Lesson 1

ATP / ADP

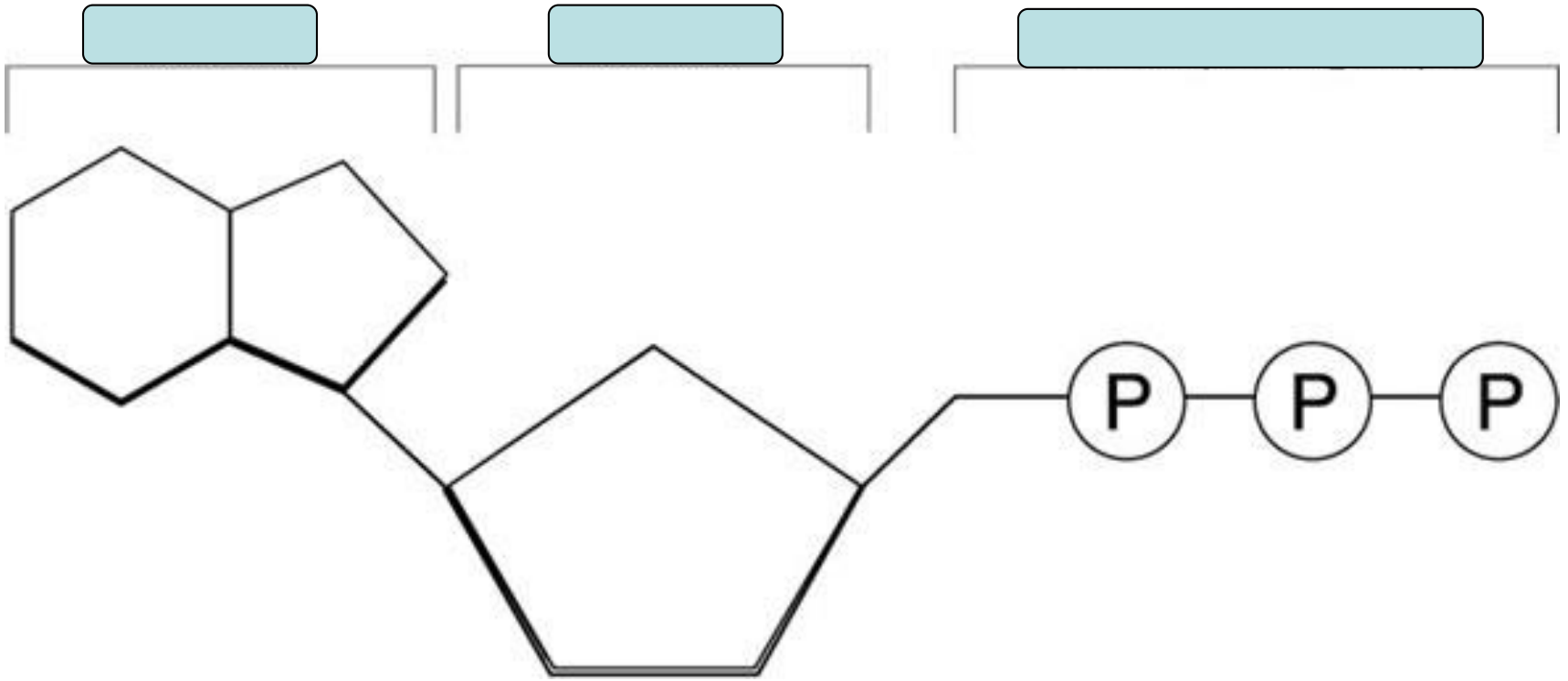
Energy

Saving for a Rainy Day

Suppose you earned extra money by having a job. At first, you might be tempted to spend all of the money, but then you decide to open a bank account.

1. What are the benefits of having a bank account?
2. What do you have to do if you need some of this money?
3. What might your body do when it has more energy than it needs?
4. What does your body do when it needs energy?

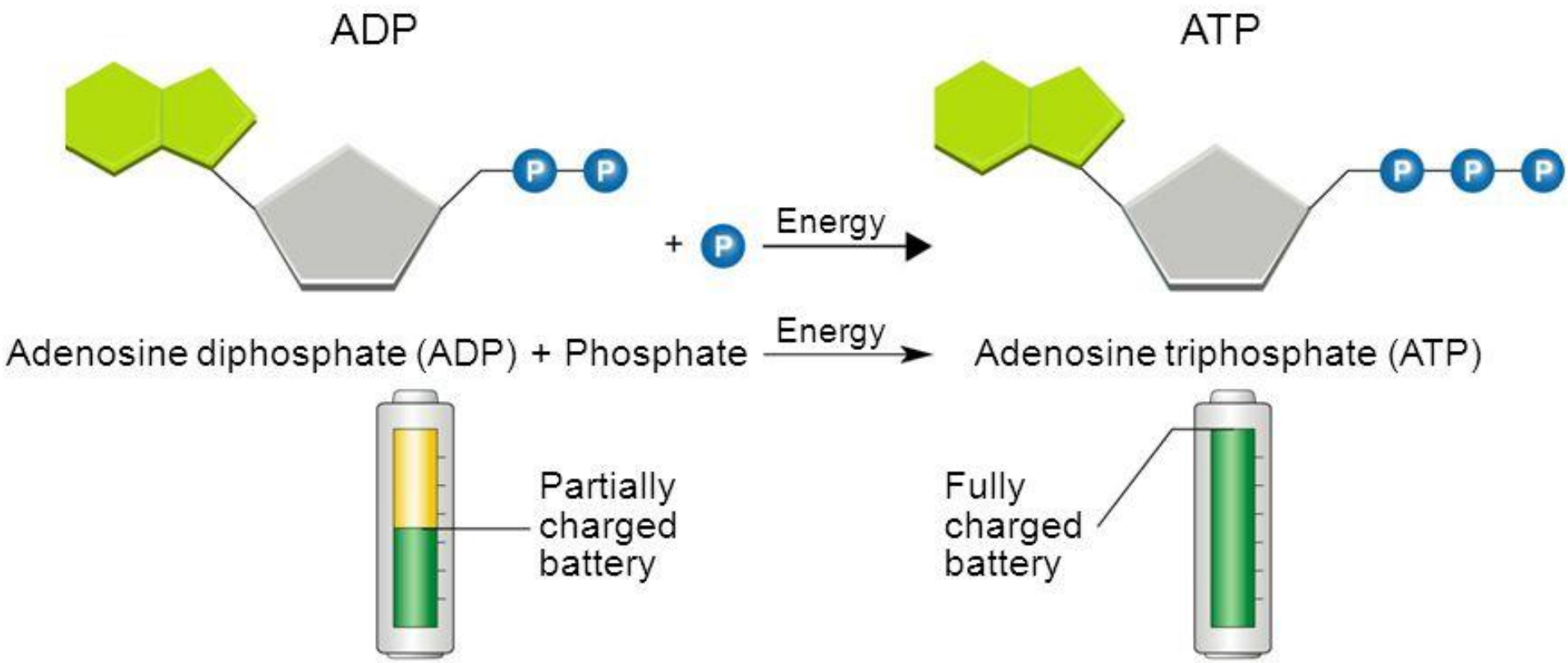
ENERGY



ATP - Adenosine Triphosphate

- Stores chemical energy released from cellular respiration
- releases energy for life processes by losing one phosphate, forming ADP (Adenosine Diphosphate)
- Stores energy released from food by adding a phosphate to ADP, forming ATP

Battery Comparison

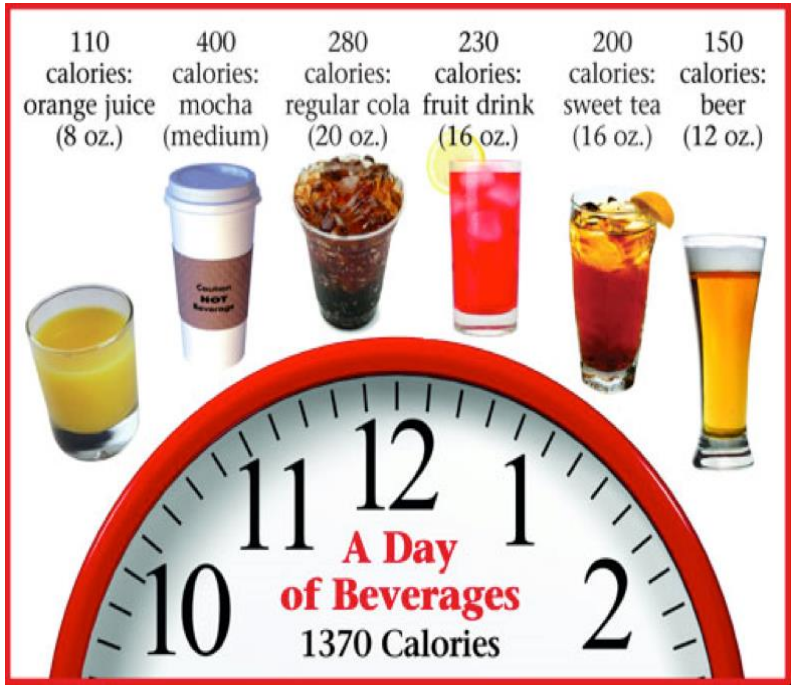


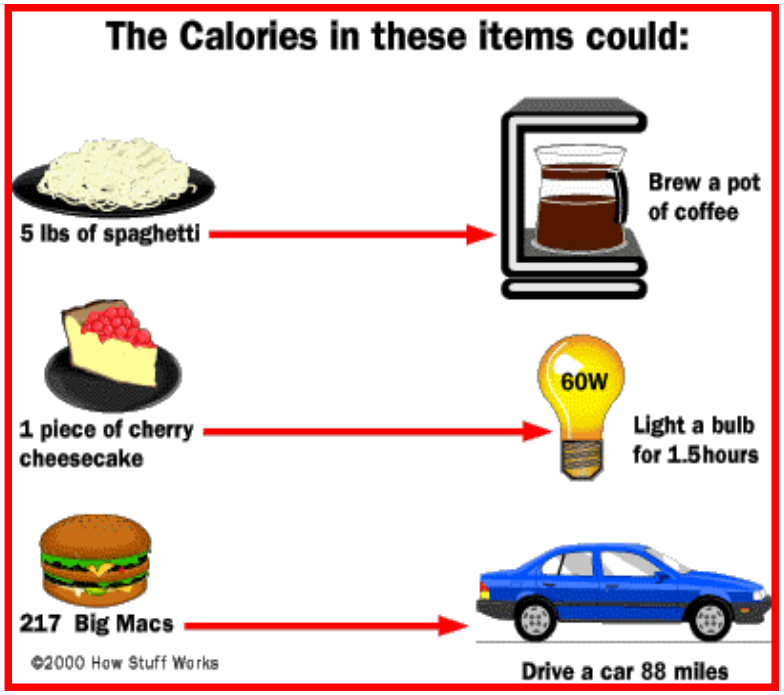
Which molecule has more stored energy?

ATP

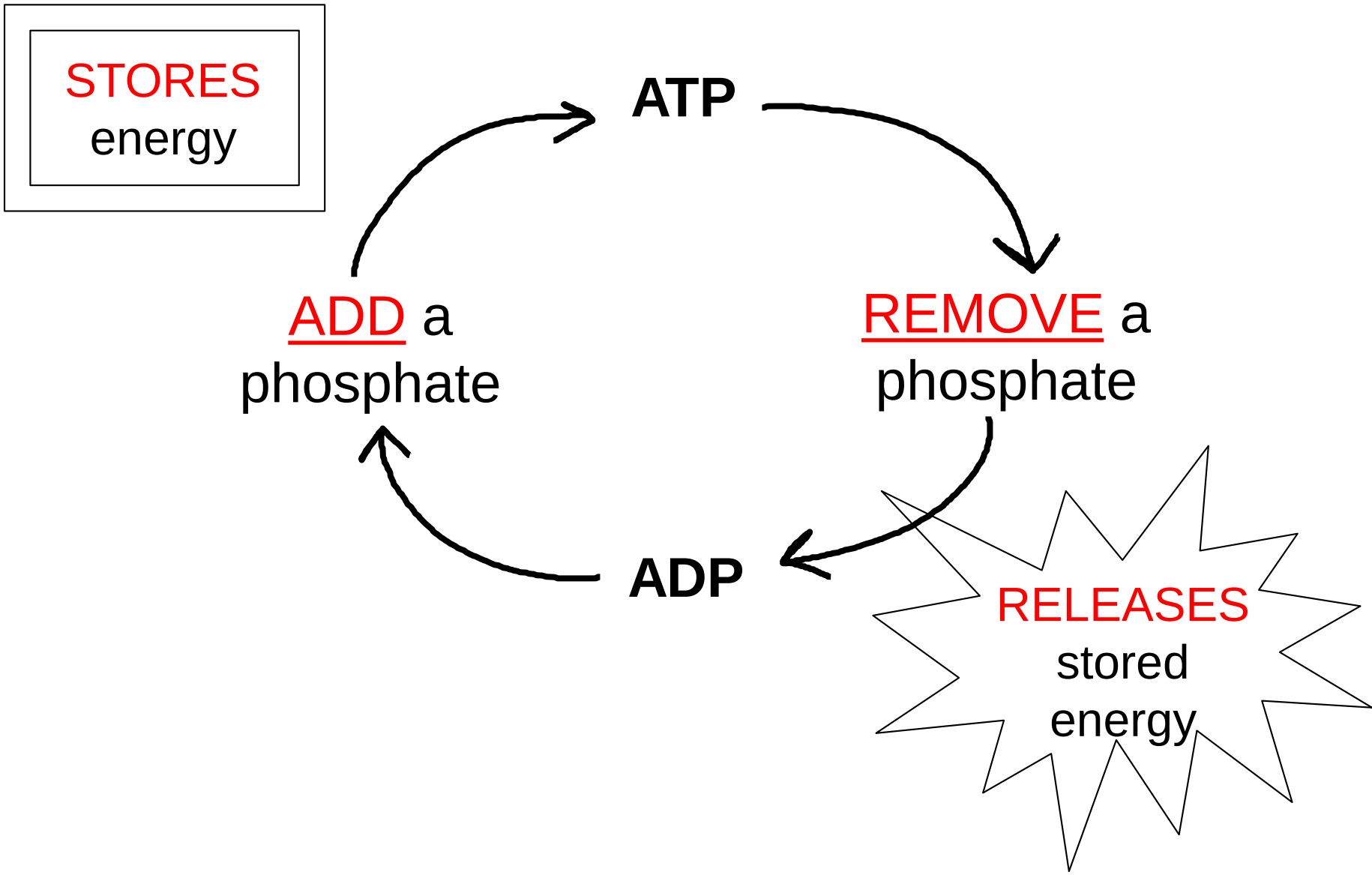
Chemical Energy & Food

- Calorie: energy needed to raise the temperature of 1 gram of water by 1 degree Celsius
- Chemical energy stored in food (glucose) is released by breaking chemical bonds during cellular respiration





ATP / ADP Cycle



ATP / ADP Chemical Reactions

Reactants → Products

(start with) (end with)

ATP + Water —Hydrolysis enzymes→ ADP + P + Energy

ADP + P + Energy —Dehydration synthesis enzymes→ ATP + Water

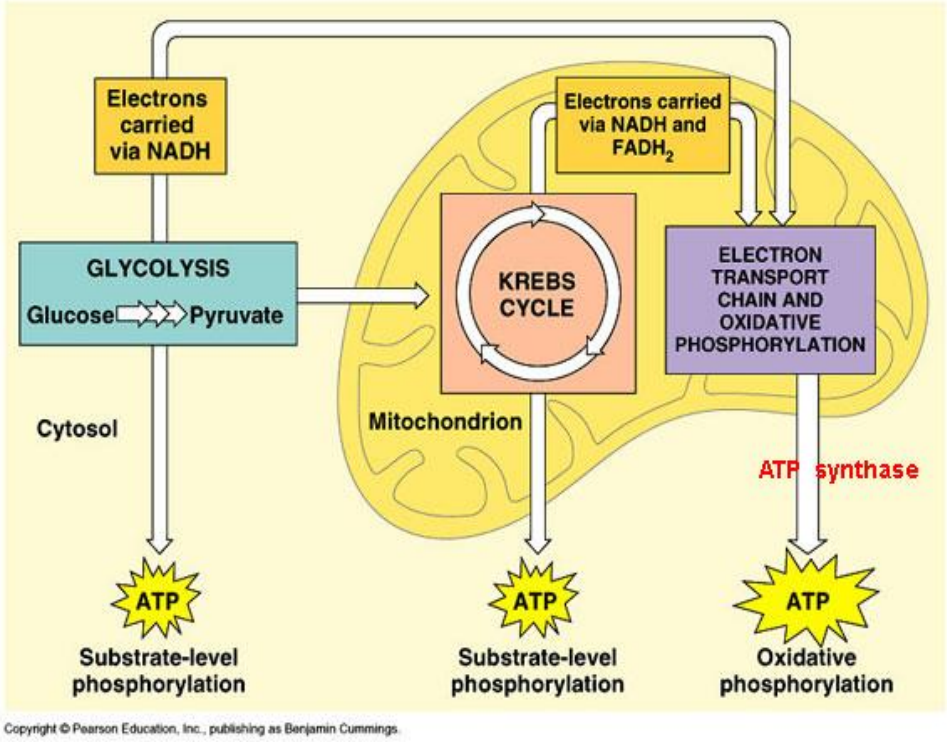
Video: Magic School Bus "Works Out"

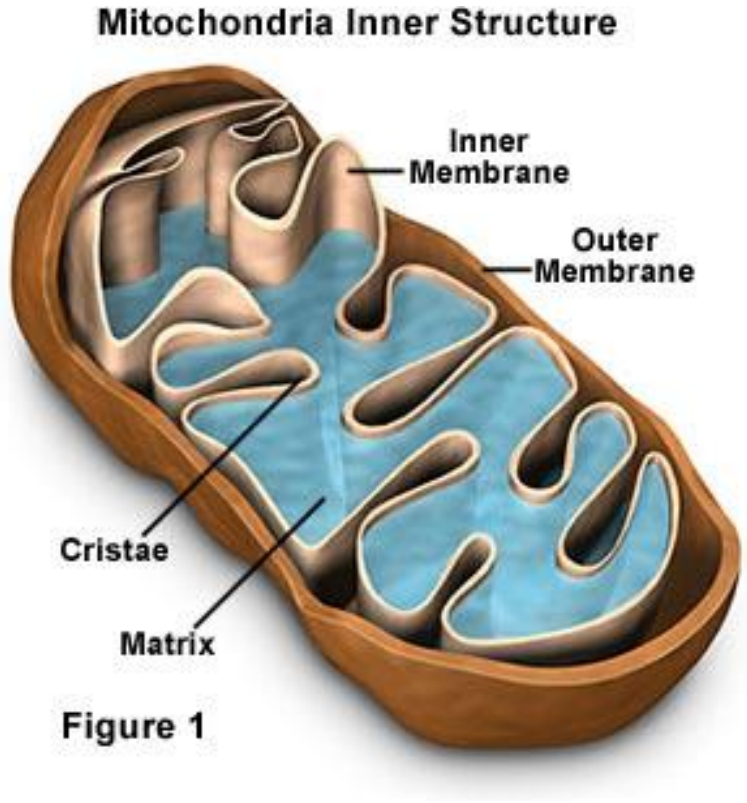
Lesson 2

Aerobic Cellular Respiration

Cellular Respiration

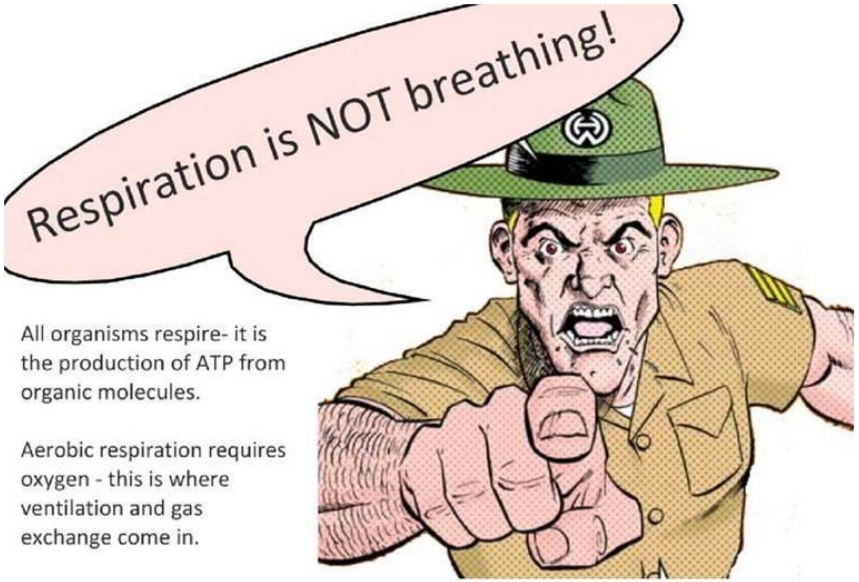
[Brainpop]





Cellular Respiration

- releases energy stored in the chemical bonds of food molecules, converting it to a useable form (ATP)
- May or may NOT require oxygen (2 types)
- occurs in the mitochondria and cytoplasm



2 types of Cellular Respiration

1) Aerobic Respiration (OXYGEN required!)

Equation:

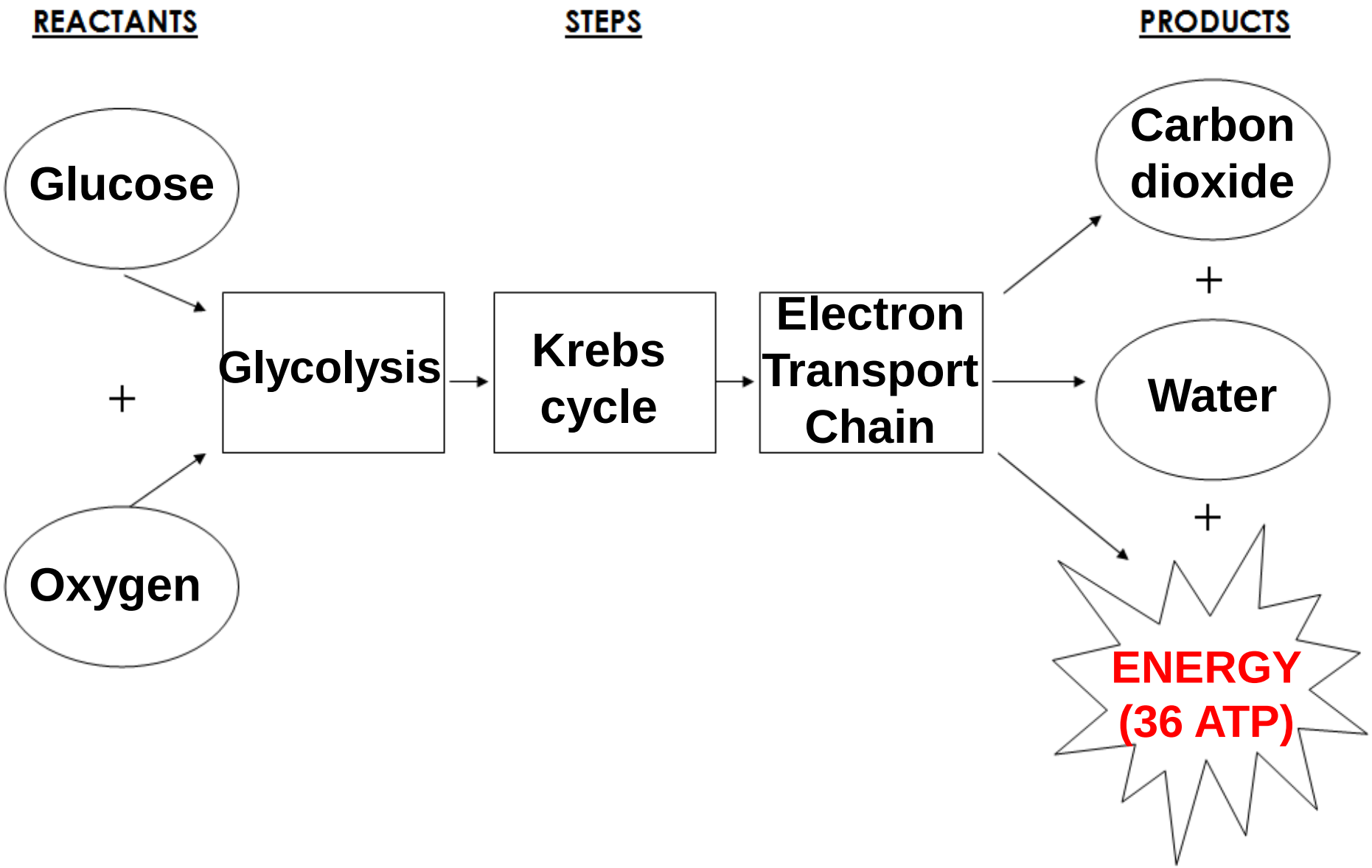
Glucose + Oxygen → Carbon dioxide + Water + ENERGY

$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O +$ 36 ATP

- Yields a net gain of 36 ATP for each glucose molecule broken down
- energy is released a little at a time through a complicated set of reactions
    1) Glycolysis (in cytoplasm)
    2) Krebs Cycle
    3) Electron Transport Chain

Glucose Song

Aerobic Respiration Flowchart



Lesson 3

- Anaerobic Respiration / Fermentation

Strongest Student Contest!

Let’s see who can hold piles of textbooks for the longest period of time!

Anaerobic Respiration

(a.k.a.Fermentation)

- **NO** oxygen required
- Produces only 2 ATP per glucose

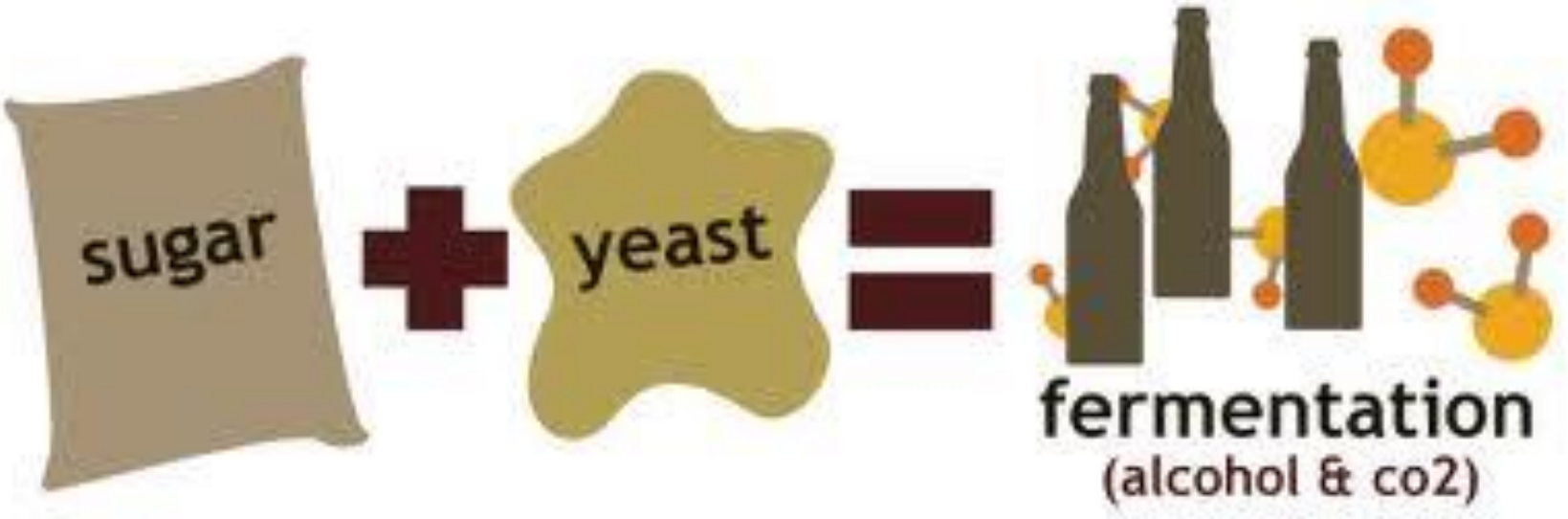
Why do it?

- Some cells lack enzymes & organelles needed for aerobic respiration
  - Ex. Prokaryotes have no mitochondria
- When oxygen supply is low some animals will do it as a last resort
  - Ex. Our muscle cells

Alcoholic Fermentation

- Produces alcohol, CO_2, and 2 ATP
- Performed by yeast (fungi)

  (needed for baking, wine and beer making)



Lactic Acid Fermentation

- Produces lactic acid and 2 ATP
- Performed by some bacteria & by animal cells as a last resort when lacking O_2
- Associated with muscle fatigue (burning pain)
- Important in production of cheese & yogurt

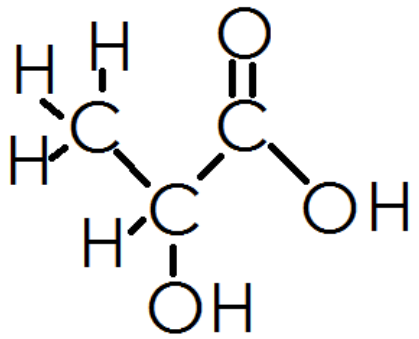
Fermentation Equations

1) Alcoholic fermentation

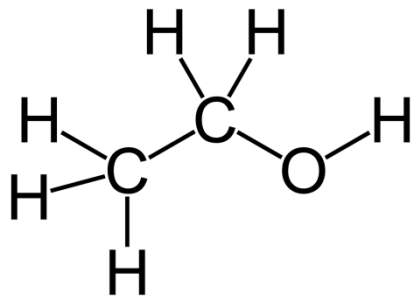
Glucose → Alcohol + CO_2 + 2 ATP

2) Lactic Acid fermentation

Glucose → Lactic acid + 2 ATP



Lactic Acid



Ethanol Alcohol

Respiration vs. Fermentation

Respiration

You have learned that respiration is a process that releases energy by combining oxygen with food. Respiration is not the only process that can release energy from food. A process called **fermentation** can also release energy but no breathing is necessary! Let's learn more about their similarities and differences.

Directions- Read the passage. Then look at the diagrams below which explain each process, and fill in the Venn Diagram on the following page.

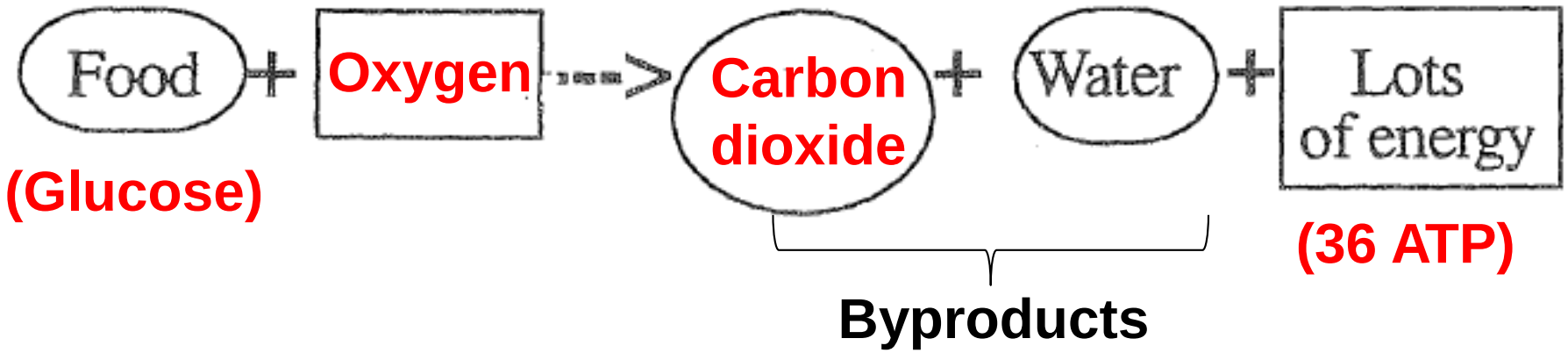
Respiration is a process which releases energy from food. A great deal of energy can be released from food with this process because the food is broken down completely. All that remains is carbon dioxide and water.

Respiration is an **aerobic** process. That means it requires oxygen. Organisms that depend on respiration cannot exist without oxygen. Most multi-celled animals depend on respiration as the principal method of releasing energy.

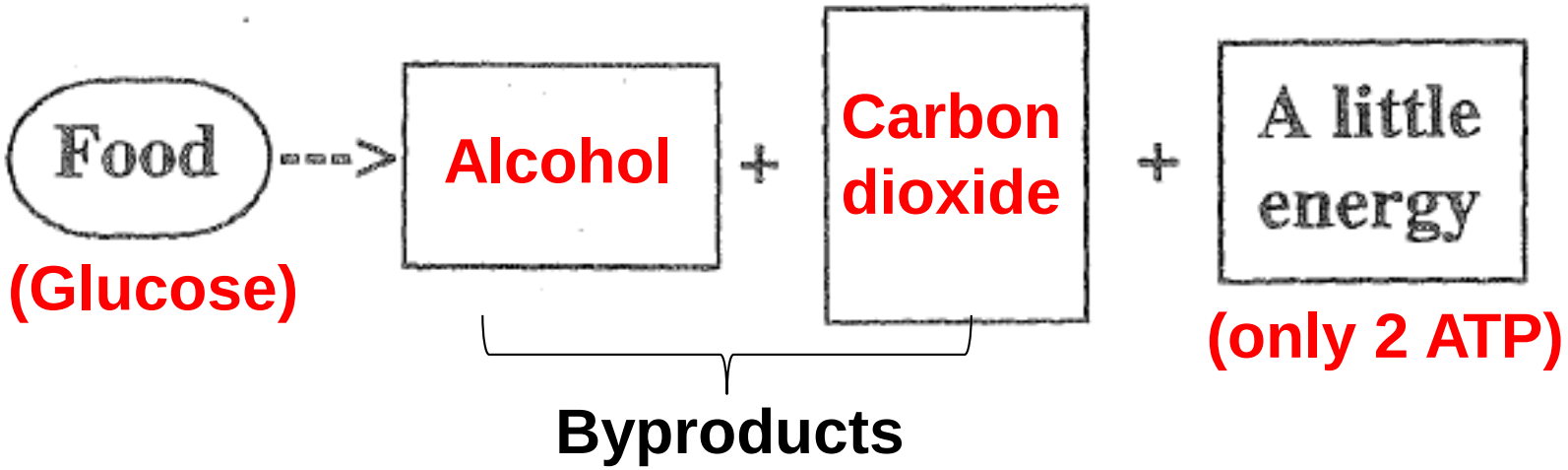
Fermentation is a process which liberates energy from food. The process is **anaerobic**. That means that no oxygen is required. The process is very inefficient because very little of the available energy in the food is released. As a result, the waste products such as lactic acid or alcohol have a great deal of energy left in them.

Fermentation can be the sole energy release system for some microbes. **Microbes** are one-celled organisms that can only be seen through a microscope.

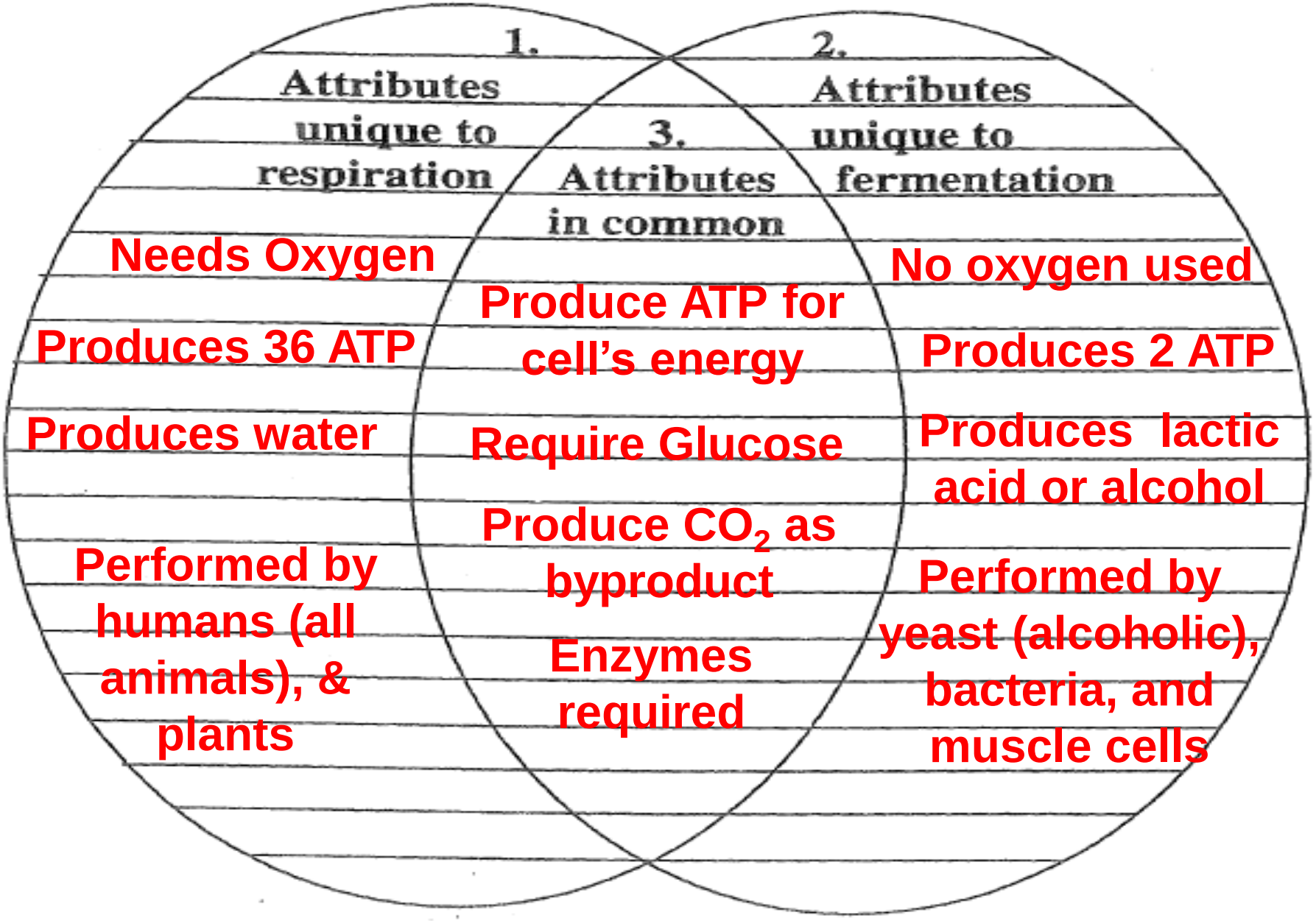
Aerobic Respiration



Alcoholic Fermentation



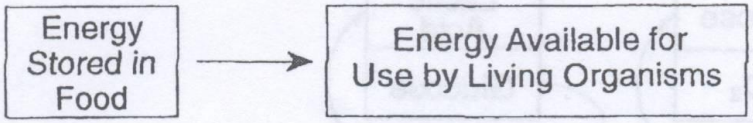
Venn Diagram



Lesson 4

SAT II – Aerobic Cellular Respiration

1. Which process is represented by the arrow in the diagram below?



_____(1) growth (3) regulation

(2) respiration (4) excretion

_____2. One way human skeletal muscles and some bacteria are similar is that they both

(1) reproduce asexually, using binary fission and regeneration

(2) lack a nuclear membrane surrounding the chromosomes

(3) carry out autotrophic nutrition when food becomes scarce in the environment

(4) produce lactic acid when oxygen is not available for respiration

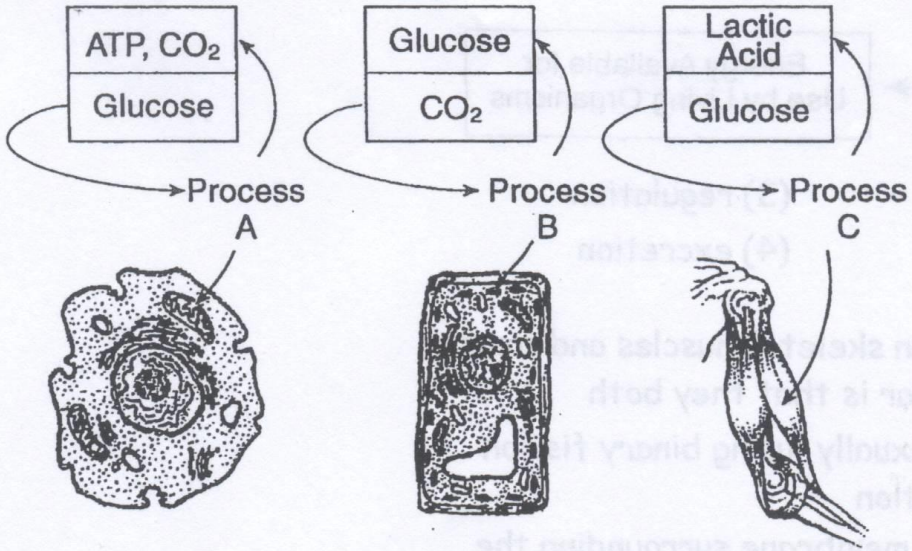
Information concerning a metabolic activity is shown below.

$$X \xrightarrow{\text{enzyme}} \text{products + energy for metabolism}$$

_____3. Substance *X* is most likely

(1) DNA (3) ATP

____4. Base your answer to the following question on the diagrams below and on your knowledge of biology. The arrow below each lettered process indicates where the process takes place.



Process *A* is known as

(1) photosynthesis
(2) fermentation
(3) dehydration synthesis
(4) aerobic respiration

Base your answers to questions 5 through 8 on the equations shown below.

Equations

(*A*) glucose + 2 ATP $\xrightarrow{Y}$ 2 pyruvic acid + 4 ATP

(*B*) 2 pyruvic acid + oxygen $\xrightarrow{Y}$ carbon dioxide + water + 34 ATP

Process *A* is known as

(1) photosynthesis
(2) fermentation
(3) dehydration synthesis
(4) aerobic respiration

Base your answers to questions 5 through 8 on the equations shown below.

Equations

(*A*) glucose + 2 ATP $\xrightarrow{Y}$ 2 pyruvic acid + 4 ATP

(*B*) 2 pyruvic acid + oxygen $\xrightarrow{Y}$ carbon dioxide + water + 34 ATP

____5. What is the combined net gain of ATP molecules at the completion of reactions *A* and *B*?

(1) 36 (2) 2 (3) 34 (4) 4

____6. What does letter *Y* represent?

(1) enzymes
(2) hemoglobin
(3) light and chlorophyll
(4) water and minerals

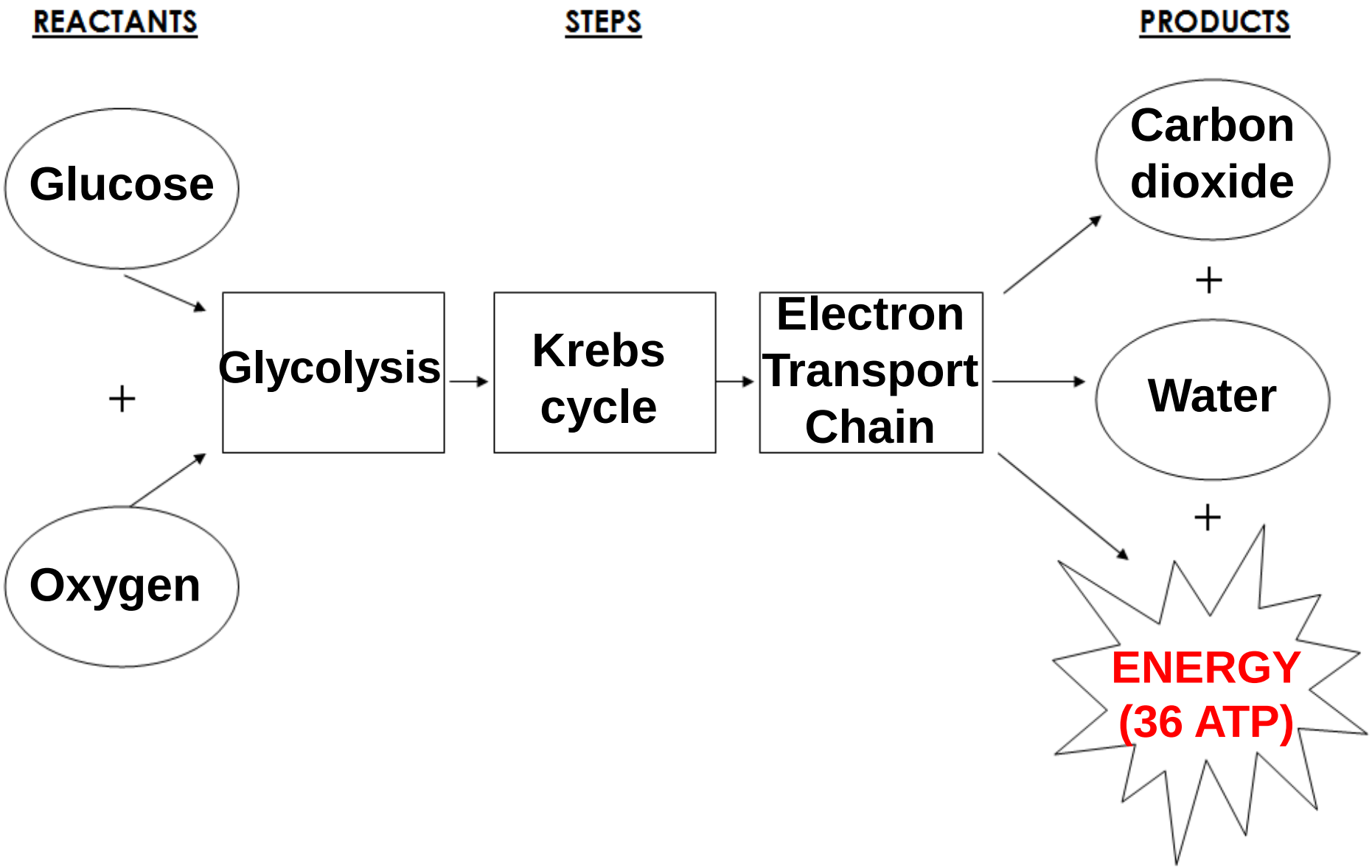
____7. In animals, the reaction in equation *B* occurs in the

(1) lysosomes (2) chloroplasts (3) mitochondria (4) ribosomes

____8. Two molecules of ATP are needed in equation *A* so that

(1) oxygen is added to hydrogen in glucose
(2) energy needed to activate this reaction is provided
(3) energy needed to trap radiant energy is provided
(4) glucose is split into hydrogen and oxygen atoms

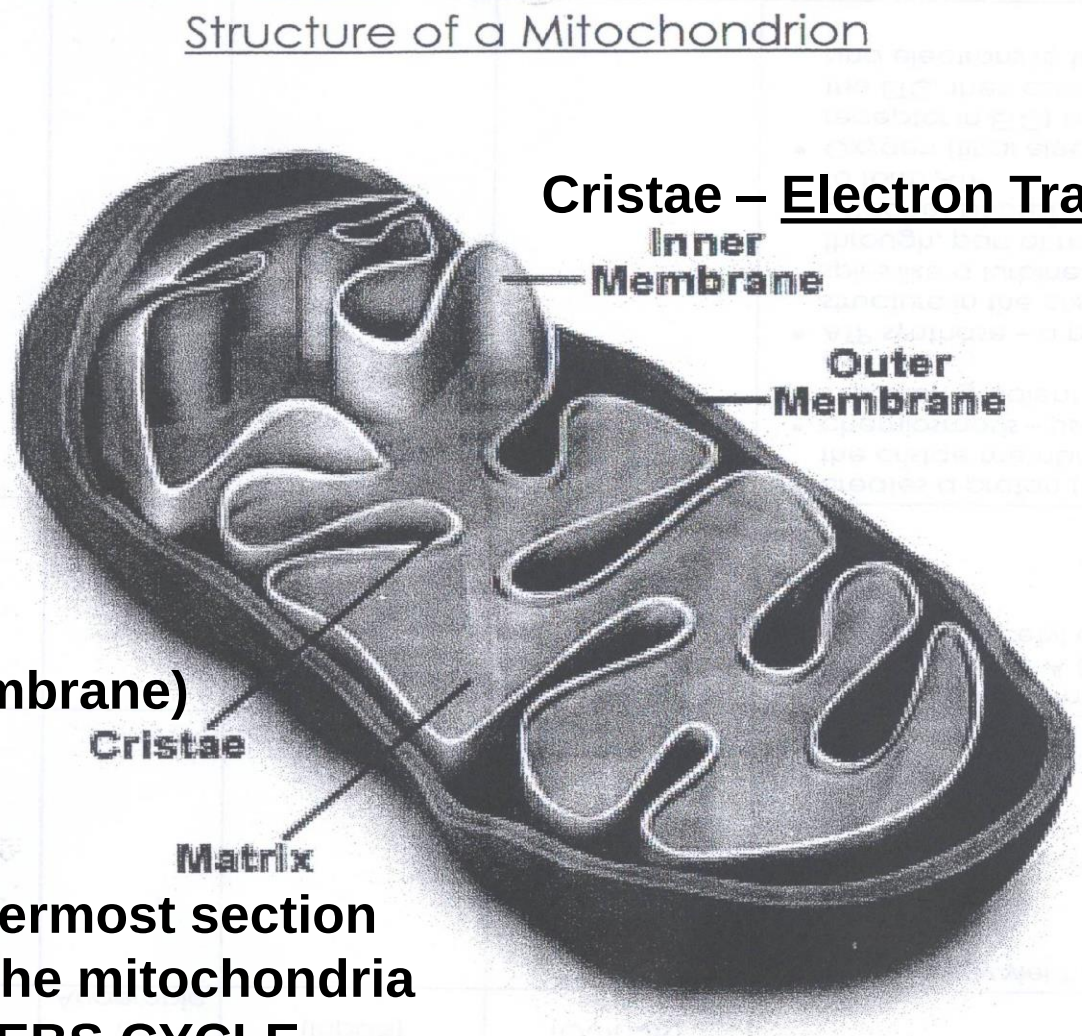
Aerobic Respiration Flowchart



SATII Material

Cytoplasm

<u>Glycolysis</u>

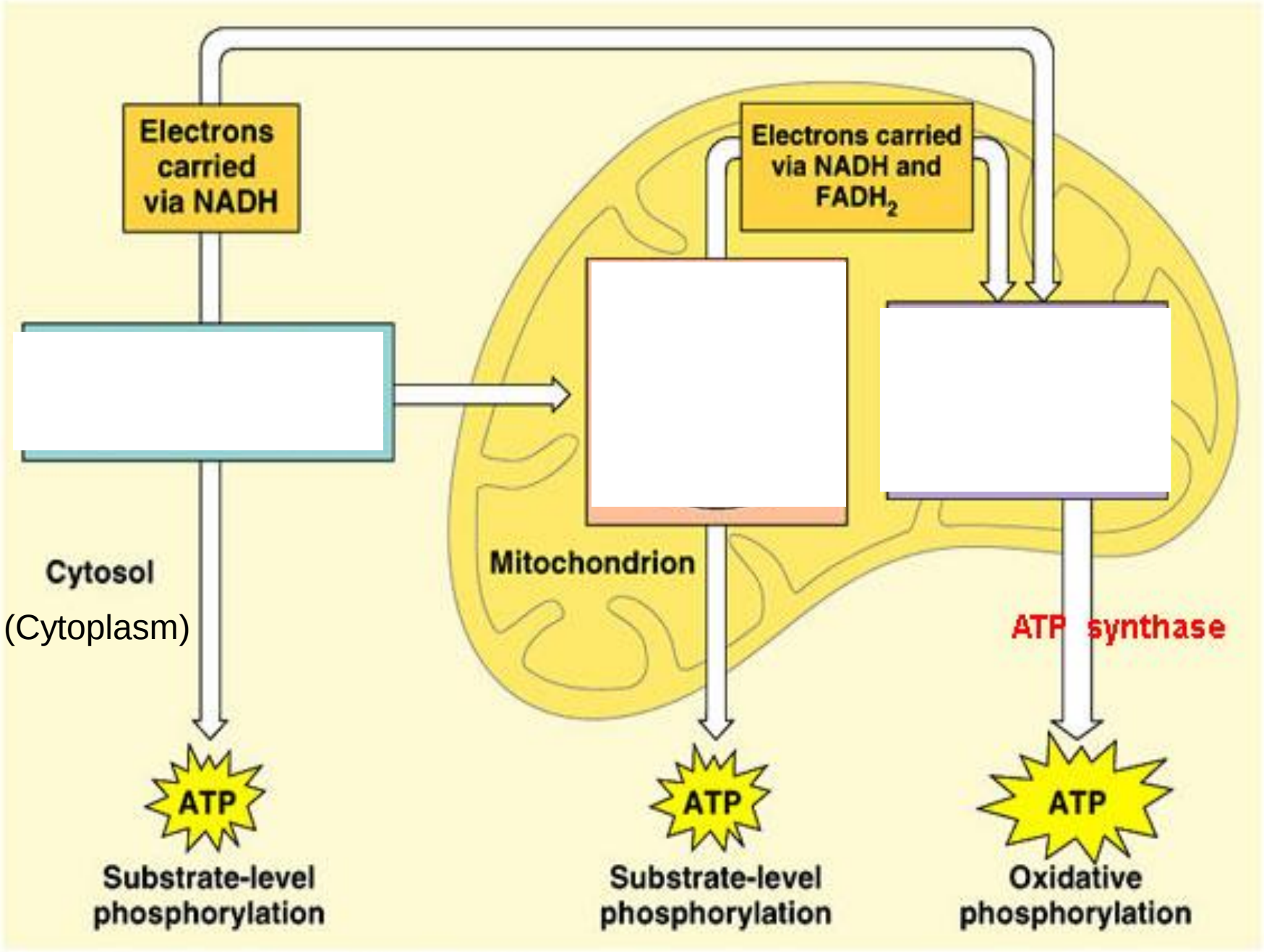


Cristae – <u>Electron Transport Chain</u>

(Inner Membrane)

Innermost section of the mitochondria

<u>KREBS CYCLE</u>



Process	Location	Aerobic or Anaerobic	Reactants (Inputs)	Products (Outputs)
Glycolysis **"splitting glucose"** Video	**Cytoplasm**	**Anaerobic: uses NO oxygen** **All cells can do it!**	**Glucose** **2 ATP needed for activation**	**2 molecules of pyruvic acid** **NADH** **4 ATP (net gain of 2 ATP)**
Krebs Cycle **AKA citric acid cycle** Video	**Matrix of mitochondria**	**Aerobic (needs O_2)**	**Oxygen** **2 Pyruvic Acids**	**CO_2 (waste)** **8 NADH** **2 $FADH_2$**
Electron Transport Chain	**Across the Cristae (mitochondria inner membrane)** ***In some prokaryotes, occurs across cell membrane**	**Aerobic (needs O_2)** **(occurs in plants, animals, algae and some bacteria!)**	**NADH** **$FADH_2$** **Oxygen (*final electron acceptor)**	**The most ATP (34)** **Water (waste)**

Process	Location	Aerobic or Anaerobic	Reactants (Inputs)	Products (Outputs)	Highlights
Glycolysis					▪ small energy yield but fast process
Krebs Cycle					▪ pyruvic acid (from glycolysis) combines with coenzyme A (made from Vitamin A) forming acetyl coA
Electron Transport Chain					▪ creates a proton (H+) gradient across the cristae membrane ▪ chemiosmosis – uses the stored energy in proton gradient to convert ADP to ATP ▪ ATP synthase – a proton channel structure in the cristae membrane that spins like a turbine, as protons move through, part of molecule turns and attaches phosphates to ADP molecules to form ATP ▪ Oxygen (final electron and proton receptor in ETC) pulls electrons through the ETC, then combines with protons and electrons to form water (waste)

Evolved first!

•Citric acid is constantly broken down and built up to produce high energy electron carriers!! (NADH and FADH2)