Cellular Respiration Tutorial

By Lori Armstrong

Course
BIO 111 (Introduction to Biology)

Description
This module is a tutorial on cellular respiration. Students will follow directions provided by their instructor to complete the module. The tutorial includes colorful diagrams, text, animation, labeling exercises, and a multiple-choice quiz to enhance and test the students' knowledge of this complex subject material. The module utilizes a CD-ROM available from the textbook publisher (*Essential Study Partner for Biology*, 7th ed., by Sylvia Mader; ISBN 0-07-2387274-0).

Transferability
Many introductory biology courses, microbiology, and physiology courses cover cellular respiration. While this module is based on a CD-ROM available through my textbook publisher (Text: *Inquiry into Life*, 9th ed., by Sylvia Mader; Publisher: McGraw-Hill Higher Education), many texts have similar CD-ROMs available, and this module could be adapted to meet the instructor's specific needs.

Faculty Technology Skill
Faculty should have basic computer skills. This includes being able to install CD-ROM onto hard drive (*Essential Study Partner* and *QuickTime* for Windows) by following instructions provided with CD-ROM or onscreen during installation process. Use of this CD-ROM and module involves mostly pointing and clicking. A tutorial is available in help the menu that describes function of icons, navigation aids, and use of study partner.

Student Technology Skill
Technology requirements are the same as that of faculty.

Faculty Equipment
A computer with a CD-ROM drive and a copy of the CD-ROM are required.

Student Equipment
Students need a computer with CD-ROM drive, a copy of *Essential Study Partner* CD-ROM, and a printer. Though not required for this module, there is a link to textbook website available, which would require Internet access for students to use.

Cost
The CD-ROM will cost approximately $15.00 per student.

Improvement on Teaching and Learning
For students, learning about cellular respiration can be difficult to conceptualize. By including diagrams, descriptions, labeling exercises, animation, and summary quiz, students get to participate in an interactive learning process, which I think they will find

beneficial and more enjoyable. It will also enable them to visualize what they have been presented in lecture over the subject.

Nontechnology Comparison

The subject of cell respiration can be very confusing for students. I like that this module gets the student more involved in the learning process, and I think it will reinforce material that has been presented in lecture.

How to Use in the Classroom

I envision this to be used as a tutorial that students complete outside the classroom. Some of the diagrams and animations could also be used to enhance lecture over this subject matter; this would require computer (with CD-ROM drive) access in the classroom, as well as a projection device and screen (whiteboard or smartboard) for the students to be able to see clearly.

Cellular Respiration Tutorial Module

By Lori Armstrong

1. To access the cell respiration tutorial, click on "Start," then "Programs." Then, click on "Biology 7e Mader ESP" and "Start ESP."

2. Click on the "Cells" icon. Under the list of topics, click on "Respiration." This unit includes the following sections: Introduction, Glycolysis, Transition (Reaction), Krebs Cycle, Electron Transport, Fermentation, Summary, Other Nutrients, and a Quiz.

3. Click on "Introduction" to begin. This figure shows an overview of the processes involved in aerobic (oxygen-requiring) cellular respiration and fermentation, an anaerobic process that does not utilize oxygen. Use your mouse to drag the arrow over each of the terms in the right-hand column (i.e., glucose, glycolysis, etc.). When you do this, the stages of respiration in which that process occurs or substance is used or produced will be highlighted with the color yellow. Remember, you can always click on "print" next to the leaf icon if you would like a hard copy to study.

4. Click on "" to proceed to a more detailed discussion of glycolysis. The first diagram shows a summary of the steps of aerobic cellular respiration. Click on "" again to begin an in-depth look at the process of glycolysis. Notice on this first diagram that two ATP molecules are "invested" in glycolysis. This small investment will ultimately lead to a large ATP "profit" if oxygen is available.

   Again, by dragging (do not click on anything) the mouse arrow over the steps, the corresponding stage in the diagram will be highlighted in yellow.

5. Click on "" to see the next steps of glycolysis. Once again, by dragging the arrow over the steps, the corresponding stage in the diagram will be highlighted in yellow. Click "" again to finish the glycolysis overview. The "products" of glycolysis include two ATP molecules, two NADH molecules, two water molecules, and two pyruvates.

6. Click "" to test your knowledge of glycolysis. To take the quiz, click on a number at the bottom of the screen, and drag it to the appropriate circle above to answer the questions. The same number can be used more than once, and some numbers may not be used at all. If you try to place an incorrect number in a circle, it will not let you; the number will automatically return to the bottom of the screen.

7. Move on to the Transition Reaction by clicking "." While no ATPs are generated by the transition reaction, two NAD molecules are reduced to form two NADH molecules, which will be used to make ATP during electron transport. Also, each of the two pyruvates from glycolysis loses a carbon and combines with a "carrier" coenzyme called CoA. The two carbons removed from pyruvate combine with oxygen to form carbon dioxide gas.

8. Click on "" to take a look at the Krebs Cycle. The first diagram is an overview showing the relationship between the Krebs Cycle and the other steps of aerobic cellular respiration. The products of the two turns of the Krebs Cycle (one for each pyruvate from glycolysis) are six NADH molecules, two $FADH_2$ molecules, four carbon dioxide (CO_2) molecules, and two ATP molecules. By clicking "" again, you will be able to see an animated representation of the Krebs Cycle steps. If necessary, click "replay" on the bottom right-hand corner of your screen to view the animation again.

9. Click on "" to proceed to the electron transport system (also referred to as respiratory chain). You are first presented with an overview diagram. Click on "" to see an animation of electron transport. The electrons from NADH and $FADH_2$ (that were reduced during the previous steps of glycolysis, the transition reaction, and the Krebs Cycle) are passed from one carrier molecule to another. As mentioned in the animation, the final acceptor of these electrons is oxygen (this is aerobic respiration and requires that oxygen be available); this negatively charged oxygen then reacts with protons (H^+) to form water. The animation also mentions that three ATP molecules are produced for each NADH and two ATP molecules are generated for each $FADH_2$; this is where the bulk of ATP molecules are produced during aerobic cellular respiration.

10. Click on "" to see the breakdown of production of ATP molecules. The four on the left, are produced "directly" during glycolysis and the Krebs Cycle. The remaining 32 on the right are produced "indirectly" from the NADH and $FADH_2$ generated during glycolysis, transition reaction, and the Krebs cycle that carried their electrons in the electron transport system.

11. To see how the anaerobic process of fermentation compares to aerobic cellular respiration, click on "." Lactic acid fermentation, shown on the left, occurs in animal cells (such as your muscles); alcoholic fermentation, shown on the right, occurs in plant and fungi cells. This is why yeast (fungi) are used for producing alcoholic beverages and yeast breads (the carbon dioxide gas causes dough to "rise"). Both types of fermentation occur in the absence of oxygen.

12. Click on "" to go to the summary page and test your understanding of both fermentation and aerobic cellular respiration. Click on the names on the right, and drag them to the appropriate box.

13. Click on "" to see how cells convert fats and proteins into ATP energy. What you have studied so far specifically deals with how cells utilize glucose, a "building block" of carbohydrates. You will need to click on "" two more times to see the entire description. While the process is fairly complex, it is important to realize that cells are able to use all three types of food molecules to generate ATP energy.

14. You are almost finished with this tutorial. Click on "□" to take the multiple-choice quiz. If you are not sure about a question, click on "review topic" before answering the question.

15. You are done! I hope this module has improved your understanding of this subject material. To exit the tutorial, click on the leaf icon, then "exit."