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Muscle Metabolism and Fatigue

Muscles get their energy from different sources depending on the situation that the muscle is working in. Muscles use aerobic respiration when we call on them to produce a low to moderate level of force. Aerobic respiration requires oxygen to produce about 36-38 ATP molecules from a molecule of glucose. Aerobic respiration is very efficient, and can continue as long as a muscle receives adequate amounts of oxygen and glucose to keep contracting. When we use muscles to produce a high level of force, they become so tightly contracted that oxygen carrying blood cannot enter the muscle. This condition causes the muscle to create energy using lactic acid fermentation, a form of anaerobic respiration. Anaerobic respiration is much less efficient than aerobic respiration—only 2 ATP are produced for each molecule of glucose. Muscles quickly tire as they burn through their energy reserves under anaerobic respiration.

To keep muscles working for a longer period of time, muscle fibers contain several important energy molecules. Myoglobin, a red pigment found in muscles, contains iron and stores oxygen in a manner similar to hemoglobin in the blood. The oxygen from myoglobin allows muscles to continue aerobic respiration in the absence of oxygen. Another chemical that helps to keep muscles working is creatine phosphate. Muscles use energy in the form of ATP, converting ATP to ADP to release its energy. Creatine phosphate donates its phosphate group to ADP to turn it back into ATP in order to provide extra energy to the muscle. Finally, muscle fibers contain energy-storing glycogen, a large macromolecule made of many linked glucoses. Active muscles break glucoses off of glycogen molecules to provide an internal fuel supply.

When muscles run out of energy during either aerobic or anaerobic respiration, the muscle quickly tires and loses its ability to contract. This condition is known as muscle fatigue. A fatigued muscle contains very little or no oxygen, glucose or ATP, but instead has many waste products from respiration, like lactic acid and ADP. The body must take in extra oxygen after exertion to replace the oxygen that was stored in myoglobin in the muscle fiber as well as to power the aerobic respiration that will rebuild the energy supplies inside of the cell. Oxygen debt (or recovery oxygen uptake) is the name for the extra oxygen that the body must take in to restore the muscle cells to their resting state. This explains why you feel out of breath for a few minutes after a strenuous activity—your body is trying to restore itself to its normal state.

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Read the text and answer the following questions:

1. When do muscles use aerobic respiration?
2. How long can aerobic respiration continue?
3. What energy molecules do muscle fibers contain?
4. What happens when muscles run out of energy?
5. What is oxygen debt?

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