STUDENT GUIDE
EXPLORE 1D LESSON 19

Food and Agriculture Center for Science Education

Part 1: Our Motivation

Record what we were trying to figure out that led to this investigation.

We've speculated on how the data we analyzed and interpreted might bring more clarity to the module question and pointed out some of the questions on our Driving Question Board that we think we can start to answer. We decided it would be useful to see a model of what is actually going on inside the body during intense exercise to put some of our speculation to the test.

Part 2: Using a Model of Increased Breathing Rate, Heart Rate, and Fatigued/Burning Muscles During Intense Exercise

As a class, you will engage in a Science Theater model to determine why you are breathing faster during exercise.

As you review your role, record a summary of the role your cells and organ will play to increase heart rate, breathing rate, and produce fatigue and burning in the muscles. Describe what function your organ has and how specialized cells contribute to its function.

How Specialized Cells Contribute:

Role: Lungs and Alveoli

When the body breathes in, it will get air from the trachea and expand. The air will fill the alveoli (like little air sacs). The oxygen molecules along the edges of the alveoli will diffuse through and into the tiny blood vessels that surround them.

Carbon dioxide flowing in the tiny vessels around the alveoli will diffuse back into the alveoli, and when the body breathes out, it will be forced out to the trachea.

Engage in the model. As you **enact** the model, record observations you make about the actions that various specialized cells take.

Organ & Specialized Cells: Lungs & Alveoli Epithelial Cells
• Epithelial cells in the lungs that make up the alveoli are thin and surrounded by capillaries. • The oxygen we breathe in can diffuse through the thin cell membranes and into the capillaries. • The carbon dioxide in those capillaries can diffuse through the thin capillary walls and the alveoli cells and be released into the lung space, then the trachea, and nose/mouth as we exhale.
Organ & Specialized Cells: Heart
• During exercise, the pacemaker cells receive an epinephrine signal, which causes them to increase their rate of contraction, leading to an increased heart rate. • This means the heart beats faster during exercise and even faster during high-intensity exercise.

As you **observe** the model, record how different organs and their specialized cells function to increase heart rate and breathing rate and produce fatigue and burning in the muscles.

Organ & Specialized Cells	Role of Specialized Cells in Increasing Heart Rate, Breathing Rate, and Producing Fatigue and Burning in the Muscles
Lungs	Epithelial mucosa cells lining the nose and mouth secrete mucous that helps to keep tissue from drying, and the mucous helps filter things out of the air that we don't want to get into our lungs (such as dust). Epithelial cells in the lungs that make up the alveoli are thin and surrounded by capillaries. The oxygen we breathe in can diffuse through the thin cell membranes and into the capillaries. The carbon dioxide in those capillaries can diffuse through the thin capillary walls and the alveoli cells and be released into the lung space, then the trachea, and nose/mouth as we exhale. The alveoli epithelial cells also serve as a barrier to keep unwanted things from the air out of the bloodstream.
Heart	During exercise, the pacemaker cells receive an epinephrine signal, which causes them to increase their rate of contraction, leading to an increased heart rate., This means the heart beats faster during exercise and even faster during high-intensity exercise.
Bloodstream	Capillaries allow oxygen and carbon dioxide to enter and exit the bloodstream. Inside the bloodstream are red blood cells that have hemoglobin molecules on them. When the oxygen gets to the muscle cell, it can enter the cell. The carbon dioxide made in the muscle cell enters the bloodstream and then unloads the carbon dioxide in the lungs/alveoli.
Brain & Autonomic Nerves	Autonomic nerve cells carry signals to organs that do things automatically (like heartbeat). The autonomic nerve cells send an electrical signal from the brain along nerves to the adrenal glands to activate the release of epinephrine.
Brain & Somatic Nerves	Somatic nerve cells carry signals from the brain to myocytes, sending a signal to contract/relax when we want to move our muscles. During exercise, we are contracting and relaxing our muscle cells to move our bodies. Signals come from the brain and through the somatic nerve cells during exercise to move the muscles.
Skeletal Muscles	Myocytes need lots of energy to move, so they have extra mitochondria in them to help make energy. The mitochondria get glucose and oxygen from the bloodstream to perform cellular respiration and make cellular energy in the form of ATP.

	Myocytes receive electrical signals from the somatic nerve cell, which causes the cell to contract. In order to contract, the myocyte has to use energy/ATP.

Use your observations from the model to summarize what changes in the body occur to produce cellular energy for exercise and to increase breathing rate, heart rate, and muscle burning.

Condition	Summary of Changes that Occur
Increased Heart Rate & Breathing Rate	Electrical signals from the brain trigger the chromaffin cells in the adrenal glands to release epinephrine. Epinephrine travels in the bloodstream to reach the lungs, heart, liver, and skeletal muscles. In the skeletal muscles and liver, epinephrine triggers myocytes and hepatocytes to break down their glycogen stores to glucose. In the heart, epinephrine triggers pacemaker cells, which make the heart beat faster and the cardiomyocytes to contract harder. In the lungs, airways are opened, and the breathing rate increases.
How Muscle Cells Get Energy for Movement	Contracting skeletal muscles utilize and require more ATP during intense exercise. They use aerobic and anaerobic respiration to generate the ATP. They get the resources (oxygen, glucose) for these processes from the bloodstream. Anaerobic cellular respiration uses glucose to generate small amounts of ATP. Aerobic cellular respiration uses glucose and oxygen to generate large amounts of ATP and produces water and carbon dioxide as byproducts.
Muscle Burn & Fatigue	The burning sensation in muscles during intense exercise can be a result of H+ ions that build up during anaerobic respiration and lower pH. The brain is alerted via nerve cells and sends a pain signal in response.

Reflect on how the lens of stability and change was useful in figuring out how the specialized cells support the body to produce cellular energy for exercise.

We observed that the body undergoes numerous changes to produce cellular energy as exercise occurs. At the stable state at rest, the body does not have a large need for cellular energy (ATP). As the body begins exercising, the need for ATP to contract muscles rapidly increases. As a result, the body undergoes several changes to make this happen. It makes the cardiomyocytes and pacemaker cells in the heart beat faster and breathing rate increases. The alveolar epithelial cells can get more oxygen into the bloodstream and more carbon dioxide out of the bloodstream. Getting more oxygen to the muscles allows the myocytes to use oxygen for aerobic respiration. The muscles break down liver and muscle glycogen so more glucose is available for aerobic and anaerobic respiration.