Chemical energy and atp answers

Needs lots of energy?To run a marathon, probably. Where does this extra energy come from? Carbohydrate loading is a strategy used by endurance athletes to maximize the storage of energy, in the form of glycogen, in the muscles. Glycogen forms an energy reserve that can be quickly mobilized to meet a sudden need for glucose, which is then turned into ATP through the process ofcellular respiration. You know that the fish you had for lunch contained protein molecules. But do you know that the atoms in that protein could easily have formed the color in a dragonfly's eye, the heart of a water flea, and the whiplike tail of a Euglena before they hit your plate as sleek fish muscle? Food consists of organic (carbon-containing) molecules which store energy in the chemical bonds between their atoms. Organisms use the atoms of food molecules to build larger organic molecules including proteins, DNA, and fats (lipids) and use the energy in food to power life processes. By breaking the bonds in food molecules, cells release energy to build new compounds. Although some energy dissipates as heat at each energy transfer, much of it is stored in the newly made molecules. Chemical bonds in organic molecules are a reservoir of the energy used to make them. Fueled by the energy from food molecules, cells can combine and recombine the elements of life to form thousands of different molecules. Both the energy (despite some loss) and the materials (despite being reorganized) pass from producer to consumer – perhaps from algal tails, to water flea hearts, to dragonfly eye colors, to fish muscle, to you! The process of photosynthesis, which usually begins the flow of energy through life, uses many different kinds of energy-carrying molecules to transform sunlight energy into chemical energy and build food. Some carrier molecules hold energy briefly, quickly shifting it like a hot potato to other molecules. This strategy allows energy to be released in small, controlled amounts. An example starts in chlorophyll, the green pigment present in most plants, which helps convert solar energy to chemical energy. When a chlorophyll molecule absorbs light energy, electrons are excited and "jump" to a higher energy level. The excited electrons then bounce to a series of carrier molecules, losing a little energy at each step. Most of the "lost" energy powers some small cellular task, such as moving ions across a membrane or building up another molecule. Another short-term energy carrier important to photosynthesis, NADPH, holds chemical energy a bit longer but soon "spends" it to help to build sugar. Two of the most important energy-carrying molecules are glucose and adenosine triphosphate, commonly referred to as ATP. These are nearly universal fuels throughout the living world and are both key players in photosynthesis, as shown below. A molecule of glucose, which has the chemical formula $C_6H_{12}O_6$, carries a packet of chemical energy just the right size for transport and uptake by cells. In your body, glucose is the "deliverable" form of energy, carried in your blood through capillaries to each of your 100 trillion cells. Glucose is also the carbohydrate produced by photosynthesis, and as such is the near-universal food for life. Glucose is the energy-rich product of photosynthesis, a universal food for life. It is also the primary form in which your bloodstream delivers energy to every cell in your body. ATP molecules store smaller quantities of energy, but each releases just the right amount to actually do work within a cell. Muscle cell proteins, for example, pull each other with the energy released when bonds in ATP break open (discussed below). The process of photosynthesis also makes and uses ATP - for energy to build glucose! ATP, then, is the useable form of energy for your cells. ATP is commonly referred to as the "energy currency" of the cell. Why do we need both glucose and ATP? Why don't plants just make ATP and be done with it? If energy were money, ATP would be a quarter. Enough money to operate a parking meter or washing machine. Glucose would be a ten dollar bill – much easier to carry around in your wallet, but too large to do the actual work of paying for parking or washing. Just as we find several denominations of money useful, organisms need several "denominations" of energy – a smaller quantity for work within cells, and a larger quantity for stable storage, transport, and delivery to cells. (Actually a glucose molecule would be about $9.50, as under the proper conditions, up to 38 ATP are produced for each glucose molecule.) Let's take a closer look at a molecule of ATP. Although it carries less energy than glucose, its structure is more complex. The "A" in ATP refers to the majority of the molecule, adenosine, a combination of a nitrogenous base and a five-carbon sugar. The "TP" indicates the three phosphates, linked by bonds which hold the energy actually used by cells. Usually, only the outermost bond breaks to release or spend energy for cellular work. An ATP molecule, shown in the Figure below, is like a rechargeable battery: its energy can be used by the cell when it breaks apart into ADP (adenosine diphosphate) and phosphate, and then the "worn-out battery" ADP can be recharged using new energy to attach a new phosphate and rebuild ATP. The materials are recyclable, but recall that energy is not! How much energy does it cost to do your body's work? A single cell uses about 10 million ATP molecules per second, and recycles all of its ATP molecules about every 20-30 seconds. An arrow shows the bond between two phosphate groups in an ATP molecule. When this bond breaks, its chemical energy can do cellular work. The resulting ADP molecule is recycled when new energy attaches another phosphate, rebuilding ATP. A explanation of ATP as "biological energy" is found at . All organisms require energy to complete tasks; metabolism is the set of the chemical reactions that release energy for cellular processes. Explain the importance of metabolism Key Takeaways Key Points All living organisms need energy to grow and reproduce, maintain their structures, and respond to their environments; metabolism is the set of the processes that makes energy available for cellular processes. Metabolism is a combination of chemical reactions that are spontaneous and release energy and chemical reactions that are non-spontaneous and require energy in order to proceed. Living organisms must take in energy via food, nutrients, or sunlight in order to carry out cellular processes. The transport, synthesis, and breakdown of nutrients and molecules in a cell require the use of energy. Key Terms metabolism: the complete set of chemical reactions that occur in living cells bioenergetics: the study of the energy transformations that take place in living organisms energy: the capacity to do work All living organisms need energy to grow and reproduce, maintain their structures, and respond to their environments. Metabolism is the set of life-sustaining chemical processes that enables organisms transform the chemical energy stored in molecules into energy that can be used for cellular processes. Animals consume food to replenish energy; their metabolism breaks down the carbohydrates, lipids, proteins, and nucleic acids to provide chemical energy for these processes. Plants convert light energy from the sun into chemical energy stored in molecules during the process of photosynthesis. Bioenergetics and Chemical Reactions Scientists use the term bioenergetics to discuss the concept of energy flow through living systems such as cells. Cellular processes such as the building and breaking down of complex molecules occur through step-by-step chemical reactions. Some of these chemical reactions are spontaneous and release energy, whereas others require energy to proceed. All of the chemical reactions that take place inside cells, including those that use energy and those that release energy, are the cell's metabolism. Most energy comes from the sun, either directly or indirectly: Most life forms on earth get their energy from the sun. Plants use photosynthesis to capture sunlight, and herbivores eat those plants to obtain energy. Carnivores eat the herbivores, and decomposers digest plant and animal matter. Cellular Metabolism Every task performed by living organisms requires energy. Energy is needed to perform heavy labor and exercise, but humans also use a great deal of energy while thinking and even while sleeping. For every action that requires energy, many chemical reactions take place to provide chemical energy to the systems of the body, including muscles, nerves, heart, lungs, and brain. The living cells of every organism constantly use energy to survive and grow. Cells break down complex carbohydrates into simple sugars that the cell can use for energy. Muscle cells may consumer energy to build long muscle proteins from small amino acid molecules. Molecules can be modified and transported around the cell or may be distributed to the entire organism. Just as energy is required to both build and demolish a building, energy is required for both the synthesis and breakdown of molecules. Many cellular process require a steady supply of energy provided by the cell's metabolism. Signaling molecules such as hormones and neurotransmitters must be synthesized and then transported between cells. Pathogenic bacteria and viruses are ingested and broken down by cells. Cells must also export waste and toxins to stay healthy, and many cells must swim or move surrounding materials via the beating motion of cellular appendages like cilia and flagella. Eating provides energy for activities like flight: A hummingbird needs energy to maintain prolonged periods of flight. The hummingbird obtains its energy from taking in food and transforming the nutrients into energy through a series of biochemical reactions. The flight muscles in birds are extremely efficient in energy production. The various types of energy include kinetic, potential, and chemical energy. Differentiate between types of energy Key Takeaways Key Points All organisms use different forms of energy to power the biological processes that allow them to grow and survive. Kinetic energy is the energy associated with objects in motion. Potential energy is the type of energy associated with an object's potential to do work. Chemical energy is the type of energy released from the breakdown of chemical bonds and can be harnessed for metabolic processes. Key Terms chemical energy: The net potential energy liberated or absorbed during the course of a chemical reaction. potential energy: Energy possessed by an object because of its position (in a gravitational or electric field), or its condition (as a stretched or compressed spring, as a chemical reactant, or by having rest mass). kinetic energy: The energy possessed by an object because of its motion, equal to one half the mass of the body times the square of its velocity. Energy is a property of objects which can be transferred to other objects or converted into different forms, but cannot be created or destroyed. Organisms use energy to survive, grow, respond to stimuli, reproduce, and for every type of biological process. The potential energy stored in molecules can be converted to chemical energy, which can ultimately be converted to kinetic energy, enabling an organism to move. Eventually, most of energy used by organisms is transformed into heat and dissipated. Kinetic Energy Energy associated with objects in motion is called kinetic energy. For example, when an airplane is in flight, the airplane is moving through air very quickly—doing work to enact change on its surroundings. The jet engines are converting potential energy in fuel to the kinetic energy of movement. A wrecking ball can perform a large amount of damage, even when moving slowly. However, a still wrecking ball cannot perform any work and therefore has no kinetic energy. A speeding bullet, a walking person, the rapid movement of molecules in the air that produces heat, and electromagnetic radiation, such as sunlight, all have kinetic energy. Potential Energy What if that same motionless wrecking ball is lifted two stories above a car with a crane? If the suspended wrecking ball is not moving, is there energy associated with it? Yes, the wrecking ball has energy because the wrecking ball has the potential to do work. This form of energy is called potential energy because it is possible for that object to do work in a given state. Objects transfer their energy between potential and kinetic states. As the wrecking ball hangs motionlessly, it has [latex]\text{0%}[/latex] kinetic and [latex]\text{100%}[/latex] potential energy. Once the ball is released, its kinetic energy increases as the ball picks up speed. At the same time, the ball loses potential energy as it nears the ground. Other examples of potential energy include the energy of water held behind a dam or a person about to skydive out of an airplane. Potential energy vs. kinetic energy: Water behind a dam has potential energy. Moving water, such as in a waterfall or a rapidly flowing river, has kinetic energy. Chemical Energy Potential energy is not only associated with the location of matter, but also with the structure of matter. A spring on the ground has potential energy if it is compressed, as does a rubber band that is pulled taut. The same principle applies to molecules. On a chemical level, the bonds that hold the atoms of molecules together have potential energy. This type of potential energy is called chemical energy, and like all potential energy, it can be used to do work. For example, chemical energy is contained in the gasoline molecules that are used to power cars. When gas ignites in the engine, the bonds within its molecules are broken, and the energy released is used to drive the pistons. The potential energy stored within chemical bonds can be harnessed to perform work for biological processes. Different metabolic processes break down organic molecules to release the energy for an organism to grow and survive. Chemical energy: The molecules in gasoline (octane, the chemical formula shown) contain chemical energy. This energy is transformed into kinetic energy that allows a car to race on a racetrack. An anabolic pathway requires energy and builds molecules while a catabolic pathway produces energy and breaks down molecules. Describe the two major types of metabolic pathways Key Takeaways Key Points A metabolic pathway is a series of chemical reactions in a cell that build and breakdown molecules for cellular processes. Anabolic pathways synthesize molecules and require energy. Catabolic pathways break down molecules and produce energy. Because almost all metabolic reactions take place non-spontaneously, proteins called enzymes help facilitate those chemical reactions. Key Terms catabolism: destructive metabolism, usually including the release of energy and breakdown of materials enzyme: a globular protein that catalyses a biological chemical reaction anabolism: the constructive metabolism of the body, as distinguished from catabolism The processes of making and breaking down carbohydrate molecules illustrate two types of metabolic pathways. A metabolic pathway is a step-by-step series of interconnected biochemical reactions that convert a substrate molecule or molecules through a series of metabolic intermediates, eventually yielding a final product or products. For example, one metabolic pathway for carbohydrates breaks large molecules down into glucose. Another metabolic pathway might build glucose into large carbohydrate molecules for storage. The first of these processes requires energy and is referred to as anabolic. The second process produces energy and is referred to as catabolic. Consequently, metabolism is composed of these two opposite pathways: Anabolism (building molecules) Catabolism (breaking down molecules) Anabolic and catabolic pathways: Anabolic pathways are those that require energy to synthesize larger molecules. Catabolic pathways are those that generate energy by breaking down larger molecules. Both types of pathways are required for maintaining the cell's energy balance. Anabolic Pathways Anabolic pathways require an input of energy to synthesize complex molecules from simpler ones. One example of an anabolic pathway is the synthesis of sugar from CO_2. Other examples include the synthesis of large proteins from amino acid building blocks and the synthesis of new DNA strands from nucleic acid building blocks. These processes are critical to the life of the cell, take place constantly, and demand energy provided by ATP and other high-energy molecules like NADH (nicotinamide adenine dinucleotide) and NADPH. Catabolic Pathways Catabolic pathways involve the degradation of complex molecules into simpler ones, releasing the chemical energy stored in the bonds of those molecules. Some catabolic pathways can capture that energy to produce ATP, the molecule used to power all cellular processes. Other energy-storing molecules, such as lipids, are also broken down through similar catabolic reactions to release energy and make ATP. Importance of Enzymes Chemical reactions in metabolic pathways rarely take place spontaneously. Each reaction step is facilitated, or catalyzed, by a protein called an enzyme. Enzymes are important for catalyzing all types of biological reactions: those that require energy as well as those that release energy. Organisms break down carbohydrates to produce energy for cellular processes, and photosynthetic plants produce carbohydrates. Analyze the importance of carbohydrate metabolism to energy production Key Takeaways Key Points The breakdown of glucose living organisms utilize to produce energy is described by the equation: [latex]{ \text{C} }_{ 6 }{ \text{H} }_{ 12 }{ \text{O} }_{ 6 }+6{ \text{O} }_{ 2 }\rightarrow 6{ \text{CO} }_{ 2 }+6{ \text{H} }_{ 2 }\text{O}+\text{energy}[/latex]. The photosynthetic process plants utilize to synthesize glucose is described by the equation: [latex]6\text{CO}_{ 2 }+6{ \text{H} }_{ 2 }\text{O}+\text{energy}\rightarrow { \text{C} }_{ 6 }{ \text{H} }_{ 12 }{ \text{O} }_{ 6 }+6\text{O}_{ 2 }[/latex]. Glucose that is consumed is used to make energy in the form of ATP, which is used to perform work and power chemical reactions in the cell. During photosynthesis, plants convert light energy into chemical energy that is used to build molecules of glucose. Key Terms adenosine triphosphate: a multifunctional nucleoside triphosphate used in cells as a coenzyme, often called the "molecular unit of energy currency" in intracellular energy transfer glucose: a simple monosaccharide (sugar) with a molecular formula of $C_6H_{12}O_6$; it is a principal source of energy for cellular metabolism Carbohydrates are one of the major forms of energy for animals and plants. Plants build carbohydrates using light energy from the sun (during the process of photosynthesis), while animals eat plants or other animals to obtain carbohydrates. Plants store carbohydrates in long polysaccharides chains called starch, while animals store carbohydrates as the molecule glycogen. These large polysaccharides contain many chemical bonds and therefore store a lot of chemical energy. When these molecules are broken down during metabolism, the energy in the chemical bonds is released and can be harnessed for cellular processes. All living things use carbohydrates as a form of energy.: Plants, like this oak tree and acorn, use energy from sunlight to make sugar and other organic molecules. Both plants and animals (like this squirrel) use cellular respiration to derive energy from the organic molecules originally produced by plants Energy Production from Carbohydrates (Cellular Respiration) The metabolism of any monosaccharide (simple sugar) can produce energy for the cell to use. Excess carbohydrates are stored as starch in plants and as glycogen in animals, ready for metabolism if the energy demands of the organism suddenly increase. When those energy demands increase, carbohydrates are broken down into constituent monosaccharides, which are then distributed to all the living cells of an organism. Glucose ($C_6H_{12}O_6$) is a common example of the monosaccharides used for energy production. Inside the cell, each sugar molecule is broken down through a complex series of chemical reactions. As chemical energy is released from the bonds in the monosaccharide, it is harnessed to synthesize high-energy adenosine triphosphate (ATP) molecules. ATP is the primary energy currency of all cells. Just as the dollar is used as currency to buy goods, cells use molecules of ATP to perform immediate work and power chemical reactions. The breakdown of glucose during metabolism is call cellular respiration can be described by the equation: [latex]{ C }_{ 6 }{ H }_{ 12 }{ O }_{ 6 }+6{ O }_{ 2 }\rightarrow 6{ CO }_{ 2 }+6{ H }_{ 2 }O+energy[/latex] Producing Carbohydrates (Photosynthesis) Plants and some other types of organisms produce carbohydrates through the process called photosynthesis. During photosynthesis, plants convert light energy into chemical energy by building carbon dioxide gas molecules (CO_2) into sugar molecules like glucose. Because this process involves building bonds to synthesize a large molecule, it requires an input of energy (light) to proceed. The synthesis of glucose by photosynthesis is described by this equation (notice that it is the reverse of the previous equation): [latex]6CO_{ 2 }+6{ H }_{ 2 }O+energy\rightarrow { C }_{ 6 }{ H }_{ 12 }{ O }_{ 6 }+6O_{ 2 }[/latex] As part of plants' chemical processes, glucose molecules can be combined with and converted into other types of sugars. In plants, glucose is stored in the form of starch, which can be broken down back into glucose via cellular respiration in order to supply ATP.

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