

Cellular Respiration

Chapter 9-1



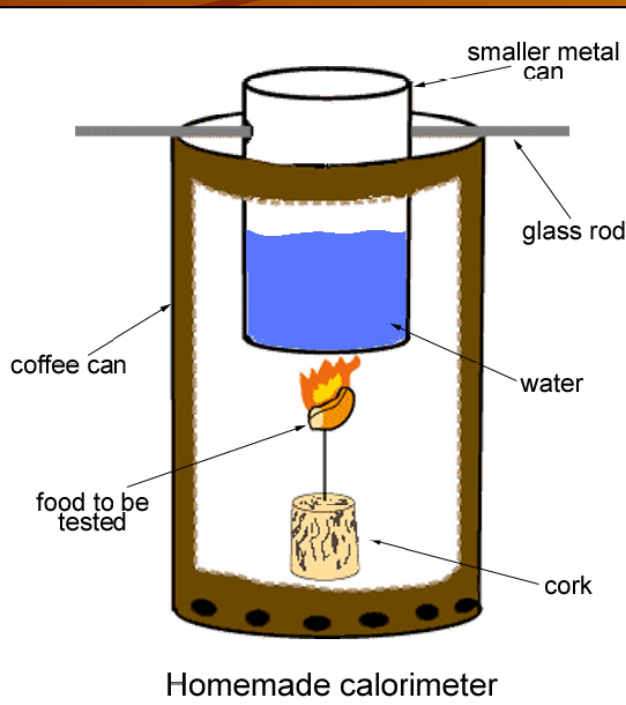
Why do we eat?

- ◆ Raw materials for cell growth
- ◆ Energy



Measuring energy in food

- ◆ Calorie – unit of energy in food
- ◆ Calorimeter – measures heat given off when food is burned



Energy in Food

◆ Glucose

- main source of food energy
- Used up quickly

◆ Starch – Glycogen

- Chain of glucose molecules
- Broken down for Long term energy

◆ Lipid

- Excess carbohydrates become lipids
- energy storage

Glucose vs. ATP

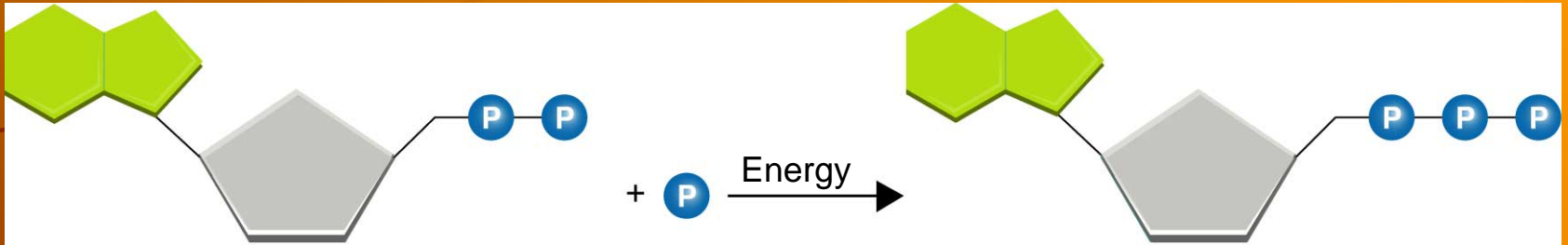
- ◆ Glucose is the source of our energy
- ◆ ATP is the form of energy our cells use
- ◆ Sun → Glucose → ATP



ATP

ADP

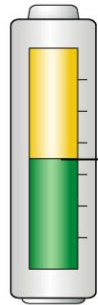
ATP



Adenosine diphosphate (ADP) + Phosphate

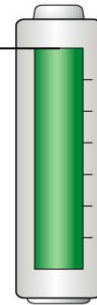
Energy

Adenosine triphosphate (ATP)



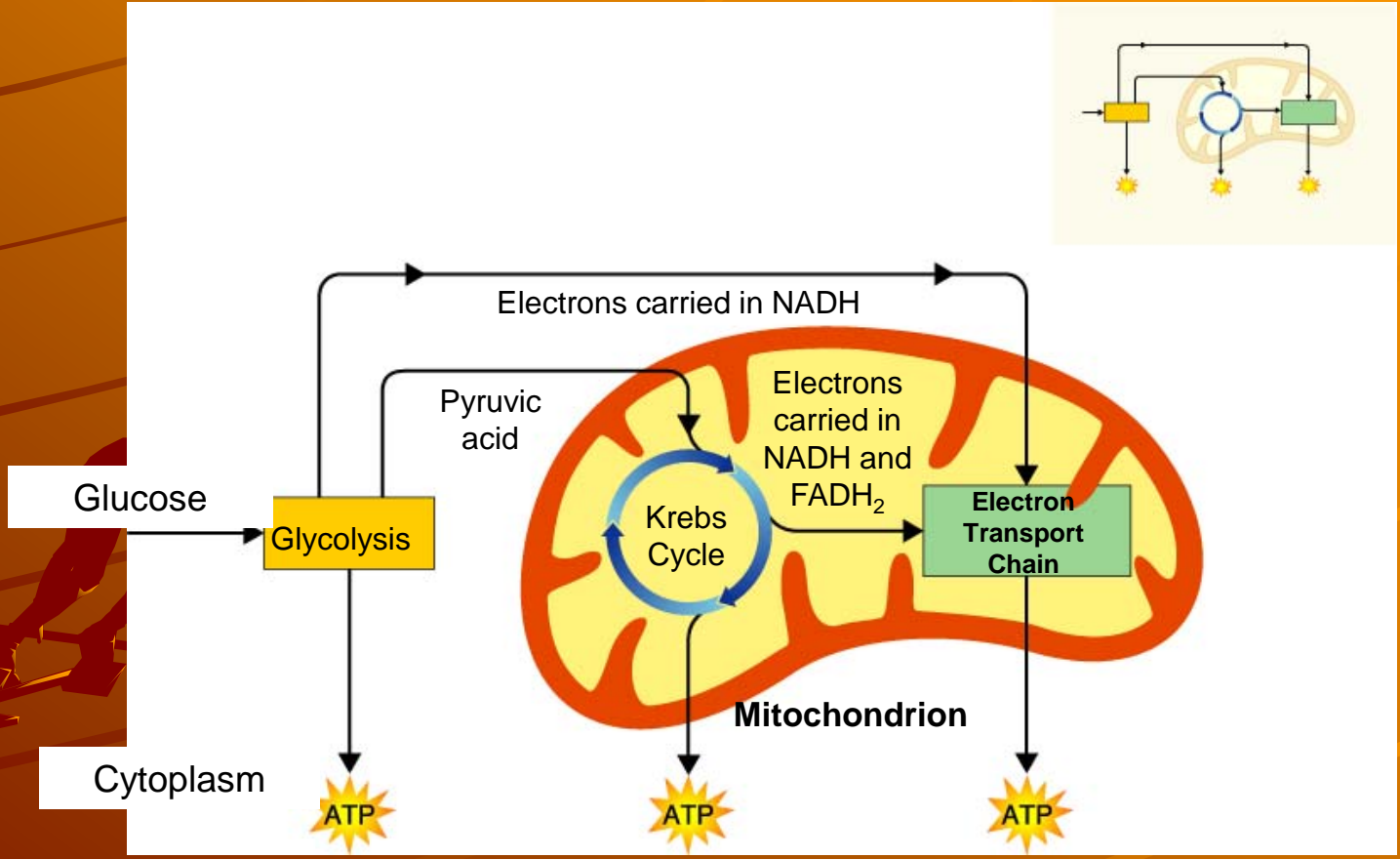
Partially
charged
battery

Fully
charged
battery



Cellular respiration

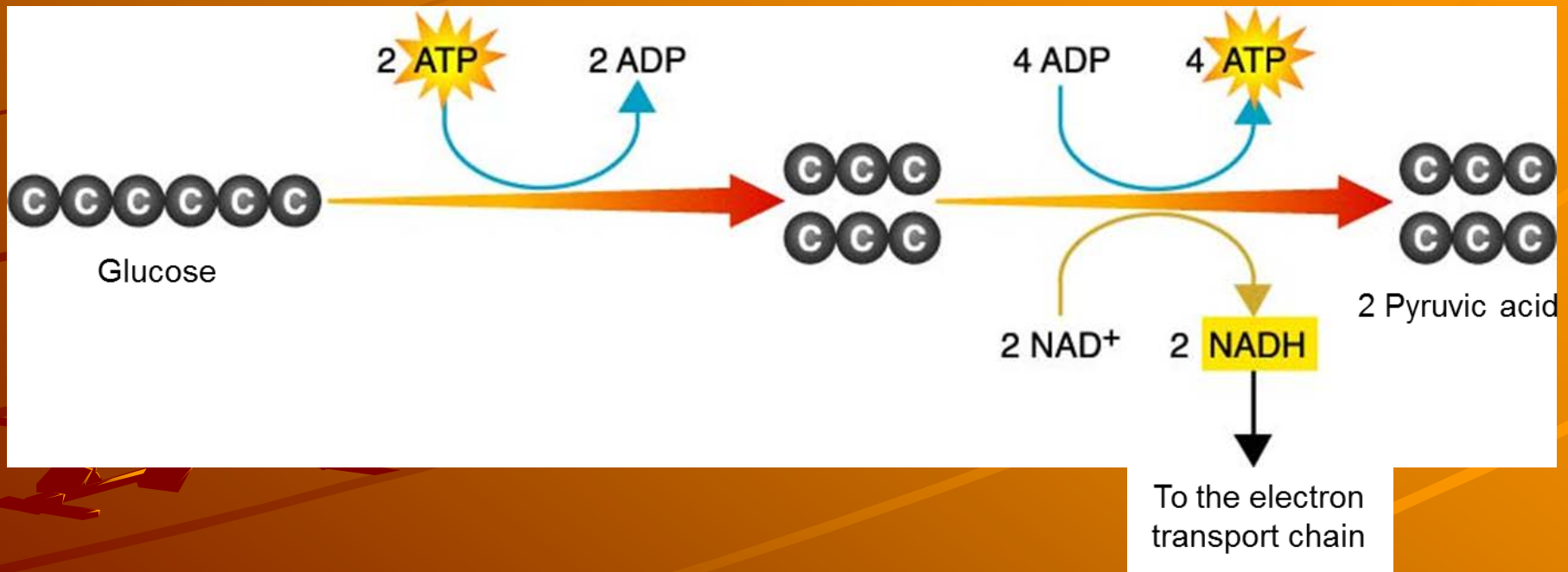
- ◆ Releases energy by breaking down glucose in the presence of oxygen
- ◆ Gradual
- ◆ $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$
- ◆ Food energy \rightarrow chemical energy
- ◆ 3 stages

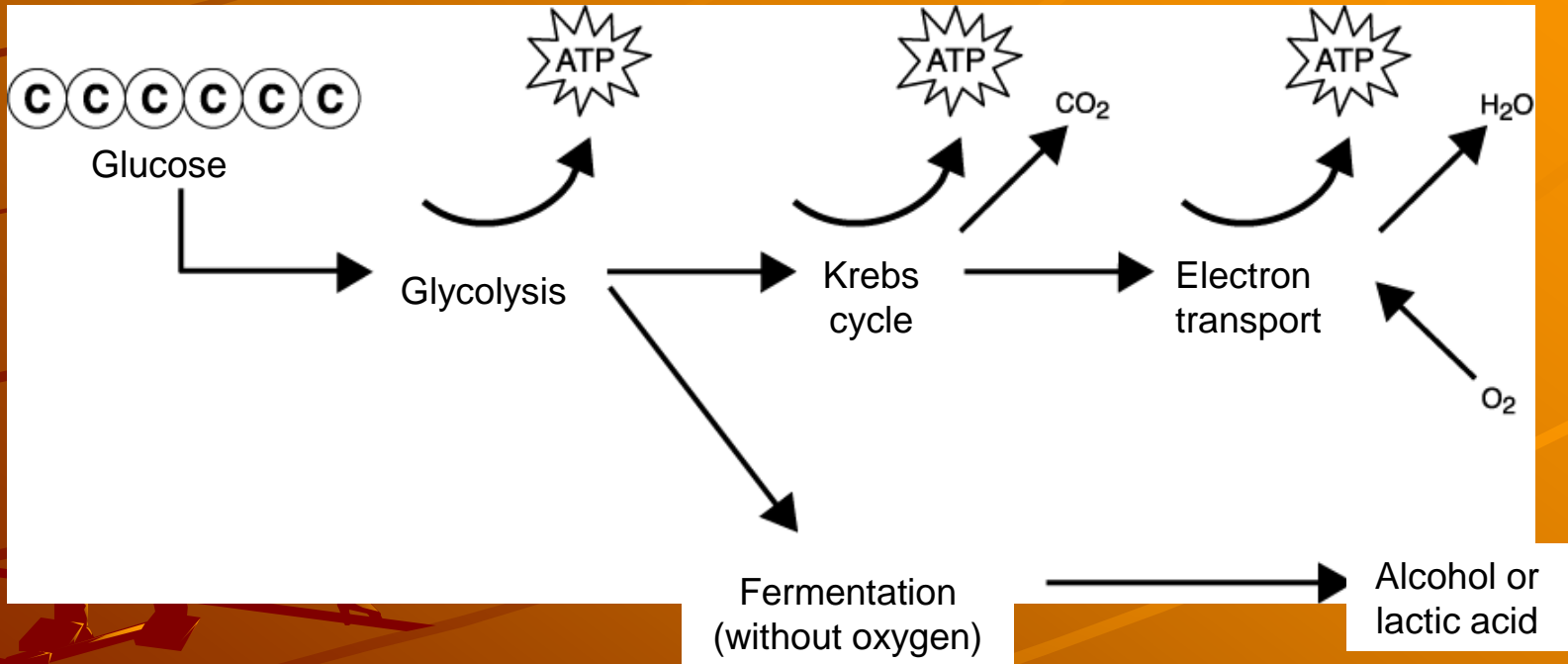


Glycolysis

- ◆ Happens in Cytoplasm
- ◆ Glucose is split
- ◆ Produces 2 molecules of pyruvic acid
- ◆ Uses 2 ATP
- ◆ Makes 4 ATP
- ◆ Net profit = 2 ATP
- ◆ $2\text{NAD}^+ \rightarrow 2\text{NADH}$
 - Carries electrons
 - Transfers energy to electron transport chain

Glycolysis

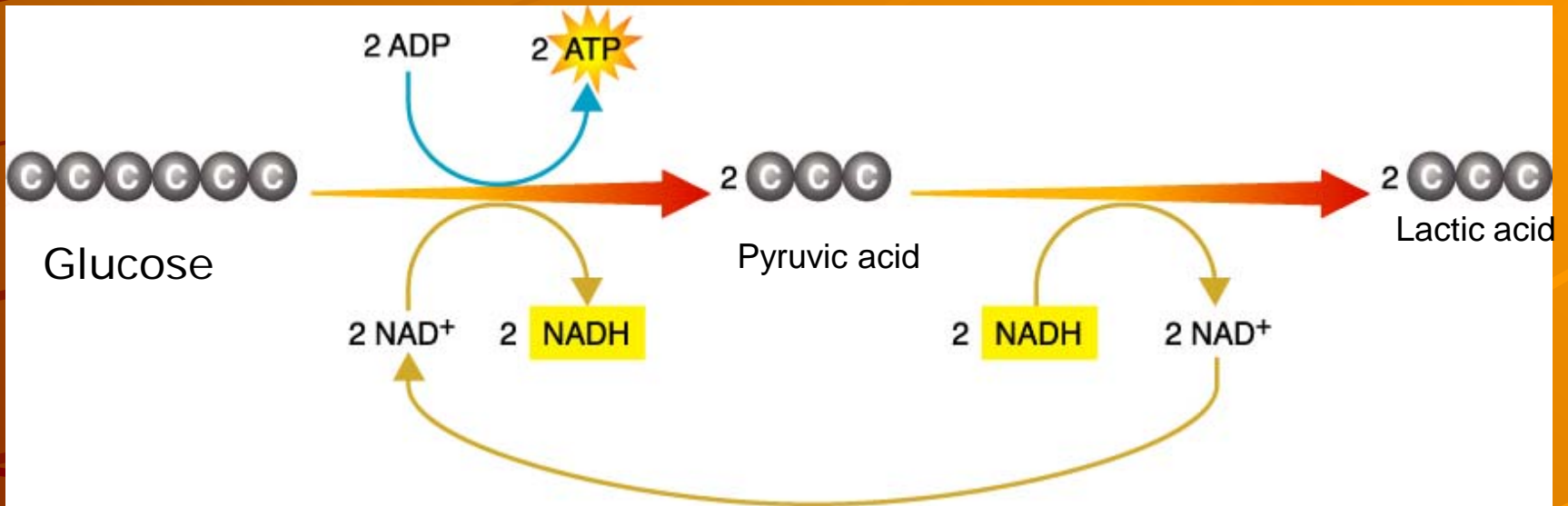




Without Oxygen

- ◆ Glycolysis stops when all NAD⁺ get filled up with electrons
- ◆ Anaerobic fermentation
 - Alcoholic Fermentation
 - ◆ Yeast
 - ◆ Makes bread rise
 - ◆ Pyruvic acid + NADH → alcohol + CO₂ + NAD⁺
 - Lactic Acid Fermentation
 - ◆ Most other organisms
 - ◆ Makes your muscles burn
 - ◆ Pyruvic acid + NADH → lactic acid + NAD⁺

Lactic Acid Fermentation



In the presence of oxygen

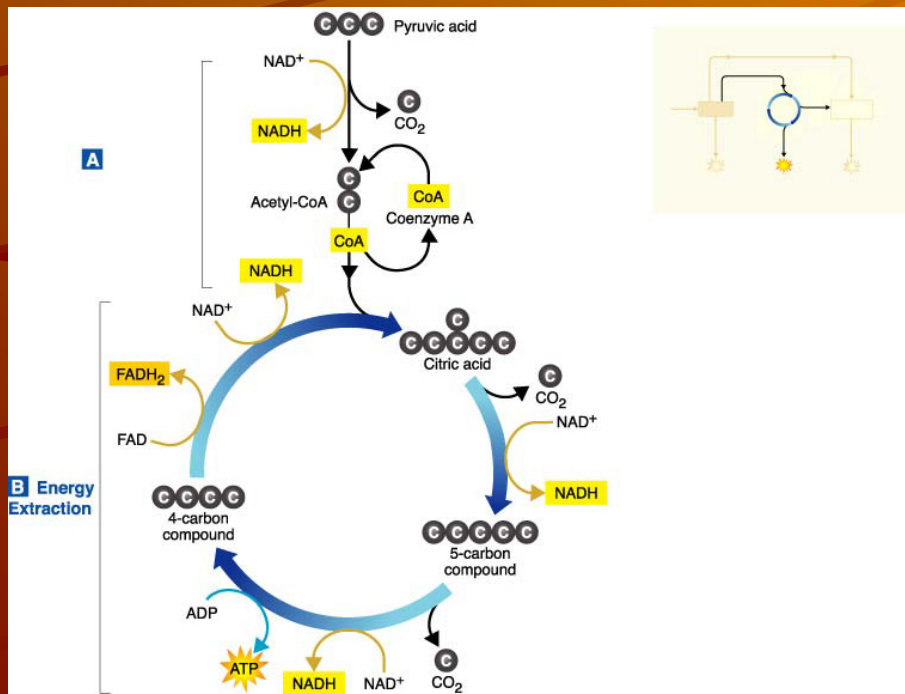
- ◆ Cellular Respiration continues
- ◆ Energy from glucose now stored in pyruvic acid
- ◆ Requires oxygen -- aerobic



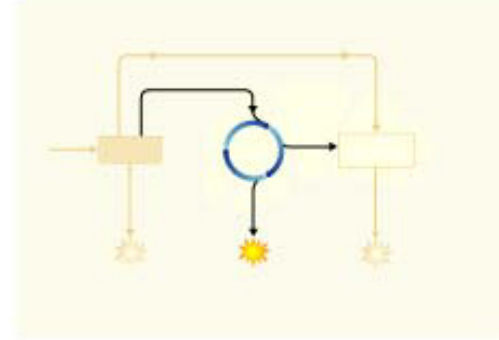
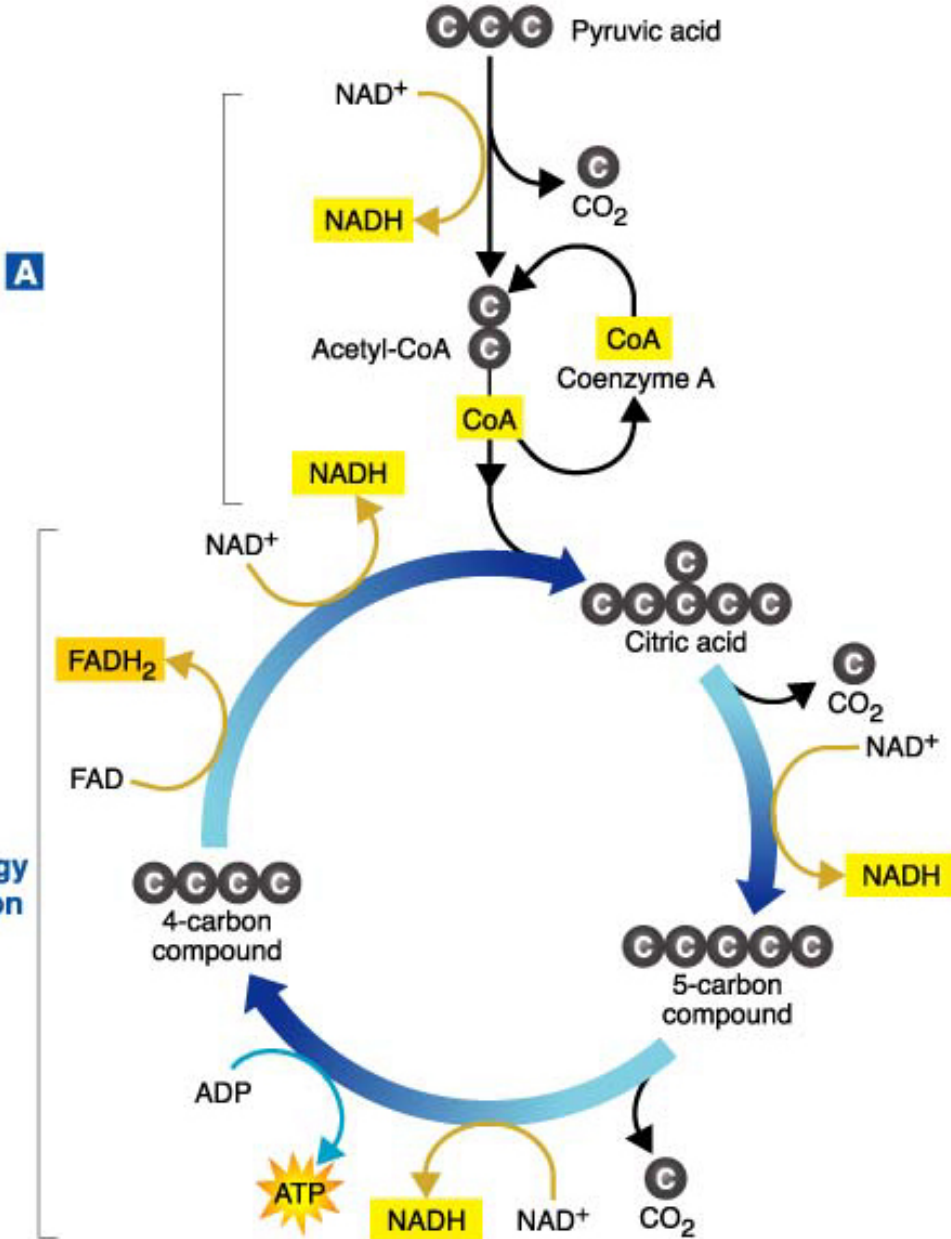
Krebs Cycle

- ◆ Pyruvic acid enters mitochondria
- ◆ Pyruvic acid \rightarrow CO_2 + citric acid
- ◆ Citric acid \rightarrow CO_2 + ATP + NADH + FADH_2

High energy electron carriers

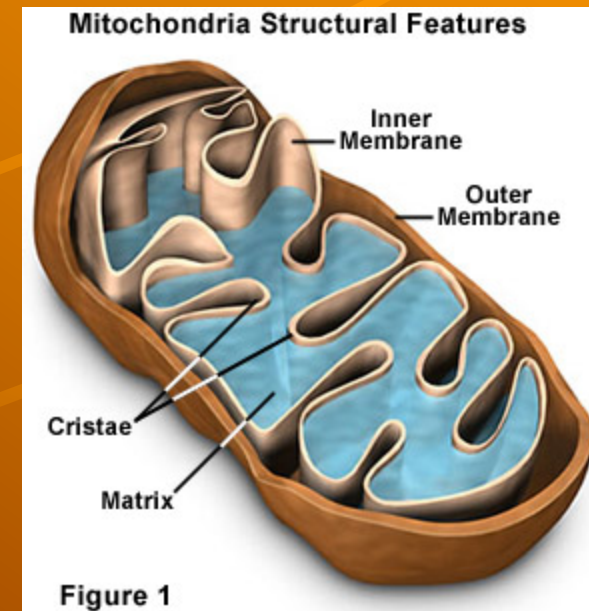
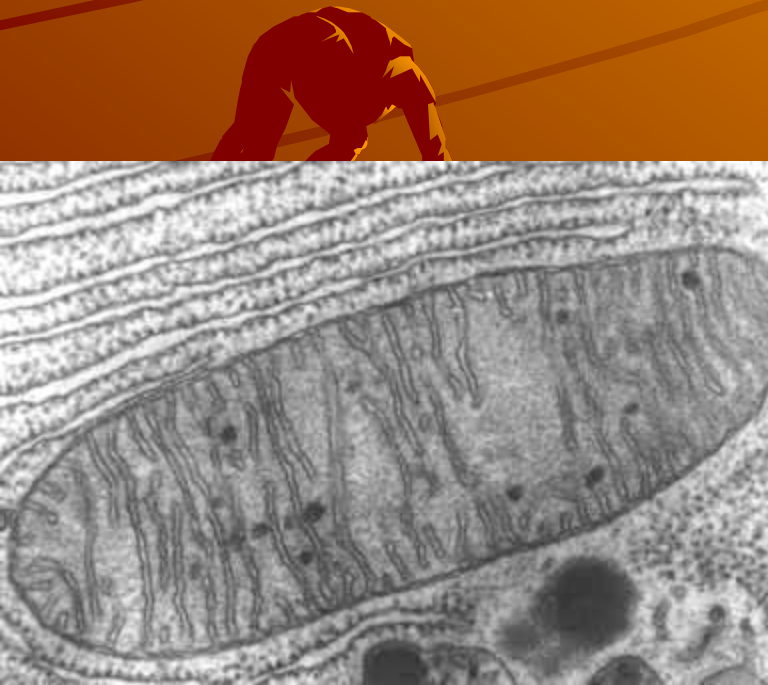


Krebs Cycle



Electron Transport Chain

- ◆ Eukaryotes – inner folded membrane of mitochondria
- ◆ Prokaryotes – within cell membrane



Electron Transport

- ◆ NADH + FADH₂ each deliver 2 electrons to transport chain
- ◆ Electrons pass down the chain to oxygen
- ◆ $O + 2H^+ + 2e^- \rightarrow H_2O$
- ◆ Energy used to pump H⁺ ions inside mitochondria in between folds
- ◆ H⁺ ions escape through ATP synthase
 - Spins
 - ADP → ATP

Electron Transport Chain

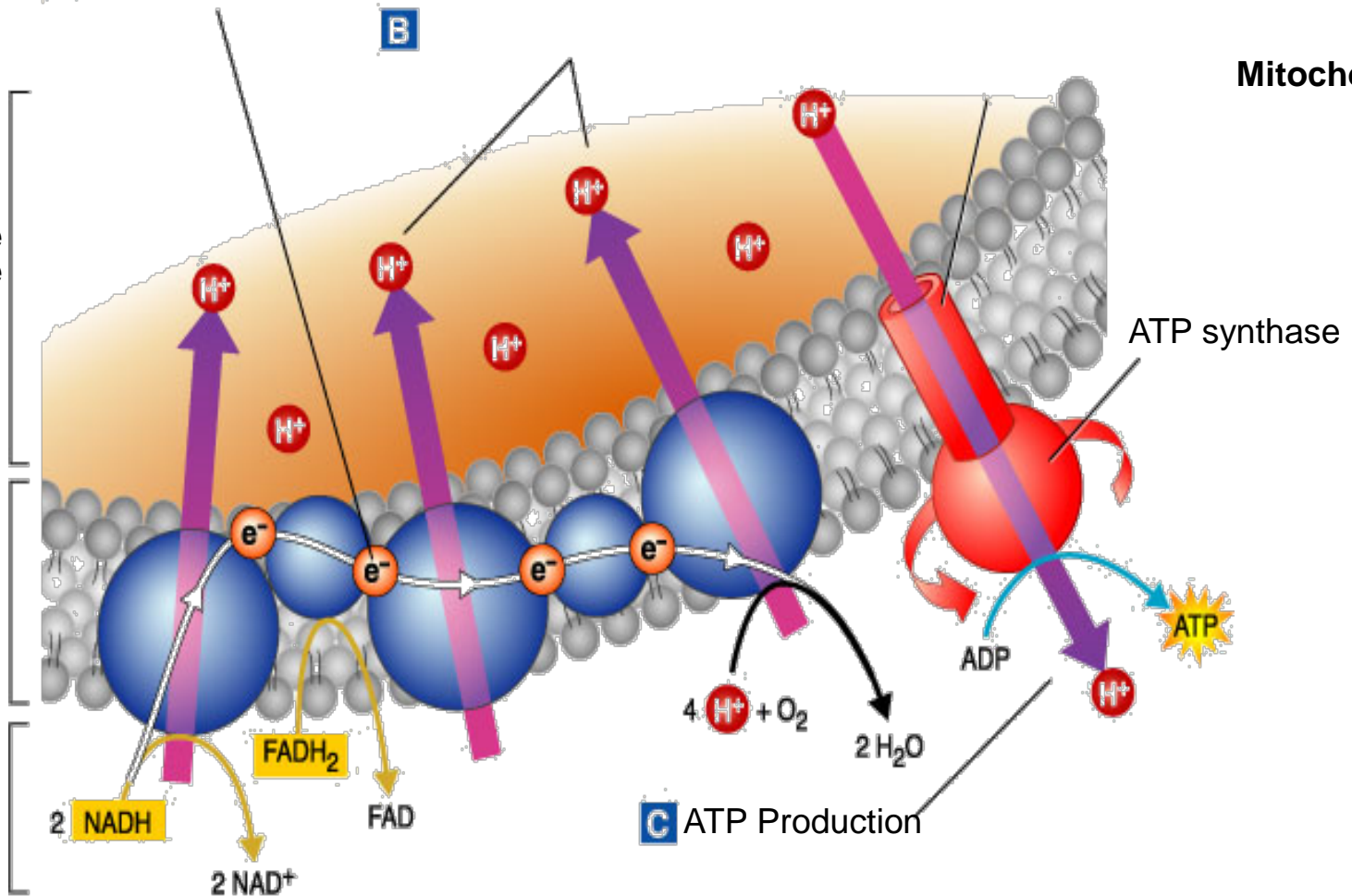


A Electron Transport

B

Mitochondrion

Intermembrane Space

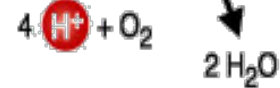


ATP synthase

ADP

ATP

C ATP Production



Totals from 1 molecule of Glucose

- ◆ Glycolysis – 2 ATP
- ◆ Krebs Cycle
 - 2 ATP
 - Carbon Dioxide
- ◆ electron transport
 - 32 ATP
 - Water
 - Heat
- ◆ Total ATP = 36 ATP



Energy and Exercise

◆ Energy sources

- Stored ATP: enough for a few seconds of exercise
- Lactic acid fermentation:
 - ◆ produces enough ATP to last about 90 seconds
 - ◆ Creates build up of lactic acid
 - ◆ Lactic acid must be flushed out of the cells by a chemical pathway requiring extra oxygen
- Cellular Respiration:
 - ◆ Produces long term energy
 - ◆ Releases energy more slowly than fermentation
 - ◆ Uses glucose or glycogen (glucose polymer)
 - ◆ Can also break down fat and protein into intermediate molecules that can enter the Krebs cycle