Teacher Notes: Marathon Mouse

Background Information

Eukaryotic cells get energy through respiration

All cells require energy to simply survive, and cells obtain that energy from food molecules, such as glucose. Food molecules are broken down in several chemical reactions that release usable energy, which is stored in high-energy adenosine triphosphate molecules (ATP). ATP is then used by cells to carry out life processes. One method eukaryotic cells use to make ATP from glucose is known as aerobic respiration, which occurs in the mitochondria. Overall, the process can be summarized in the following reaction:

Glucose + Oxygen → Water + Carbon Dioxide + ATP

Exercise changes cells

The show describes two types of muscle cells, slow twitch and fast twitch. Slow-twitch muscles are important for endurance. They have lots of mitochondria and efficiently burn both fat and glucose. Fast-twitch muscles, which are used in quick bursts of activity, have fewer mitochondria and primarily burn glucose. The number of slow- and fast-twitch fibers in any particular muscle appears to be genetically determined. However, athletes can gear their training to especially develop one kind of muscle. For example, endurance training will develop more slow-twitch muscle, on a percent-total-mass basis. These slow-twitch muscles will contain more and larger mitochondria and have an improved ability to convert fats into usable energy.

Endurance in a pill

The video describes a genetically engineered mouse that could run longer and farther than normal mice. How? Researchers turned a gene, called PPAR delta, on overdrive. From birth, the mouse's muscle cells made more mitochondria and burned more fat than the muscle cells of normal mice would.

Additional research on mice showed that a drug known as AICAR had the same influence as endurance training. The drug works by triggering the cell's fuel gauge, making it behave as if energy is scarce, even when it's not. The cell responds by increasing the amount of slow-twitch muscle, on a percent-total-mass basis. The cells even burn fat better. Could the drug work in humans? No one knows—yet.

Answer Key

Lesson Plan: Step 7

- Mouse 1 is the control mouse (no exercise, no drugs, mitochondria/cells stayed the same).
- Mouse 2 exercised daily (increased number of mitochondria-rich cells).
- Mouse 3 received Drug x (same effect as exercise).
- Mouse 4 received Drug y (no effect).

Student Handout: Procedure

1. Summarize the function of mitochondria.
   - Mitochondria convert food energy, such as glucose, into usable energy known as ATP. Because of this, mitochondria are often referred to as the "powerhouses" of the cell.
2. Predict how the number of mitochondria-rich muscle cells would change in each of the situations below.
   - Answers will vary.
3. In the table below, enter the number of mitochondria-rich muscle cells shown in each of your images.
   - Answers will vary slightly, but should reflect the approximate numbers below:

Mouse Number	Number of mitochondria-rich cells at beginning of experiment	Number of mitochondria-rich cells at end of experiment
Mouse 1	4	4
Mouse 2	4	10
Mouse 3	4	8
Mouse 4	5	5

Student Handout: Questions

1. Explain your conclusions about how and why each treatment affected the number of mitochondria-rich cells for each of the four mice.
   - The number of mitochondria-rich cells in Mouse 1 and 4 did not change, whereas the number of mitochondria-rich cells in Mouse 2 and 3 increased. No treatment resulted in no change in the number of mitochondria-rich cells. Exercise caused the number of mitochondria-rich cells to increase because mitochondria supply energy required for activity. Drug X appears to mimic exercise, since Drug X caused an increase in mitochondria-rich cells also. Drug Y, however, appears to have no effect on the number of mitochondria-rich cells.
2. In both the Marathon Mouse experiment and the hypothetical experiment above, one mouse received no special treatment. What was the purpose of having this mouse in the experiment?
   - The mouse that was left in its cage served as the experimental control. The mouse was included in the experiment as a standard for comparison, to provide a baseline against which to compare the other mice.
3. List some pros and cons of a drug that can produce the same effects as exercise.
   - Pros: maintain muscle mass of chronically ill or hospitalized patients and people unable to get sufficient exercise. Cons: potential for abuse by athletes; side effects; potential for addiction; potential for entering the human food chain through animals treated with the drug.

4. Imagine that you could design an animal with great endurance, either flying, running, or swimming. Draw the animal and label its endurance characteristics. (If possible, watch the How the Body Responds to Exercise video.)

   - Answers will vary. Endurance characteristics could include: more slow-twitch muscle, increased number of mitochondria in each muscle cell, increased blood flow to the muscles, and increased ability to use oxygen efficiently.

Rubric

Task	Excellent	Satisfactory	Needs Improvement
Complete the *Marathon Muscles* student handout and graph the hypothetical data.	• Students use Web resources effectively to answer questions. • Students show ability to obtain, graph, and interpret data. • Students use information effectively to justify predictions.	• Students need assistance while using resources. • Students have difficulty obtaining, graphing, and interpreting data. • Students make predictions but cannot justify their reasoning.	• Students have difficulty using Web resources to answer questions. • Students cannot obtain, graph, or interpret the experimental data. • Students cannot make predictions based on information.