MP3 Tutor Topic: Cellular Respiration Part 1–Glycolysis
Estimate Time: 8:51
Vocabulary: enzyme, glycolysis, mitochondria

Hey there. This is Eric Simon and welcome to another MP3 Tutor session. Did you ever have one of those days that you just couldn't seem to get going? Low energy and no drive? Today was like that for me until I remembered that I had skipped breakfast. By the end of my second lecture, I was really running low on fuel. Naturally, I downed some food and I now I'm back up and running.

The meal that I ate provided energy in the form of food. Food is fuel or chemical energy that powers our cells. Cellular respiration is the process that cells use to extract energy from food. This tutor session is actually part one of two audio sessions on the topic of cellular respiration. Both tutor sessions are organized around a single graphic brochure that will help you to organize your learning. So, if you have access to pencil and paper, round them up. But if you don't right now, don't worry; you should still be able to follow along. Let's get started!

Take a standard piece of paper and fold it into thirds—as if you were folding a business letter—to make a three-part brochure. You will fill out this brochure to summarize cellular respiration. Orient your folded brochure so that the long sides are vertical and the cover or outside page opens up to the left like a book.

On the cover, let's put cellular respiration into a global context:

- Halfway down, on the right-hand side, write the term, "Cellular respiration."
- Directly to the left of this, write the term "Photosynthesis."

How are these two processes related? Photosynthesis uses sunlight energy to build sugar from carbon dioxide and water. Let's show this in a diagram. Imagine a circle in the center with the terms "Photosynthesis" at 9 o'clock and "Cellular respiration" at 3 o'clock.

- On your diagram, place the raw materials for photosynthesis at 6 o'clock: CO_2 and H_2O.
- At 12 o'clock, put the products of photosynthesis: glucose and oxygen.
- Connect the circle together with a large circular arrow pointing in a clockwise direction. The cycle you have just drawn is the basis of the carbon cycle in the biosphere.
- Draw a sun in the upper left-hand corner of your page and a jagged arrow from the sun to the term photosynthesis. This indicates incoming light energy.
- On the other side of the diagram, draw a jagged arrow that exits the circle from the term cellular respiration. Point this arrow to two phrases: "ATP for cell work" and "Heat lost."

Your diagram now shows that energy is not recycled, it flows through the system, entering as sunlight, powering work, and dissipating eventually as heat. You can add other items and titles to the cover to suit yourself—maybe the names of organelles involved, or a smaller diagram that shows how breathing is related.

Let's now explore cellular respiration at the cellular level.

Most cells depend on chemical energy in the form of glucose. Glucose stores a great deal of energy—too much to release at once in a cell and way more than needed to power the individual chemical reactions. For this reason, a cell has to break down glucose into smaller chunks of energy that can later be used to power other reactions. The smaller chunks of energy are stored as the molecule ATP. ATP is an important product of cellular respiration.

In the cell, energy is extracted from glucose via multi-step pathways that occur in the cytoplasm and in the **mitochondria**. Energy extraction begins with the process of **glycolysis** in the cytoplasm. Only a small amount of available energy is extracted in glycolysis and oxygen is not required to extract it. Most of the energy available in food is extracted in the mitochondria utilizing two distinct processes: the citric acid cycle and the electron transport chain. These two processes do require oxygen. Try to keep this big picture in mind:

glycolysis→citric acid cycle→electron transport chain

For now, let's focus on the first steps of energy processing: glycolysis.

Glycolysis is like an assembly line, or in this case a disassembly line. A number of different **enzymes** in the cytoplasm play a role in taking apart a glucose molecule. In any pathway like this, there are inputs and outputs. These are the important things for you to remember. The individual details of each step are not quite as important.

Let's move back to the brochure now. Open your brochure and turn it over to the blank side. You will see three panels marked by creases in the paper. On the left-most panel, let's diagram the inputs and outputs of glycolysis.

- At the center of the top of this panel, write the title of this section, "Glycolysis."
- Immediately below this term, indicate that this process takes place in the "Cytoplasm." Also indicate that this step does not require oxygen (maybe write "O_2" with a circle and a slash through it).
- Skip a few lines until you are about $^1/_4$ of the way down the page. Here indicate the starting material, "Glucose." To keep track of the carbons during glycolysis, write "6C" in parentheses after the word glucose to remind you that glucose has six carbons.
- Below glucose, about halfway down, enter the term "2 Pyruvic Acids." Write "2 times 3C" after pyruvic acid, since each pyruvic acid molecule contains three carbons. Pyruvic acid is one of the main outputs of glycolysis and these molecules have quite a bit of energy still left to be extracted.
- Immediately below the pyruvic acid add the term "4 ATP."
- Connect glucose to pyruvic acid with a large arrow that symbolizes the multi-step process of glycolysis.
- To the left of this arrow write "2 ATP" with an arrow flowing into the large arrow. This is another input. Two ATPs are required to start up glycolysis.
- To the right of the large arrow, draw a semi-circle arrow that flows into and then out of the large arrow. Label the incoming (or input) arrow with the term "2 NAD+." Label the outgoing (or output) arrow with the term "2 NADH."
- Near the bottom of the page draw a line and label it: "The Bottom Line." Under it, write "2 Net ATP." This is the final output, and this completes our diagram of glycolysis.

Your diagram shows you a quick summary of glycolysis:

- The inputs are glucose, 2 ATP, and 2 NAD+.
- The outputs are pyuvic acid, 4 ATP, and 2 NADH.

The big result from glycolysis is the production of two molecules of ATP. This is useful cellular energy, but just a smidge. What about the other two products of glycolysis, pyruvic acid and NADH? Both of these products have potential energy that the cell can tap to produce much more ATP. However, unlike glycolysis, oxygen must be available to extract this remaining energy within the mitochondria. In the next MP3 Tutor session, we'll complete this brochure as we cover the remaining steps of cellular respiration.

I hope this has helped you understand glycolysis. Don't forget to study all of your resources. There is a fair bit of material within your textbook and on your CD-ROM to help you with this topic. Good luck!