 Enzymes: Structure, Functions, and Classification Written by Ashma Shresthain Biochemistry Enzymes are biological catalysts with extraordinary catalytic power. Likewise, others were named for their source: trypsin, named in part from the Greek trying "to wear down," was obtained by rubbing pancreatic tissue with glycerin. However, the same enzyme may have two or more names, or two different enzymes have the same name. Because of such ambiguities and the ever-increasing number of enzyme discoveries, international agreement led to the adoption of a system for naming and classifying enzymes. Class Actions Oxidoreductases These are responsible for the transfer of electrons (hydride ions or H atoms). Transferases These aid in group transfer reactions. Hydrolases These are useful in hydrolysis reactions (transfer of functional groups to water). Lyases These help in the addition of groups to double bonds, or formation of double bonds by removal of groups. Isomerases These enzymes assists in the transfer of groups within molecules to yield isomeric forms. Ligases These catalyzes the formation of C-C, C-S, C-O, and C-N bonds by condensation reactions coupled to ATP cleavage. Note: The function of most enzymes is the catalysis of the transfer of atoms, electrons, or functional groups. Therefore, they have different classifications, code numbers, and names assigned according to the type of transfer reaction, the donor group, and the group acceptor. This system classifies enzymes into six classes based on the type of reaction they catalyze. These classes have their specific subclasses. Each enzyme has a four-part classification number and a systematic name identifying the reaction it catalyzes. For example, the formal systematic name of the enzyme catalyzing the reaction, ATP + D-glucose -> ADP + D-glucose 6-phosphate, is ATP: glucose phosphotransferase. This denotes that the enzyme is the catalyst for transferring a phosphoryl group from ATP to glucose. The assigned Enzyme Commission number (E.C. number) for this enzyme is 2.7.1.1. The number 2 means the class name (transferase). Then, the number 2 denotes the subclass phosphotransferase. Similarly, the third number, 1, denotes the acceptor as phosphotransferase having a hydroxyl group. Finally, the number, 1, means D-glucose is the acceptor for the phosphoryl group. For many enzymes, a trivial or common name is more commonly used. Hexokinase is the common name for this enzyme. IUBMB (International Union of Biochemistry and Molecular Biology) maintains a complete list describing the thousands of known enzymes. (https://iubmb.qmul.ac.uk/enzyme/rules.html). How do Enzymes Work? The mechanism of enzyme action involves several key steps that occur at the molecular level. Enzymes facilitate biochemical reactions by lowering the energy needed for a reaction to proceed, thereby increasing the reaction rate. This process occurs through specific interactions between the enzyme, substrate, and other molecules. Substrate Binding Enzyme substrate binding Enzyme substrate binding The enzyme's active site, which has a specific three-dimensional shape complementary to the substrate molecule, initially binds to the substrate. This binding can occur through a lock-and-key mechanism (where the substrate fits precisely into the active site) or an induced fit mechanism (where the active site reshapes slightly to accommodate the substrate). x Ezoic Formation of the Enzyme-Substrate Complex Once the substrate binds to the active site, it forms a temporary enzyme-substrate complex. This complex is stabilized by various interactions, such as van der Waals forces, hydrogen bonds, and electrostatic interactions between the enzyme and substrate. Mechanism of enzymes action Simple enzyme mechanism, showing the formation of the enzyme-substrate complex and the chemical step. Catalysis While bound to the enzyme, the substrate undergoes chemical transformations that lead to the formation of products. Enzymes catalyze these reactions by giving an alternative reaction pathway that requires less activation energy than the uncatalyzed reaction. Active Site Residues Within the active site, specific amino acid residues play crucial roles in catalysis. These residues can act as acids or bases, nucleophiles, or participate in covalent bond formation with the substrate. Common catalytic residues include serine, cysteine, histidine, lysine, aspartate, and glutamate. Transition State Stabilization Enzymes stabilize the reaction's transition state, the high-energy intermediate state that occurs during the conversion of substrate into product. By stabilizing the transition state, enzymes lower the activation barrier, making it easier for the reaction to proceed. x Ezoic Product Release After the catalytic reaction occurs, the enzyme releases the products chemically different from the original substrate. The enzyme is then free to bind to another substrate molecule and repeat the catalytic cycle. Enzyme-Product Complex In some cases, the enzyme may transiently form an enzyme-product complex after catalysis, where the product remains bound to the enzyme briefly before being released. Regulation Enzyme activity can be regulated through various mechanisms such as allosteric regulation, covalent modification, competitive and non-competitive inhibition, feedback inhibition, and enzyme induction or repression. These regulatory mechanisms ensure that enzyme activity is precise to the metabolic needs of the cell or organism. Factors affecting Enzyme activity Various factors can influence enzyme activity, impacting enzymatic reaction efficiency and rate. Understanding these factors is crucial for optimizing enzyme function in biological processes, industrial applications, and research settings. Here are the main factors affecting enzyme activity: Temperature Enzyme activity is susceptible to temperature changes. Generally, increasing temperature increases the rate of enzymatic reactions by providing more kinetic energy to molecules, which enhances their collision frequency and leads to more successful enzyme-substrate interactions. However, extremely high temperatures can denature enzymes, causing loss of their catalytic activity due to disruption of their three-dimensional structure. Each enzyme can operate at an optimal temperature range with maximum activity, known as the temperature optimum. pH The pH level of the environment influences enzyme activity by affecting the ionization state of amino acid residues at the active site. Enzymes have an optimal pH range at which they function most efficiently. Deviations from this pH range can alter the enzyme's structure and charge distribution, reducing activity or denaturation. For example, pepsin, an enzyme in the stomach that digests proteins, works optimally in an acidic pH environment, while enzymes in the small intestine, such as pancreatic enzymes, function optimally in a slightly alkaline pH range. Substrate Concentration Enzyme activity often depends on the concentration of substrate molecules available for binding to the enzyme's active sites. As substrate concentration increases, enzyme activity increases because more enzyme-substrate complexes can form. However, at a certain point known as the saturation point, all enzyme active sites become occupied, and substrate concentration increases do not significantly increase the reaction rate. This point is essential in understanding enzyme kinetics and the concept of enzyme saturation. Enzyme Concentration The amount of enzyme in a reaction also affects enzyme activity. Generally, higher enzyme concentrations lead to faster reaction rates because more enzyme molecules are available to catalyze the conversion of substrates to products. However, like substrate concentration, there can be a saturation point where adding more enzymes does not increase the reaction rate if substrate concentration is limited. Cofactors and Coenzymes Many enzymes require specific cofactors or coenzymes for optimal activity. Cofactors can be metal ions (such as Mg^{2+}, Zn^{2+}, Fe^{2+}) or organic molecules, while coenzymes are often vitamins or derivatives of vitamins. These cofactors and coenzymes assist enzymes in catalyzing reactions by participating in chemical reactions, transferring functional groups, or stabilizing reaction intermediates. Inhibitors Enzyme activity can be inhibited by various molecules known as inhibitors. Inhibitors are of two types: irreversible and reversible inhibitors. Reversible inhibitors include competitive inhibitors (compete with the substrate for the active site), non-competitive inhibitors (bind to an allosteric site and change the enzyme's conformation), and uncompetitive inhibitors (bind to the enzyme-substrate complex). Irreversible inhibitors covalently bind to the enzyme, permanently inhibiting its activity. x Ezoic Enzyme inhibitors Top: enzyme accelerates conversion of substrates to products. Middle: by binding to enzyme, inhibitor blocks binding of substrate. Bottom: by binding to enzyme, inhibitor disrups conversion of substrates to products. Binding sites in blue, substrates in black, inhibitors in green, allosteric site in light green. Activators and Modulators In contrast to inhibitors, activators and modulators can enhance enzyme activity. The molecules that bind to enzymes are activators and increase their catalytic activity. Allosteric activators bind to allosteric sites and induce conformational changes that enhance enzyme activity. Modulators can also alter enzyme activity by affecting conformation and activity through allosteric regulation. Enzyme Structure and Conformational Changes Enzyme structure and conformational dynamics play a crucial role in their activity. Changes in enzyme structure due to mutations, denaturation, or environmental factors can significantly affect enzyme activity and specificity.

Functions of Enzymes Enzymes play vital roles in biochemical reactions and metabolic processes within living organisms. Their functions are diverse and essential for maintaining life processes. Catalysis Enzymes act as biological catalysts, increasing biochemical reaction rates by using less activation energy. This catalytic activity allows cells to carry out metabolic processes efficiently, such as breaking down nutrients, synthesizing biomolecules, and producing energy. Digestion These play a crucial role in digestion by breaking down complex macromolecules into smaller, absorbable molecules. For example: x Ezoic Amylase breaks down starch into glucose during carbohydrate digestion. Proteases hydrolyze proteins into amino acids. Lipases aid in the hydrolyzation of fats into fatty acids and glycerol. Energy Production Enzymes participate in energy production pathways like glycolysis, Krebs cycle, and oxidative phosphorylation. These pathways involve enzyme-catalyzed reactions that convert carbohydrates, fats, and proteins into energy-rich molecules such as ATP (adenosine triphosphate) that cells use for various cellular processes. Synthesis of Biomolecules Enzymes are involved in synthesizing biomolecules essential for cellular structure, function, and regulation. Examples include: DNA polymerase and RNA polymerase catalyze the synthesis of DNA and RNA, respectively, during replication and transcription. Although not enzymes, ribosomes facilitate protein synthesis (translation) by assembling amino acids into polypeptide chains based on mRNA instructions. Detoxification These in the liver and other organs participate in detoxification by metabolizing and eliminating harmful substances (such as drugs, toxins, and foreign compounds) from the body. These enzymes, such as cytochrome P450 enzymes, modify xenobiotics to make them more water-soluble for excretion. Cell Signaling Enzymes are involved in cell signaling pathways, where they catalyze reactions that regulate cellular responses to external stimuli, including hormones, neurotransmitters, and growth factors. Examples include protein kinases that phosphorylate proteins in signal transduction cascades and phosphatases that dephosphorylate them. Immune Response Enzymes are part of the immune system's defense mechanisms. For instance, enzymes like lysozyme and proteases in tears, saliva, and mucus help protect against pathogens by breaking down their cell walls or proteins. x Ezoic Repair and Maintenance Enzymes participate in DNA repair mechanisms, ensuring genomic stability and integrity. Enzymes such as DNA repair polymerases, nucleases, and ligases recognize and correct DNA damage caused by various factors, including radiation, chemicals, and oxidative stress. Regulation of Metabolic Pathways These play a crucial role in regulating metabolic pathways by controlling the rates of specific reactions. Regulation can occur through feedback inhibition, allosteric regulation, covalent modification (such as phosphorylation), and gene expression changes affecting enzyme levels. References Nelson, D., Lehninger, A., Cox, M., & Nelson, D. (2005). Lecture notebook for Lehninger principles of biochemistry, fourth edition (pp. 601-612). W.H. Freeman. odwell, V., Bender, D., Botham, K., Kennelly, P., & Weil, P. (2015). Harper's illustrated biochemistry (30th ed., pp. 161-167). McGraw Hill. Substrate Binding Formation of the Enzyme-Substrate Complex Catalysis Active Site Residues Transition State

Stabilization Product Release Enzyme-Product Complex Regulation Factors affecting Enzyme activity Temperature pH Substrate Concentration Enzyme Concentration Cofactors and Coenzymes Inhibitors Activators and Modulators Enzyme Structure and Conformational Changes Functions of Enzymes Catalysis Digestion Energy Production Synthesis of Biomolecules Detoxification Cell Signaling Immune Response Repair and Maintenance Regulation of Metabolic Pathways General Properties of Enzymes All enzymes are proteins except for a small group of catalytic RNA molecules.Classification and Nomenclature of Enzymes The naming of many enzymes is done by adding the suffix "-ase" to their substrates' name or a word or phrase that describes their activity. Thus, DNA polymerase catalyzes the polymerization of nucleotides to form DNA, and urease catalyzes the hydrolysis of urea. Before the specific reaction catalyzed was known, other enzymes were named for a broad function. For example, pepsin, from the Greek word pepsis, meaning "digestion," was given to an enzyme known to act in the digestion of foods.Enzymes are highly specific and function in aqueous solutions under very mild conditions of temperature and pH. They act in organized sequences and catalyze hundreds of stepwise reactions that degrade nutrient molecules, conserve and transform chemical energy, and form biological macromolecules from simple precursors.Table of Contents General Properties of Enzymes Structure of Enzymes Primary Structure Secondary Structure Tertiary Structure Quaternary Structure (if applicable) Active Site Regulatory Sites (if applicable) Other structural components of enzymes Classification and Nomenclature of Enzymes How do Enzymes Work?Others may require an additional chemical component called a cofactor--one or more inorganic ions, like Mg2, Mn2, Fe2, or Zn2, or a complex organic or metallo organic molecule called a coenzyme.Enzymes have a specific three-dimensional structure that enables them to bind to substrates and conduct chemical reactions.General structure of enzymes may be similar to the primary, secondary, tertiary, or quaternary structure of proteins.Measurements of enzymes in erythrocytes, plasma, and tissues help diagnose some diseases and deficiencies, especially inheritable genetic disorders.Thus, protein enzymes' primary, secondary, tertiary, and quaternary structures are essential to their catalytic activity.This structure is stabilized by various interactions such as hydrogen bonds, disulfide bonds, hydrophobic interactions, and electrostatic interactions between amino acid side chains.Quaternary Structure (if applicable) Some enzymes consist of multiple polypeptide chains, and their quaternary structure refers to the arrangement of these subunits.Regulatory Sites (if applicable) Some enzymes have regulatory sites separate from the active site, where molecules such as inhibitors or activators can bind.CONTINUE READING link to Pentose Phosphate Pathway: Steps and Functions Pentose Phosphate Pathway: Steps and Functions The primary breakdown of glucose-6-phosphate is the formation of pyruvate through glycolysis.Primary Structure This refers to the linear sequence of amino acids in the enzyme's polypeptide chain.Active Site This is a crucial feature of enzyme structure where the substrate binds, and the catalytic reaction occurs.A prosthetic group is a coenzyme or metal ion that tightly or covalently binds to the enzyme protein.We are trying our best to make this site user-friendly and resourceful with timely/updated information about each pathogen, disease caused by them, pathogenesis, and laboratory diagnosis.Secondary Structure Enzymes often exhibit secondary structures such as alpha-helices and beta-sheets.x Ezoic Tertiary Structure It is the three-dimensional arrangement of the entire polypeptide chain, including the secondary structural elements.The active site is typically a small crevice or pocket on the enzyme's surface that is similar in shape and chemical properties to the substrate molecules.These regulatory molecules can modulate the enzyme's activity, inhibiting or enhancing its catalytic function.x Ezoic Other structural components of enzymes Some enzymes do not require chemical groups for activity except their amino acid residues.This blog shares information and resources about pathogenic bacteria, viruses, fungi, and parasites.Hence, as biological catalysts, enzymes play a significant role in biochemical processes.The integrity of the enzyme's native protein conformation affects its catalytic activity.If an enzyme is broken down into component amino acids, its catalytic activity is permanently destroyed.Like other proteins, enzymes have molecular weights ranging from approximately 12,000 to greater than 1 million.These structures result from hydrogen bonding between amino acids in the polypeptide chain.It often involves specific amino acid residues that directly participate in catalysis (catalytic residues).A holoenzyme is a complete, catalytically active enzyme with its bound coenzyme, with or without metal ions.x Ezoic Coenzymes can act as transient carriers of specific functional groups.The pyruvate enters the Krebs cycle to form ATP, the energy currency for the cell.ABOUT US SUBSCRIBE TO BLOG VIA EMAIL Enter your email address to subscribe to this blog and receive notifications of new posts by email.Chemical reactions like sucrose oxidation cannot happen in the correct time frame and thus cannot sustain life.Catalytic activity is usually lost if an enzyme is denatured or dissociated into its subunits.These have active sites where the interaction with the substrate occurs.Active site is present in all the enzymes and regulatory modification can occur in some enzymes.The sequence is determined by the gene encoding the enzyme and is crucial for its overall structure and function.The secondary structure helps determine the overall folding of the enzyme.The interactions between subunits can also contribute to the enzyme's stability and function.Most are derived from vitamins and organic nutrients required in small amounts in the diet.Share your queries or comments This site uses Akismet to reduce spam.We know living systems derive energy from the surroundings through biochemical processes.For example, the oxidation of sucrose to CO_2 and H_2O generates a high amount of power, which we utilize to move, taste, see, and think.The protein part of such an enzyme is an apoprotein or apoenzyme.CONTINUE READING ABOUT US Microbeonline.com is an online guidebook on Microbiology, precisely speaking, Medical Microbiology.Enzymes affect reaction rates but not equilibria.These are not consumed in overall reactions.Enzymes are required in a few amounts during chemical reactions.Some enzymes require a coenzyme and one or more metal ions for activity.I had recently completed my Masters degree in Medical Microbiology.Key interest in virology and molecular biology.So, a combination of cells performing similar functions is a tissue.They are also critical practical tools in medicine, the chemical industry, food processing, and agriculture.Enzymes are extremely specific to their substrate.Structure of Enzymes As discussed earlier, most enzymes are proteins.Recent Posts link to Different Types of Tissues in Plant and Animal Different Types of Tissues in Plant and Animal As we all know, cells are the building blocks of living things.These tissues form organs.Most eukaryotic organisms function as...Glucose-6-phosphate...They are central to every biochemical process.Passionate about writing and blogging.We love to get your feedback.Learn how your comment data is processed.