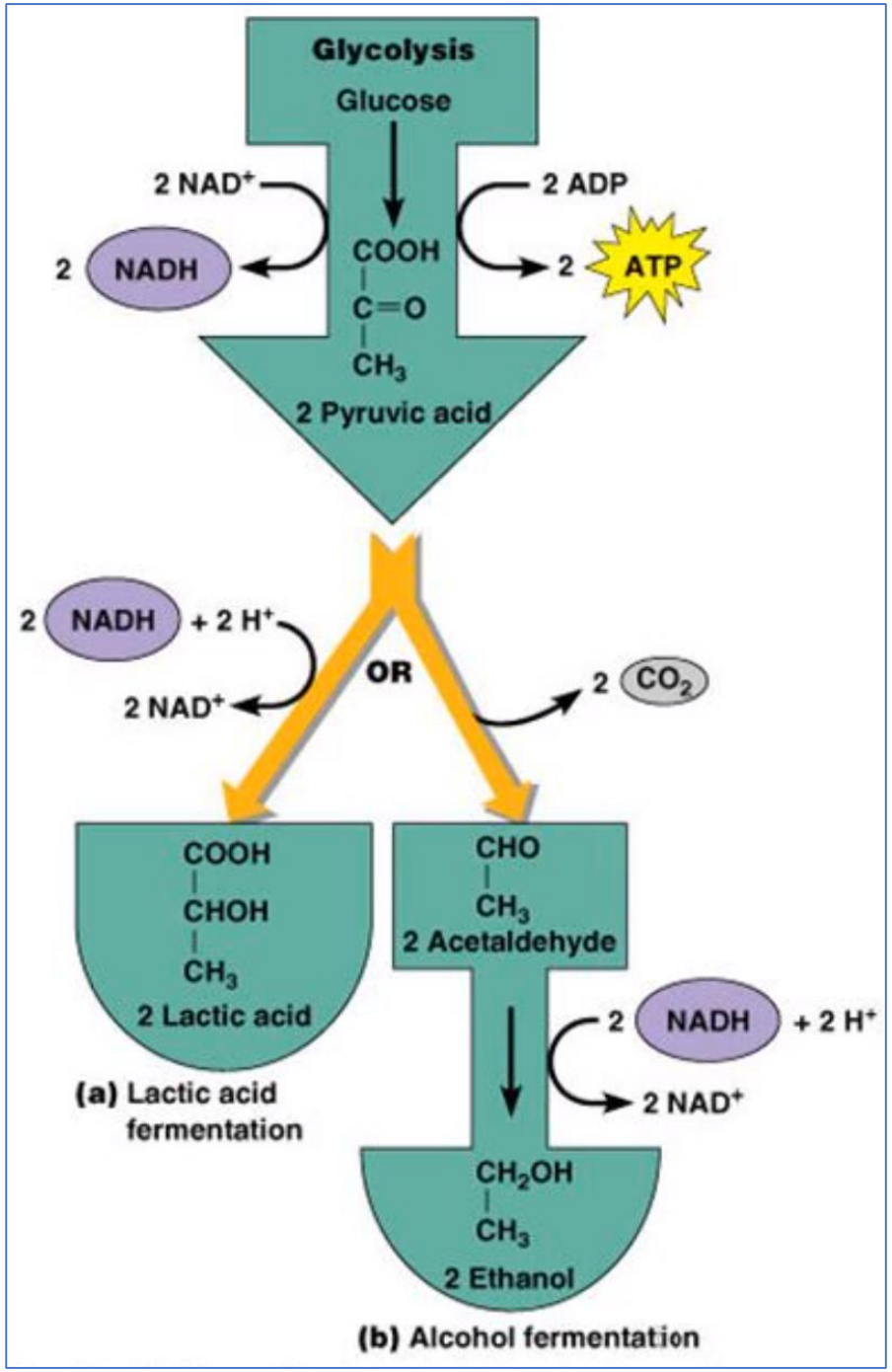


Carbohydrates are a major energy source

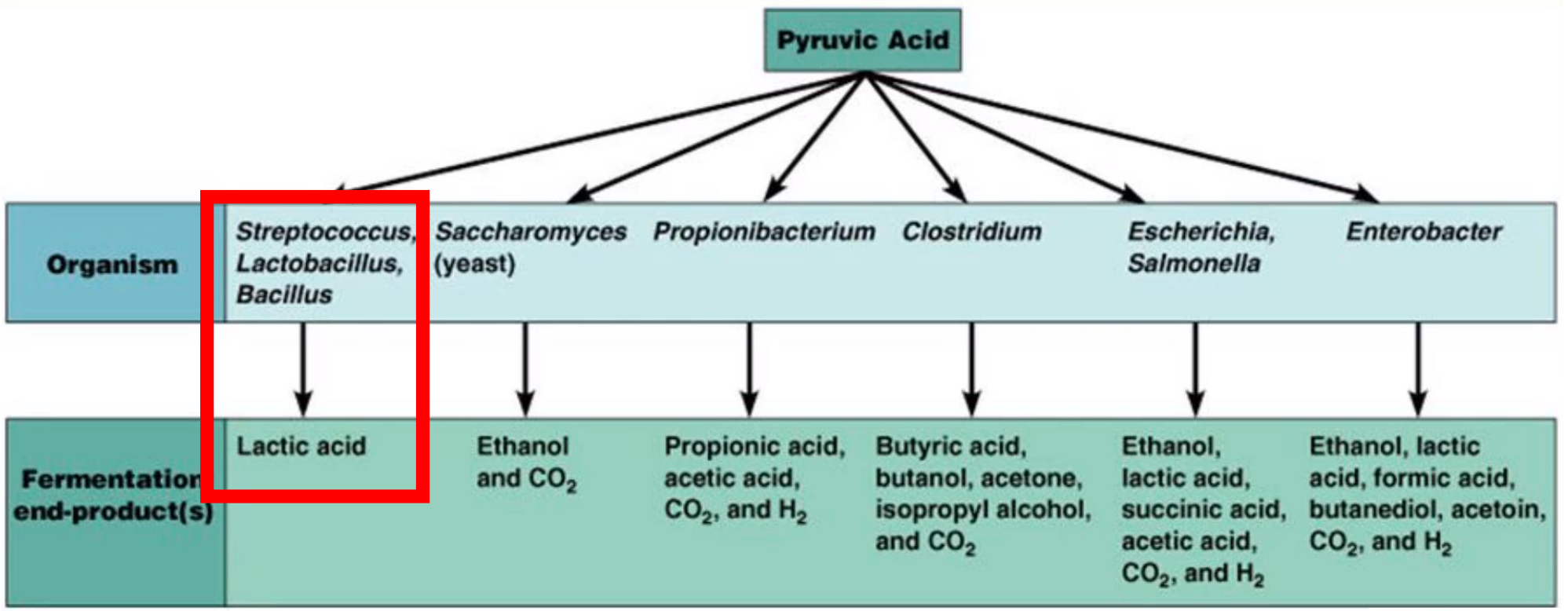


Fermentation

- Release energy from organic molecules by oxidation, with no need for O_2, Krebs cycle or electron transport.
- Can take place in the presence of O_2
- Organic molecules as final electron acceptors.
- Yields 2 ATP molecules per glucose from substrate level phosphorylation.



Fermentation



Glycolysis is a major energy source

TABLE 5.5 Aerobic Respiration, Anaerobic Respiration, and Fermentation Compared

Energy-Producing Process	Growth Conditions	Final Hydrogen (Electron) Acceptor	Type of Phosphorylation Used to Generate ATP	ATP Molecules Produced per Glucose Molecule
Aerobic respiration	Aerobic	Molecular oxygen (O_2)	Substrate-level and oxidative	36 or 38*
Anaerobic respiration	Anaerobic	Usually an inorganic substance (such as NO_3^-, SO_4^{2-}, or CO_3^{2-}), but not molecular oxygen (O_2)	Substrate-level and oxidative	Variable (fewer than 38but more than 2)
Fermentation	Aerobic or anaerobic	An organic molecule	Substrate-level	2

*In prokaryotic aerobic respiration, 38 ATP molecules are produced; in eukaryotic aerobic respiration, 36 ATP molecules are produced.

Further reading:

- Murray - Medical Microbiology 8th Edition
  Section 4: Bacteriology
  Chapter 13: Bacterial metabolisim and genetics

- Jawetz, Melnick & Adelberg's Medical Microbiology, 26th edition-
  Section 1: Fundamentals of Microbiology-
  Chapter 6:Microbial metabolsim