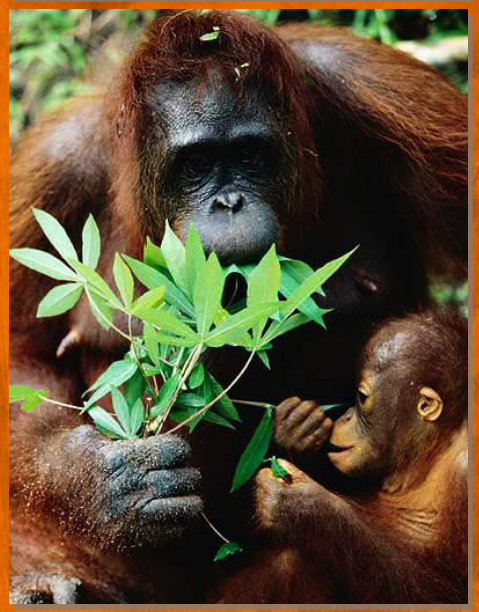

Cellular Respiration
Release of Energy From Food (glucose)!

Energy needs of life

- Animals are energy consumers
  - What do we need energy for?
    - synthesis (building for growth)
    - reproduction
    - active transport
    - movement
    - temperature control (making heat)



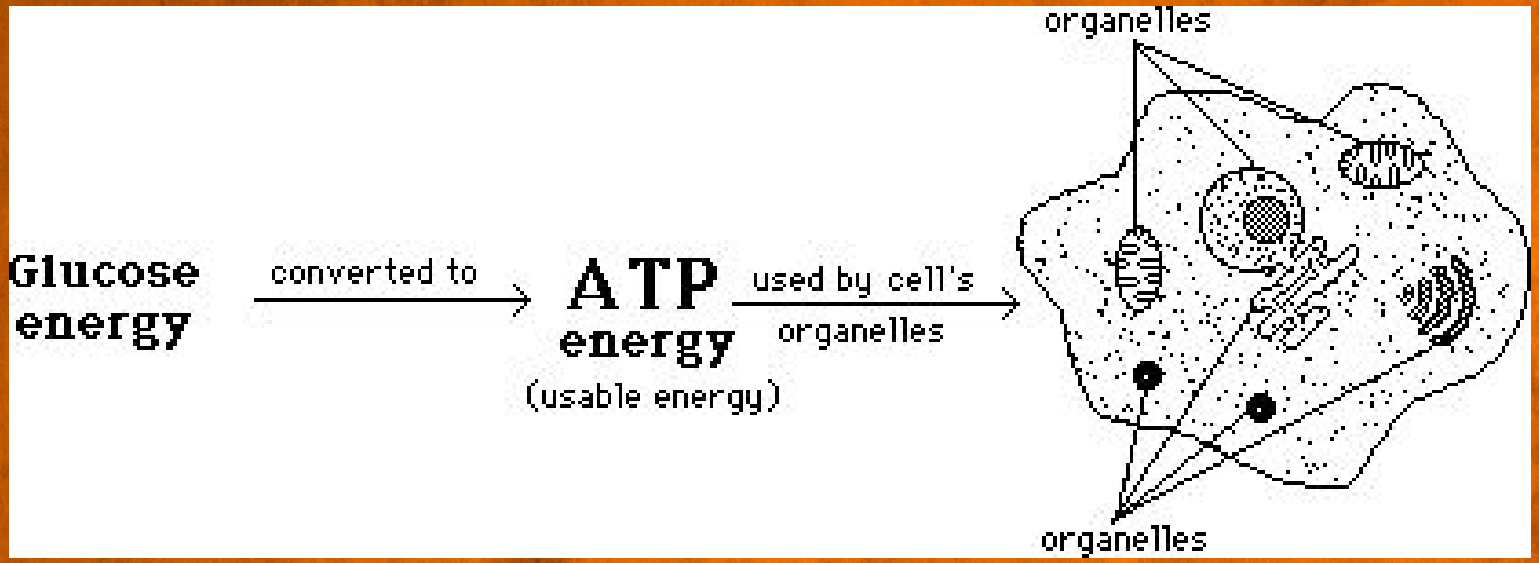
Where do we get energy?

- Energy is stored in organic molecules
  - carbohydrates, fats, proteins
- Animals eat these organic molecules → food (glucose)
  - digest food to get
    - fuels for energy (ATP)
    - raw materials for building more molecules
      - carbohydrates, fats, proteins, nucleic acids

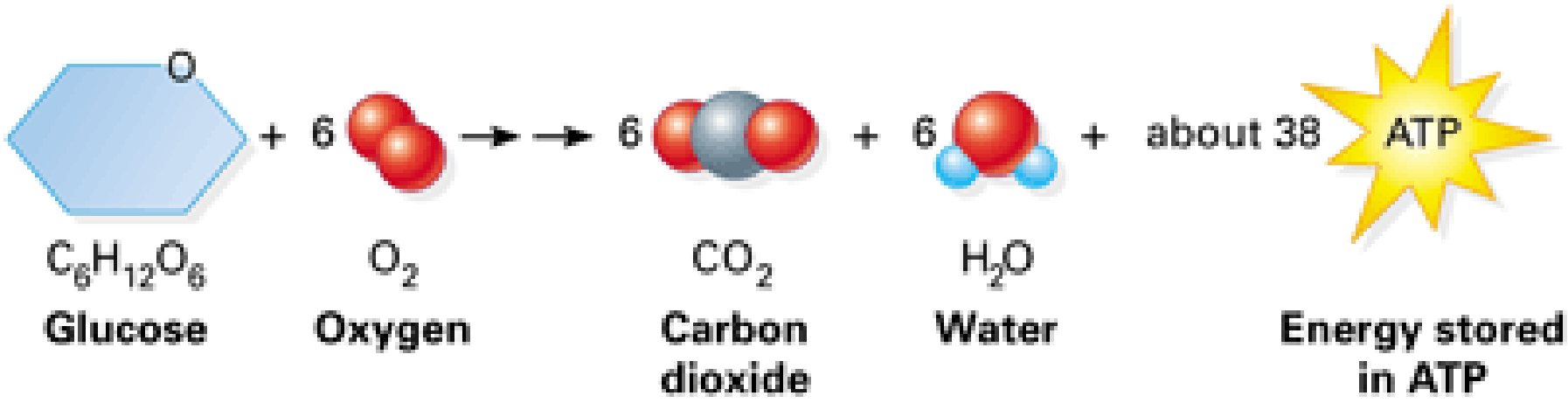
- Plants produce glucose through photosynthesis, but need to break down the sugar for energy use

Overview of Cellular Respiration

- Cellular respiration is the process that **releases energy** by breaking down glucose and other food molecules



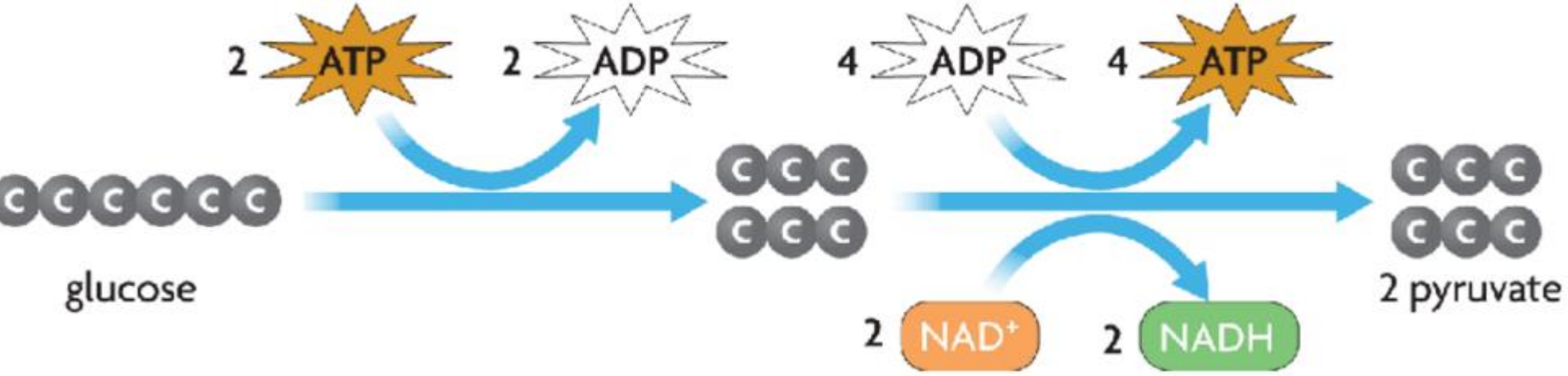
The Cellular Respiration Equation



What do you notice about the cell respiration equation in regards to the photosynthesis equation?

Glycolysis

- Means the **splitting** or **break-down** of **glucose** (the starting molecule of glycolysis)
- Occurs in **cytoplasm** of all **eukaryotic** cells (every organism)
- It does **not** require oxygen.
- A net gain of **2 ATP** is made during glycolysis.
- Forms 2 **pyruvate** (pyruvic acid)



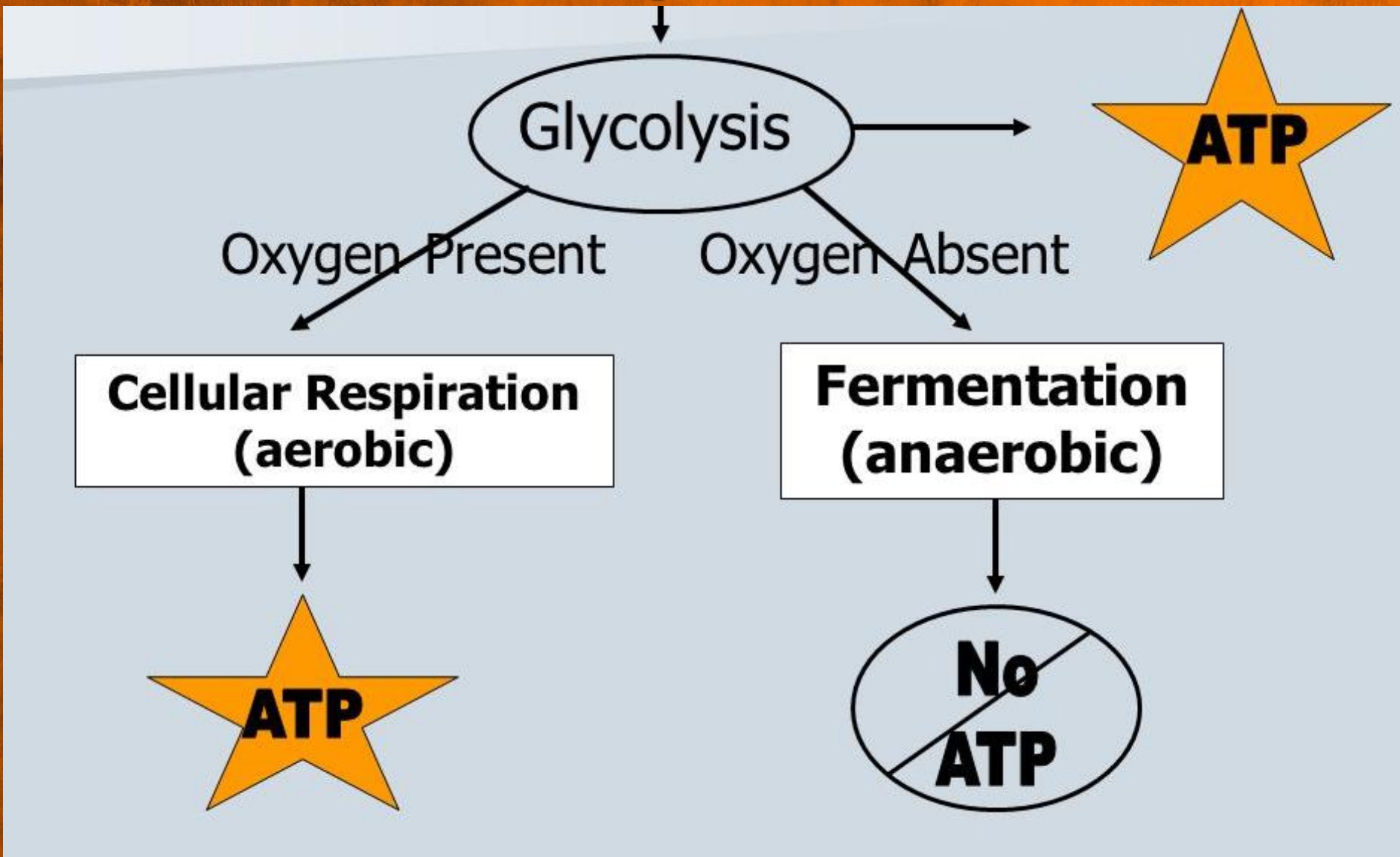
Energy Pathways

- All cells perform **glycolysis** first.
- The energy pathway that pyruvate takes at the end of glycolysis depends on the presence or absence of **oxygen**.
- <u>There are 2 pathways glycolysis can go through, Aerobic or Anaerobic</u>:

1. If there is **oxygen** available, pyruvate enters the **Krebs cycle** followed by the electron transport chain (**ETC**) in the **mitochondria= Aerobic respiration**

2. If oxygen is **NOT** available, pyruvate will undergo **fermentation = anaerobic respiration**

Aerobic vs. Anaerobic Respiration



AEROBIC Respiration

- When oxygen is present, there are 3 steps in cellular respiration

  - 1. Glycolysis
  - 2. Krebs Cycle
  - 3. Electron transport chain

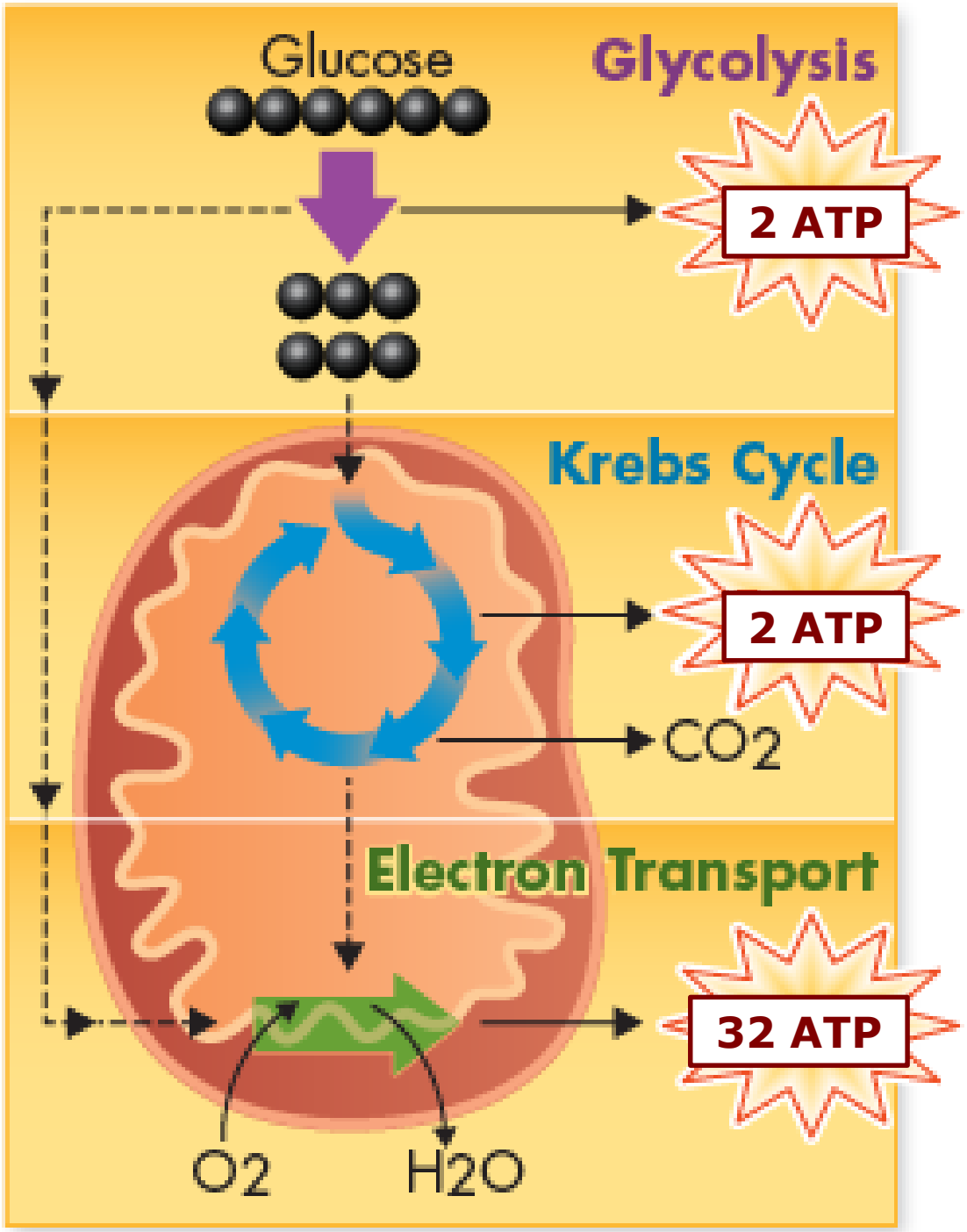
- These 3 steps ensure that energy is not lost as heat or light and that energy is released gradually or over a longer time (thus improving efficiency and effectiveness)

The Krebs Cycle/ Citric Acid Cycle

- Occurs in the mitochondria

- After glycolysis and in the **presence of oxygen**, pyruvic acid (pyruvate) is used in the Krebs Cycle.
- Here pyruvic acid (pyruvate) is broken down into acetyl Co-A and carbon dioxide in a series of energy extracting reactions
- Citric acid is the first product of the Krebs Cycle, hence its use as the alternative name citric acid cycle

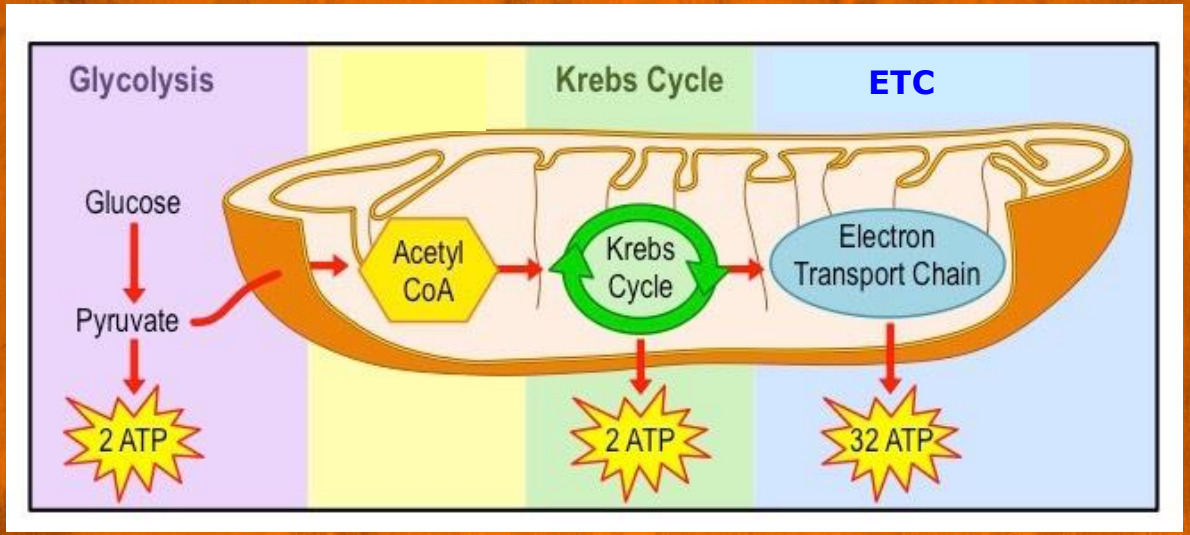
AEROBIC Respiration



Aerobic Respiration Totals

Energy produced per glucose molecule

- **Glycolysis = Net 2 ATP**
- **Kreb's Cycle = 2 ATP**
- **Electron Transport Chain = 32 ATP**
- **Total = 36 ATP per glucose molecule**



ANAEROBIC Respiration/ FERMENTATION

- After glycolysis, if no oxygen is available, fermentation occurs

- There are 2 types of fermentation:

  - 1. Alcoholic Fermentation

  - 2. Lactic Acid Fermentation

Alcoholic Fermentation

- Alcoholic Fermentation (in absence of oxygen)
  - yeasts and anaerobic bacteria do fermentation
    - Make bread, beer & wine
  - Creates ethyl alcohol (alcohol) and CO_2 as waste
  - This CO_2 is what causes bread dough to rise

Reaction:

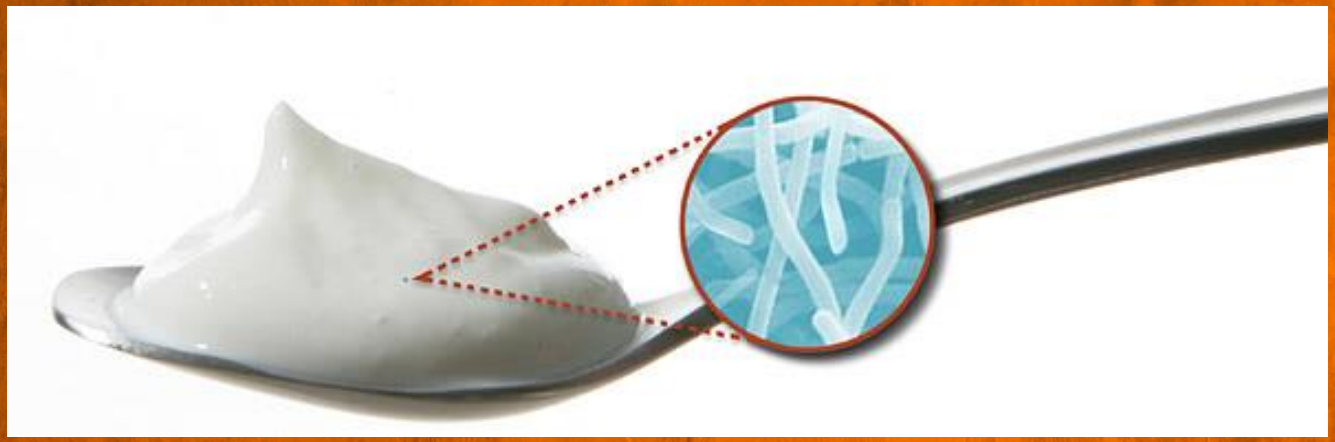
glucose $\rightarrow$ ATP + CO_2+ alcohol

yeast

bacteria

Lactic Acid Fermentation

- Lactic acid fermentation (in absence of oxygen)
  - Occurs in bacteria
  - In bacteria, this process is used to make yogurt
  - The bacteria convert the **lactose** (milk sugar) to lactic acid, which thickens the milk and gives it the tangy taste characteristic of yogurt



Reaction

- glucose $\rightarrow$ ATP + lactic acid

Lactic Acid Fermentation

- Lactic acid fermentation (in absence of oxygen)
  - Occurs in animals
  - is produced by muscles during rapid exercise when the body cannot supply enough oxygen to the tissues
  - Lactic acid fermentation occurs because the cells still need to generate usable energy when oxygen is not present in cells and they CANNOT wait for more
  - Muscle cells can continue to produce ATP through glycolysis when oxygen runs low using lactic acid fermentation, but muscle fatigue and pain may result.

Lactic Acid Fermentation

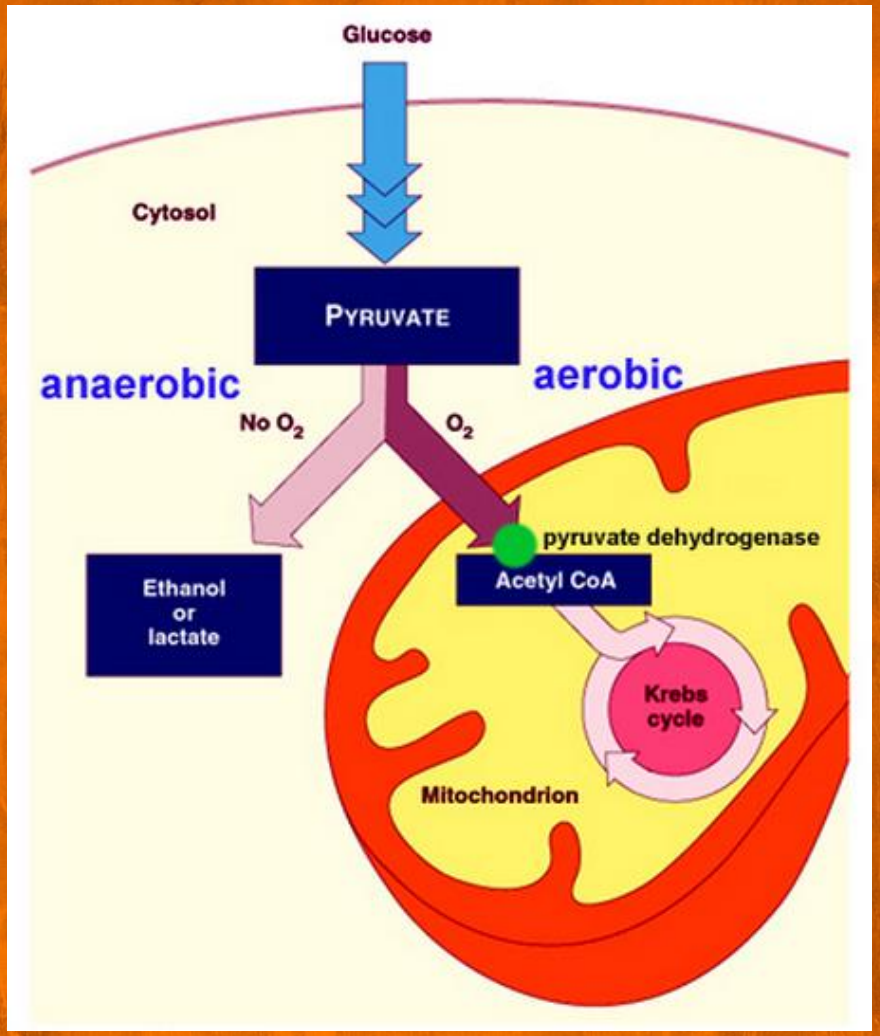
Think about an athlete… if he doesn't have enough energy he can't keep running… so his cells must produce energy whether they are getting enough oxygen or not!

- Why should athletes pace themselves while running long events?
  - Sprinting causes lactic acid build up
  - An efficient circulatory system (blood/heart) will deliver oxygen to break down lactic acid
  - Humans can only sprint for limited periods of time

Anaerobic Respiration Totals

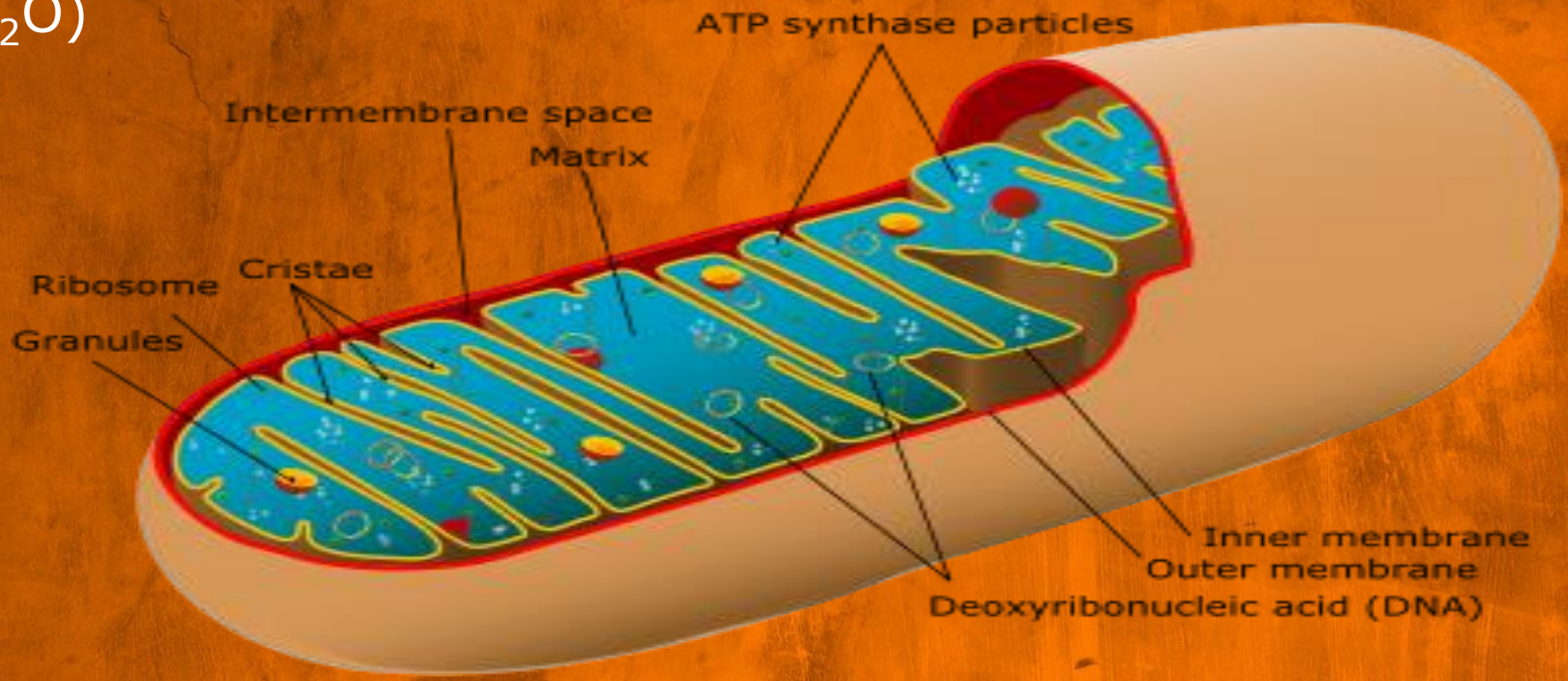
Energy produced per glucose molecule

- **Glycolysis = Net 2 ATP**
- **Fermentation = 0 ATP**
- **Total = 2 ATP per glucose molecule**



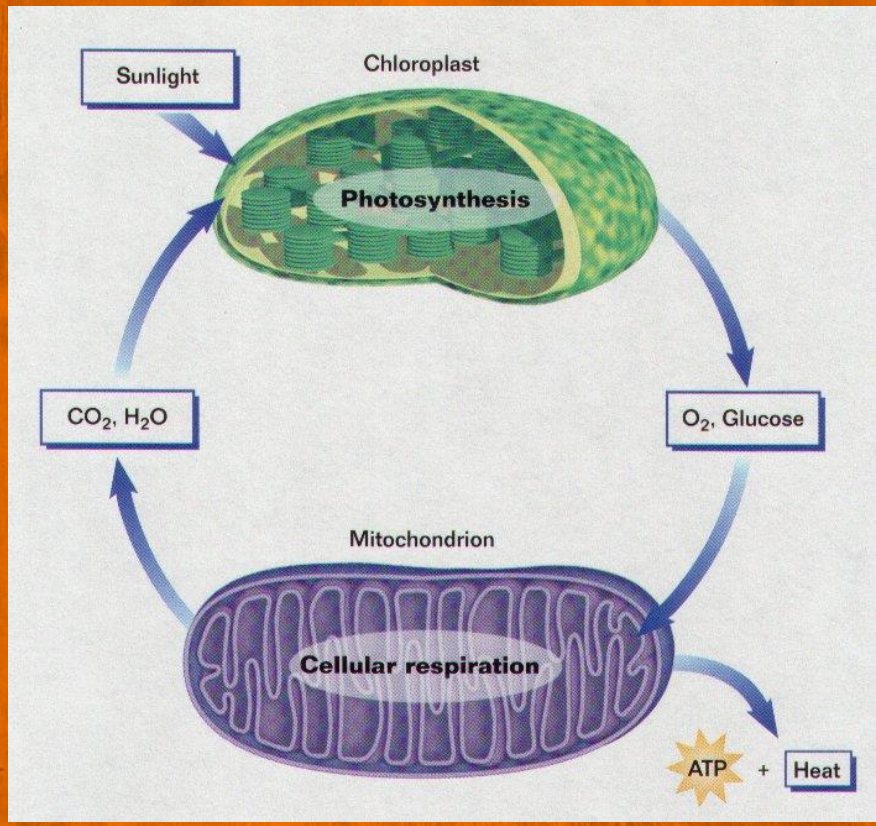
Mitochondria

- Site of aerobic cellular respiration; occurs in both plants & animals (most organisms).
- Energy conversion that takes place in mitochondria= the energy in the bonds of glucose molecules is transferred to the phosphate bonds in ATP.
- The oxygen we breathe comes from the splitting of water (H_2O)



Photosynthesis vs. Cellular Respiration

- Almost opposite processes
  - Photosynthesis removes carbon dioxide from the atmosphere
  - Cellular respiration puts carbon dioxide back into the atmosphere
  - The reactants (raw materials) of one are the products of the other
- Energy is captured and stored in the chloroplast and released in the mitochondria.
- How would both diagrams differ?
  - Light is the main energy source for photosynthesis, while glucose is the main energy source for cellular respiration!



Photosynthesis vs. Cellular Respiration

- Photosynthesis is light-energy dependent

- Cellular Respiration is light-energy independent

Practice Question

- Which organisms carry out photosynthesis?

- Which organisms carry out cellular respiration?