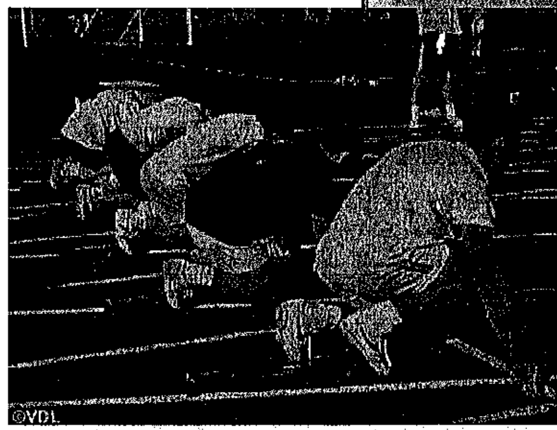
Metabolism & Cellular Respiration

A runner crouches at the starting line. He is about to sprint as fast as he can. To perform his best, his body must utilize the energy it stored from breakfast. He had chewed his food well to make it easier to digest and waited three hours before exercising. But how did his body convert a meal into energy it could use?

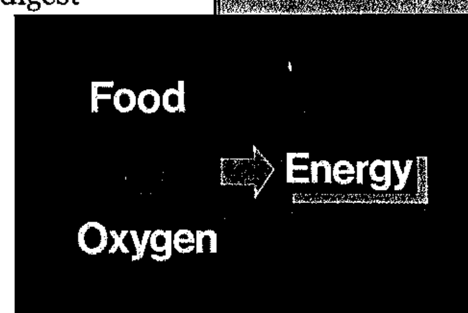


The body needs energy to fuel daily activities, like exercise.

The answer is metabolism. Metabolism is a term that refers to all the chemical reactions that maintain life in an organism. Such chemical reactions happen inside cells. Whether a person is sleeping, sitting, or exercising, metabolism is always at work.

Cellular Respiration

There are specific metabolic pathways in charge of turning food energy into chemical energy. Cellular respiration is a series of chemical reactions that break down nutrients for energy. In most organisms, this process requires oxygen. The molecules that serve as energy sources are called macronutrients because cells can digest them into smaller units. Macronutrients include proteins, carbohydrates, and fats. A protein is composed of amino acids, a carbohydrate is a string of simple sugars, and a fat is made of three fatty acids attached to one glycerol.



When cells have nutrients from food and oxygen, they can make energy.

Where does chemical energy come from? Energy is found in the bonds that connect atoms. Cells gain energy by breaking a bond. Conversely, they must spend energy to form a bond. The molecule that is most commonly used by cells to store energy is called adenosine triphosphate (ATP). Without ATP, cells cannot operate or complete work. Cells form ATP as a way to store energy that they obtain from breaking down glucose, a type of simple sugar. Cellular respiration is the main way that cells form ATP.

The overall process of cellular respiration involves three complex steps: glycolysis, the Krebs cycle, and the electron

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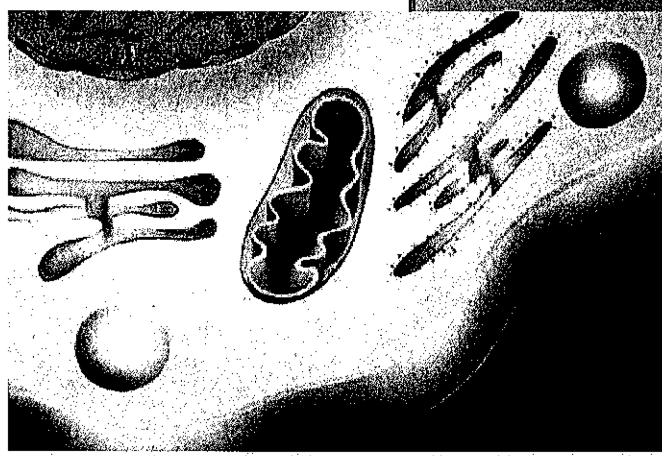
transport chain.

Step 1: Glycolysis
Glycolysis occurs in the cell's cytoplasm. The cell doesn't need oxygen for this step, so it is characterized as an anaerobic reaction. During glycolysis, a molecule of glucose is split into two smaller molecules known as pyruvates. Breaking glucose into pyruvate yields two molecules of ATP. It also leaves the cell with two electron carriers, which are molecules that relay electrons from one part of the cell to another. They play a vital role in the electron transport chain, which is where the bulk of the ATP is generated in cellular respiration.


The reactions of cellular respiration take place in the cytoplasm (the blue area) and the mitochondrion (the bean-shaped organelle).

The two pyruvate molecules travel to the mitochondrion, an organelle that is known as the cell's "power house" because it is the main site of ATP production. The remaining steps of cellular respiration take place in the mitochondrion.

Once the pyruvates are in the mitochondrion, a reaction converts each pyruvate into a molecule called acetyl CoA. It also produces two more energy carriers. This process is considered aerobic because it requires the presence of oxygen. Carbon dioxide is a by-product of this reaction.

Step 2: The Krebs Cycle
Still inside the mitochondrion, the acetyl CoA molecules undergo a series of reactions known as the Krebs cycle. During the Krebs cycle, the acetyl CoA molecules are broken down and modified in a process that yields two more ATP molecules (one from each molecule of acetyl CoA). Carbon dioxide is a by-product of this reaction. The most important result of these reactions, though, is the output of eight additional electron carriers.

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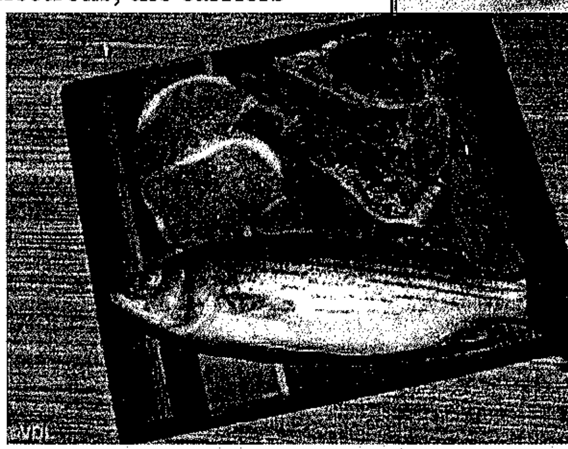
Step 3: The Electron Transport Chain

Remember the electron carriers from glycolysis and the Krebs cycle? All twelve electron carriers travel to the inner mitochondrial membrane, the site of the electron transport chain. The electron transport chain is a series of chemical reactions. The electron carriers drop off their electrons at the beginning of the chain and the electrons pass down the chain through one reaction after another. As the electrons "fall" down the electron transport chain, energy is released that is ultimately captured and stored in ATP molecules. During this portion of cellular respiration, about 32 molecules of ATP are produced from what was originally one molecule of glucose.

Oxygen is a crucial component for the reactions responsible for generating ATP. At the end of the electron transport chain, oxygen accepts electrons and bonds with hydrogen to make water. Since oxygen accepts the electrons, the carriers can continually shuttle more to the start of the electron transport chain. If this were not the case, the series of reactions would be unable to continue and electrons would stop moving down the chain, causing ATP production to halt.



Meat is a source of protein.

Energy from Fat and Protein

Glucose isn't the only source of energy. The body can utilize fat too. Because a fat molecule has many more bonds to break than a glucose molecule, the cell generates ter times more ATP from a fat molecule than it can from a glucose molecule. However, the body needs carbohydrates to break down fat.

On the other hand, protein isn't normally used for fuel. The body needs it to make structures like muscles and enzymes. Cells will only break down amino acids for ATP as a last resort. For example, if a person is starving. But not much energy comes out of it.

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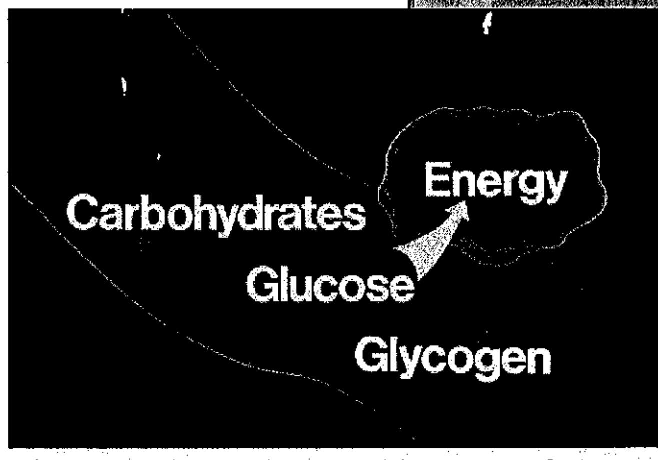
How Is Energy Stored?

If an individual consumes more food than the body needs, their body saves the energy for later. Carbohydrates are put aside as glycogen in the liver and muscles. Sometimes athletes such as runners will eat foods rich in carbohydrates the night before a race. Doing so increases their bodies' glycogen reserves. As soon as the race begins, the bodies have an ample stock of glucose to fuel the cells.



Cells break down carbohydrates into glucose for energy. If the cell has more glucose than it needs, it stores it in the form of glycogen.

Lipids are stored in adipose tissue. Since fat is rich in energy, the body prefers to store it. Cells will utilize carbohydrates first, and only metabolize fat when the sugar supply is depleted. If a person eats excess sugar, the body will continue to reserve the fat and not use it.

Proteins are broken down into an amino acid pool the cell can draw from later. Each day, the body makes the most of its proteins by taking amino acids from the pool. If a person eats excess protein, it can turn into fat.

Cells are productive and organized, and they know precisely what to do with each nutrient that comes in. The second a person breathes in, numerous chemical reactions arise. Thanks to metabolism, the body gets exactly what it needs at every moment.

Discovery Education:

Metabolism and Cellular Respiration

Directions: Use the discovery education article, "Metabolism and Cellular Respiration," and your textbook to answer the following questions on a separate sheet of paper. You must glue these questions to your paper or write out each question to receive full credit.

1. What is metabolism? 7%

2. What is cellular respiration and what does this process require? 7%

3. Identify two things cells must have in order to make energy. 7%

4. Why is cellular respiration important? 7%

5. Identify the reactants and products of cellular respiration. 7%

6. What is ATP? 7%

7. How is energy stored? 7%

8. Identify the Who, What, When, Where, Why, and How of this article. 7%

9. Sequencing: Identify the steps pertaining to cellular respiration and place them in sequential order. 7%

10. Main idea: What is the main idea of this article? 7%

11. Summarize: Write a 1-2 paragraph (1/2) page synopsis summarizing the article, metabolism and Cellular Respiration." Each paragraph should be a minimum of 5-7 sentences. 30%