Citric Acid Cycle Review Activity

Goals

Students will be able to appreciate the details of steps within the Kreb’s Cycle. Students will be able to understand the steps of the Kreb’s Cycle at functional level through physical practice of “modeled mechanisms” of Kreb’s Cycle steps. Students will express curiosities surrounding the generation of cellular energy, through a written assignment.

Background

One of the most fundamental concepts in all of biology is how we generate energy from food and nutrition sources we bring in to the body. Unfortunately, the very process of cellular respiration that generates this energy is very complex at a biochemical level. Because so much of the Kreb’s cycle can only be appreciated after years of chemistry and physics, many times the Kreb’s cycle is both under taught by teachers and under appreciated by students.

Without actually teaching the biochemistry required to appreciate the energy dynamics of how ATP is generated there are activities that can hint toward and facilitate the appreciation of phosphorylation cascades. By modeling some of these steps students gain the ability to see that chemical, physical and structural aspects of Kreb’s Cycle reactions are all involved in biological reactions.

Activity

Students pass through each of the eight main steps of the Kreb’s Cycle by stopping at each station and completing the critical mechanistic steps by phosphorylating molecules and moving the energy containing portions of molecules toward making ATP, or by releasing waste products such as CO2 by blowing up balloons with the number of molecules written on each balloon so that when blown up they reveal the actual number of molecules released.

At each station the students are required to come up with a new question they have about energy transformation, the Kreb’s Cycle, or cellular respiration in general. This list of questions will be answered either by students, or through the “Ask a Biologist” web site. These questions will be discussed one week later.

Assessment

Formative assessment will take place in the form of a summary sheet by filling in the details of the Kreb’s Cycle on a handout of the cycle with certain input and output details left out to be filled in by the students. Students will complete summative assessment with an essay question response to the following topics: What conceptually is going on with
the Kreb’s Cycle? Without using numbers describe the mechanism of energy production in the Kreb’s Cycle. What would you like to know about the Citric Acid Cycle?

**Learning Styles**

This lesson plan is oriented toward students who learn from specific experiences, learn by doing, learn through extroversion, learn by systematic planning. These learning styles will be addressed by a hands on and multimedia activity designed to review the most important inputs and outputs of the Krebs Cycle. This activity is meant to provide one more teaching approach to this challenging topic of the Krebs cycle. It gives the student a chance to delve deeper into the Krebs cycle while having a fun time reviewing the topics on which they’ll most likely be tested.

**Time Frame and Time Required**

This lesson plan is intended to fall in the middle or toward the end of a unit on Cellular Respiration and the Citric Acid Cycle. A conceptual familiarity of the Citric Acid Cycle is a prerequisite.

This activity requires one hour in classroom, and one hour homework for writing assignment.

**Arizona State Science Standards Addressed**

**Strand 4: Life Sciences**

**Concept 1. The cell**

- PO 1. Describe the role of energy in cellular growth, development, and repair.
- PO 4. Analyze the mechanisms of transport of materials into and out of cells.

**Concept 5: Matter, Energy, and Organization in living systems**

- PO 1. Compare the processes of photosynthesis and cellular respiration.
- PO 2. Describe the role of organic and inorganic chemical such as ATP

**Strand 5: Chemistry**

**Concept 4. Chemical Reactions**

- PO 2. Identify the indicators of chemical change, including formation of a precipitate, evolution of a gas, color change, absorption or loss of heat energy.
Citric Acid Cycle Activity

Imagine yourself small enough to ride alongside a molecule of glucose that has just been broken down in glycolysis into two pyruvates. Then, each pyruvate crosses the mitochondrial membrane and something goes wrong because you were sitting on the surface of the pyruvate molecule as it entered the mitochondria. The pyruvate was successfully converted into Acetyl CoA, and you made it in unscathed, however it looks like you will have to help that Acetyl CoA cycle itself through the Citric Acid cycle. You need to help make some energy.

Your job is to cycle around following Acetyl CoA through the eight main steps of the Krebs cycle to ensure that all of the important transformations take place. You’ll have to add water when necessary, maybe take water out. You may have to allow an NAD+ to sweep in and take a hydrogen atom out of the system, to form NADH (later these will help make lots of energy in the electron transport chain). You’ll have to keep track of the things you bring in and out of the system.

Instructions:

Set Up: Take a new Citric Acid Cycle kit for each pass through the cycle. In each step listen to the audio recording and find the inputs and outputs for the step that you are doing.

Start at Step 1 where Acetyl CoA is fed into the system and is converted into citrate. Then work your way around taking care and keeping track of the required additions and expulsions from the system. Follow the system all the way around until you have created an ATP and have made Oxaloacetate the start and finish molecule in the Citric Acid cycle. Then do it again since each molecule of glucose breaks down into 2 pyruvates which both need to be processed in the Citric Acid cycle.

At each station you will need to perform an action to keep the Citric Acid cycle moving along. To find out what to do, listen to the audio instructions at each step. Then find the chemicals you need in your kit of inputs, outputs and waste products. You can place the inputs from your kit onto the input part of the cycle sheet, and you can place the outputs onto the output section. When you are finished with a station, if you think something is or will generate useable energy for the cell, put it into the energy pouch. Clean up your materials and bring everything with you as you cycle around the room.

Use the chart on the following page to record what is coming in and what is going out of the Citric Acid cycle. On the left write in at least one observation or question per step, and on the right, write in each item that comes in or goes out of the cycle.

After completing the Citric Acid Cycle activity, look over your Citric Acid Cycle Tracker Sheet and Observations. Use what you have written as an outline for the essay question portion of this project. Then using the sheet provided write a short essay that explains what you know and what you would like to know about the Citric Acid Cycle.
**Citric Acid Cycle Tracker Sheet**

Use this sheet to track the inputs and outputs for two cycles of the Citric Acid Cycle using the Inputs and Outputs columns on the right and fill in your questions and observations in the column labeled Observations on the left. At the bottom right fill in the total amount of ATP that is generated from processing one molecule of glucose.

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<thead>
<tr>
<th>Observations</th>
<th>Summary of Input and Outputs</th>
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<tbody>
<tr>
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<td>Inputs</td>
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<td>Totals of ATP for 1 molecule of Glucose</td>
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<td>ATP=?</td>
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Write a short response that creatively explores some of the curiosities you have with regard to the Citric Acid Cycle. Using no more than this sheet of paper discuss your understanding of the Citric Acid Cycle. Be sure to address particular inputs and outputs such as Acetyl Co-A, NADH, FAFH2, and ATP. First make an effort to explain the cycle, and then think and write about what you don’t quite understand about the cycle.

Some additional questions to consider are: When we eat and breathe, do our cells also eat and breathe? If glucose makes ATP, why don’t people simply eat glucose and not worry about other foods?

This essay question will be evaluated both on your ability to concisely explain the Citric Acid Cycle and for scientific interest or questions raised based on the cycle.