Science Objectives

- Students will understand that cells utilize chemical energy from glucose by breaking chemical bonds.
- Students will be familiar with several important pioneers in metabolic science.
- Students will know that cells use enzymatic pathways to catalyze glycolysis, the Krebs cycle (or Citric Acid Cycle) and the electron transport chain.

Vocabulary

- glycolysis
- Krebs cycle
- electron transport chain
- NADH
- ATP
- glucose
- metabolize
- pyruvic acid
- $FADH_2$

About the Lesson

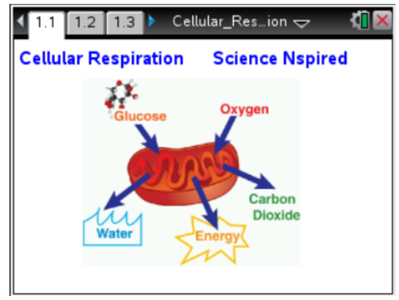
- Using several simulations, students will explore three pathways involved in cellular respiration. Assessments are embedded in the activity to engage discussion and gauge learning.
- As a result, students will:
  - Learn the basic functions of glycolysis, the Krebs cycle and the electron transport chain as metabolic pathways that extract energy from food.
  - Learn to recognize the relative energetic content of the energy-containing molecules glucose, NADH, $FADH_2$ and ATP.

TI-Nspire™ Navigator™

- Send out the *Cellular_Respiration.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Activity Materials

- Compatible TI Technologies: TI-Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software



Tech Tips:

- This activity includes class captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Cellular_Respiration_Student.doc
- Cellular_Respiration_Student.pdf

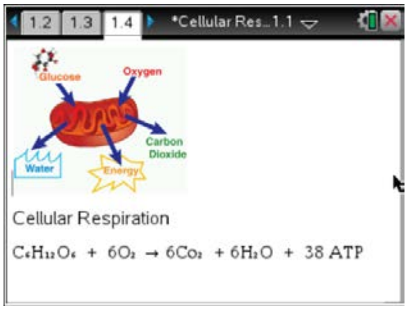
TI-Nspire document

- Cellular_Respiration.tns

Discussion Points and Possible Answers

Allow students to read the background information on the student activity sheet.

Part 1: Glycolysis



Move to pages 1.2 – 1.4.

1. Students should read the background information on pages 1.2 and 1.3, then look at the figure on page 1.4. Following those pages, there are several questions that assess the students' background knowledge of metabolism. These questions should be used for discussion after the students answer them.

Move to pages 1.5 – 1.7.

Have students answer questions 1-3 on the device, the activity sheet, or both.

Q1. Which molecule does a cell need to access the maximum chemical energy in glucose?

Answer: D. oxygen

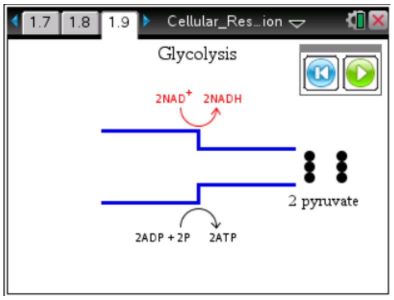
Q2. To catalyze the conversion of one glucose molecule into 38 ATP molecules, the cell uses many enzymes.

Answer: agree

Q3. Why does the cell convert glucose to ATP rather than use the energy directly from the sugar? Explain.

Sample Answer: There is a lot of energy available in glucose, but much of it would be wasted if it weren't broken into smaller energy units first. Think of breaking up glucose, (or the sugars that get converted into glucose so they can enter this pathway), like making change for a large bill. There are many transactions that require smaller energy currency.

Move to pages 1.8-1.9.



2. Page 1.8 gives information about the process of glycolysis. Have students use the navigation buttons to view the simulation of glycolysis multiple times.

Tech Tip: To view a summary of the simulation, have students select menu or **Document Tools ( ) > Cellular Respiration > Reaction Summary.**

Tech Tip: To view a summary of the simulation, have students select
> **Cellular Respiration > Reaction Summary.**

Move to pages 1.10 – 1.11.

Have students answer questions 4-5 on the device, the activity sheet, or both.

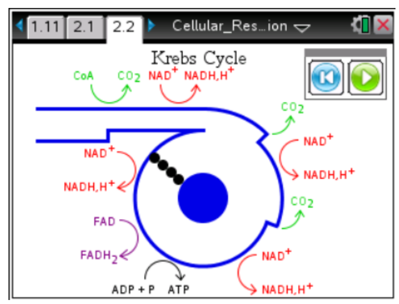
Q4. Glycolysis starts with a 6-carbon sugar. What becomes of these 6-carbons at the end of this pathway?

Answer: C. 2 3-carbon pyruvic acids

Q5. Glycolysis pairs the catabolism (breakdown) of glucose with the anabolism (formation) of which molecules?

Answer: B. ADP and NADH

Part 2: The Krebs Cycle



Move to Pages 2.1 and 2.2.

3. Page 2.1 contains information about the Krebs Cycle. As students move to the simulation of the Krebs Cycle on page 2.2, have students use the navigation buttons to view the simulation multiple times.

Move to pages 2.3 – 2.5.

Have students answer questions 6-8 on the device, the activity sheet, or both.

Q6. Two substrates combine to make a 6 carbon substrate that loses 2 carbons during the cycle. What becomes of these carbons?

Answer: A. CO_2

Q7. Based on your observations, which of these releases more energy?

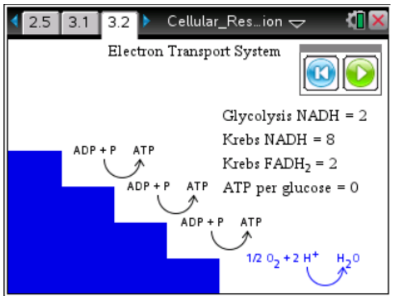
Answer: B. Krebs Cycle

Q8. Where does the 2 carbon substrate that starts the Krebs Cycle come from?

Answer: C. anabolism of lipids

Move to pages 3.1 – 3.2.

4. Page 3.1 contains information about the Electron Transport System (ETS). As students move to the simulation of ETS on page 3.2, have students use the navigation buttons to view the simulation multiple times



Move to pages 3.3 – 3.6.

Have students answer questions 9–12 on the device, the activity sheet, or both.

Q9. Based on your observations, which molecule has the most energy?

Answer: B. NADH

Q10. The simulation refers to oxidative phosphorylation, which is similar to respiration in that both require which molecule?

Answer: A. oxygen

Q11. FADH2 can be converted into how many ATPs?

Answer: C. 2

Q12. NADH can be converted into how many ATP molecules?

Answer: D. 3

Assessment

Move to pages 4.1 – 4.3.

Have students answer questions 13-15 on the device, the activity sheet, or both.

Q13. Which of the following is a major source of energy for cellular respiration?

Answer: D. glucose

Q14. Without oxygen, glycolysis cannot complete the pathway, and only one pyruvate is produced per glucose. This is more efficient.

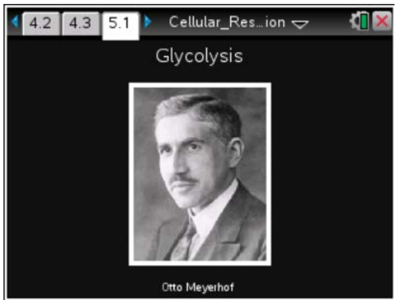
Answer: B. False; Without oxygen, oxidative phosphorylation cannot be complete. This is less efficient.

Q15. Imagine an enzyme that needs 2 ATP to unwind each base pair of DNA. How many glucose molecules would it take to unwind 108 base pairs of DNA ?

Answer: B. 6

2 × 108 = 216 ATP required to unwind this strand of DNA
216 ATP X 1 glucose/38 ATP = 6 glucose molecules required.

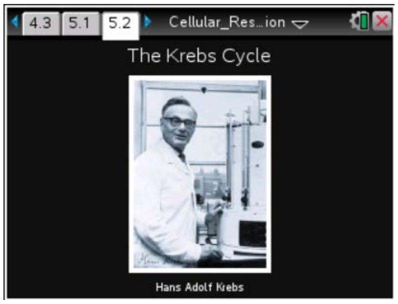
Move to page 5.1.



Students will see a picture of Nobel Laureate Otto Meyerhof and the following information is given:

> Dr. Meyerhoff studied how cells use the energy in sugar, and was able to show that the process yeast use to metabolize sugar is that same that mammals use. He was awarded the 1922 Nobel Prize for this work.

Move to page 5.2.



Students will see a picture of Nobel Laureate Hans Adolf Krebs and the following information is given:

> Dr. Hans Adolf Krebs described the energy creating reactions in all living matter, including the Krebs cycle (or Citric Acid Cycle). He was able to piece together an enzymatic pathway for creating where the product of the last reaction is the substrate of the first. He won the Nobel Prize in 1953 for this discovery.

Move to page 5.3.

Have students answer question 16 on the device, the activity sheet, or both.

Q16. Meyerhof's work found that glycolysis happens in which organisms?

Suggested Answer: All organisms.

TI-Nspire Navigator Opportunities

Choose a student to be a Live Presenter to demonstrate the simulations. The questions in the activity may be distributed as Quick Polls or used as a formative or summative assessment.

Wrap Up

When students are finished with the activity, retrieve the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using Slide Show.

Assessment

- Formative assessment will consist of questions embedded in the .tns file. The questions will be graded when the .tns file is retrieved. The Slide Show will be utilized to give students immediate feedback on their assessment.