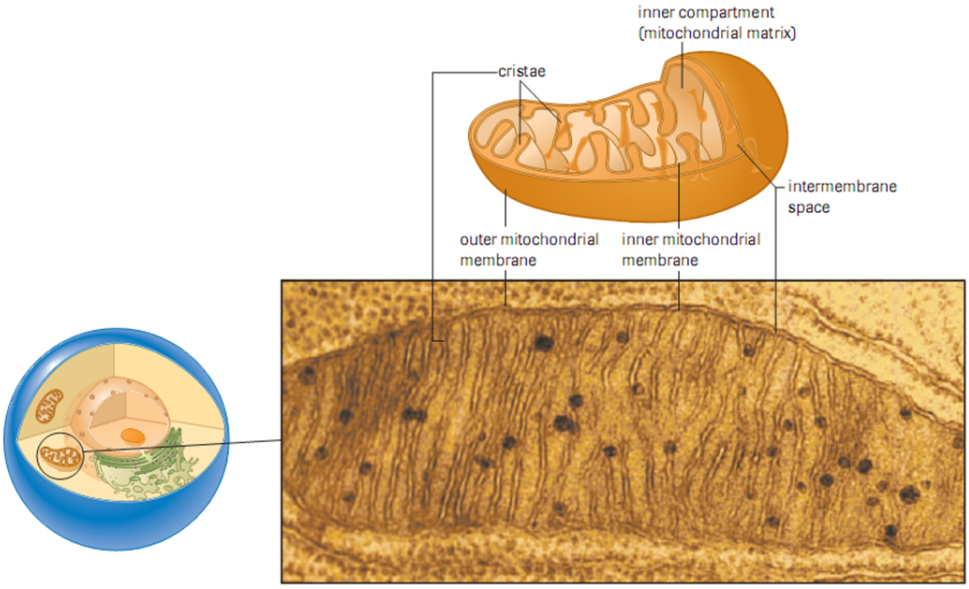
Cellular Respiration – Chapter 7 – Lesson 2 – Aerobic Cellular Respiration

- Aerobic cellular respiration starts with **glycolysis**

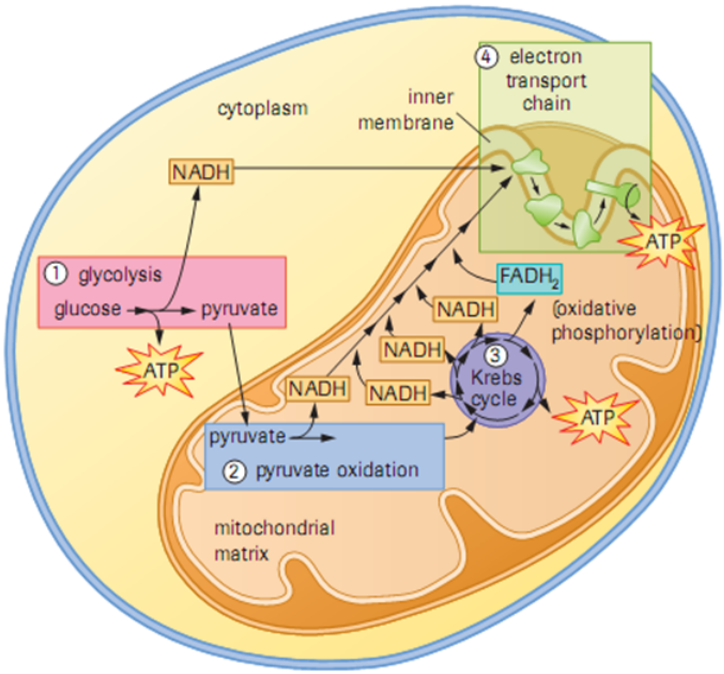
- Aerobic cellular respiration takes place in the **mitochondria** of the cell



- The two **pyruvate** molecules produced in glycolysis are now used in aerobic cellular respiration

- Aerobic cellular respiration occurs in 4 steps

  Stage 1: glycolysis
  Stage 2: pyruvate oxidation
  Stage 3: the Krebs cycle
  Stage 4: the electron transport chain and chemiosmosis



Stage 2: Pyruvate Oxidation

- Recall that by the end of Stage 1, glycolysis, the cell had formed 2 ATPs, 2NADHs and 2 pyruvate molecules—all in the cytoplasm

- Stage 2 begins when the two pyruvate molecules formed in glycolysis are transported through the two mitochondrial membranes into the matrix

- There, the following three changes occur to each pyruvate molecules:

1. A **CO_2** is removed from each pyruvate and released as a waste product.
    - This step is the source of one-third of the carbon dioxide that you breathe out.
2. The remaining 2-carbon portions are oxidized by NAD^+
    - Each NAD^+ molecule gains two hydrogen ions and two electrons from pyruvate
        - This creates **2 NADH** molecules which go on to **Stage 4**
    - the remaining 2-carbon compound becomes an acetic acid (acetyl) group.
3. A compound called coenzyme A (CoA) becomes attached to the acetic acid group, forming **acetyl-CoA**
    - The acetyl-CoA then enters the next stage of aerobic cellular respiration, the **Krebs cycle**.

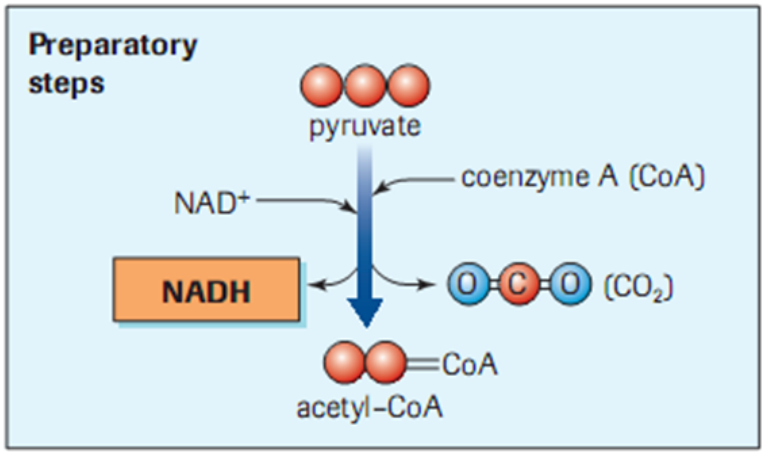


Figure 3
Pyruvate oxidation results in three changes to pyruvate:
1. A CO_2 portion is removed.
2. NAD^+ is reduced by two H atoms.
3. Coenzyme A is attached to the remaining 2-carbon portion (acetyl group).

Because 2 pyruvate molecules enter this step from glycolysis, this step produces

- **2 NADH** molecules
- **2 CO_2** molecules
- **2 acetyl CoA** molecules

Stage 3: The Krebs Cycle

- The Krebs cycles uses the **acetyl CoA** molecules from **Stage 2**

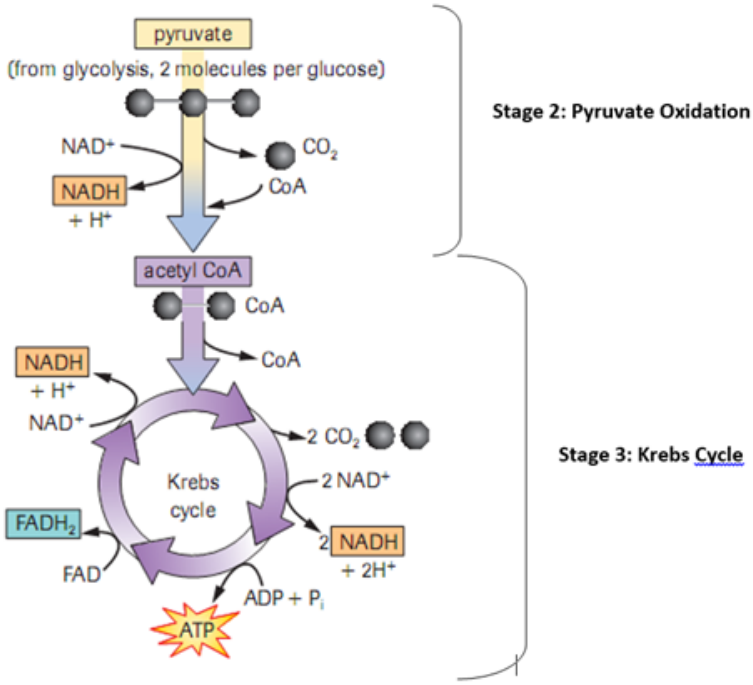
- The Krebs cycle occurs in 8 steps

- By the end of the Krebs cycle, all of the carbon atoms that were once in glucose have been turned into CO_2 molecules

Key Features of the Krebs Cycle

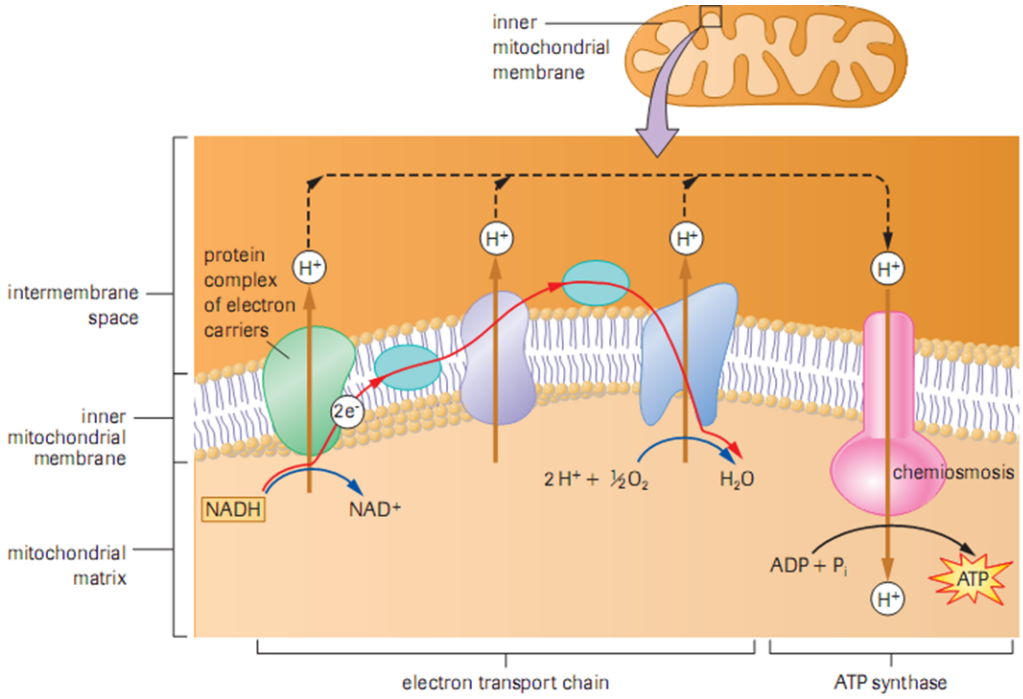
1. The acetyl CoA molecules loses the **CoA**
   a. The CoA gets reused in Stage 2

2. The 2-carbon acetyl molecule gets used to make
   a. **2 CO_2** molecules – get breathed out
   b. **3 NADH** molecules – go onto Stage 4
   c. **1 $FADH_2$** molecules – go onto Stage 4
   d. **1 ATP** molecule – used by the cell for energy



Stage 4: Electron Transport and Chemiosmosis

- Proteins in the inner membrane of the mitochondria set up the electron transport chain
- These proteins use high energy electrons from **NADH** and **$FADH_2$** to pump H^+ ions
    - The H^+ ions are pumped across the membrane against the concentration gradient



- The electrons that are passed down the electron transport chain (ETC) are eventually given to **oxygen**
    - The oxygen then reacts with H^+ ions to make water (the other waste product of cellular respiration)
    - Without oxygen, the ETC does not occur
    - Oxygen is known as the **final electron acceptor**
- An enzyme called ATP synthase then uses the energy from the flow of H^+ ions to make ATP
    - ADP + P → ATP
- This Stage makes the most ATP (22) and brings the total for aerobic cellular respiration to **36 ATP** molecules

Lesson 2 Review Questions

Read pgs 213-220

1. What stages of aerobic cellular respiraon take place in the mitochondria?

2. What happens to NAD+ in Stage 2 of aerobic cellular respiraon?

3. What is the role of coenzyme A?

4. Describe the funcon of NAD+ and FAD in aerobic cellular respiraon.

5. What are the final products of aerobic cellular respiraon?

6. As a result of glycolysis, pyruvate oxidaon, and the Krebs cycle, only a small poron of the energy of glucose has been converted to ATP. In what form is the rest of the usable energy found at this stage of the process?

7. Arrange the following types of cells in order of increasing number of mitochondria in the cytoplasm: nerve cell, skin cell, fat cell, heart muscle cell. Provide a raonale for your sequence.

8. (a) In eukaryoc cells, where does glycolysis occur?

(b) What two products of glycolysis may be transported into mitochondria for further processing?

9. Describe two funcons that mitochondrial membranes serve in energy metabolism.

10. (a) Describe how electron transport complexes set up a proton gradient in response to electron flow.

(b) How is the energy used to drive the synthesis of ATP?

(c) What is the name of this process?

11. (a) Disnguish between an electron carrier and a terminal electron acceptor.
(b) What is the final electron acceptor in aerobic respiraon?

12. (a) Explain the role of $FADH_2$ in the electron transport chain.

(b) Explain why $FADH_2$ does not generate as many ATP molecules as NADH does.

13. Aerobic cellular respiraon stops if no oxygen is present. Explain why.