Plant Physiology

Unite IV
Respiration
Or
Cellular respiration

❖Cellular Respiration

A catabolic, exergonic, oxygen (O_2) requiring process that uses energy extracted from macromolecules (glucose) to produce energy (ATP) and water (H_2O).

❖ $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + energy$

glucose

ATP

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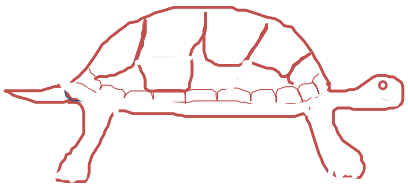
Question:

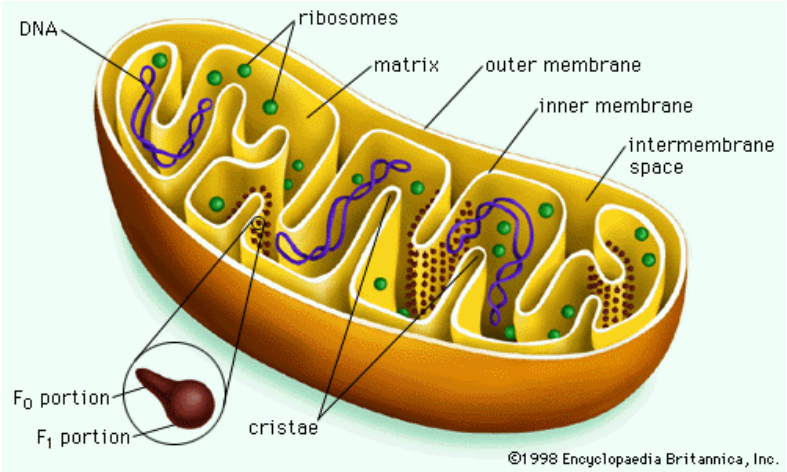
In what kinds organisms does cellular respiration take place?

- **Plants - Autotrophs: self-producers.**
- **Animals - Heterotrophs consumers.**



Mitochondria.

Organelles where cellular respiration takes place.



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❖ Redox Reaction.

- Transfer of one or more electron (s) from one reactant to another.
- Two types:-
  1. Oxidation
  2. Reduction

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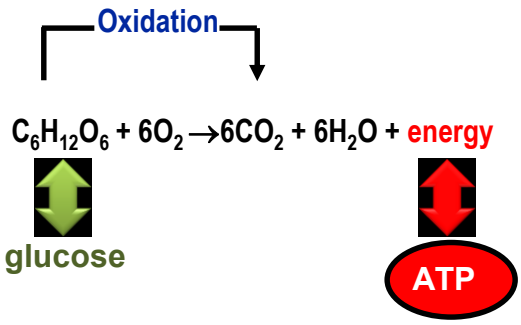
❖ Oxidation Reaction.

- The loss of electrons from a substance.
- Or the gain of oxygen.



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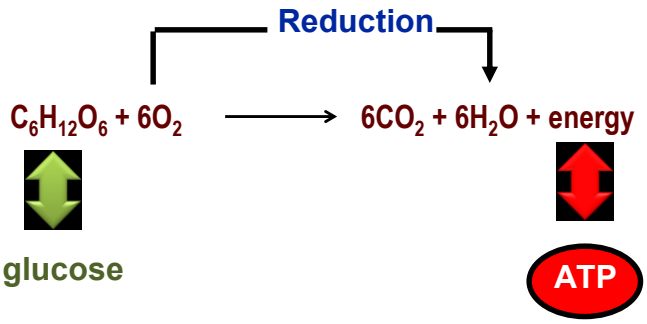
❖Reduction Reaction.

- The gain of electrons to a substance.
- Or the loss of oxygen.



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❖Breakdown of Cellular Respiration.

Three main parts (reactions).

1. Glycolysis (splitting of sugar)
   * cytosol, just outside of mitochondria.
2. Krebs Cycle (Citric Acid Cycle)
   * mitochondrial matrix
3. Electron Transport Chain (ETC) and Oxidative Phosphorylation
   * Also called Chemiosmosis
   * inner mitochondrial membrane.

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1. Glycolysis.

- Occurs in the **cytosol just outside of mitochondria.**
- **Two phases (10 steps):-**

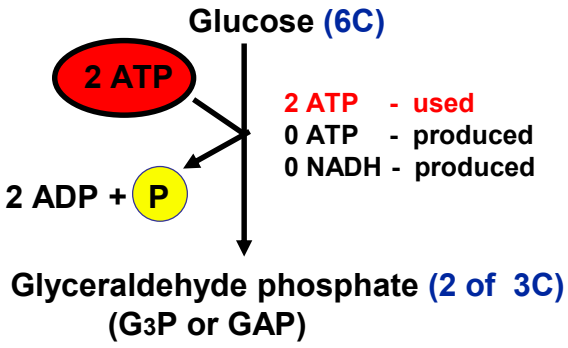
A. Energy investment phase.

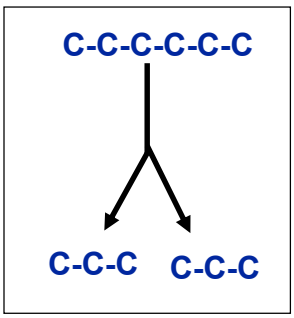
a. Preparatory phase (first 5 steps).

B. Energy yielding phase.

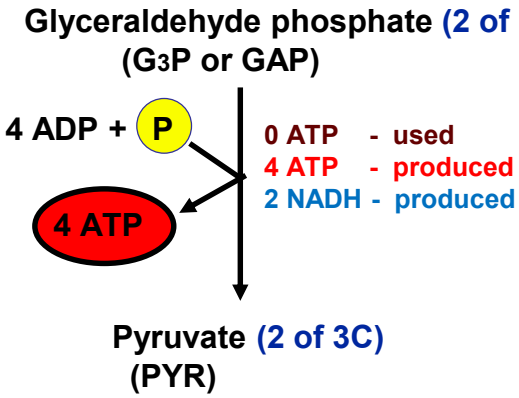
a. Energy payoff phase (second 5 steps).

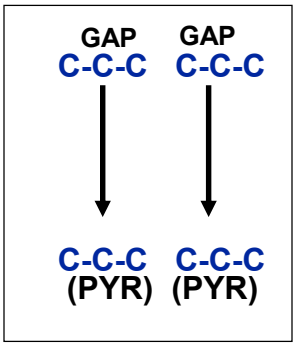
A. Energy Investment Phase:-





B. Energy Yielding Phase:-





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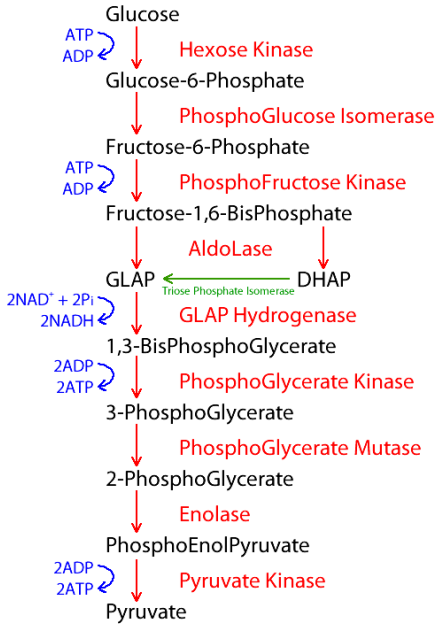

- **Total Net Yield of Glycolysis.**

2 molecules of 3C-Pyruvate (PYR)

2 molecules of ATP (Substrate-level Phosphorylation)

2 molecules of NADH

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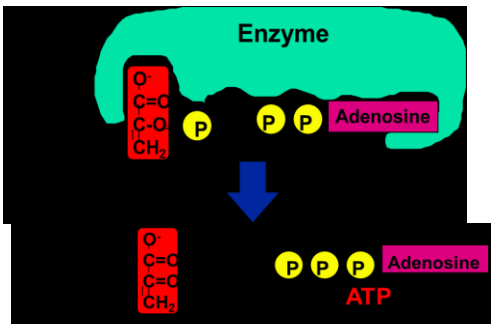
❖Substrate-Level Phosphorylation.

- **ATP is formed when an enzyme transfers a phosphate group from a substrate to ADP.**

Example:
PEP to PYR



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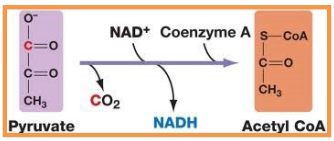
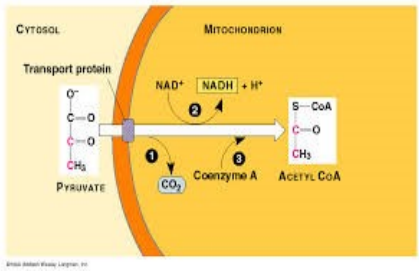
❑Oxidation of Pyruvate.

- Occurs when Oxygen is present (aerobic).
- 2 Pyruvate (3C) molecules are transported through the mitochondria membrane to the matrix and is converted to 2 Acetyl CoA (2C) molecules.





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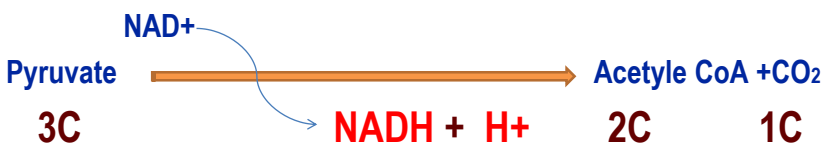
- End Products: oxidation of pyruvate.

  2 molecules of NADH.
  2 molecules of CO_2.
  2 molecules of Acetyl CoA (2C).



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2. Krebs Cycle (Citric Acid Cycle).

- Location: mitochondrial matrix.
- Acetyl CoA (2C) bonds to Oxaloacetic acid (4C - OAA) to make Citrate (6C).
- It takes 2 turns of the Krebs cycle to oxidize 1 glucose molecule.

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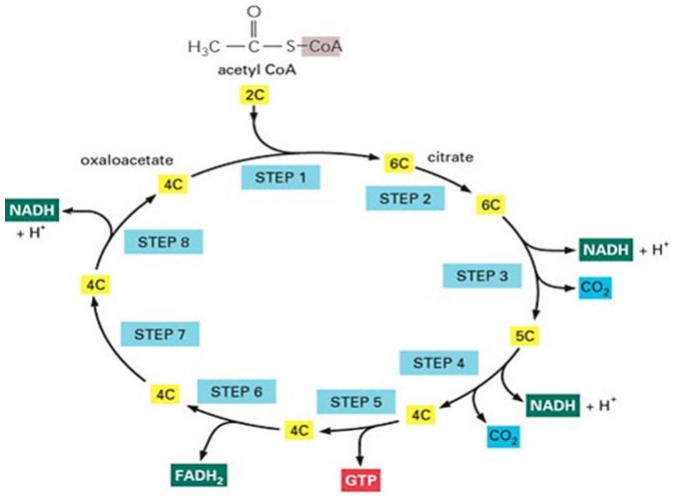
❖ Krebs Cycle (Citric Acid Cycle)



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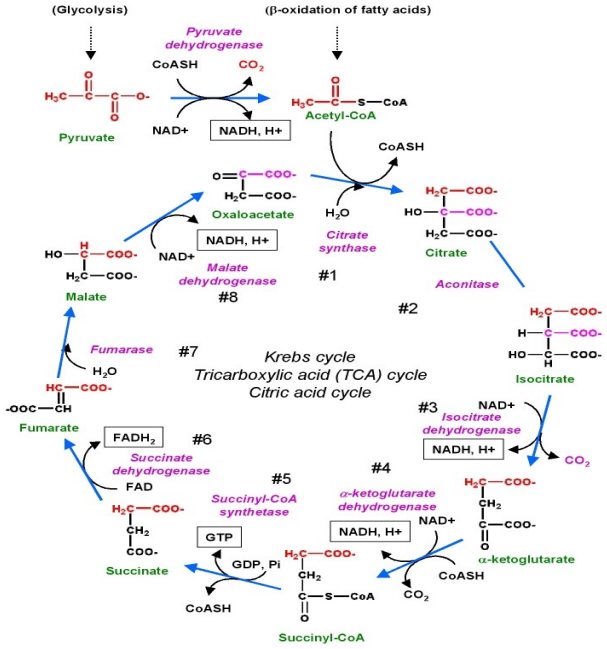

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- **Steps of Krebs cycle or citric acid cycle.**

In order for pyruvate from glycolysis to enter the Kreb's Cycle it must first be converted into acetyl-CoA by the pyruvate dehydrogenase complex which is an oxidative process wherein NADH and CO_2 are formed. Another source of acetyl-CoA is beta oxidation of fatty acids.

1. Acetyl-CoA enters the Kreb Cycle when it is joined to oxaloacetate by citrate synthase to produce citrate. This process requires the input of water. Oxaloacetate is the final metabolite of the Krebs Cycle and it joins again to start the cycle over again, hence the name Kreb's Cycle. This is known as the committed step

2. Citrate is then converted into isocitrate by the enzyme aconitase. This is accomplished by the removal and addition of water to yield an isomer.

3. Isocitrate is converted into alpha-ketoglutarate by isocitrate dehydrogenase. The byproducts of which are NADH and CO_2.

4. Apha-ketogluterate is then converted into succiynl-CoA by alpha- ketogluterate dehydrogenase. NADH and CO_2 are once again produced.

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5. Succynl-CoA is then converted into succinate by Succinyl-CoA synthetase which yields one ATP per succynl-CoA.

6. Succinate coverts into fumarate by way of the enzyme succinate dehydrogenase and [FAD] is reduced to [$FADH_2$] which is a prosthetic group of succinate dehydrogenase. Succinate dehydrogenase is a direct part of the ETC. It is also known as electron carrier II.

7. Fumarate is then converted to malate by hydration with the use of fumerase.

8. Malate is converted into oxaloacetate by malate dehydrogenase the byproducts of which are NADH.

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❖ Krebs Cycle Summary

- Oxygen (Aerobic).
- Cyclical series of oxidation reactions that give off CO_2 and produce one ATP per cycle.
- Turns twice per glucose molecule.
- Produces two ATP.
- Takes place in matrix of mitochondria.
- Each turn of the Krebs Cycle also produces 3NADH, 1$FADH_2$, and 2CO_2.
- Therefore, for each Glucose molecule, the Krebs Cycle produces 6NADH, 2$FADH_2$, 4CO_2, and 2ATP.

Q / Give a general description of the Krebs cycle.

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❖ **Total net yield (2 turns of Krebs cycle)**

1. **2 - ATP** (substrate-level phosphorylation)
2. **6 - NADH**
3. **2 - $FADH_2$**
4. 4 - CO_2

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❖ **A Little Krebs Cycle History.**

- **Discovered by Hans Krebs in 1937.**
- **He received the Nobel Prize in physiology or medicine in 1953 for his discovery.**
- **Forced to leave Germany prior to WWII because he was Jewish.**

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3. Electron Transport Chain (ETC) and Oxidative Phosphorylation (Chemiosmosis)

- The **H+** then move via **diffusion (Proton Motive Force)** through **ATP Synthase** to make **ATP**.
- All **NADH** and **$FADH_2$** converted to **ATP** during this stage of **cellular respiration**.
- Each **NADH** converts to **3 ATP**.
- Each **$FADH_2$** converts to **2 ATP** (enters the ETC at a lower level than **NADH**).

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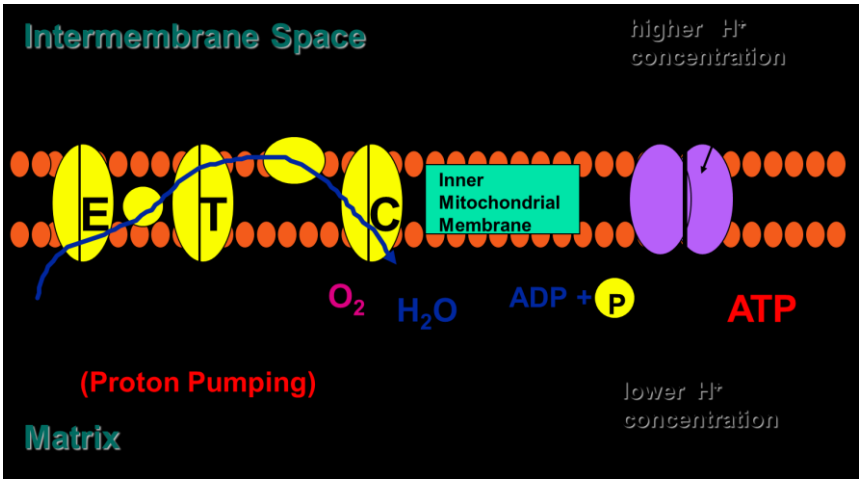
❖ ETC and Oxidative Phosphorylation (Chemiosmosis for NADH)



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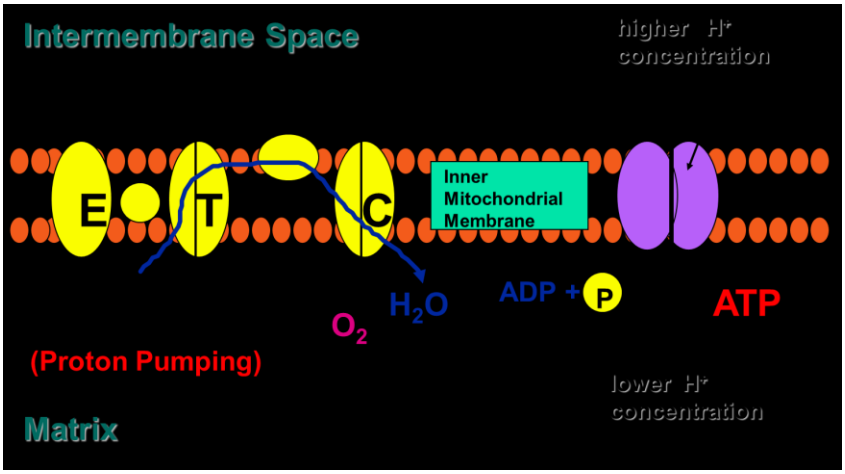
- **ETC and Oxidative Phosphorylation (Chemiosmosis for $FADH_2$)**



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- **TOTAL ATP YIELD of Cellular respiration**

1. 04 ATP - substrate-level phosphorylation.

2. 34 ATP - ETC & oxidative phosphorylation.

38 ATP - TOTAL YIELD

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