Fuel for the Body
Glycolysis

GK-12 Theme Based Lesson
Molecules to Muscles
**Vocabulary**

- **Glycolysis** – the *breakdown of sugar* in the body
- **Isomers** – compounds with the *same chemical formula but different structures*
- **Phosphorylation** – addition of a *phosphate group* ($\text{PO}_3^{2-}$) to a molecule
- **Fermentation** – breakdown of glucose in the *absence* of oxygen; *no ATP can be produced*
- **Respiration** – breakdown of glucose in the *presence* of oxygen; *ATP continues to be produced*
Glycolysis: Overall Picture (p. 873)

- 2 molecules of ATP produced for every molecule of glucose used
- EXCELLENT energy source
Glycolysis: Step 1

Add a phosphate group to carbon #6 (phosphorylation).

What you’ll need to know for the test:

Each circle represents a carbon atom. The different color means the carbon is phosphorylated.
Glycolysis: Step 2

Isomerization

Both of these molecules have the chemical formula $C_{6}H_{11}O_{10}P$

**Question:** Do you think these compounds would have similar properties?
Glycolysis: Step 3

Add a phosphate group to carbon #1 (phosphorylation).

Fructose-6-phosphate → Fructose-1,6-diphosphate

Phosphofructokinase

ATP Counter: -2
Glycolysis: Step 4

This is the step that gives us the name **glycolysis**. The fructose is split into two smaller molecules.

Fructose-1,6-diphosphate $\xrightarrow{\text{Aldolase}}$ Dihydroxyacetone phosphate + Glyceraldehyde 3-phosphate

ATP Counter: -2
Glycolysis: Step 5

Isomerization

Both of these molecules have the chemical formula $\text{C}_3\text{H}_5\text{O}_6\text{P}$
Only “G-3-P” is used in Step 6, so the isomerization equilibrium is pulled toward “G-3-P”

**Question:** What is this principle called?

**Answer:** LeChatelier’s Principle
Glycolysis: Step 6 (2 molecules)

Oxidation of carbon #1 AND phosphorylation

\[
\begin{align*}
\text{Glyceraldehyde 3-phosphate} & \quad \rightarrow \quad \text{1,3-diphosphoglyceric acid} \\
\end{align*}
\]

The phosphate comes from inorganic phosphate, which is always floating around in the cell

**Question:** Why don’t cells just use inorganic phosphate to produce energy?

**ATP Counter**

-2
Glycolysis: Step 7 (2 molecules)

Production of ATP (finally!)

Reactive!

1,3-diphosphoglyceric acid

2 ADP  →  2 ATP

Phosphoglycerokinase

3-phosphoglyceric acid

Our ATP counter is now officially at ZERO.

**Question:** Is the *production* of ATP energetic?

Or is it the later *use*?
Glycolysis: Step 8 (2 molecules)

Isomerization

Both of these molecules have the chemical formula $\text{C}_3\text{H}_5\text{O}_8\text{P}$
Glycolysis: Step 9 (2 molecules)

Dehydration to produce an enol (alcohol + alkene in the same molecule)

\[
\begin{align*}
\text{2-phosphoglyceric acid} & \xrightarrow{\text{Enolase}} \text{Phosphoenolpyruvic acid} + \text{H}_2\text{O} \\
\end{align*}
\]

Identify the alkene and the alcohol (actually a carboxylic acid)

What is dehydration?

ATP Counter: 0
Glycolysis: Step 10 (2 molecules)

Final production of ATP

Phosphoenolpyruvate

Pyruvate kinase

Pyruvate

It took 10 steps to show a gain of ATP!

ATP Counter
+2
Respiration

- Respiration - breakdown of glucose in the presence of oxygen; ATP continues to be produced

- Slow, continuous movements
  - Breathing
  - Slow walking
  - Paced exercise

- 30 ATP molecules produced per glucose in respiration!!

\[
\begin{align*}
2 \text{Pyruvic acid} & \xrightarrow{\text{Respiration}} \text{CoA} \xrightarrow{\text{CoA}} \text{Acetyl CoA} \\
\text{NAD}^+ & \xrightarrow{\text{NADH + H}^+} \text{CO}_2 \\
\text{To Krebs Cycle} & \\
\end{align*}
\]
Fermentation

- **Fermentation** – breakdown of glucose in the *absence* of oxygen; **no ATP can be produced**
- **Fast, quick bursts** of movement
  - Sprinting
  - Weightlifting (usually)
- Fermentation causes the “burn” felt during intense exercise (lactic acid)

\[ \text{2 Pyruvic acid} \xrightarrow{\text{Fermentation}} \text{Ethanol} + \text{CO}_2 + \text{Lactic Acid} \]

FEEL THE BURN!
Importance of Fermentation

- **BEER!**
- Yeast ferments “wort” to produce alcohol and CO$_2$
- Other applications in food:
  - Wines
  - Cheese
  - Bread (especially sourdough)
Homework (kinda...)

- Hold a piece of UNCOOKED pasta in your mouth for about 15 minutes. What happens to the flavor after a while?
  - Pasta (starch in general) is a polymer of glucose units. Your saliva will eventually break the bonds between glucose units, liberating single glucose molecules. This is what produces the sweet flavor.
  - Ironically, cellulose is an isomer of starch. Only one connection is changed, and that renders it inedible.
Questions?

- Why does sour cream have an expiration date?
- What is the speed of dark?
- When will all the rhetorical questions end?
- How much deeper would the ocean be without sponges?
- What was the best thing before sliced bread?
- Where can I buy powdered water?
- If you’re in a car travelling at the speed of light and you turn your headlights on, what happens?
- Does PetsMart sell dognip?