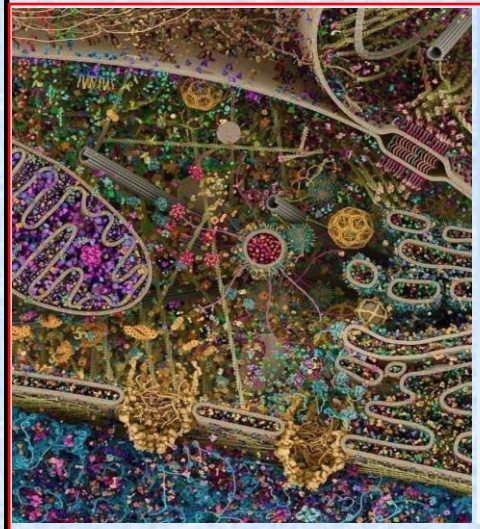
General Animal Biology

Zoo-109 | علم الأحياء | **109- حـيـن**



For Pre-Medical Students **Common First Year**

السنة الأولى المشتركة - المسار الصحي

1444-H - 2023

Reference: *Campbell, N. A. and Reece, J. B. (2014). Biology (10th edition). Pearson Education. Inc. USA.*

عمادة التعليم الإلكتروني والتعلم عن بعد
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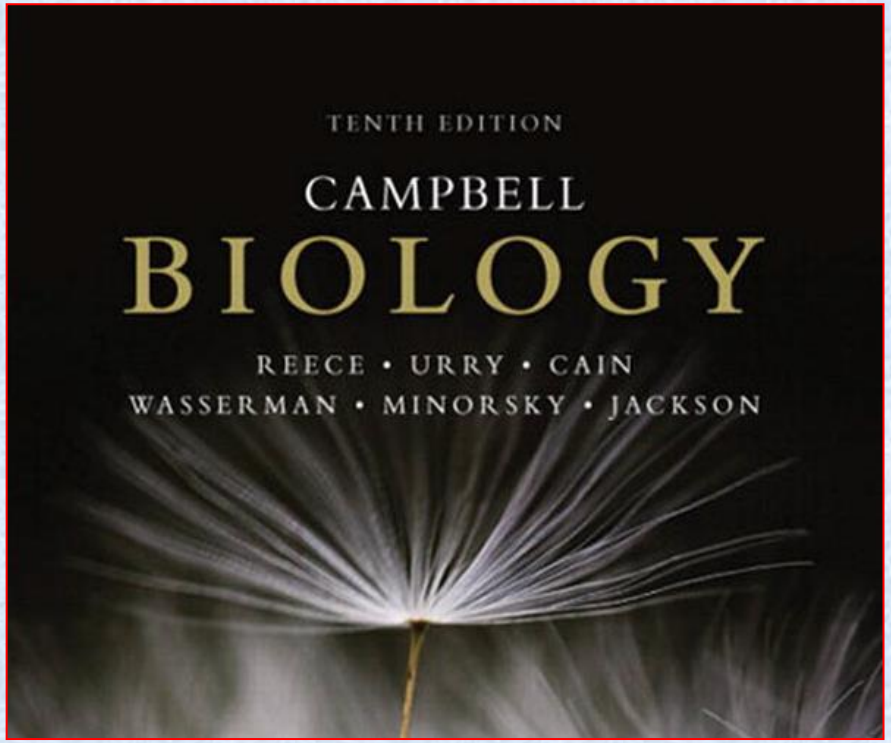
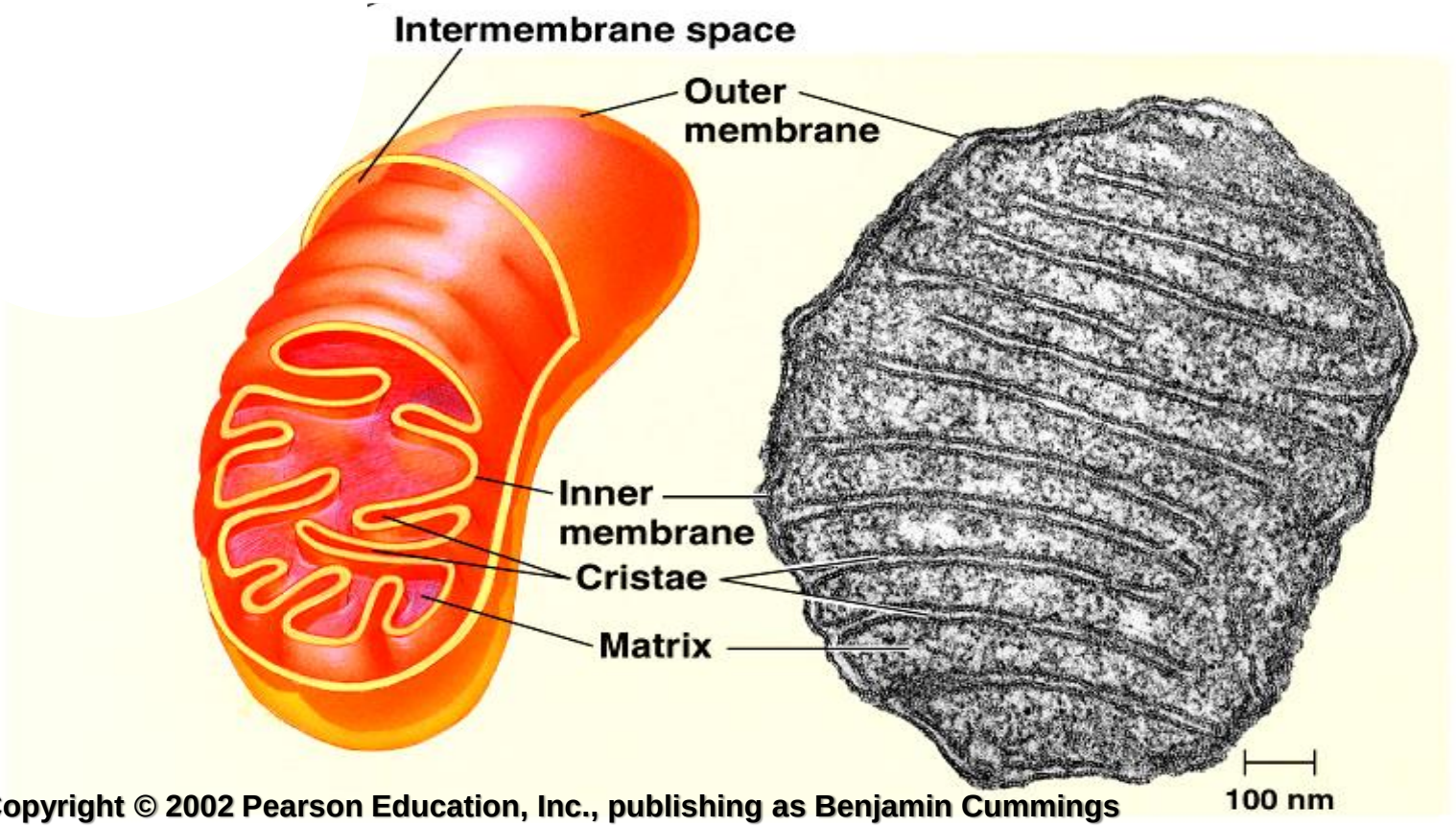
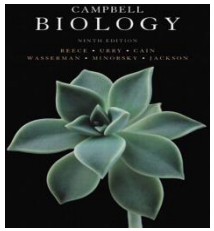


بسم الله الرحمن الرحيم

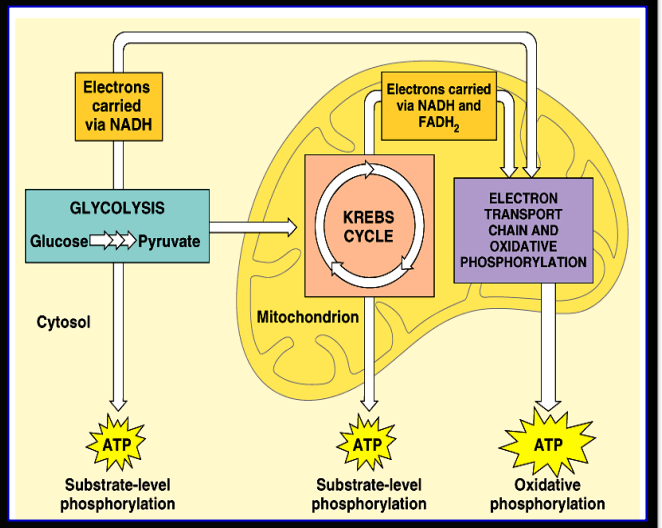
CELLULAR RESPIRATION: Harvesting chemical energy





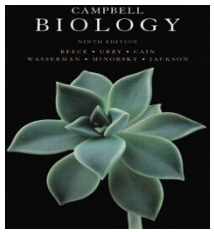
Objectives

Cellular Respiration: involves three stages:



1. **Glycolysis** harvests chemical energy by oxidizing glucose into two **pyruvates** produces about **5%** of ATP (in the cytoplasm).
2. **Krebs cycle** completes the energy-yielding oxidation of organic molecules and produces another **5%** of ATP (in the mitochondrial matrix).
3. **Electron transport chain** to synthesis ATP and produces about **90%** of ATP (inner mitochondrial membrane).

Cellular respiration generates many ATP molecules. From each glucose molecule, it produces (38 ATP molecules).



Phosphorylation

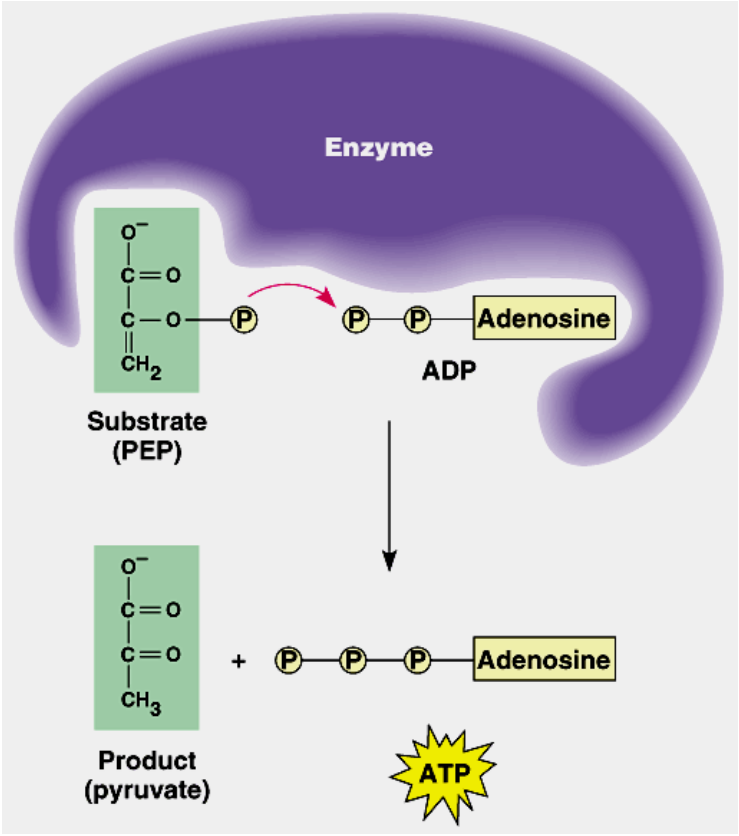
I- Substrate-level phosphorylation:

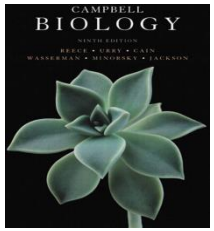
- **Some ATP is generated in glycolysis and Krebs cycle by *Substrate-level phosphorylation*. Phosphate group is transferred from an organic molecule (the substrate) to ADP, forming 10% of the total ATP (4 ATP).**

II- Oxidative phosphorylation:

- **As electrons passed along the Electron transport chain, their energy stored in the mitochondria in a form that can be used to synthesize the rest 90% of the ATP (34 ATP).**

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





1- Glycolysis (splitting glucose): harvests chemical energy by oxidizing glucose into 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: إستهلاك طاقة

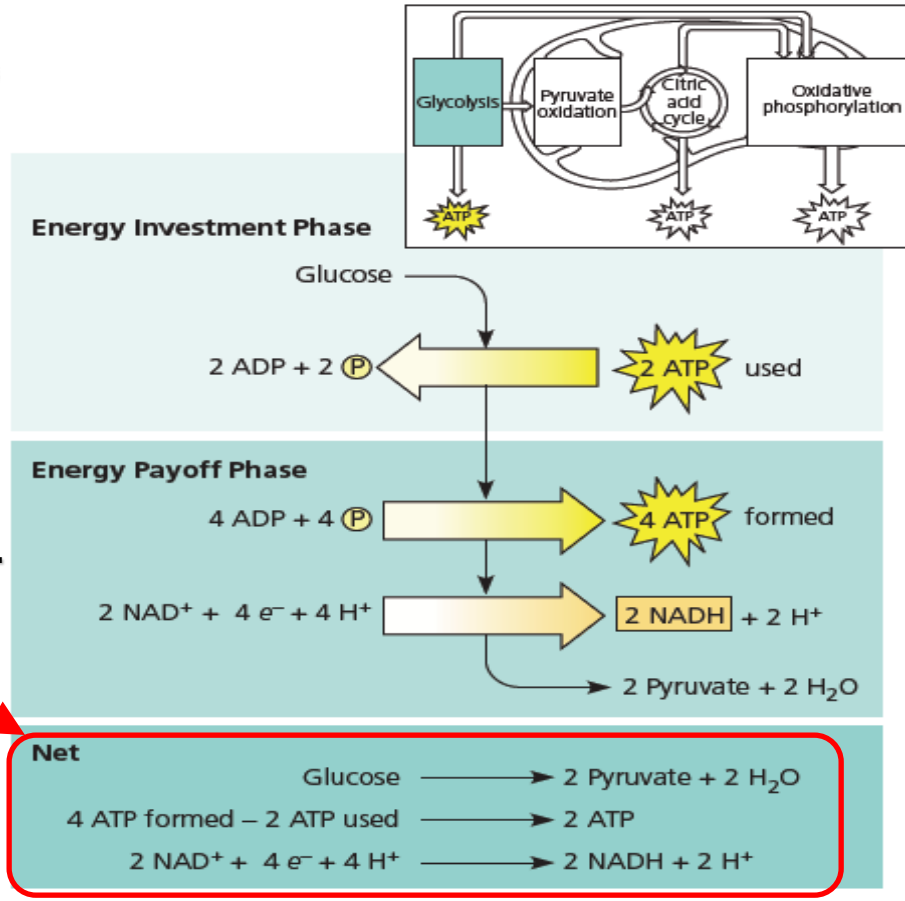
ATP is consumed to provide activation energy by phosphorylating glucose (this requires 2 ATP per glucose).

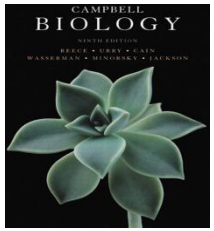
2)- Energy payoff phase: إنتاج طاقة

ATP is produced by substrate-level phosphorylation and NAD^+ is reduced to NADH.

- 4 ATP and 2NADH are produced per one glucose molecule.
- Thus, the net yield from glycolysis is 2 ATP + 2 NADH + 2 Pyruvate molecules per one glucose molecule.

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

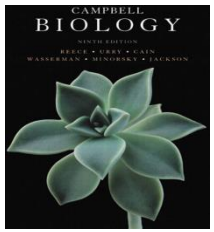
1)- Glucose is phosphorylated twice by adding 2 P coming from 2 ATP (substrate-level-phosphorylation).

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.

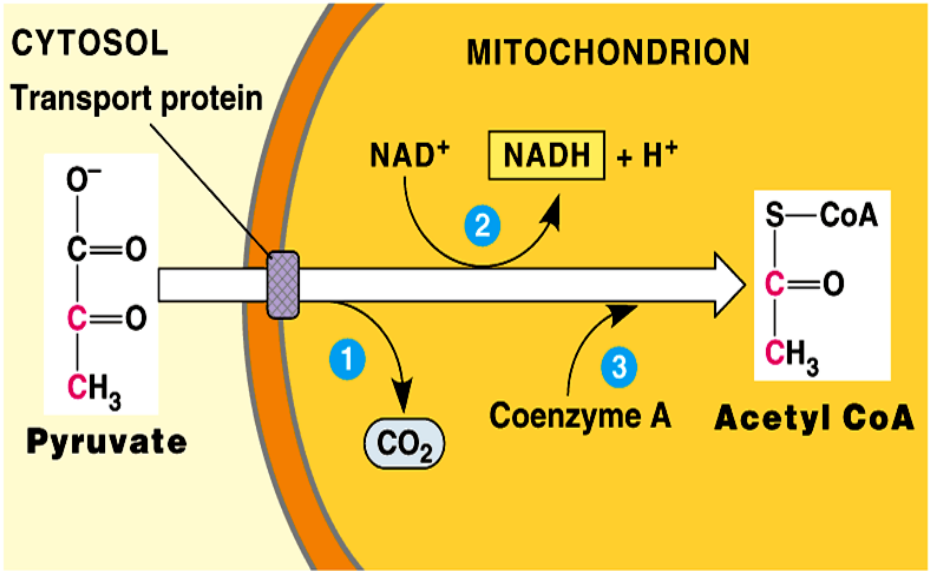
The net yield of this process is the formation of 2 NADH, 2 ATP and 2 Pyruvate molecules.



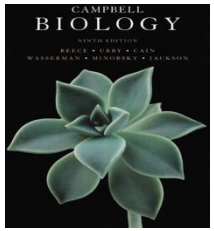
2. The Krebs cycle completes the energy-yielding oxidation of organic molecules (*in mitochondrial matrix*)

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 O_2 is present, pyruvate enters the mitochondrion where enzymes of the Krebs cycle complete the oxidation of this organic fuel to CO_2.
- As pyruvate enters the mitochondrion which modifies to acetyl-CoA which enters the Krebs cycle in the matrix.
  - A carboxyl group is removed as CO_2.
  - A pair of electrons is transferred from the remaining two-carbon fragments to NAD^+ to form NADH.
  - The oxidized fragment, acetate, combines with the Coenzyme A to form acetyl-CoA.



This cycle is called Pre-Krebs cycle الدورة التحضيرية لدورة كريبس



2. The Krebs cycle completes the energy-yielding oxidation of organic molecules (*in mitochondrial matrix*)

It is the main source for preparing most of the cellular NADH (storing energy molecule), **and for producing some more of the cellular ATP.**

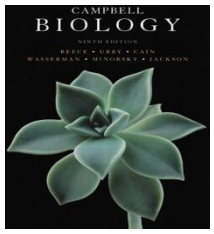
It includes two cycles :

Pre-Krebs cycle المرحلة التحضيرية

The Pyruvate is the substrate for this cycle

Krebs cycle

The acetyl-CoA is the substrate for this cycle



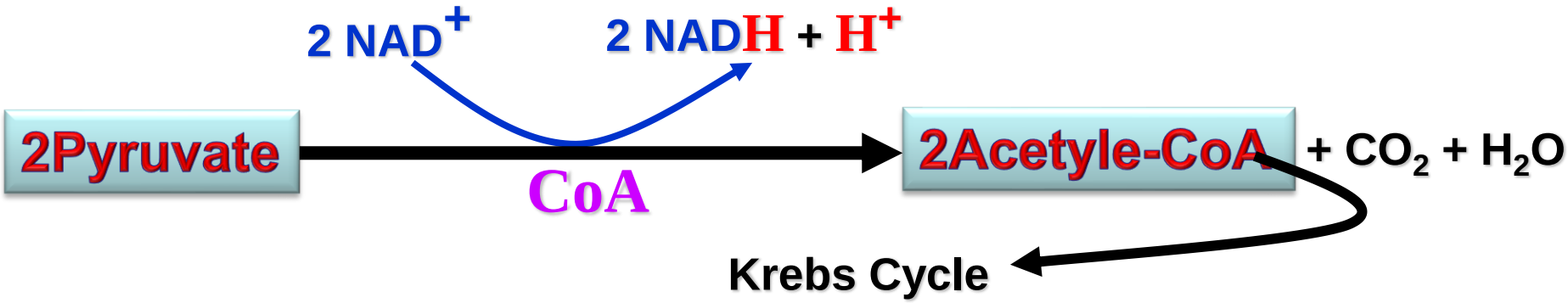
A)- Pre-Krebs cycle

Pyruvate is converted into acetyle-CoA in the presence of O_2 through 3 steps.

a)- $C{=}O^-$ group of pyruvate is released as CO_2.

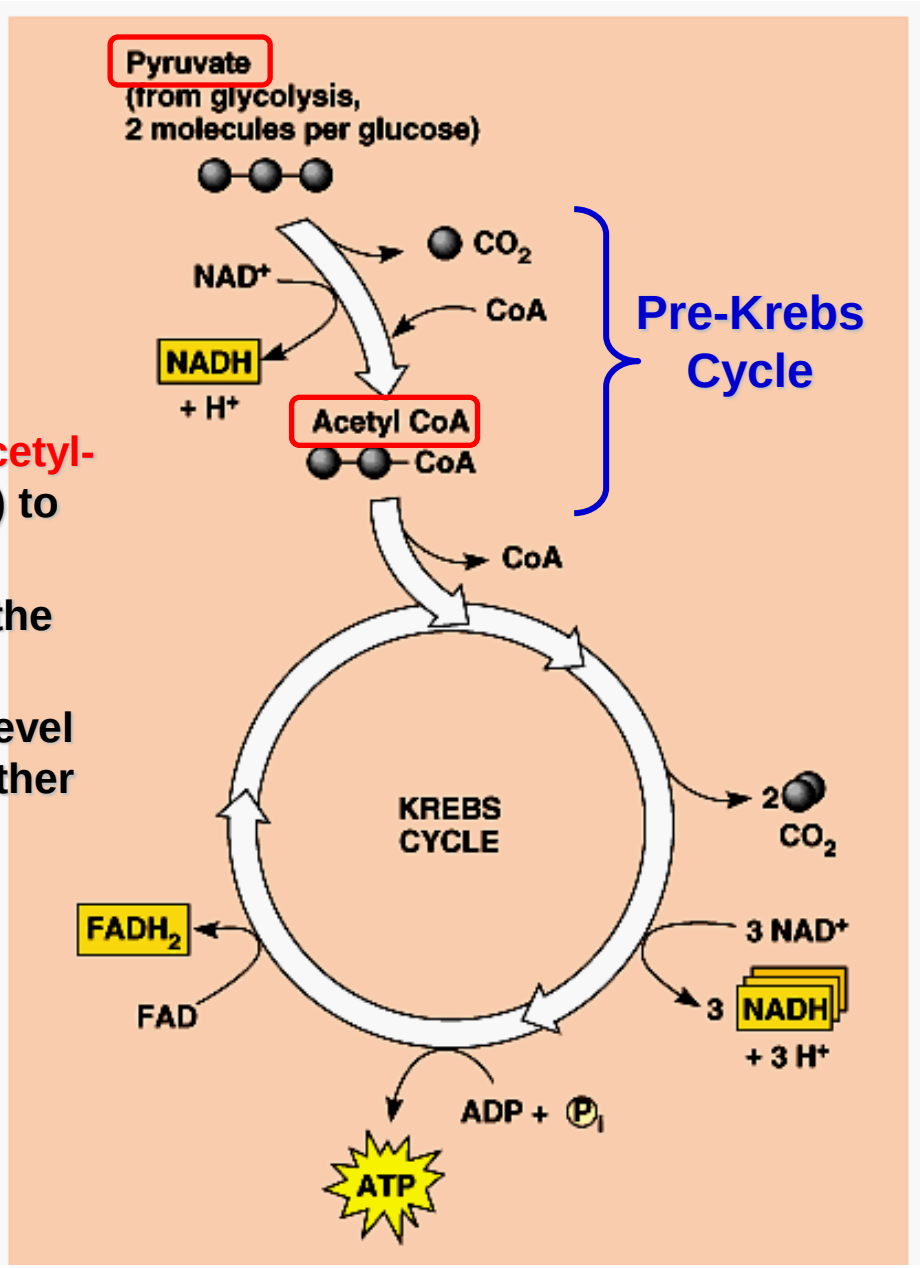
b)- The remaining two-C fragments are oxidized (releasing e^-) into acetate and the resulting e^- transform NAD^+ into NADH.

c)- The coenzyme-A (CoA) transform acetate compound into acetyl-CoA, which will be ready for Krebs Cycle for further oxidation.



B)- Krebs cycle

It has eight steps starting with 2 acetyle-CoA compounds. They are summarized as shown in the figure:



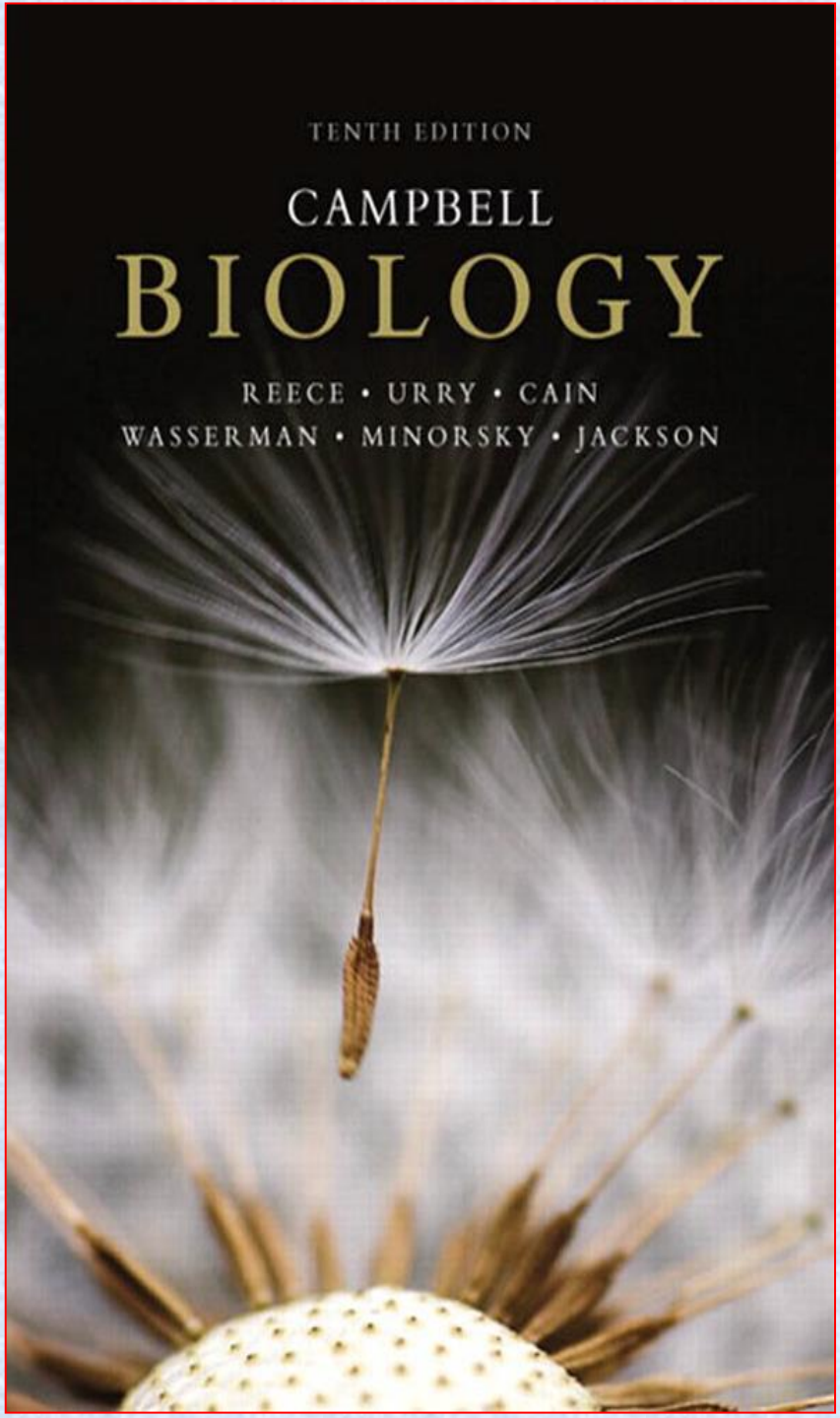
- This cycle begins when acetate from each acetyl-CoA combines with oxaloacetate (4 C atoms) to form citrate (citric acid).
- Ultimately, the oxaloacetate is recycled and the acetate is broken down to CO_2.
- Each cycle produces one ATP by substrate-level phosphorylation, 3 NADH, and 1 $FADH_2$ (another electron carrier) per acetyl CoA.

Thus, the outcome of the two cycles (for the 2 Acetyle-CoA molecules) is:

Output

- 2 ATP
- 6 NADH
- 2 $FADH_2$

Flavin Adenine Dinucleotide



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General Animal Biology

(Zoo-109)

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Thank you very much

شكرا جزيلا

Zoology Department