

Energy of Life Notes 2024

Concept: An organism's metabolism transforms matter and energy, subject to the laws of thermodynamics

Metabolism is the totality of an organism's chemical reactions. Metabolism as a whole manages the material and energy resources of the cell.

A _____ pathway leads to the release of energy by the breakdown of complex molecules to simpler compounds. Example: Catabolic pathway occur when your digestive enzymes break down food and release energy.

_____ pathways consume energy to build complicated molecules from simpler ones. Example: Anabolic pathways occur when your body links together amino acids to form muscle protein in response to physical exercise.

Energy Types

Energy is defined as the capacity to do _____.

Anything that is moving is said to possess kinetic energy.

An object at rest can possess potential energy if it has stored energy as a result of its position or structure.

_____ energy, a form of potential energy, is stored in molecules, and the amount of chemical energy a molecule possesses depends on its chemical bonds.

Thermodynamics is the study of energy transformations that occur in matter.

-The first law of thermodynamics states that the energy of the universe is constant and that energy can be transferred and transformed but it cannot be created or destroyed.

-The second law of thermodynamics states that every energy transfer or transformation increases the entropy, or the amount of disorder or randomness in the universe.

Concept: The free-energy change of a reaction tells us whether or not the reaction occurs spontaneously

Gibbs Free Energy

Free energy is defined as the part of a system's energy that is able to perform work when the temperature of a system is _____.

ΔG is a symbol for a change in free energy. $\Delta G = \Delta H - T\Delta S$ T=Temperature, H=enthalpy (a measure of energy in a thermodynamic system), S denotes entropy.

-An _____ reaction is one in which energy is released. Exergonic reactions occur spontaneously (that does not necessarily mean quickly) and release free energy to the system. $\Delta G < 0$.

-An _____ reaction is one that requires energy in order to proceed. Endergonic reactions absorb free energy; that is they require free energy from the system. $\Delta G > 0$

-Is the breakdown of glucose in cellular respiration exergonic or endergonic?
(ΔG is -686kcal/mol.)

Concept: ATP powers cellular work by coupling exergonic reactions to endergonic reactions

The energy needs of life

Organisms are _____ systems

-What do we need energy for?

- synthesis: building biomolecules
- reproduction
- movement
- active transport
- temperature regulation

Where do we get the energy from?

-Work of life is done by energy _____. It uses exergonic (catabolic) reactions to fuel endergonic (anabolic) reactions

Living economy

-Fueling the body's economy needs to eat high energy organic molecules. Food = carbohydrates, lipids, proteins, nucleic acids. Our bodies break them down (digest = catabolism) to capture released energy in a form the cell can use.

-Our bodies need an energy currency and a way to pass energy around. They need a short-term energy and storage molecule.

ATP

Adenosine TriPhosphate is a modified nucleotide

nucleotide = adenine + ribose + P_i $\rightarrow$ AMP

AMP + P_i $\rightarrow$ ADP

ADP + P_i $\rightarrow$ _____

-adding phosphates is endergonic

How does ATP store energy?

-Each negative PO_4 more difficult to add. It requires a lot of stored energy in each _____. The most energy stored in 3rd P_i . The 3rd P_i is hardest group to keep bonded to molecule.

-The bonding of negative P_i groups is unstable. They are considered "spring-loaded". P_i groups "pop" off easily & release chemical energy

How does ATP transfer energy?

-ATP $\rightarrow$ ADP: releases energy ($\Delta G = -7.3$ kcal/mole)

-This energy is fuel other reactions

-Phosphorylation: the released P_i can transfer to other molecules which can destabilize the other molecules
enzyme that phosphorylates (add phosphate groups) = "_____"

ATP/ADP cycle

Can't store ATP as it good energy donor, but not good energy storage as it is too reactive, it transfers P_i too easily. It is only short-term energy storage. _____ & fats are long term energy storage

Concept: Enzymes speed up metabolic reactions by lowering energy barriers

Enzymes as Catalysts

- _____ are substances that can change the rate of a reaction without being altered in the process.

-Enzymes are macromolecules that are biological catalysts. They accomplish this by lowering the activation energy and helping the transition state to form. Thus, the reaction can occur more quickly because the transition state is not as much of a hurdle to overcome. Enzymes do NOT change the energy of the starting point or the ending point of the reaction. They only lower the activation energy.

-The activation energy of a reaction is the amount of energy it takes to _____ a reaction-the amount of energy it takes to break the bonds of the reactant molecules. Enzymes speed up reactions by lowering the activation energy of the reaction=but without changing the free-energy change of the reaction. The reactant that the enzyme acts on is called a _____.

-The active site is the part of the enzyme that binds to the substrate. The enzyme and substrate form a complex called an enzyme-substrate complex that is generally held together by weak interactions. The substrate is then converted into products, and the products are released from the enzyme.

Cells need enzymes

-Most of the crucial reactions that occur in the cell require enzymes. Yet enzymes themselves are highly specific-in fact, each enzyme catalyzes only one kind of reaction. This is known as enzyme specificity.

-Because of this, enzymes are usually named after the molecules they target. In enzymatic reactions, the targeted molecules are known as substrates. For example, maltose, a disaccharide, can be broken down into two glucose molecules. Our substrate, maltose, gives its name to the enzyme that catalyzes this reaction: maltase.

-Many enzymes are named simply by replacing the suffix of the substrate with -ase. Using this nomenclature, maltose becomes maltase.

Enzyme Activity

-The activity of an enzyme can be affected by several factors:

-Protein enzymes have complicated _____-dimensional shapes that are dramatically affected by changes in pH and temperature. Changes in the precise shape of an enzyme usually mean the enzyme will not be effective.

-Many enzymes require nonprotein helpers, termed _____, to function properly. Cofactors include metal ions like zinc, iron, and copper and function in some crucial way to allow catalysis to occur. If the cofactor is organic, it is more properly referred to as a coenzyme. Coenzymes are organic cofactors; vitamins are examples of coenzymes.

-Competitive inhibitors are reversible inhibitors that compete with the substrate for the active site on the enzyme. Competitive inhibitors are often chemically very similar to the normal substrate molecule and reduce the efficiency of the enzyme as it competes for the active site.

-Noncompetitive inhibitors do not directly compete with the substrate molecule; instead, they impede enzyme activity by binding to another part of the enzyme. This causes the enzyme to change its shape, rendering the active site nonfunctional.

Concept: Regulation of enzyme activity helps control metabolism

Enzyme Regulation

- Many enzyme regulators bind to an allosteric site on the enzyme, which is a specific binding site, but not the active site. Once bound, the shape of the enzyme is _____, and this can either stimulate or inhibit enzyme activity.
- The end product on an enzymatic pathway can switch off its pathway by binding to the allosteric site of the enzyme in the pathway. This type of allosteric inhibition is termed feedback inhibition.
- Feedback inhibition increases the efficiency of the pathway by turning it off when the end product accumulates in the cell.