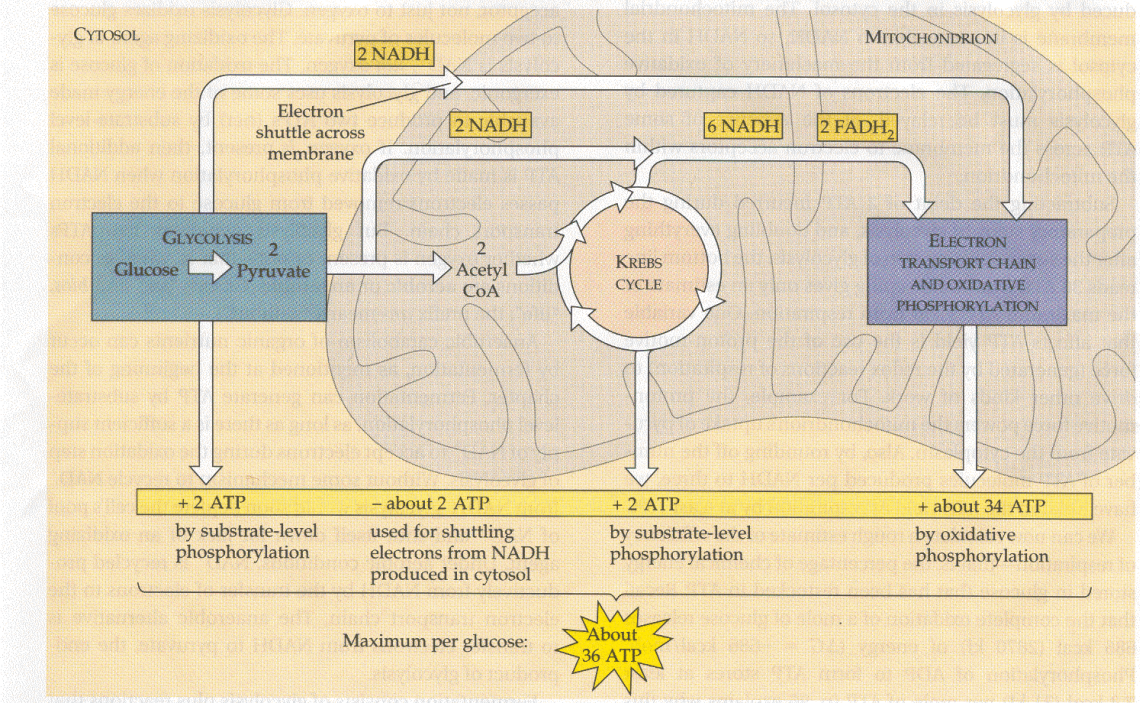
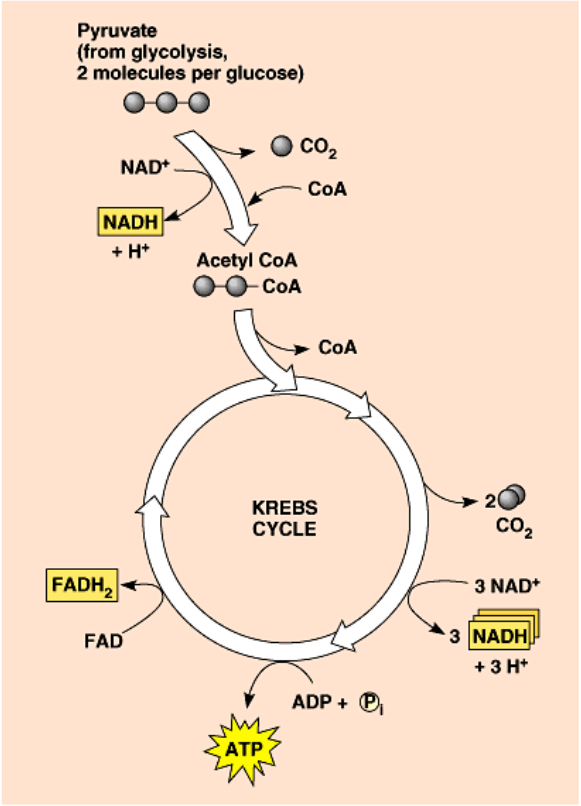
AEROBIC RESPIRATION

- Happens in the *mitochondria*
- Two steps:
  - 1: citric acid or Krebs cycle
  - 2: electron transport chain



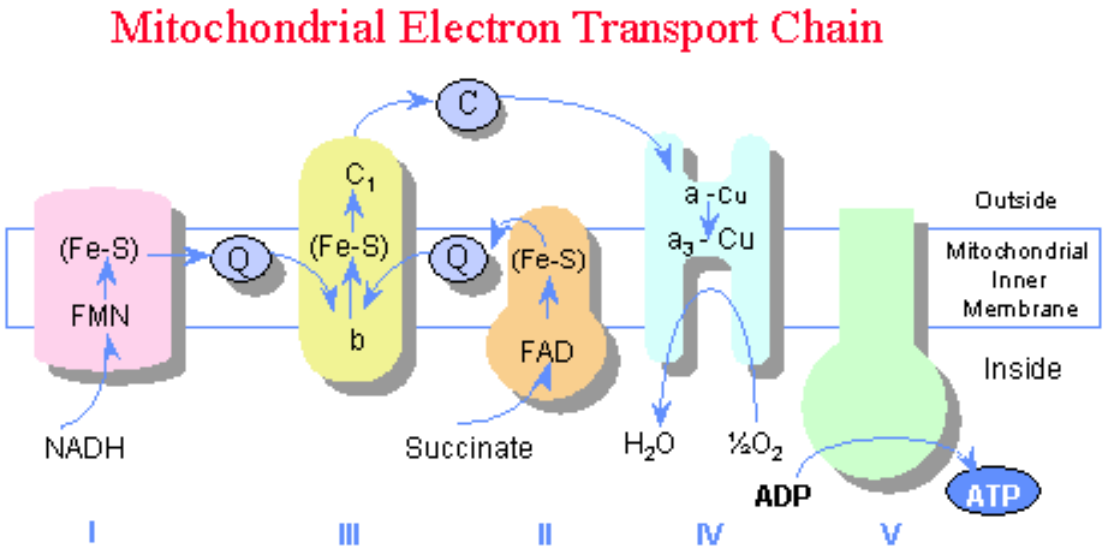
KREBS CYCLE

- Each pyruvic acid goes through the Krebs cycle
- The pyruvic acid from glycolysis is converted through a series of steps
- Pyruvic acid -> CO_2 + H_2O + ATP + 4 NADH + $FADH_2$
- Net 2 ATP



ELECTRON TRANSPORT CHAIN

- The cell uses ATP for energy, so NADH and $FADH_2$ need to be converted to ATP
- They are changed in the ETC
- Ends with hydrogen joining with oxygen to make water
- NET 32 ATP



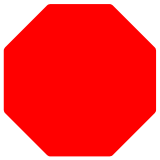
MINI QUIZ

1. What happens before respiration?
2. What is respiration called in the presence of oxygen?
3. How much energy is made in the Krebs cycle?
4. What is the purpose of the Electron Transport Chain?
5. Where does aerobic respiration take place?

AEROBIC RESPIRATION

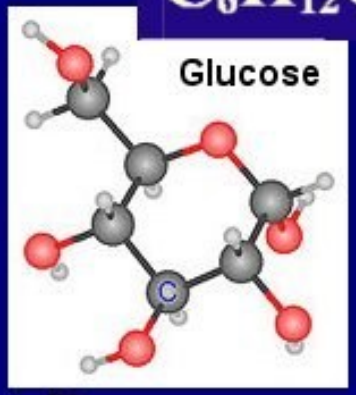
- Remember: glycolysis must come first to make the pyruvic acid!
- The pyruvic acid enters the Krebs cycle
  - Krebs produces ATP, NADH, and $FADH_2$
- The NADH and $FADH_2$ from Krebs enters the ETC to convert to ATP

- Glycolysis, Krebs, and ETC total to make **36 ATP**
- $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 36ATP$



Cellular Respiration

$C_6H_{12}O_6 + 6O_2$ ------> $6CO_2 + 6\ H_2O$ + Energy



6 Oxygen

Mitocondrion

6 Water

6 Carbon dioxide

GLYCOLYSIS occurs in the cytoplasm

KREBS CYCLE

ELECTRON TRANSPORT

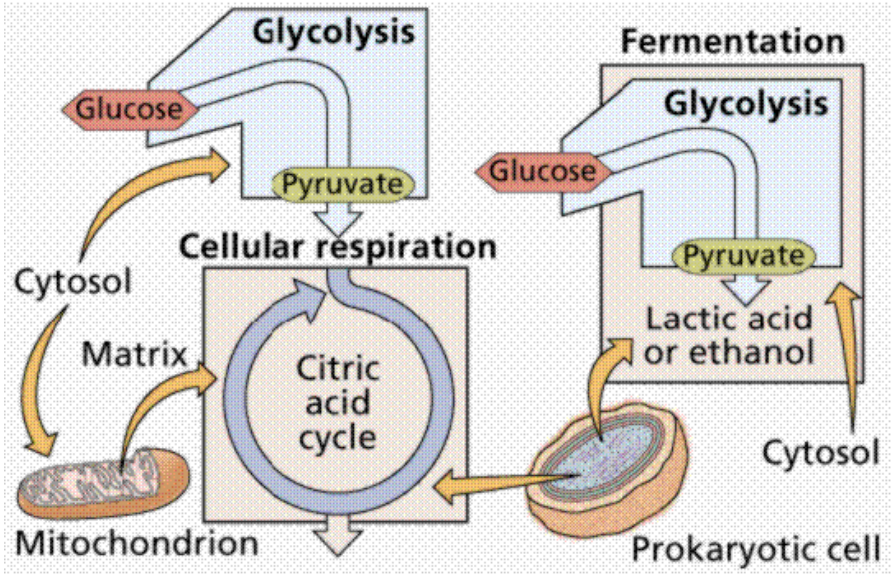
2 ATP

2 ATP

32 ATP

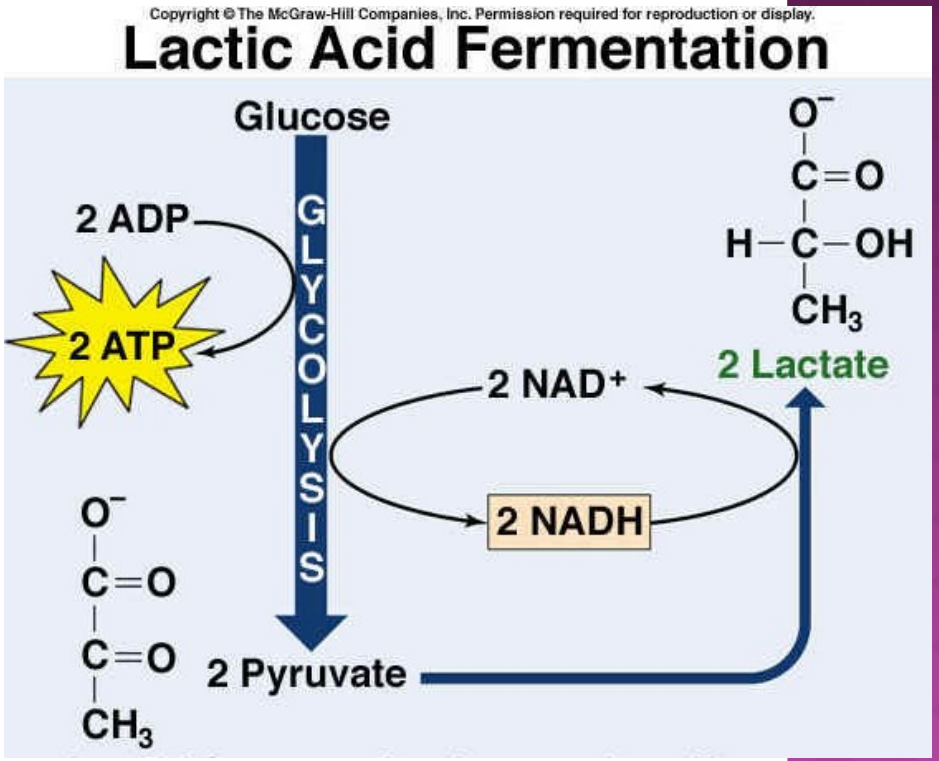
ANAEROBIC FERMENTATION

- If NO oxygen is available, the pyruvic acid from glycolysis *can not go through Krebs or ETC*
- A common anaerobic process is **fermentation**
  - Fermentation is not an efficient process and makes far fewer ATP than aerobic respiration



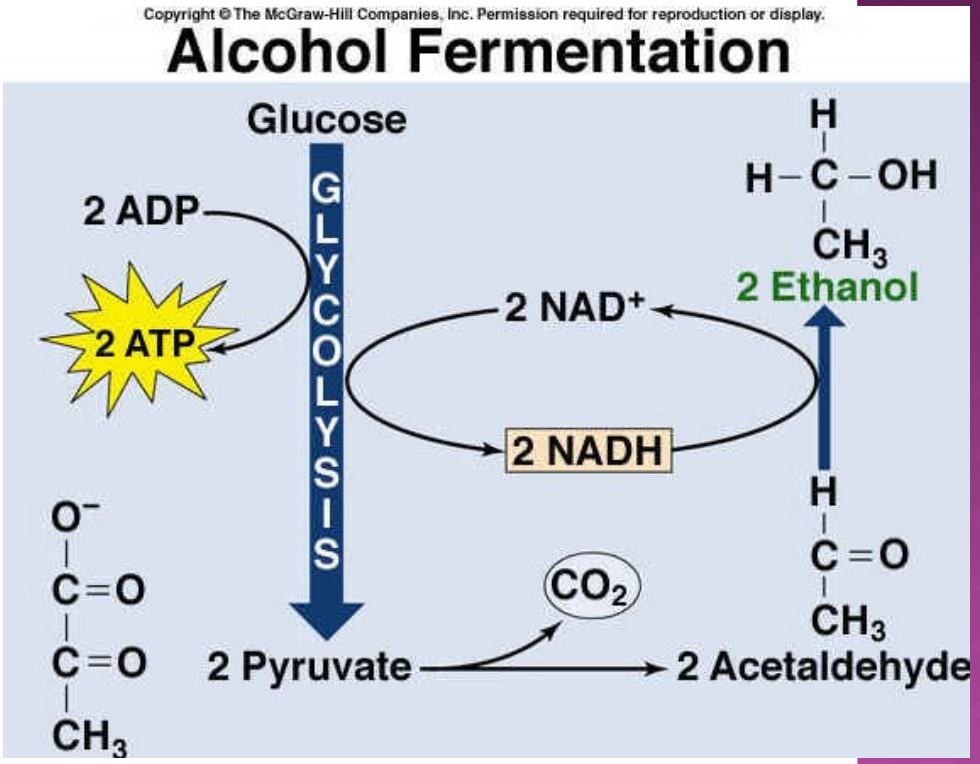
FERMENTATION

- Lactic acid fermentation
  - Happens in muscle cells during vigorous exercise
  - Glucose -> pyruvic acid -> lactic acid + energy
  - This process replaces aerobic respiration so the cell can keep making energy even without oxygen
  - Will cause lactic acid to build up in the cells (cramping)



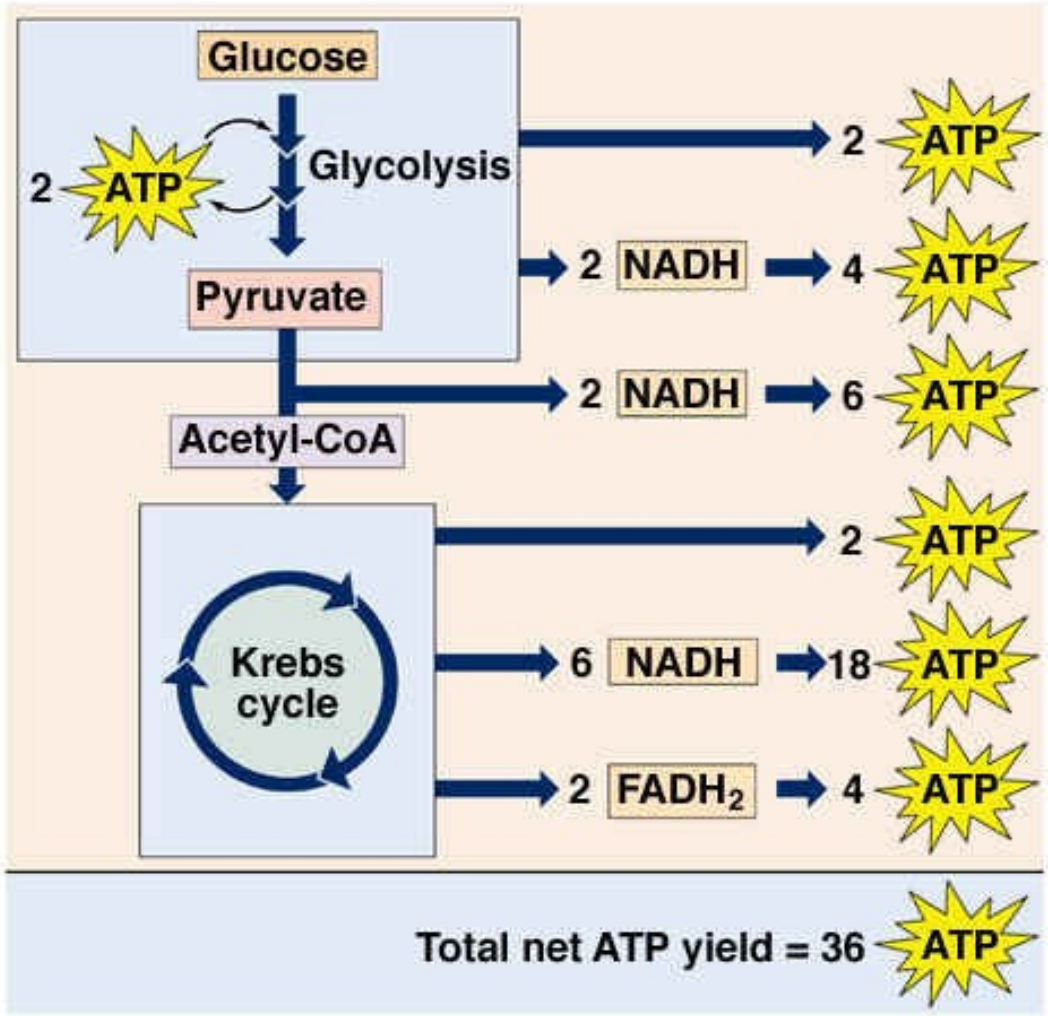
FERMENTATION

- Alcohol fermentation
  - Happens in yeast and some bacteria
  - Glucose -> pyruvic acid -> alcohol + CO_2 + energy



SUMMARY

ATP Theoretical Yield



MINI QUIZ

1. What is respiration called in the absence of oxygen?
2. What happens before fermentation?
3. What type of fermentation happens in yeast?
4. What type of fermentation results in muscle cramps?
5. Does fermentation make more or less energy than aerobic respiration?