


Cellular Respiration

Chapter 9

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FOOD = Energy

Energy

- Weakness is a feeling triggered by lack of energy
- You feel tired when you are hungry because food serves as a source of energy
- Food provides living things with the chemical building blocks they need to grow and reproduce

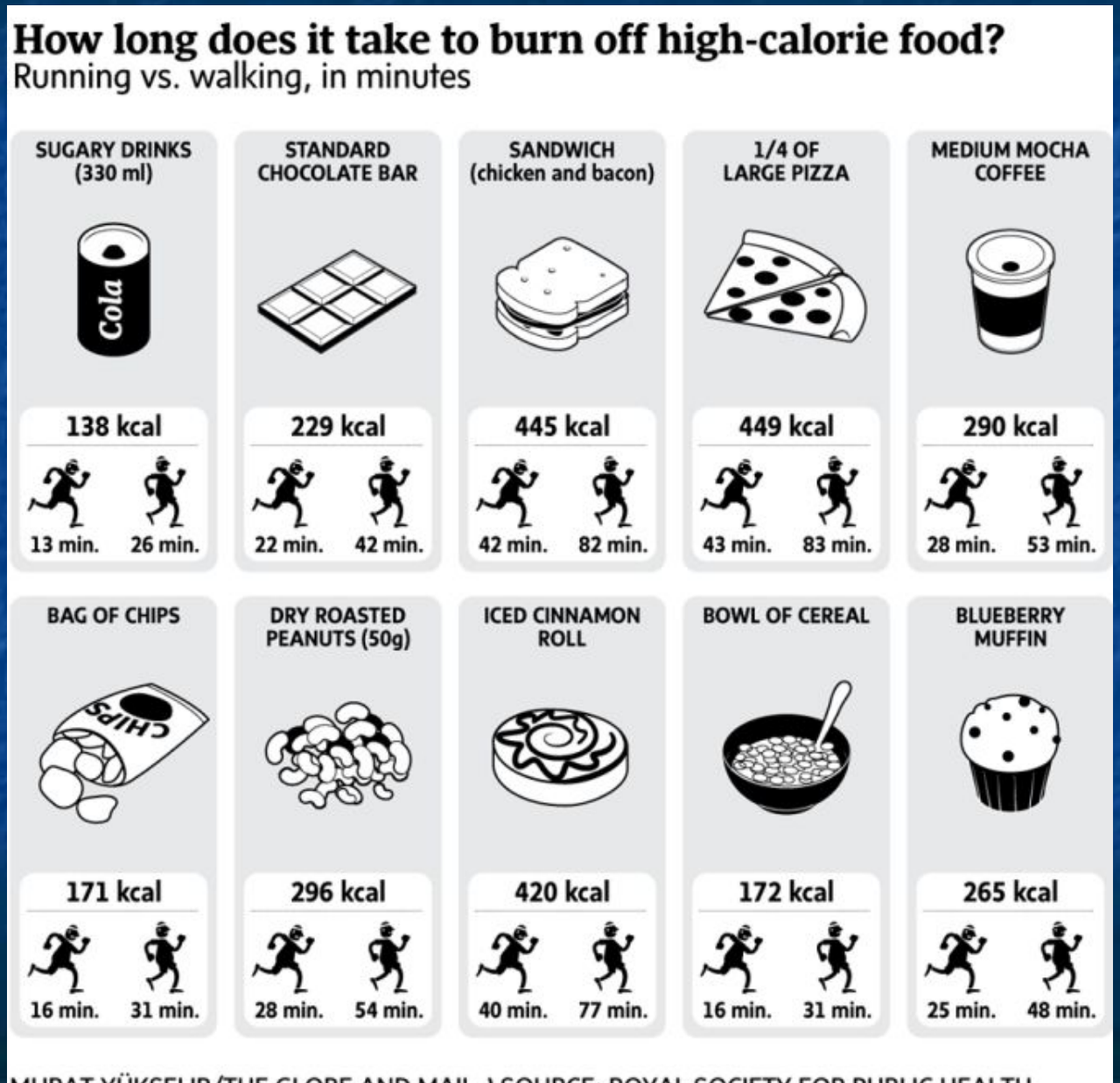
Calorie

- The amount of energy needed to raise the temperature of 1 gram of water 1 degree Celsius
- Stored in Proteins, Lipids, and Carbs
- Carb & Proteins have 4 Calories per gram
- Lipids have 9 Calories per gram
- Cells do not simply burn food and release as heat
  - food gets broken down gradually

Energy

- Organism get the energy they need from food
- Living organisms obtain energy by breaking down food molecules during cellular respiration

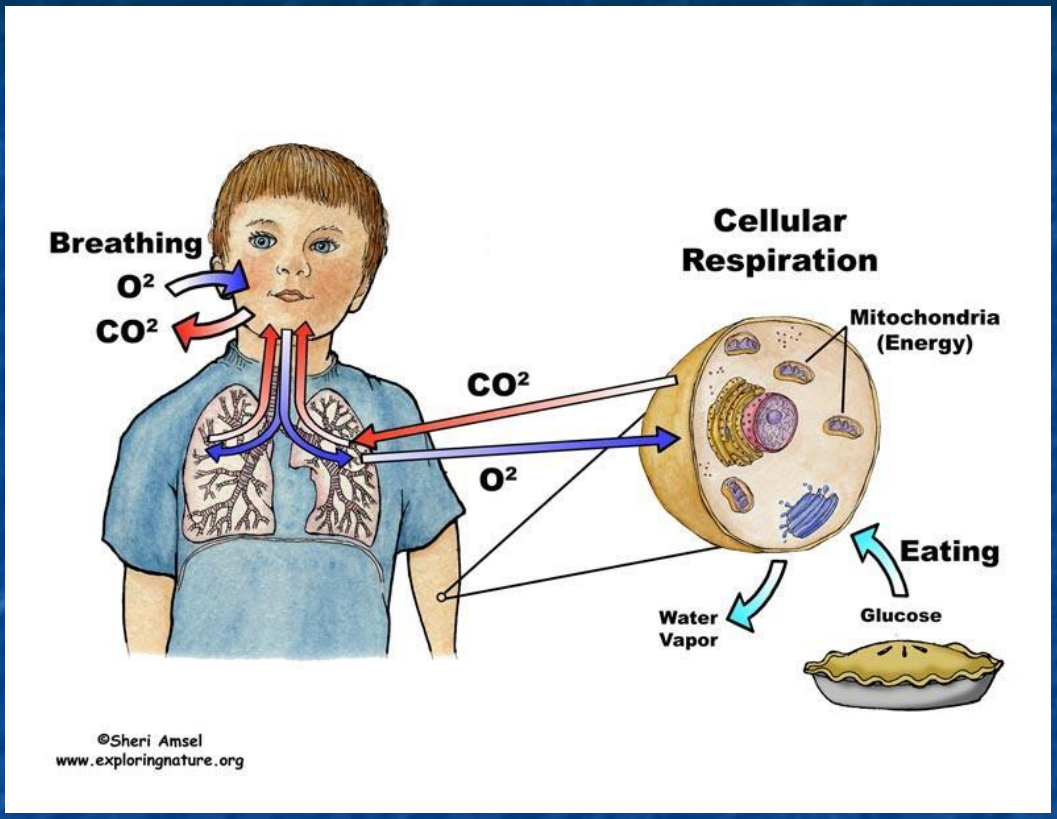
You are WHAT you EAT



You are what you eat

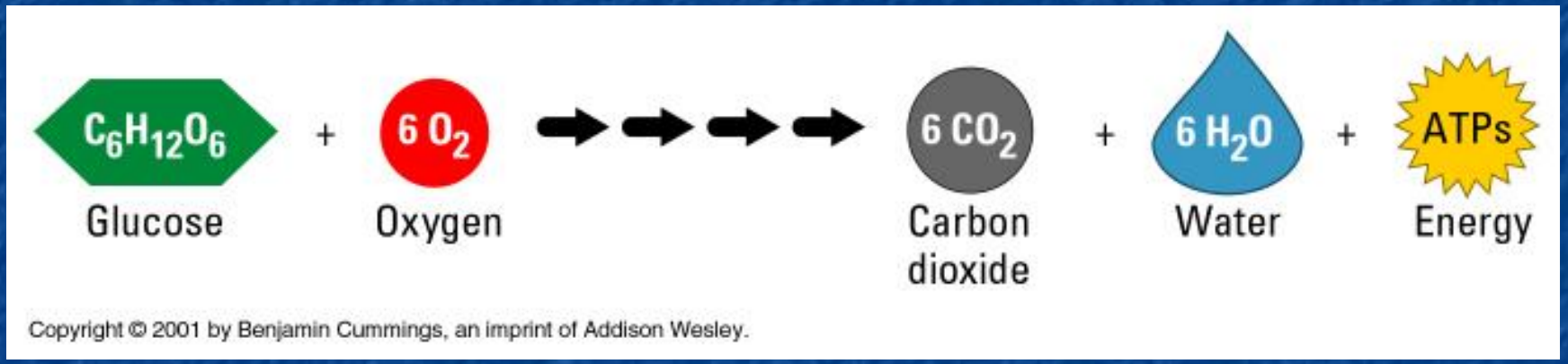
Candy	Calories	Sugar (g)	Fat (g)	Activity to burn it off
10 Candy Corns	75	17.2	0	9 minutes jogging
1 fun size bar	80	8.5	4	7 minutes swimming
1 Peanut Butter Cup	105	10.1	6.5	16 minutes cycling
1 miniature Kit-Kat	42	4.2	2.2	12 minutes walking
1.7 ounces Peanut M&Ms	144	14.4	7.5	16 minutes jogging
2 Lollipops	51	10	0	4 minutes swimming
3 big gummies	90	18	0	14 minutes cycling
If you eat all of this: Total	587	82.4	20.2	164 minutes walking

Cellular Respiration



- The process that releases energy from food in the presence of oxygen

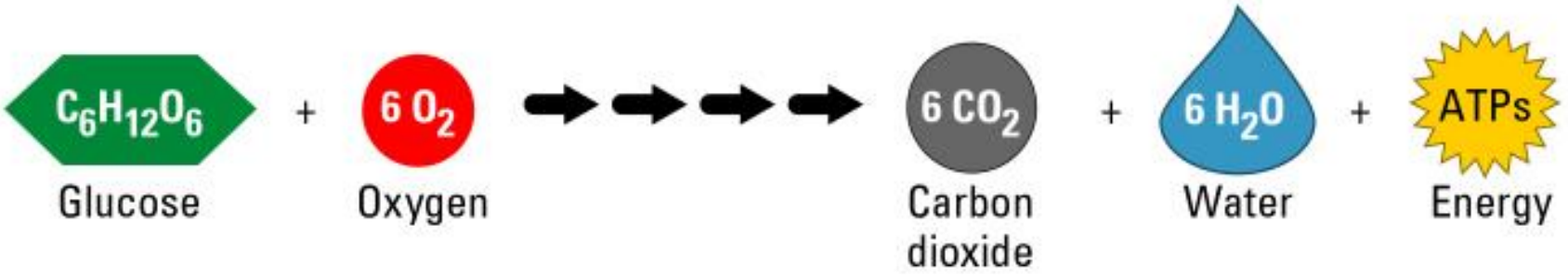
Cellular Respiration Equation



- How does this compare to photosynthesis?

Chemical Equation

- What are the reactants?
- What are the products?



3 stages of Cellular Respiration

- 1. Glycolysis
- 2. Krebs Cycle
- 3. Electron Transport Chain (ETC)

2 types of Respiration

- ***AEROBIC RESPIRATION***: oxygen must be present
- ***ANAEROBIC RESPIRATION***: oxygen does not need to be present

Organelle

- Mitochondria

The cell's energy factories, the mitochondria manufacture ATP to fuel all of life's activities.

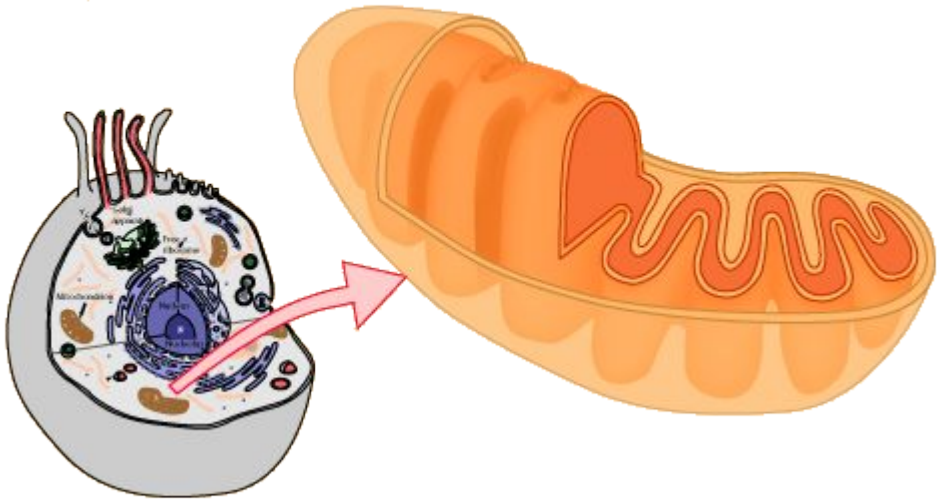


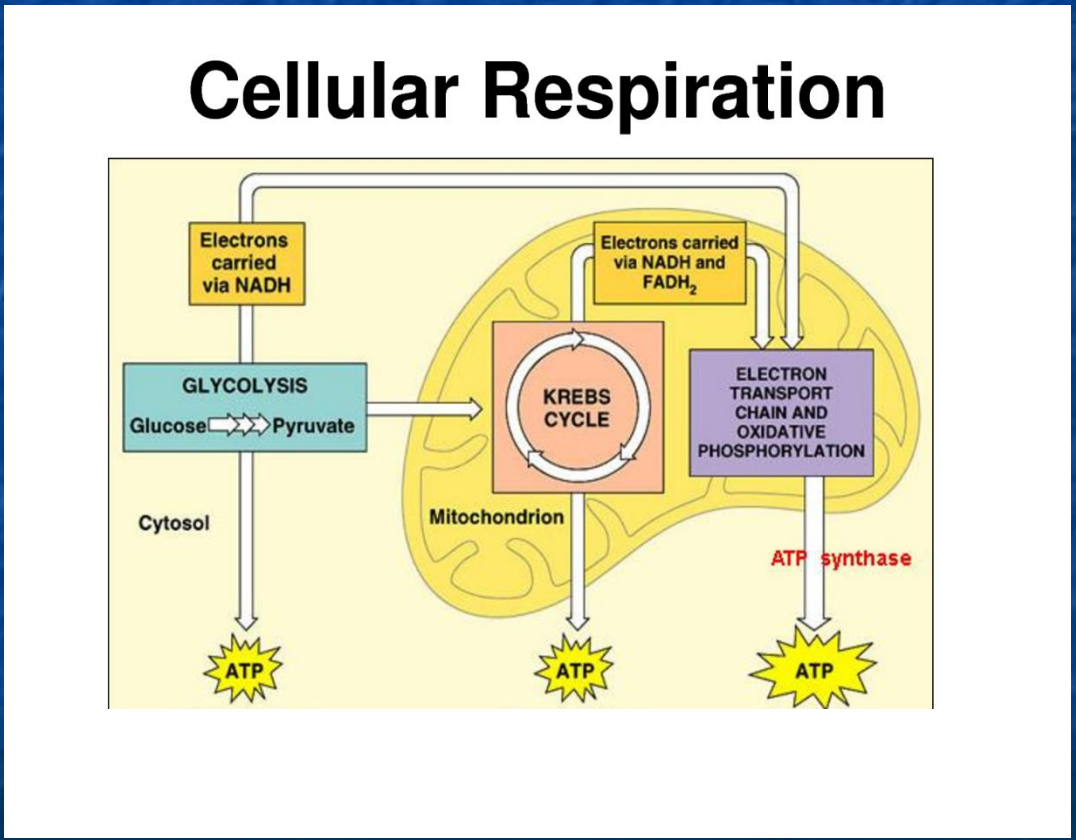
Diagram of the flow of CR

- This must be memorized
  - A box represents a process

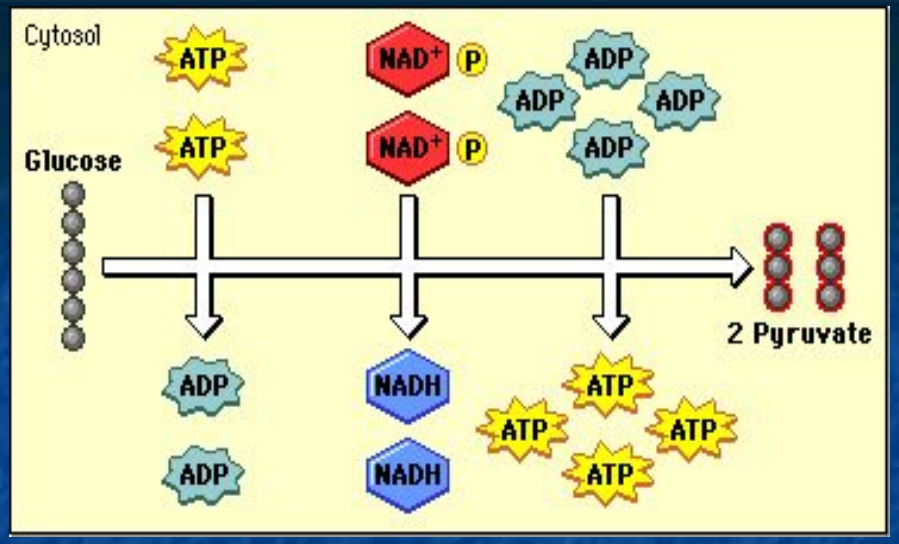
  - A cloud represents a product
    - *What is Glycolysis?*
    - *What is Pyruvic acid or pyruvate?*

Steps of CR

- So what are the steps of Cellular Respiration
- 1. Glycolysis
- 2. Krebs Cycle
- 3. ETC



Glycolysis



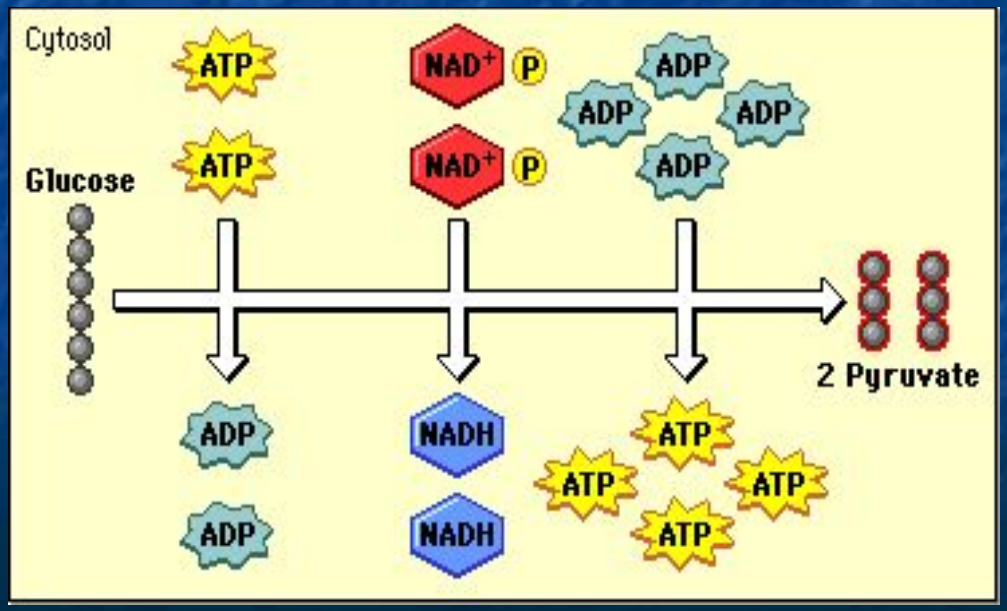
- Means sugar breaking
- Glucose is broken down in the cytoplasm
- It is anaerobic which means it does not need oxygen
- This is an enzyme-assisted process that will break down glucose into pyruvate (pyruvic acid)
- 2 ATP are needed to start Glycolysis
- Glucose is made of 6 carbons

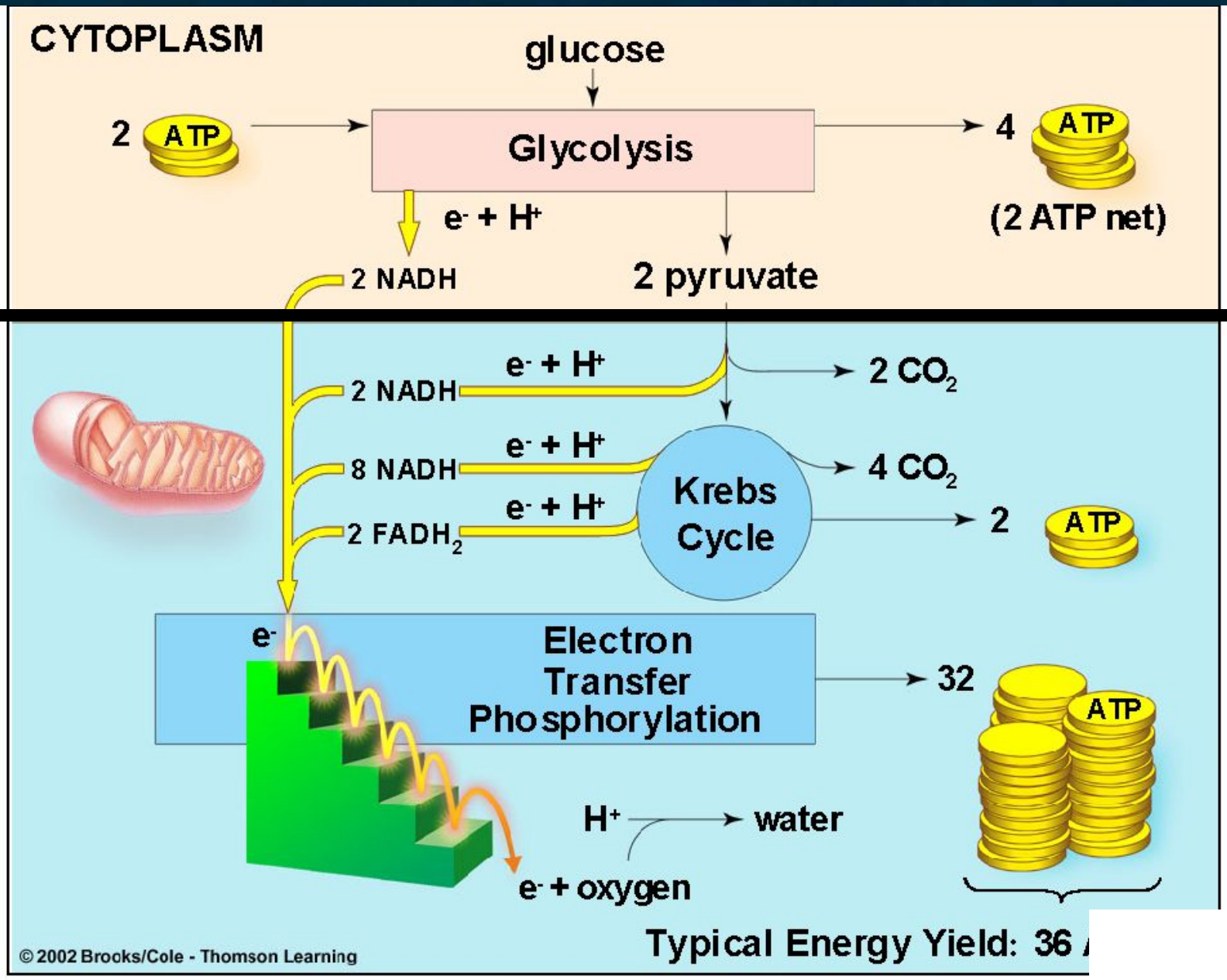
Glycolysis

- It is broken down by ATP into two 3-carbon compounds
- This 3-Carbon compound is called pyruvate and produces 4 ATP
- The end result is
  - the Net gain of 2 ATP (why only 2?)
  - 2 pyruvates
  - 2 NADH are produced (they are electron energy carriers)

End result of Glycolysis

- 2 pyruvates (pyruvic acid)
- 2 ATP
  - Why is it only 2 ATP produced if this process makes 4?




CYTOPLASM
glucose
2 ATP
Glycolysis
4 ATP
(2 ATP net)
e- + H+
2 NADH
2 pyruvate
e- + H+
2 NADH
2 CO2
e- + H+
8 NADH
4 CO2
e- + H+
2 FADH2
Krebs Cycle
2 ATP
e-
Electron Transfer Phosphorylation
32 ATP
H+ water
e- + oxygen
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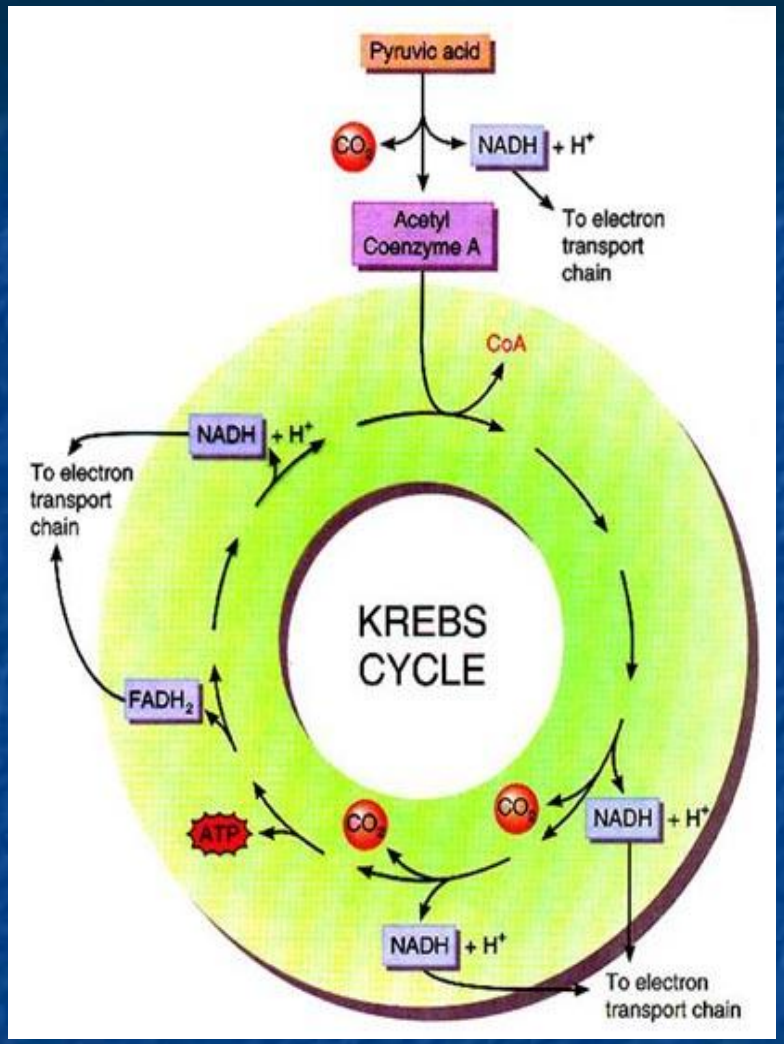
Typical Energy Yield: 36



KREBS CYCLE

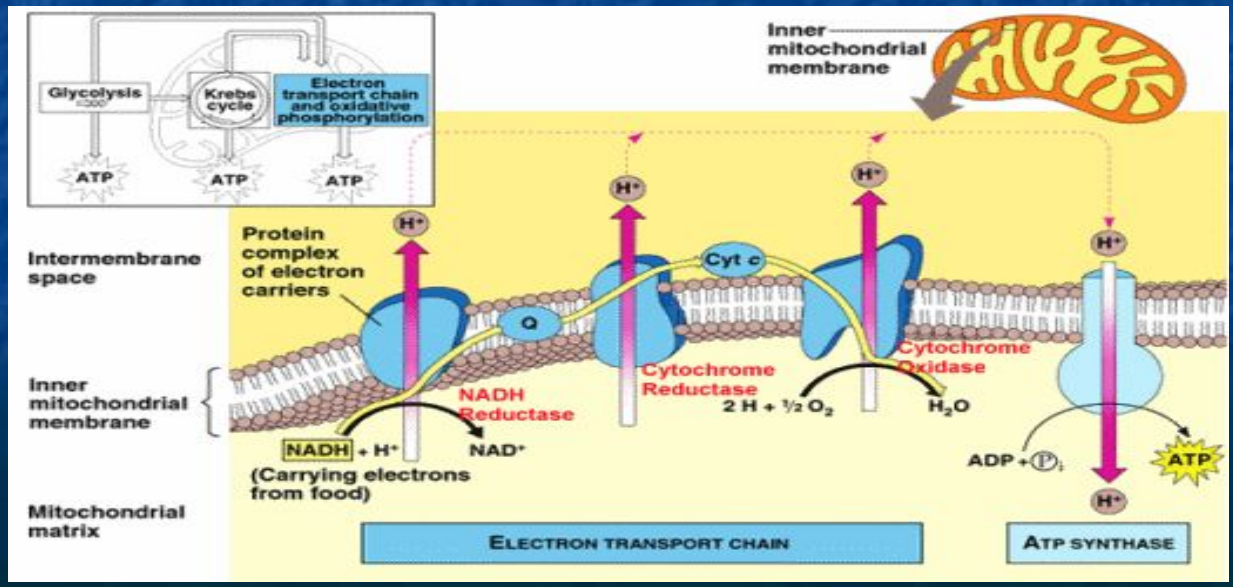
- Second stage
- Oxygen is present thus called aerobic respiration
- This occurs in the mitochondria of eukaryotes
- In Prokaryotes it happens in the cytoplasm

KREBS CYCLE

- In this stage the pyruvate is converted into many different types of molecules
- This cycle is completed 2 times since there were 2 pyruvates
- This will produce
- 8 NADH (electron energy carrier)
- 2 $FADH_2$ (electron energy carrier)
- 2 ATP
- 6 CO_2

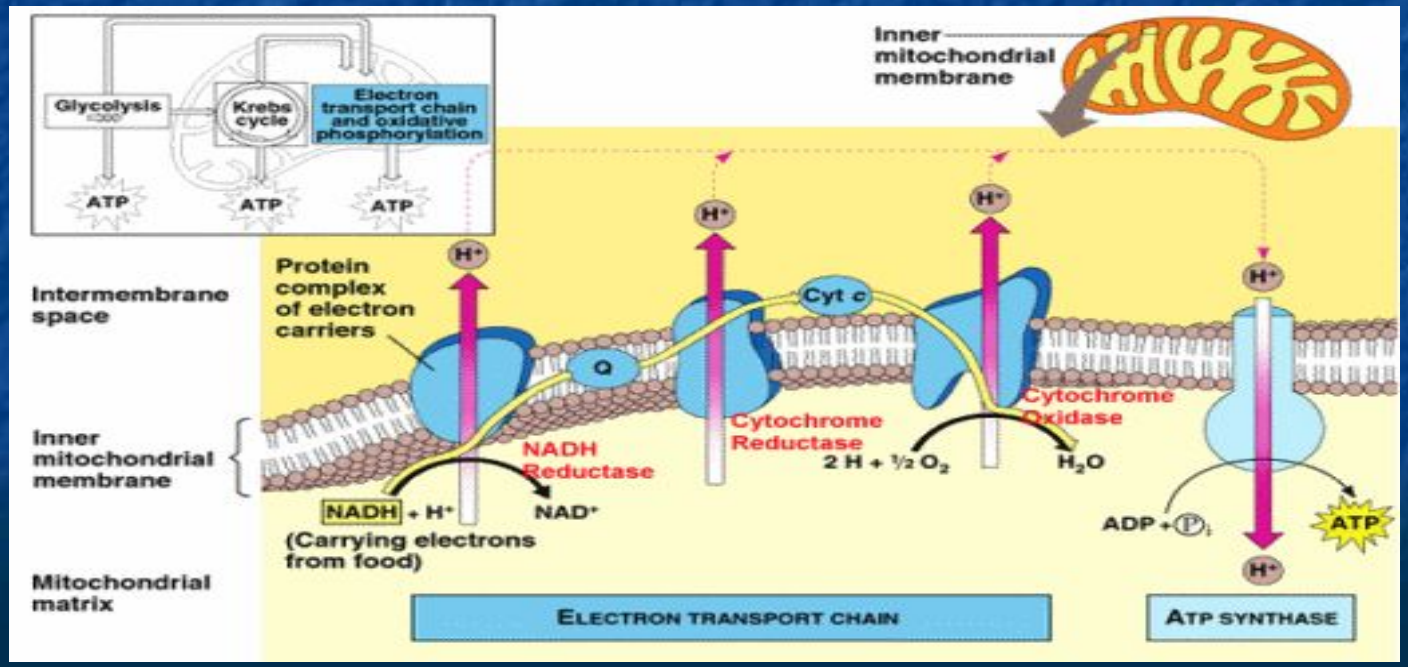
Electron Transport Chain

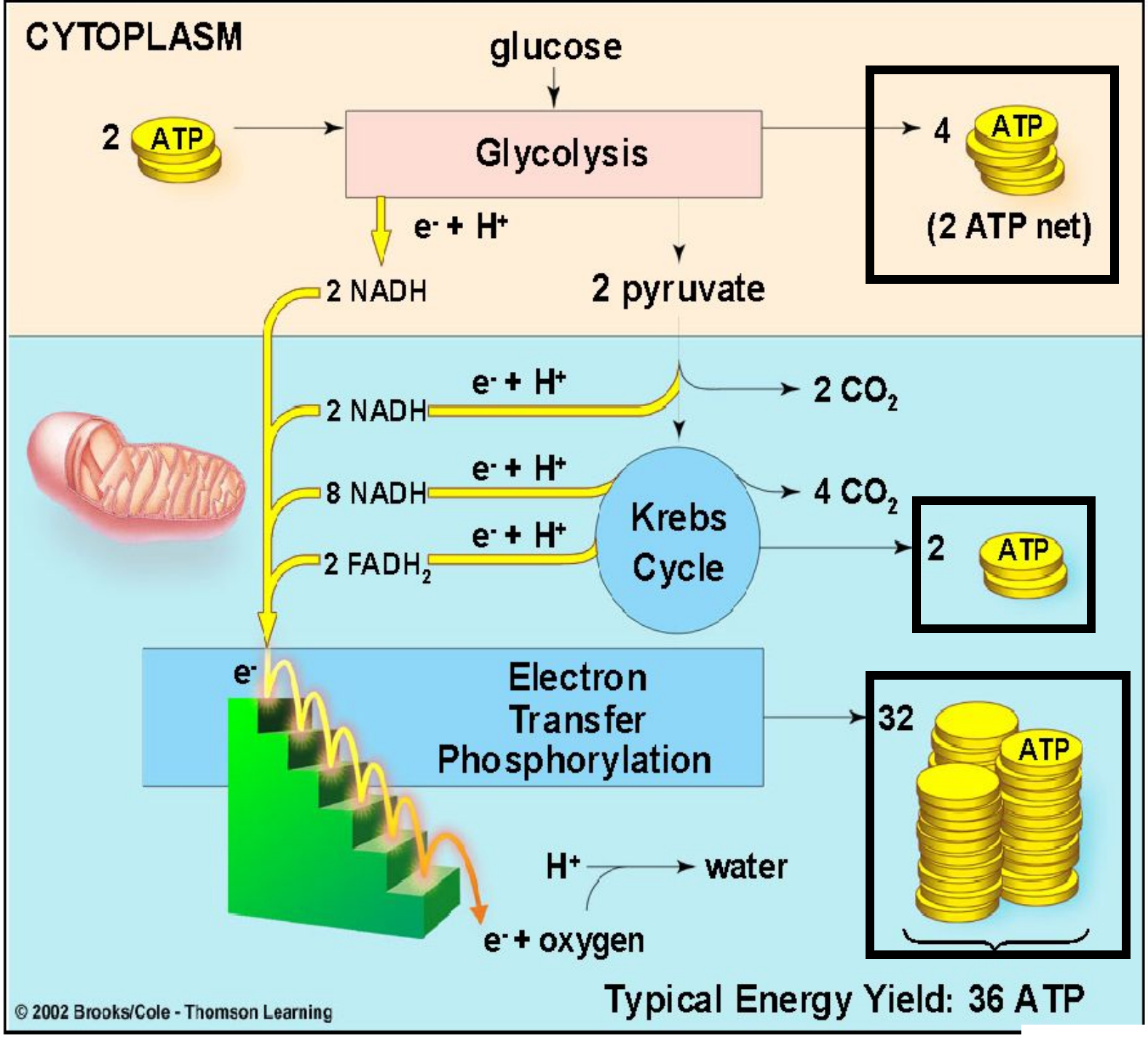
- Third stage (last)
- Most ATP is produced in this process
- $NADH$ & $FADH_2$ release Hydrogen ions to create energy
- These H^+ ions move along the mitochondria membrane



End Result of ETC

- 32 ATP
- Water
  - Some of the <u>oxygen</u> unite with <u>Hydrogen</u> to create <u>water</u> – released as <u>sweat</u>




CYTOPLASM
glucose
2 ATP
Glycolysis
4 ATP
(2 ATP net)
e- + H+
2 NADH
2 pyruvate
e- + H+
2 NADH
2 CO2
e- + H+
8 NADH
4 CO2
e- + H+
2 FADH2
Krebs Cycle
2 ATP
e-
Electron Transfer Phosphorylation
32 ATP
H+ water
e- + oxygen
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Typical Energy Yield: 36 ATP

End Products of Cellular Respiration

- ***HOW MANY ATP HAVE BEEN MADE?***
  - **Glycolysis** produced: 2 ATP
  - **Krebs Cycle** produced: 2 ATP
  - **ETC** produced: 32 ATP

- **TOTAL ATP**: 36 ATP from 1 glucose molecule

Why does this make sense?

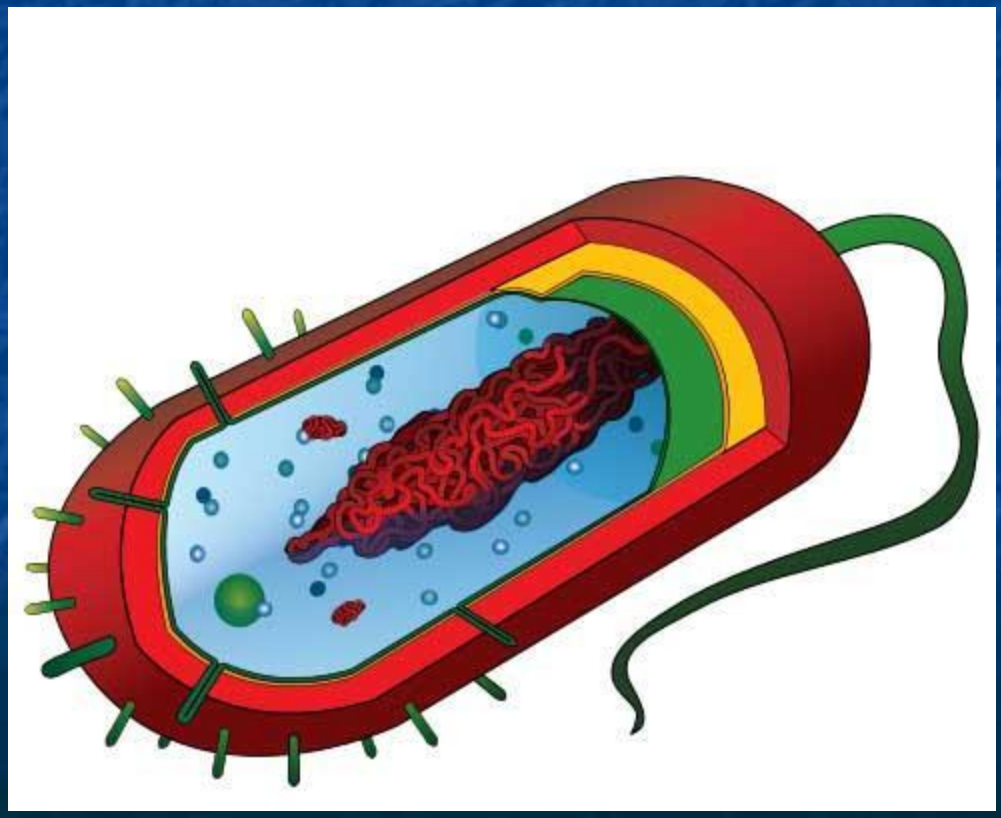
1)our bodies need energy

2)36 ATP per glucose will give the organism plenty of energy to do what it needs

TRIVIA FACT: the body uses about 1 million ATP molecules per second !!!

Prokaryotic Aerobic Cellular Respiration

- No mitochondria
- Must use cell membrane instead
- Results in 38 ATP



Essential Questions

- What are the stages of cellular respiration?
- What is the role of the electron carriers in cellular respiration?
- How many ATP are produced in: Glycolysis, Krebs Cycle, ETC, all of aerobic respiration?
- When is most CO_2 produced?
- When is most water produced?

- *Vocabulary: anaerobic respiration, aerobic respiration, glycolysis, Krebs cycle, fermentation*

Yeast Lab

Ingredients for each balloon

- **Bottle A (red):** 5 ml Sugar, 2 mL Yeast
- **Bottle B (yellow):** 30 mL Sugar, 2 mL Yeast
- **Bottle C (orange):** 30 mL Sugar, 5 mL Yeast, 5 mL salt
- **Bottle D (Green):** 2 mL Yeast
- **Bottle E (Blue):** 30 ml Sugar, 5 mL salt

Questions

1. Do yeast use energy and produce a gas when sugar is available?
2. Do you expect yeast to produce a gas when sugar is available? Why or why not? (2)
3. Do you expect yeast to produce a gas when no sugar or other food is available? Why or why not? (2)
4. Name the Independent Variable and Dependent Variable for this laboratory exercise. Be specific. (2)
5. Name the control for this laboratory exercise.
6. What are the constants for this laboratory exercise? (3)
7. Make a hypothesis for this experiment. (2)

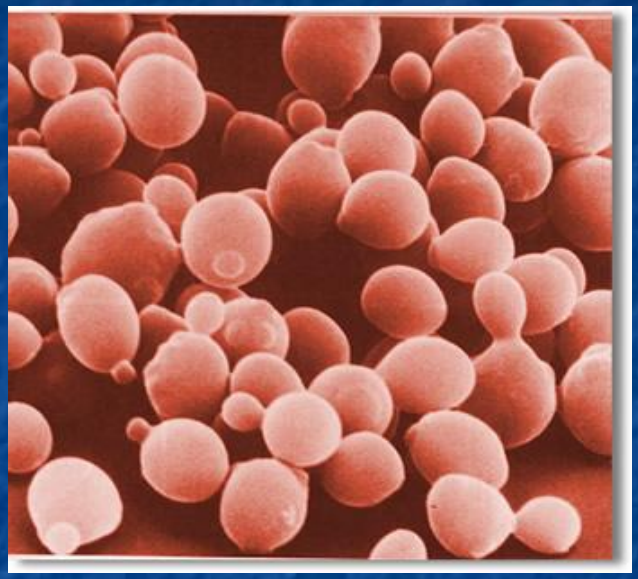
Questions

8. Which balloon was the biggest?
9. Which balloon was the smallest?
10. What is the cellular respiration equation?
11. When you make bread, if you just mix flour, sugar, and water, the dough does not rise, and the bread will be flat and hard. If you include yeast in the bread dough, then the dough rises and the bread is bigger and fluffier. *Can you explain how the yeast helps the bread dough to rise?*
12. Explain how this equation just occurred during our investigation of the metabolism of yeast.

NO OXYGEN available !!!!

- The cell must go through anaerobic respiration
- Start with Glycolysis then fermentation
- Occurs in the cytoplasm and mitochondria
- 2 types
  - Lactic Acid Fermentation
  - Alcoholic Fermentation

Alcoholic Fermentation



- Yeast and other microorganisms go thru this
- Produces CO_2 and ethyl alcohol
- CO_2 released as bubbles
- Used to bread and beverages
- Formula

Pyruvic acid + NADH ☐ Alcohol + CO_2 + NAD^+

Lactic Acid Fermentation

- Converts pyruvic acid into lactic acid
- Formula
  - Pyruvic acid + NADH ☐ lactic acid + NAD^+

- bacteria that produce lactic acid are important
  - They create
    - Cheese, yogurt, buttermilk, sour cream, pickles, sauerkraut

Lactic Acid Fermentation

- Human lactic acid fermenters
- When the body is exhausted from strenuous exercise it runs out of oxygen
- Muscle cells go thru this process
- The muscle left the lactic acid which makes you sore
- Once the Oxygen is replenished the soreness disappears

ANAEROBIC RESPIRATION Results

- ***How many ATP have been produced?***
- Glycolysis produced:
  - 2 ATP
- Lactic Acid Fermentation produced:
  - 0 ATP
- Total amount: 2 ATP

- ***How many ATP have been produced?***
- Glycolysis produced:
  - 2 ATP
- Alcoholic Fermentation produced:
  - 0 ATP
- Total amount: 2 ATP

Why does this make sense? …

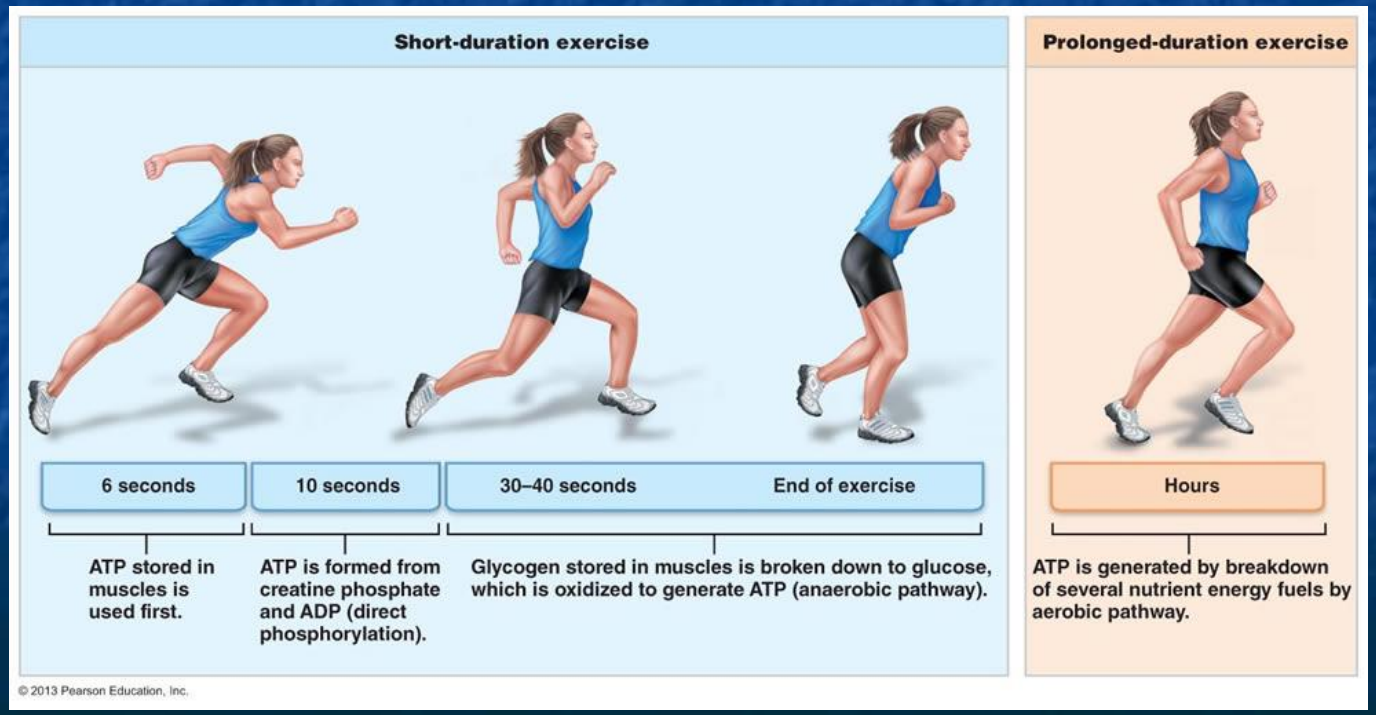
The body is not using oxygen efficiently to break down pyruvate to give the body enough energy

Energy and Excercise

- Running a race

Energy and Excercise

- Humans have 3 sources of ATP
  - 1. ATP already in muscles
  - 2. ATP made during lactic acid fermentation
  - 3. ATP made during aerobic respiration



Quick need Energy need

- Think being chased
- For short quick bursts of energy the body uses ATP already in muscles
- Uses the ATP made by lactic acid fermentation
- The ATP gets replenished with oxygen once you are done and breath deeply

Long-term energy need

- Exercise longer than 90 seconds
  - Cellular respiration is the only way to create ATP
  - Practice and conditioning are super important
  - Stores carbohydrate glycogen
    - Trains muscles to be able to continue on and not tire out so quickly
      - Athlete –vs- Couch-potato

Short-duration exercise

6 seconds	10 seconds	30–40 seconds	End of exercise
ATP stored in muscles is used first.	ATP is formed from creatine phosphate and ADP (direct phosphorylation).	Glycogen stored in muscles is broken down to glucose, which is oxidized to generate ATP (anaerobic pathway).	

Prolonged-duration exercise

Hours
ATP is generated by breakdown of several nutrient energy fuels by aerobic pathway.

AEROBIC Respiration pg 72

- 1) Number of ATP produced during each part of aerobic respiration
- 2) Total ATP from 1 glucose
- 3) Equation
- 4) Draw Flowchart

ANAEROBIC RESPIRATION PG 73

Divide in half (T chart)

1) # of ATP produced
2) Name the products produced
3) Where does it occur (organelle)
4) 2 benefits
5) Draw flowchart

Website

- http://www.sumanasinc.com/webcontent/animations/content/cellularrespiration.html

- SOL Review
- http://solpass.org/hs.htm
- Here are questions on Respiration and Photosynthesis