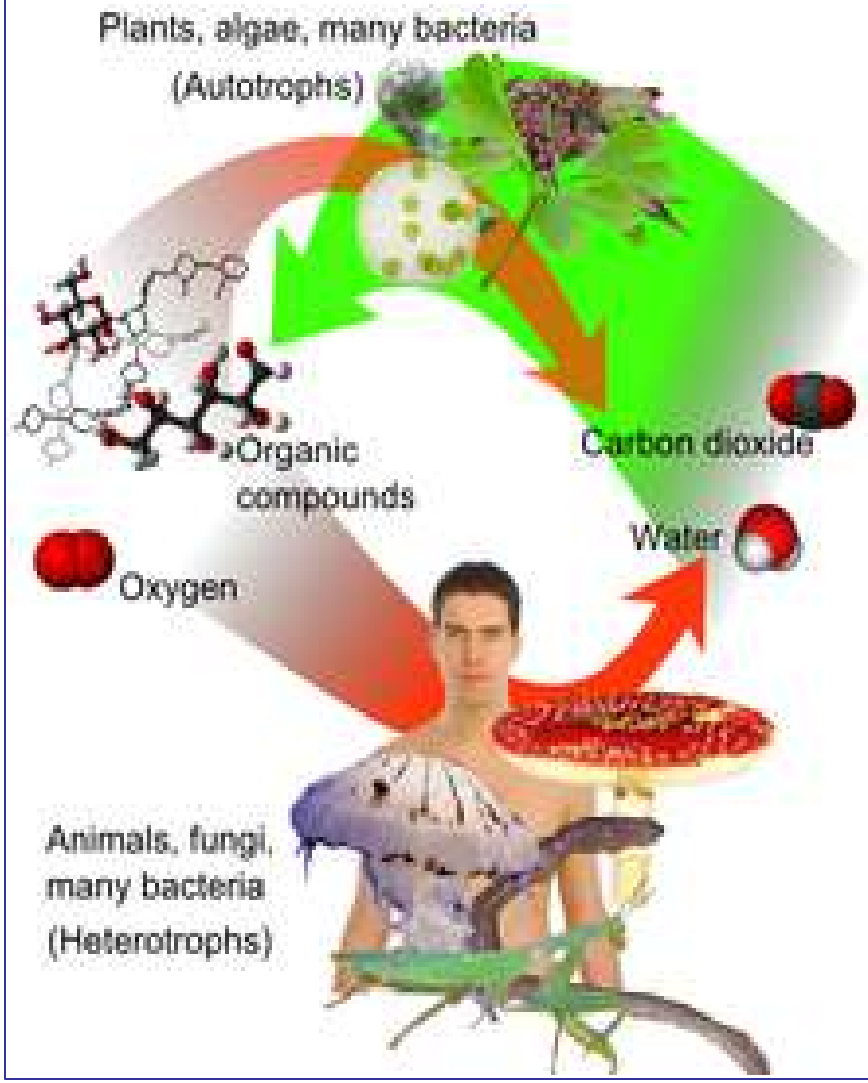


Cellular Respiration Chapter 9

Aerobic Respiration – Equation

$$C_6H_{12}O_6 + \underline{6}\ O_2 \longrightarrow \underline{6}\ H_2O + \underline{6}\ CO_2 + 36\ ATP$$

food (glucose, a carbohydrate)

oxygen

water

carbon dioxide

energy molecule

Does this look familiar?

The BIG Question is…

Do only animals respire?

Or do plants respire too?

- **Only plants** perform photosynthesis
- **Plants AND animals** perform cellular respiration!

(Can you explain why??)

Energy Review

- **Energy Storing Molecules**
  - ATP, NADPH (NAD^+), FADH (FAD^+), $FADH_2$
- **@ATP** supplies most of the energy that drives metabolism in living things@
- ATP *releases* energy when converted into ADP

Cellular Respiration Overview
Chapter 9-1

- **Living things get most of the energy they need from glucose.**
  - Autrotrophs make glucose using photosynthesis
  - Heterotrophs get glucose from food they eat
- **Cellular Respiration**
  - The process that releases energy by breaking down glucose and other food molecules in the presence of oxygen.

Cellular Respiration Overview

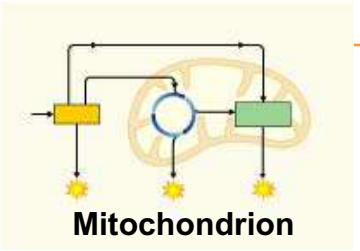
- Cellular Respiration Overall Equation

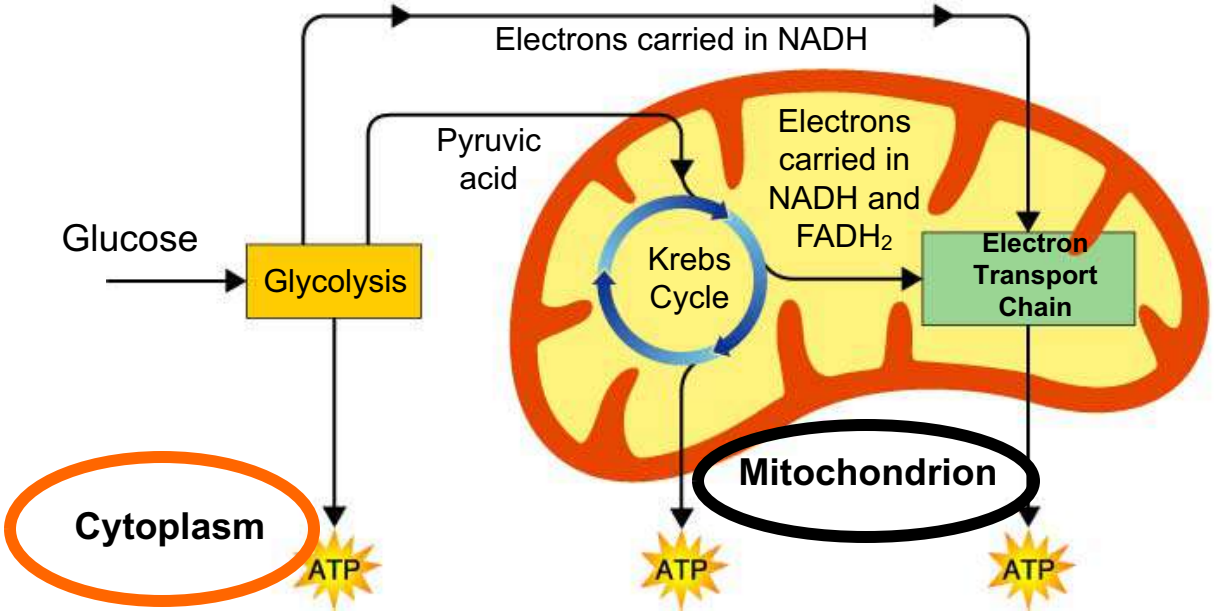
  $6O_2 + C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O +$ Energy

- Three Stages
  1. Glycolysis
  2. Kreb's Cycle
  3. Electron Transport Chain
- The Main form of Energy produced = ATP

Figure 9–2

Cellular Respiration: An Overview





Glycolysis

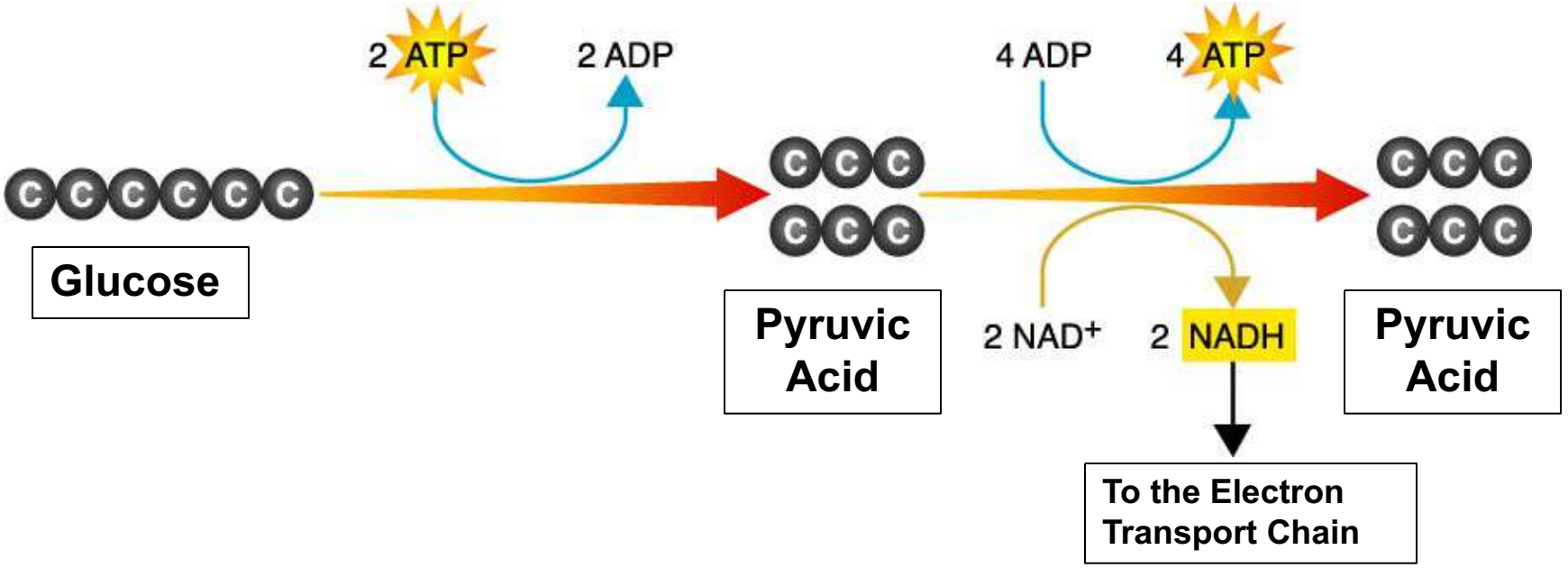
- Glyco = Glucose lysis = Breakdown
- Occurs in the cytoplasm of the cell
- @Molecules of GLUCOSE are broken down into 2 molecules of Pyruvic Acid.@
- Cell must use (invest) 2 ATP
- Produces Energy Carrier Molecules
  - 4 ATP
  - 2 NADH

Glycolysis

- http://highered.mcgraw-hill.com/sites/0072507470/student_view0/chapter25/animation__how_glycolysis_works.html

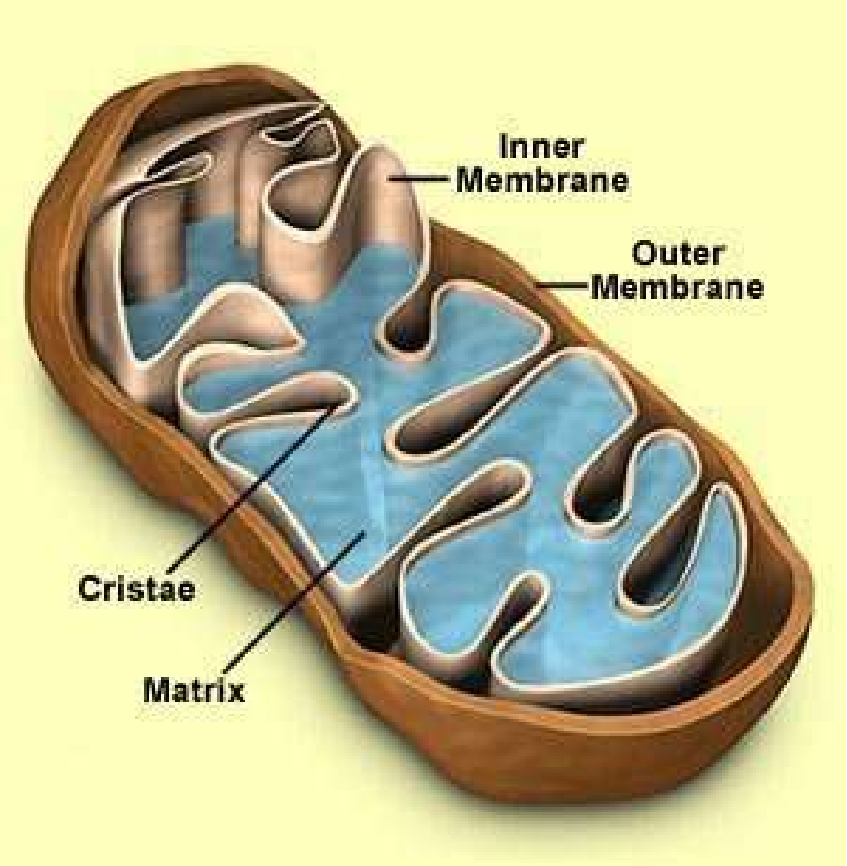
Pyruvate = Pyruvic Acid

Glycolysis


2 ATP
2 ADP
4 ADP
4 ATP
C C C C C C
Glucose
C C C
C C C
Pyruvic Acid
2 NAD+
2 NADH
C C C
C C C
Pyruvic Acid
To the Electron Transport Chain

The “Mighty” Mitochondria

- @The mitochondria is the organelle where the final stages of cellular respiration occurs.@
  - Kreb’s Cycle
  - Electron Transport Chain
- Cells that use a lot of energy have high numbers of mitochondria.
  - Example: Muscle cells in the heart!!



Kreb's Cycle
Chapter 9-2

- @Aerobic Process =Only if oxygen is present!@
- Occurs in the MATRIX of the mitochondria
- Pyruvic Acid from Glycolysis enters to form
  - 1 ATP
  - 3 NADH
  - 1 $FADH_2$
  - CO_2 *(which is released when we exhale!!)*
- AKA….Citric Acid Cycle

Kreb's Cycle

- http://highered.mcgraw-hill.com/sites/0072507470/student_view0/chapter25/animation__how_the_krebs_cycle_works__quiz_1_.html

Electron Transport Chain
Chapter 9-2

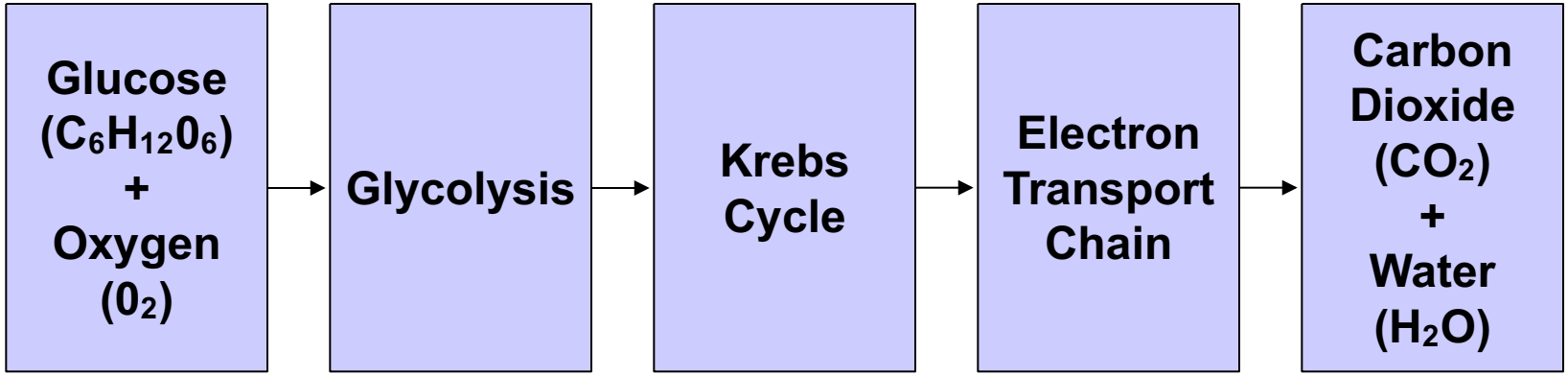
- Energy carrier molecules produced during Glycolysis and the Kreb's Cycle enter the ETC
  - NADH
  - $FADH_2$
- Occurs in the folds of the Inner Membrane of the Mitochondria (Cristae)
- The electrons are passed down a chain of proteins until they reach the final electron acceptor…..oxygen!
  - So this step is aerobic (requires oxygen)
- @The ETC produces 32 ATP and H_2O@

Electron Transport Chain

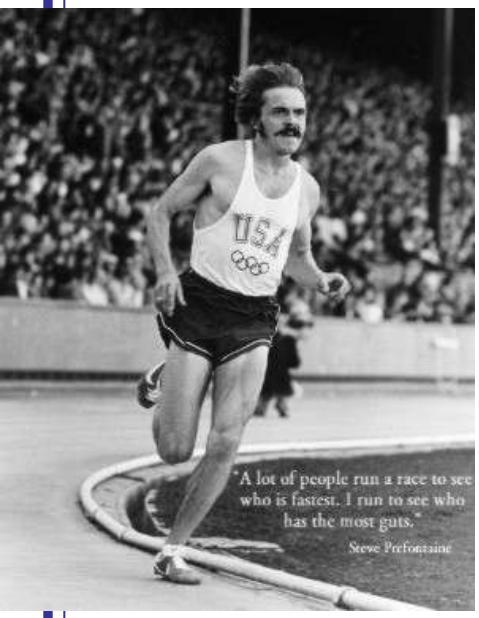
- http://highered.mcgraw-hill.com/sites/0072507470/student_view0/chapter25/animation__electron_transport_system_and_atp_synthesis__quiz_1_.html

The chain then repeats in the same way with $FADH_2$

Cellular Respiration Flowchart



What happens if



NO OXYGEN

is available??

The Kreb's Cycle and Electron Transport Chain can't function!!

These are anaerobic conditions!!

Fermentation

- The cell can use Fermentation instead!!
- Occurs in the Cytoplasm
  - Just like glycolysis!!
- Fermentation
  - A series of reactions that convert NADH (from glycolysis) back into NAD allowing glycolysis to keep producing a small amount of ATP

2 Types of Fermentation

- Alcoholic Fermentation
  - Yeasts use this process to form ethyl alcohol and carbon dioxide as waste products.
    - This causes bread dough to rise
    - This is how some alcoholic beverages are made

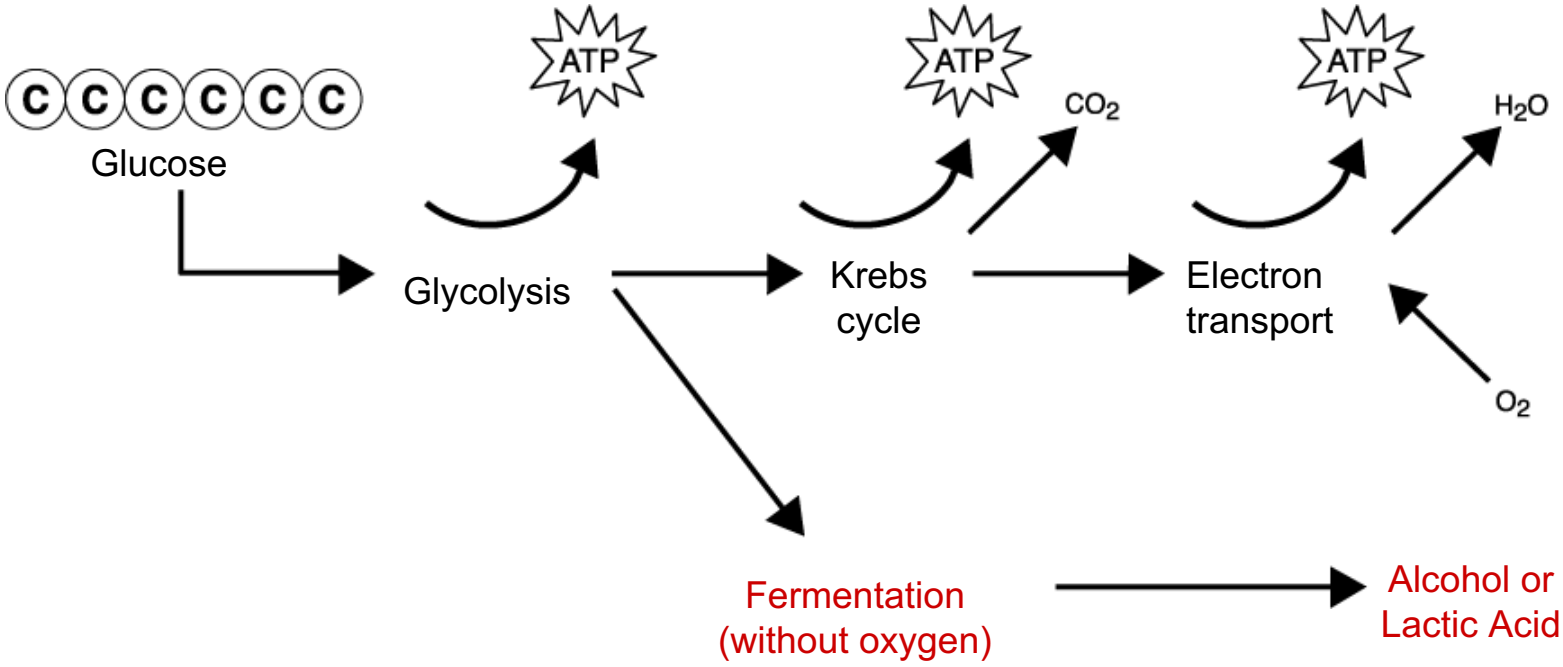
Pyruvic Acid + NADH $\rightarrow$ alcohol + CO_2 + NAD+

Lactic Acid Fermentation

- Occurs in bacteria (unicellular organisms)
  - This is how cheese, yogurt, and pickles are made.
- Occurs in muscles during rapid exercise
  - When your body runs out of oxygen your muscle cells must produce some ATP using fermentation and glycolysis
  - Lactic Acid build-up causes muscle soreness or burning after intense activity.

Pyruvic Acid + NADH $\rightarrow$ lactic acid + NAD+

Chemical Pathways



Comparing ATP Production

- First, your body breaks down glucose through **aerobic respiration** to produce **36 ATP per glucose molecule**; however, this is a slow process.
- When muscle cells cannot get enough O_2 they break down glucose through **lactic acid fermentation** to produce **2 ATP per glucose…**
- @Therefore, AEROBIC RESPIRATION is much more efficient in terms of ATP production @– 36 ATP compared to 2 ATP!

Where is glycolysis performed in the cell and what does it produce?

- In the cytoplasm
- 4 ATP
- 2 NADPH
- Makes pyruvate (pyruvic acid)

Where does the Kreb's cycle occur and does it use oxygen?

- Matrix of the mitochondria
- Aerobic process

If no oxygen is present after glycolysis, what process occurs? Is this a more efficient pathway?

- Fermentation
- No, aerobic makes 36 ATP whereas anaerobic makes 2ATP.