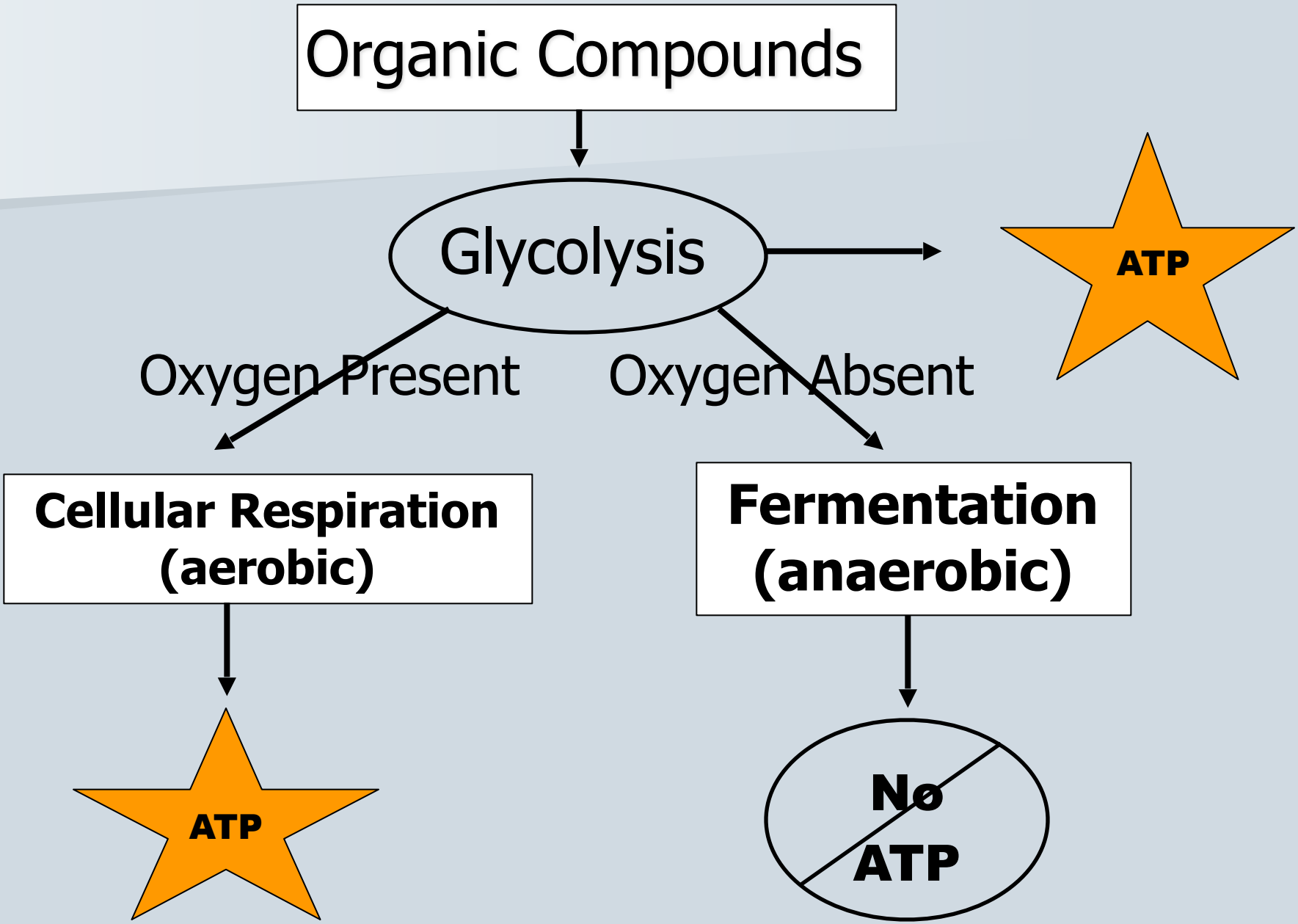
Cell Respiration II – Krebs Cycle and The Electron Transport Chain

1. Where does the Krebs Cycle take place?
2. What is the main function of the Krebs Cycle?
3. How many ATP, NADH and $FADH_2$ are produced in the Krebs Cycle?
4. Where does the electron transport chain take place?
5. What is the main function of the ETC?
6. What are the two phases of the ETC? What happens at each phase?
7. Explain how ATP synthase works?
8. How efficient is aerobic cellular respiration over all?

Overview of Respiration



Cellular Respiration – 2 Stages

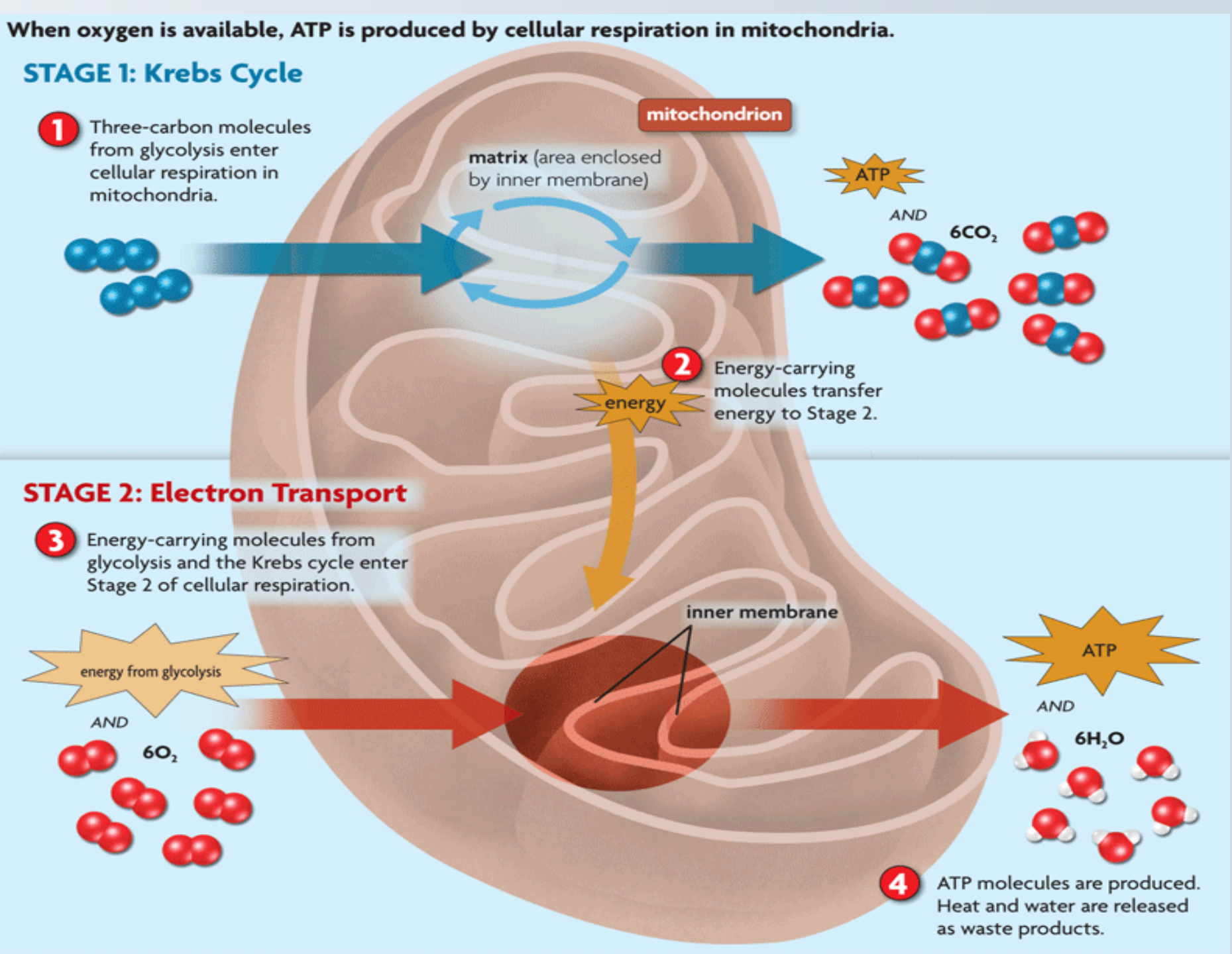
* occurs in the mitochondria

1) Krebs Cycle

= produces molecules that carry energy to the second stage of cellular respiration

Cellular Respiration – 2 Stages (cont)

- pyruvate from glycolysis is broken down
- some ATP and other energy storage molecules are made
- carbon dioxide is given off as a waste product

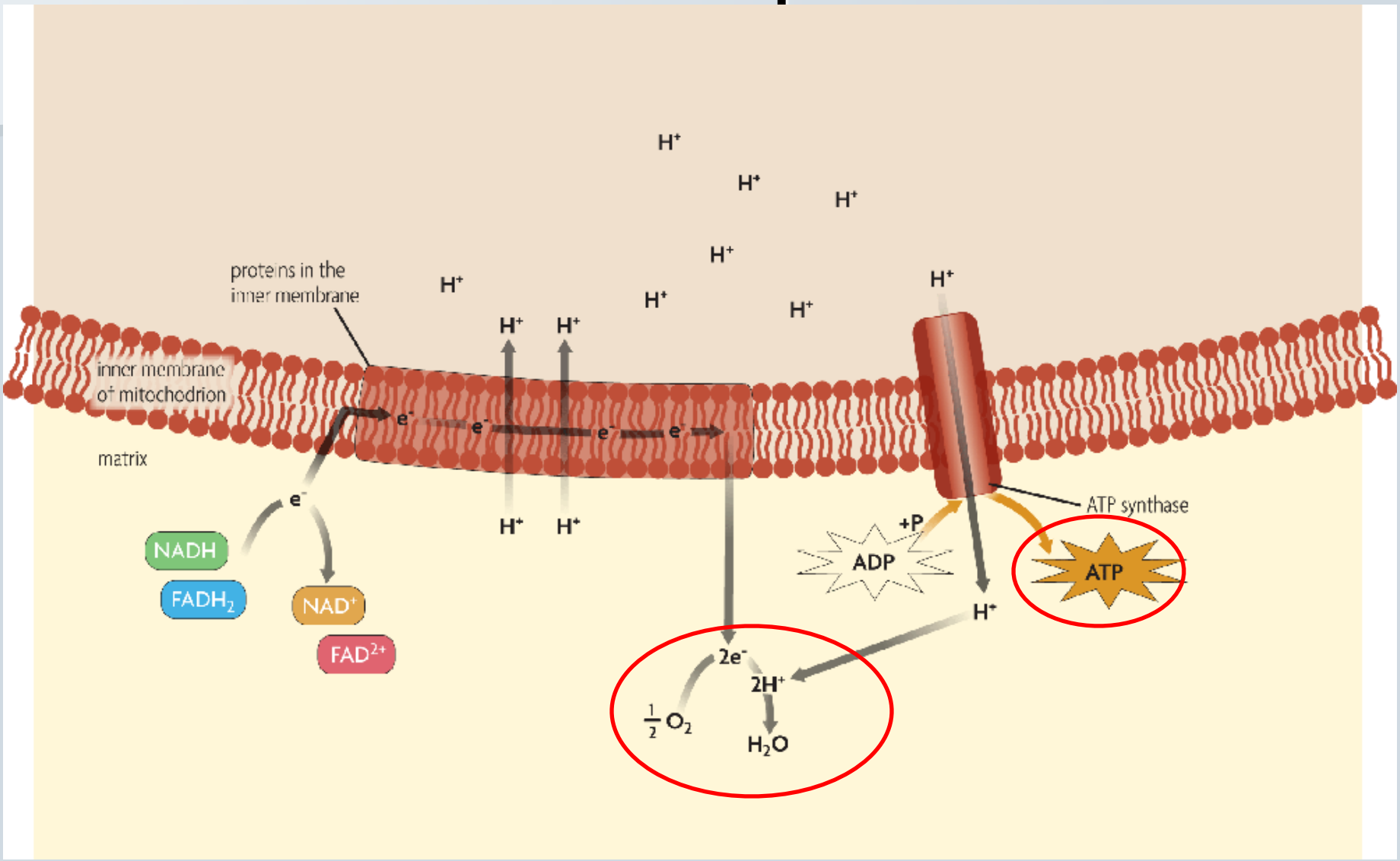

When oxygen is available, ATP is produced by cellular respiration in mitochondria.
STAGE 1: Krebs Cycle
1 Three-carbon molecules from glycolysis enter cellular respiration in mitochondria.
mitochondrion
matrix (area enclosed by inner membrane)
ATP
AND
6CO2
2 Energy-carrying molecules transfer energy to Stage 2.
energy
STAGE 2: Electron Transport
3 Energy-carrying molecules from glycolysis and the Krebs cycle enter Stage 2 of cellular respiration.
inner membrane
energy from glycolysis
AND
6O2
ATP
AND
6H2O
4 ATP molecules are produced. Heat and water are released as waste products.

Cellular Respiration – 2 Stages (cont)

2) Electron Transport Chain

- made of proteins
- uses energy from Krebs cycle and oxygen to make ATP
- water and heat are given off as waste products

Electron Transport Chain

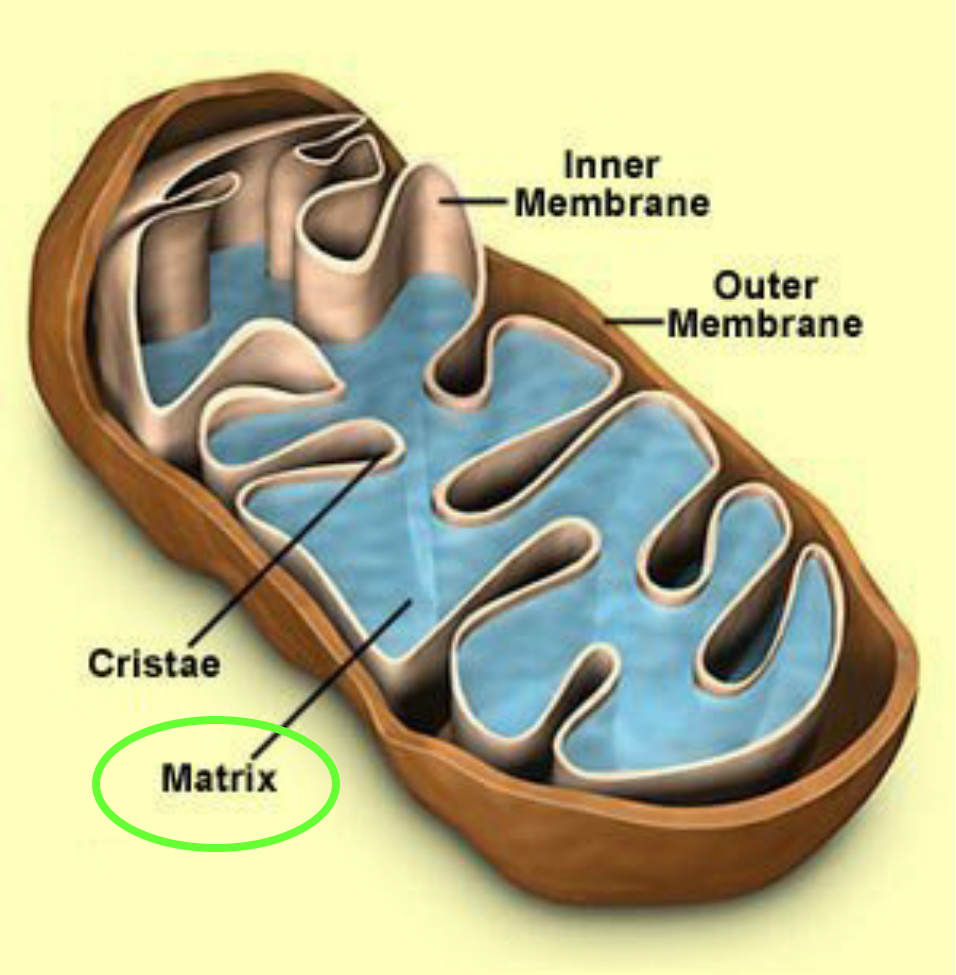


Cellular Respiration – 2 Stages (cont)

Efficiency of Cellular Respiration = 66% (38 ATP are made)

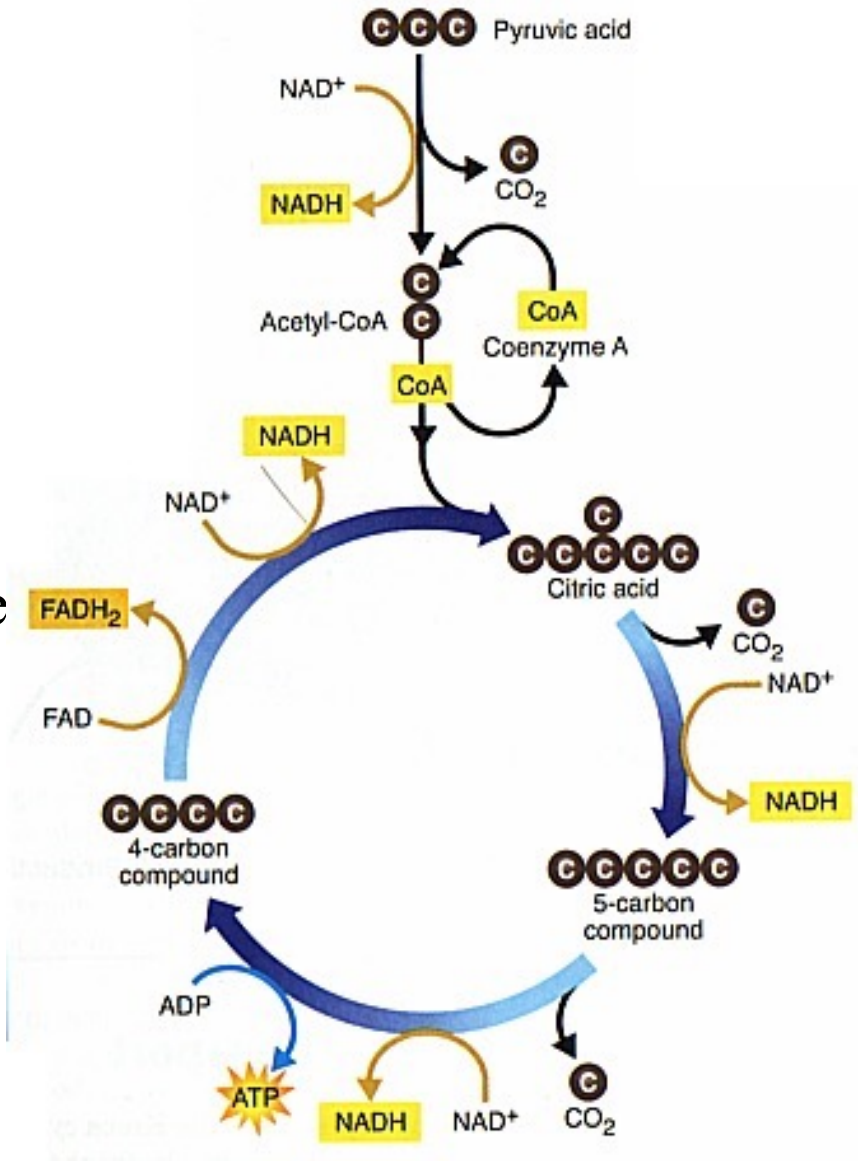
The Krebs Cycle

- Takes place in the **matrix** (inner folds) of the mitochondria
- Converts Pyruvic acid to CO_2
- **Main functions**
  - harvesting of high energy electrons (NADH) from glucose.
  - Also produces 2 ATPs for the cell

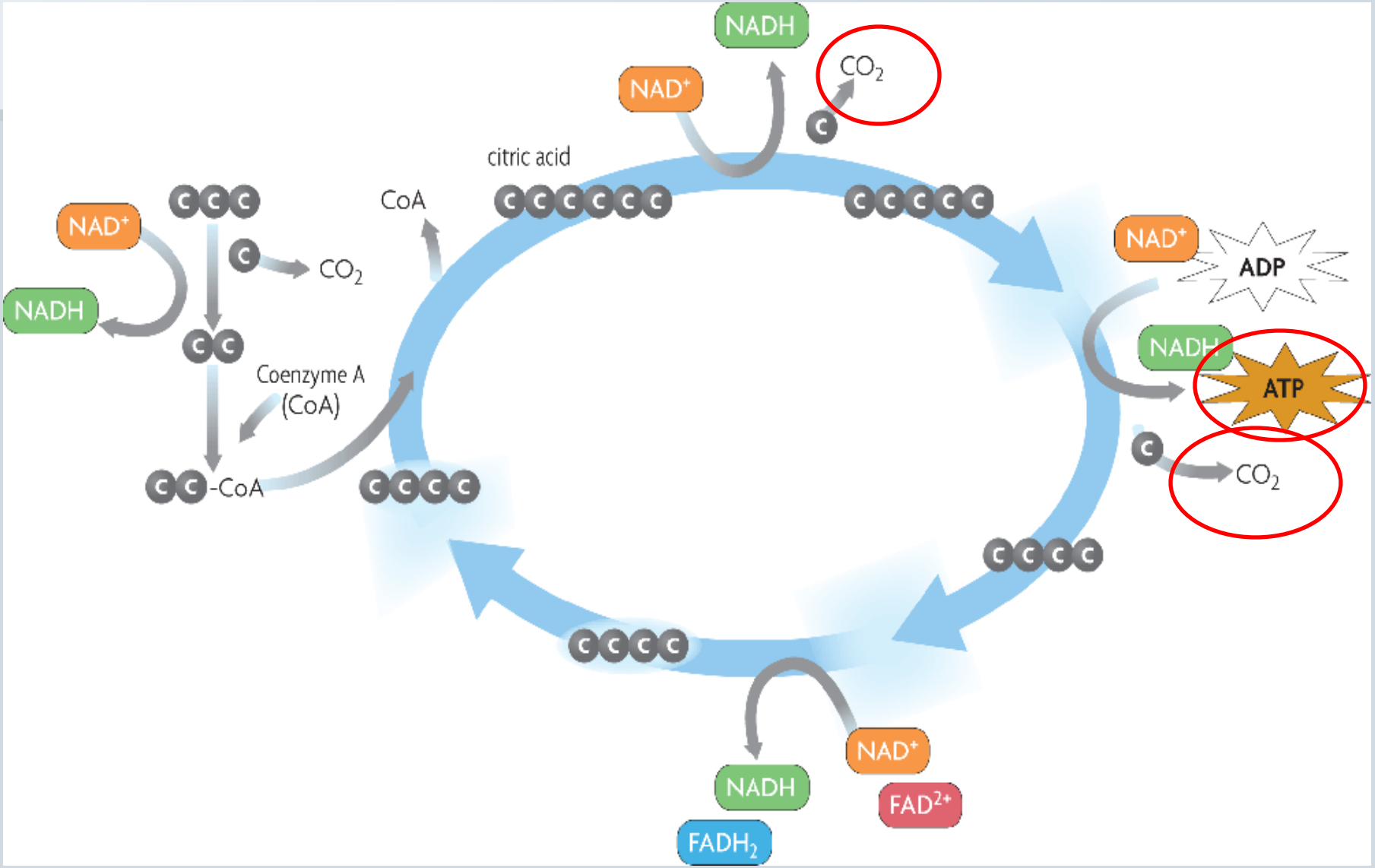


Krebs Cycle-Mechanism

- Pyruvic acid (3 carbons) is broken down to CO_2
- 1 ATP, 4 NADH and 1 $FADH_2$ are produced ($FADH_2$ is an electron carrier like NADH)
- How may times does the Krebs cycle have to turn for one molecule of glucose to be processed? (hint: remember glucose is a **<u>6 carbon</u>** molecule)
- How many ATPs, NADH and $FADH_2$ are produced?

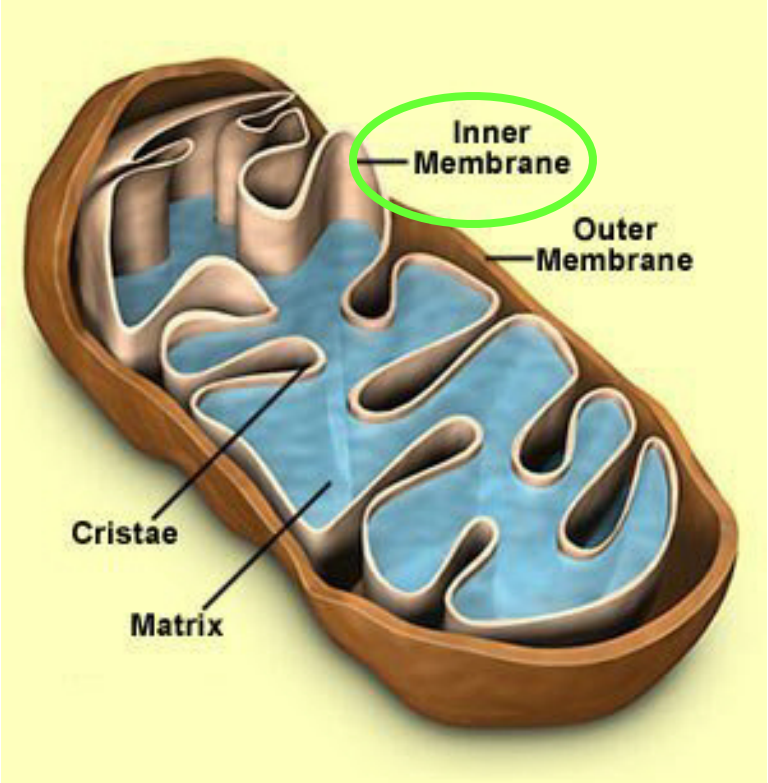


Krebs Cycle


NADH
NAD+
CO2
citric acid
CoA
NAD+
CO2
NADH
Coenzyme A
(CoA)
-CoA
NAD+
ADP
NADH
ATP
CO2
NAD+
FAD2+
NADH
FADH2

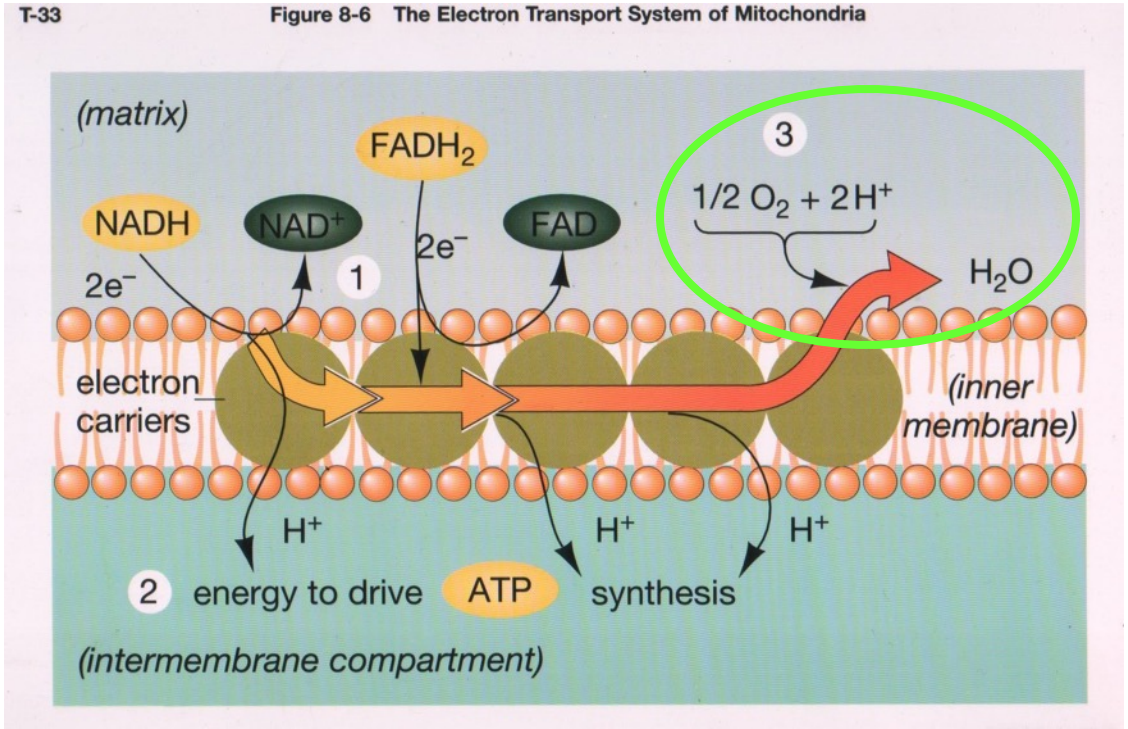
Electron Transport Chain

- Occurs within the inner membrane of the mitochondria
- **<u>Main function</u>**
  - Convert high energy electrons into lots and lots of ATP
- Where do these high energy electrons come from?
  - all that NADH and $FADH_2$ the cell made during glycolysis and the Krebs Cycle.
- The ETC produces a net gain of ~34 ATP



Electron Transport Chain - Mechanism

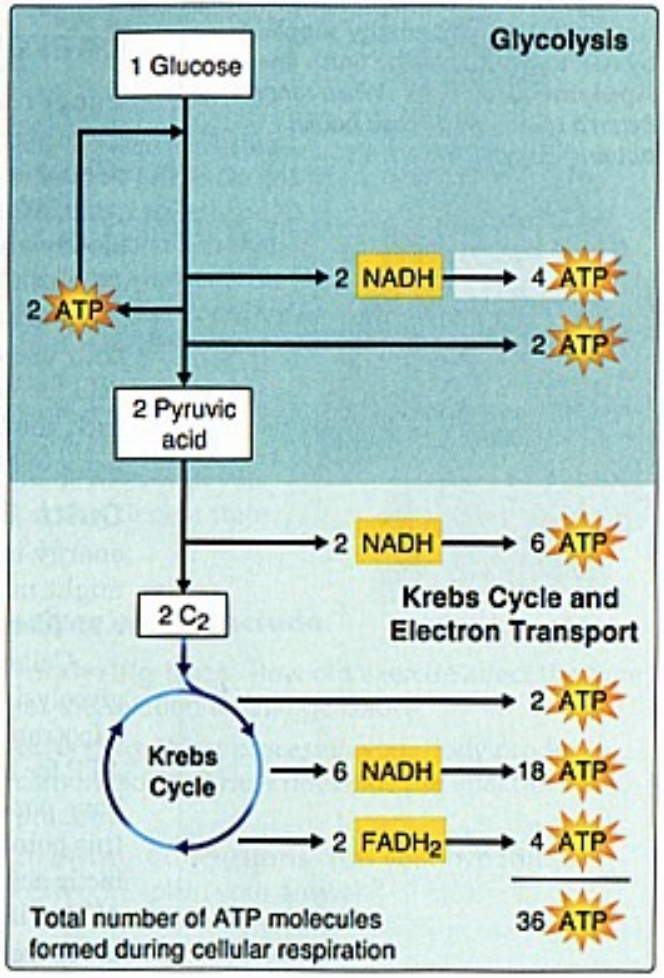
- Electron Carriers embedded in the membrane use the energy from NADH and $FADH_2$ to drive H^+ across the membrane **<u>AGAINST ITS CONCENTRATION GRADIENT</u>**
- This creates an environ. Where H^+ wants to diffuse back across the membrane but can't.

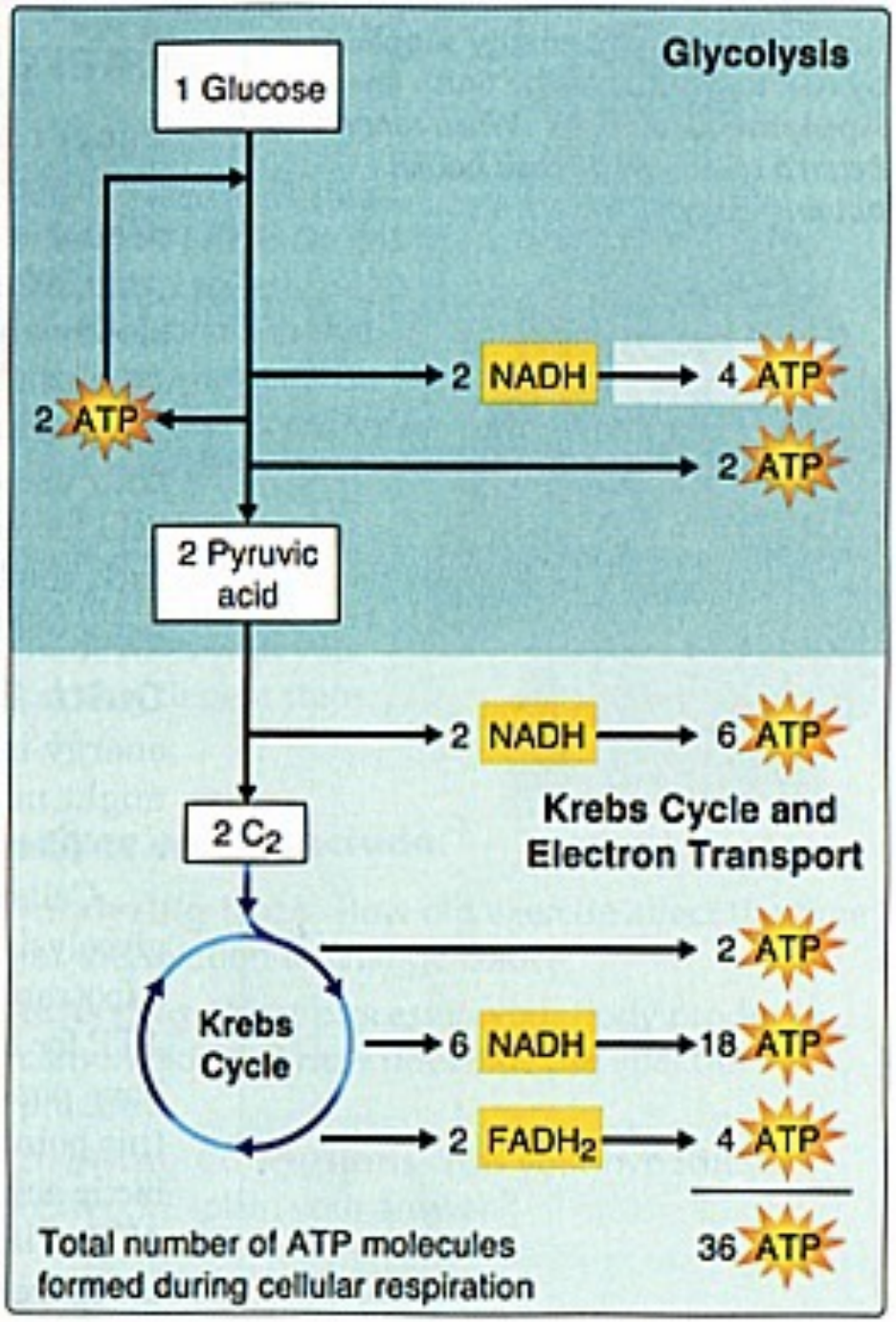


- Conc. gradients like this are stored energy (potential energy)
- At the end of the ETC the electrons are past to O_2 which causes it to bond with H^+ forming H_2O (water)

ATP totals from Aerobic Cell Respiration

- **<u>36 to 38 ATPs produced</u>**
- About 38% of energy from glucose captured
- Rest lost as heat
- More efficient then an automobile engine




Glycolysis
1 Glucose
2 ATP
2 NADH
4 ATP
2 ATP
2 Pyruvic acid
2 NADH
6 ATP
Krebs Cycle and Electron Transport
2 C_2
2 ATP
Krebs Cycle
6 NADH
18 ATP
2 $FADH_2$
4 ATP
Total number of ATP molecules formed during cellular respiration
36 ATP