How Cells Harvest Chemical Energy 6

You need to eat and breathe because your cells need food and oxygen for energy. In every cell in your body, organic molecules and oxygen interact in a complex process called cellular respiration. In this process, food molecules such as glucose are broken down and the energy contained in their chemical bonds is used to make ATP. The ATP made in cellular respiration is then used to drive cellular activities. Right now, ATP produced in cellular respiration is being used to generate the nerve impulses from your eyes to your brain, to move your muscles, and to drive your heartbeat. This chapter explains how your cells harvest the energy that keeps you alive.

Organizing Your Knowledge

Exercise 1 (Introduction – Module 6.3)

Review the basic terms and concepts of cellular respiration by filling in the blanks below.

Right now, you are breathing at a steady rate of 12 to 20 breaths per minute. Breathing, or [1]_____, is necessary for life, but why? Breathing allows the body to take in [2]_____ gas and expel waste [3]_____. Your breathing is closely related to [4]_____, the aerobic harvest of the energy in food molecules by cells. Most of the time, most cells acquire energy by taking in both [5]_____ and [6]_____ from the blood. These two substances interact, the sugar is broken apart, and [7]_____ and [8]_____ are produced. In the process, some of the energy is stored in molecules of [9]_____, which provide the energy for body activities. To make enough ATP for their needs, average human beings must take in food that provides about [10]_____ kilocalories (kcal) of energy per day.

When using oxygen, cells are said to function [11]_____. Cells making ATP this way capture about [12]_____ of the energy in glucose. For short bursts, cells can make ATP [13]_____ — that is, without using oxygen. This process is much less efficient; it only banks about [14]_____ % of the energy in glucose. But it is useful during intense bursts of activity, such as sprinting or heavy lifting.

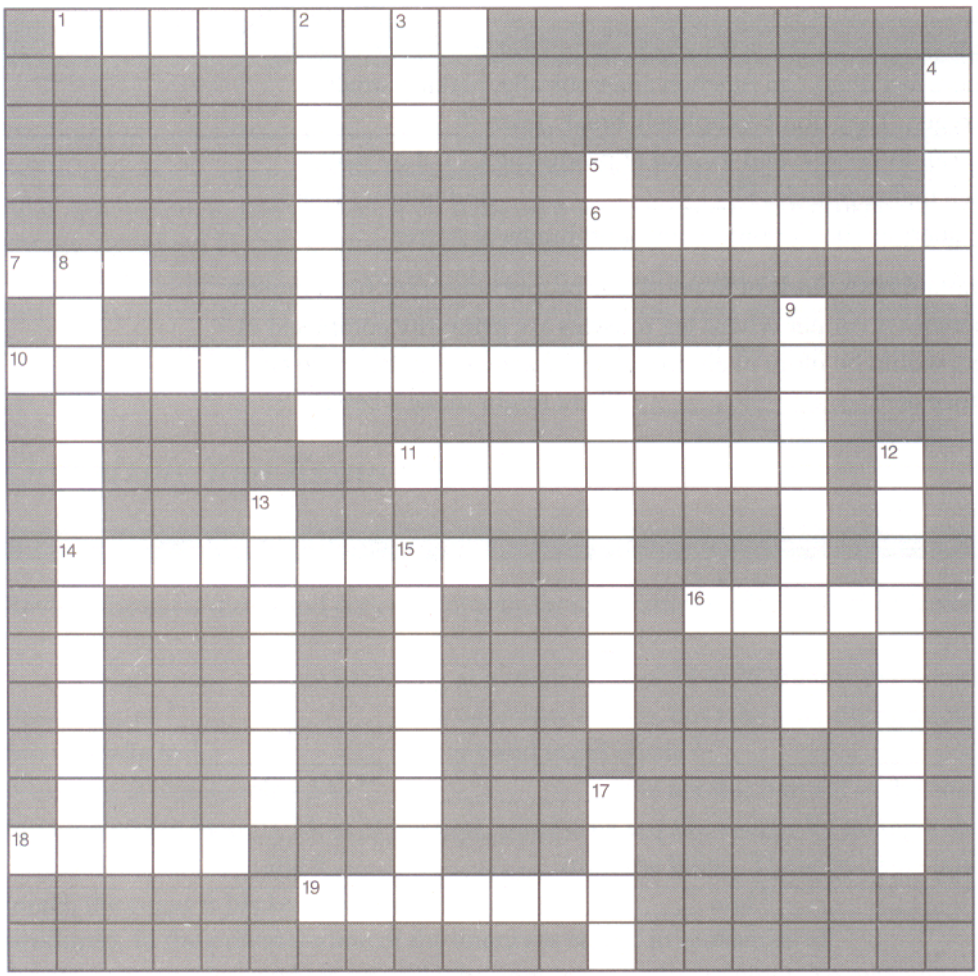
Muscles contain a mixture of two kinds of cells, or fibers, specialized either for aerobic or anaerobic ATP production. [15]_____ fibers can sustain repeated, long contractions, by continuously producing ATP via [16]_____cellular respiration. Slow fibers are long and [17]_____, maximizing their surface area and contact with nearby [18]_____ that deliver oxygen. They have many [19]_____, the structures where aerobic ATP breakdown occurs. And they are rich in [20]_____, a red protein related to hemoglobin that supplies O_2

molecules. The [21]_____ meat of a turkey leg consists mostly of myoglobin-rich slow muscle fibers. The white meat of a turkey breast, on the other hand, consists mostly of [22]_____ muscle fibers, which are specialized for quick, powerful bursts of flight. These fibers are [23]_____ and are more powerful than slow fibers, having [24]_____ mitochondria and [25]_____myoglobin than slow fibers. During intense activity, when the blood cannot deliver O_2 fast enough for aerobic cellular respiration, fast fibers can function anaerobically, making small amounts of ATP without oxygen. They don't completely break down [26]_____, and therefore do not capture all its energy, and instead of producing CO_2 they make [27]_____, which makes muscles [28]_____ and fatigue. This is why [29]_____ fibers are best at producing short bursts of power.

Human muscles contain both kinds of fibers. Their proportions vary from muscle to muscle, and person to person. A runner whose leg muscles are primarily composed of [30]_____ fibers would be more likely to excel in distance events, while an individual with an abundance of [31]_____ fibers might make a better sprinter.

Exercise 2 (Modules 6.4 – 6.7)

How does the cell capture the energy of organic molecules in ATP? Review the basic concepts by completing this crossword puzzle.



Across

1. The cell transfers energy by shuttling ____ from molecule to molecule.
6. Energy released in the electron transport chain moves ____ ions (H^+) across a membrane.
7. ATP is made from ____ and inorganic phosphate.
10. Substrate-level ____ is a simpler way to make ATP than chemiosmotic phosphorylation.
11. A sequence of electron carriers forms the electron ____ chain.
14. ____ is loss of an electron.
16. A molecule such as glucose is oxidized when it ____ an electron.
18. ____ is short for "oxidation-reduction."
19. Oxygen is ____ in cellular respiration.

Down

2. ____ is gain of an electron.
3. A coenzyme called ____ is used to carry hydrogen atoms in redox reactions.
4. A molecule is reduced when it ____ an electron.
5. Most cells make most of their ATP via a process called ____.
8. A ____ enzyme strips hydrogen atoms from organic molecules.
9. ATP ____ use energy from a gradient of ion concentration to make ATP.
12. In substrate-level phosphorylation an enzyme transfers a ____ group to ATP.
13. NADH delivers electrons to an electron ____.
15. Glucose is ____ in cellular respiration.
17. NAD^+ picks up electrons and hydrogen, forming ____.

Exercise 8 (Modules 6.8 – 6.14)

Web/CD Activity 6A *Overview of Cellular Respiration*
Web/CD Activity 6B *Glycolysis*
Web/CD Activity 6C *The Krebs Cycle*
Web/CD Activity 6D *Electron Transport and Chemiosmosis*

Check your overall understanding of cellular respiration by matching each of the phrases below with one of the three stages of the process. Use G for glycolysis, K for Krebs cycle, and E for electron transport and chemiosmosis.

_____ 1. Generates most of the ATP formed by cellular respiration
_____ 2. Begins the oxidation of glucose
_____ 3. Occurs outside the mitochondrion
_____ 4. Produces 4 ATPs per glucose by substrate-level phosphorylation, but 2 ATPs per glucose are used to get it started
_____ 5. Oxidizes NADH and $FADH_2$, producing NAD^+ and FAD
_____ 6. Carried out by enzymes in the matrix (fluid) of the mitochondrion
_____ 7. Here electrons and hydrogen combine with O_2 to form H_2O
_____ 8. Occurs along the inner mitochondrial membrane
_____ 9. Generates most of the CO_2 produced by cellular respiration
_____ 10. $FADH_2$ and NADH deliver hydrogen ions and electrons to this stage
_____ 11. ATP synthase makes ATP
_____ 12. Reduces NAD^+ and FAD, producing NADH and $FADH_2$

Exercise 9 (Module 6.15)

Web/CD Activity 6E *Fermentation*

Review fermentation by filling in the blanks below.

1. _____ anaerobes can make their ATP by fermentation or aerobic respiration.
2. _____ is an organism that normally uses aerobic respiration to produce ATP, but it can generate ATP without oxygen, via alcoholic fermentation.
3. Fermenters replenish their supply of NAD^+ by using NADH to oxidize _____ acid.
4. When oxygen is scarce, human _____ cells can make ATP by lactic acid fermentation.
5. Fermentation enables cells to make ATP in the absence of _____ .
6. For every molecule of glucose consumed, glycolysis produces two molecules of pyruvic acid, two molecules of ATP, and two molecules of _____ .
7. The waste products of alcoholic fermentation are _____ and carbon dioxide.
8. _____ acid fermentation is used to make cheese and yogurt.
9. Fermentation generates two _____ molecules for every molecule of glucose consumed.
10. A cell can use _____ to generate a small amount of ATP, but it must somehow recycle its supply of NAD^+.
11. Like aerobic respiration, alcoholic fermentation produces _____ gas as a waste product.
12. Strict _____ require anaerobic conditions and are poisoned by oxygen.