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What Is An Enzyme? Factors That Affect Enzymes

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Abstract: This article explores the fundamental role of enzymes as biological catalysts that regulate metabolic reactions essential for life. It explains the mechanisms of enzyme activity, including substrate specificity, active sites, and the lock-and-key and induced-fit hypotheses. The paper also discusses how environmental factors such as temperature and pH influence enzyme activity and how enzyme reactions can be measured experimentally. Furthermore, recent scientific innovations are highlighted, including the use of enzymes in medicine, biotechnology, and environmental sustainability. Developments such as CRISPR-Cas genome editing, enzyme-based biosensors for disease detection, and PETase for plastic degradation demonstrate the growing importance of enzyme research in addressing global challenges. The integration of bioinformatics, nanotechnology, and machine learning represents the future of enzyme science, offering new possibilities for drug design, renewable energy, and green chemistry. Overall, this study emphasizes both the natural significance of enzymes in sustaining life and their expanding applications through human innovation.

Keywords: Enzyme, catalyst, metabolic reaction, active site, lock-and-key hypothesis, CRISPR-Cas, biosensor, PETase, bioinformatics, nanotechnology, green chemistry, biotechnology.

INTRODUCTION:

In modern biology, enzymes represent one of the most essential and intensively studied classes of biomolecules. They serve as the core of all metabolic processes within living organisms, ensuring the continuous maintenance of vital life activities. Through enzymatic catalysis, complex biochemical reactions occur rapidly, under mild conditions, and with minimal energy expenditure. Therefore, understanding the structure, mechanisms, and functional significance of enzymes remains a central topic not only in biology but also in medicine, biotechnology, food science, and environmental studies.

Today, enzyme-based technologies play an increasingly vital role in improving human life and promoting environmental sustainability. Breakthroughs such as the CRISPR-Cas genome-editing system, enzyme-based biosensors, and the discovery of PETase—an enzyme capable of degrading plastics—mark a new era in biological science. Consequently, exploring the natural roles, catalytic mechanisms, and modern scientific applications of enzymes has become one of the most dynamic and forward-looking fields in contemporary research.

Many chemical reactions can be sped up by substances called catalysts. A catalyst alters the rate of a chemical reaction, without being changed itself. Within any living organism, chemical reactions are taking place all the time. These reactions are called

metabolic reactions. Almost every metabolic reaction is controlled by catalysts called enzymes. Without enzymes, the reactions would take place very slowly or not at all. Enzymes ensure that the rates of metabolic reactions are fast enough to sustain life.

For example, inside the intestines, large molecules are broken down to smaller ones in the process of digestion. These reactions are speeded up by enzymes. A different enzyme is needed foe each kind of nutrient. For example, starch is digested to a sugar called maltose by an enzyme called amylase. Proteins are digested to amino acids by protease. These enzymes are also found in plants. For example, in germinating seeds enzymes digest the food stores (mainly starch) for the growing seedling.

Another enzyme which speeds up the breakdown of a substance is catalase. Catalase works inside all the cells of living organisms. It breaks down hydrogen peroxide to water and oxygen. This is necessary because hydrogen peroxide is produced by many of the chemical reactions which take place inside cells. Hydrogen peroxide is a very dangerous substance and must be broken down immediately.

$$\text{Hydrogen peroxide} \xrightarrow{catalase} \text{water+oxygen}$$

Not all enzymes help to break things down. Many enzymes help to make large molecules from small ones. For example, enzymes help to link amino acids together to make proteins inside cells.

Enzymes are named according to the reaction that they catalyse. Their names often end in -ase. For example, enzymes that catalyse the breakdown of carbohydrates are called carbohydrases. If they break down proteins, they are proteases. If they break down fats and oils (lipids) they are lipases. Sometimes, enzymes are given more specific names than this. For example, we have seen that the carbohydrase that breaks down starch is called amylase. A carbohydrase that breaks down maltose is called maltase. A carbohydrase that breaks down sucrose is called sucrase. The substance that an enzyme changes is called its substrate. The substrate of amylase is starch. The substrate of lipase is lipids. Notice how careful you have to be to spell the name of the enzyme and its substrate correctly, and to write clearly. Maltose and maltase can look almost the same if you do not write carefully.

Each type of enzyme has molecules with a very specific shape. The enzyme molecule has a ‘dent’ in it, called the active site.

An enzyme works by allowing a molecule of its substrate to fit into the active site, where the substrate and the enzyme bind together. For this to happen, the fit has to be perfect. We say that the shape of the enzyme and the shape of the substrate are complementary to one another. When the substrate is in the active site and bound to the enzyme, the enzyme changes the substrate into a new substance called the product. Then the product breaks away from the enzyme. Now the enzyme is free, and ready to bind with another substrate molecule. The substrate is a single molecule, and it is broken into two product molecules. Enzymes can also catalyse reactions where two substrate molecules bind with its active site and are joined together to form a single product molecule.

Not all enzymes work inside cells. Those that do are deseribed as intracellular. Enzymes that are secreted by cells and catalyse reactions outside cells are described as extracellular. Digestive enzymes in the gut are extracellular enzymes. Some organisms secrete enzymes outside their bodies. Fungi, for example, often do this in order to digest the food on which they are growing.

Like all globular proteins, enzyme molecules are coiled into a precise three-dimensional shape. Hydrophilic R groups (side-chains) on the outside of the molecule make them soluble in the water in the cytoplasm. Enzyme molecules have a special feature called an active site. The active site of an enzyme is a region to which another molecule (or molecules) can bind. This molecule is the substrate of the enzyme. The shape of the active site allows the substrate to fit perfectly. The idea that the enzyme has a particular shape into which the substrate fits exactly is known as the lock-and-key hypothesis. The substrate is the key whose shape fits the lock of the enzyme. The substrate is held in place by temporary bonds which form between the substrate and some of the R groups of the enzyme’s amino acids. This combined structure is termed the enzyme-substrate complex.

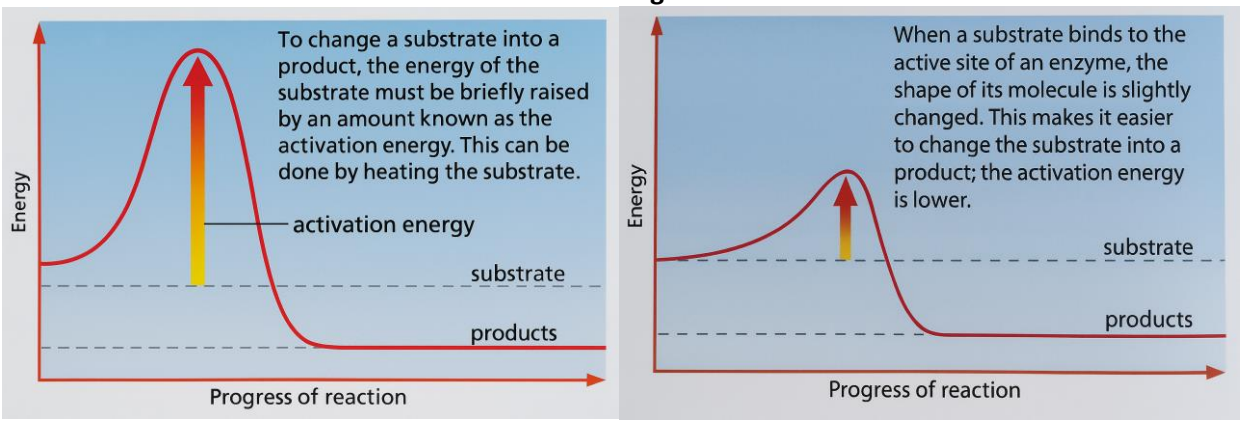
Each enzyme will act on only one type of substrate molecule. This is because the shape of the active site

will only allow one shape of molecule to fit. The enzyme is said to be specific for this substrate. You can also describe the enzyme as showing specificity. In 1959 the lock-and-key hypothesis was modified in the light of evidence that enzyme molecules are more flexible than is suggested by a rigid lock and key. The modern hypothesis for enzyme action is known as the induced-fit hypothesis. It is basically the same as the lock-and-key hypothesis, but adds the idea that the enzyme, and sometimes the substrate, can change shape slightly as the substrate molecule enters the enzyme, in order to ensure a perfect fit. This makes the catalysis even more efficient.

The interaction between the substrate and the active site, including the slight change in shape of the enzyme (induced fit) which results from the binding of the substrate, is clearly shown by the enzyme lysozyme. Lysozyme is found in tears, saliva and other secretions. It acts as a natural defence against bacteria. It does this by breaking the polysaccharide chains that form the cell walls of the bacteria.

Enzymes increase the rate at which chemical reactions occur. Without enzymes, most of the reactions that occur in living cells would occur so slowly that life could not exist. In many chemical reactions, the substrate is not converted to a product unless some energy is added. This energy is called activation energy. One way of providing the extra energy needed is to heat the substances. For example, in the Benedict's test for reducing sugar you need to heat the Benedict's reagent and sugar solution together before they will react. Enzymes avoid this problem because they decreasethe activation energy of the reactions they catalyse (Figure 1 (a,b)). They do this by holding the substrate or substrates in such a way that their molecules can react more easily. As a result, reactions catalysed by enzymes take place rapidly at a much lower temperature than they otherwise would.

Figure 1



a) without enzyme **b) with enzyme**

You may be able to carry out an investigation into the progress of an enzyme-controlled reaction by measuring the rate at which the product is formed from the substrate. The enzyme catalase is found in the tissues of most living things and catalyses the breakdown of hydrogen peroxide into water and oxygen. (Hydrogen peroxide is sometimes produced inside cells. It is toxic (poisonous), so it must be got rid of quickly.) The oxygen that is released can be collected and measured, so it is an easy reaction to follow.

The reaction begins very quickly. As soon as the enzyme and substrate are mixed, bubbles of oxygen are released. A large volume of oxygen is collected in the first minute of the reaction. As the reaction continues, however, the rate at which oxygen is released gradually slows down. The reaction gets slower and slower, until it eventually stops completely. The explanation for the course of the reaction is quite straightforward. When the enzyme and substrate are first mixed, there are a large number of substrate molecules. At any moment, almost every enzyme molecule has a substrate molecule in its active site. The rate at which the reaction occurs depends on:

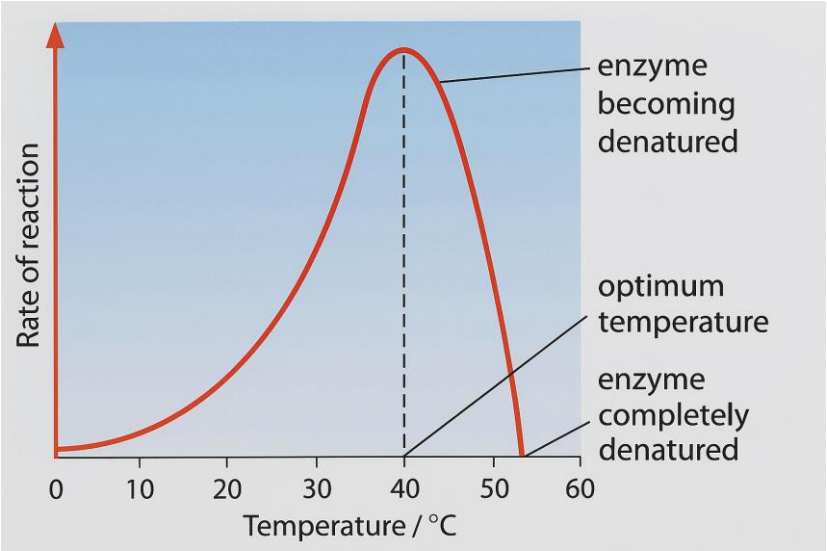
- how many enzyme molecules there are
- the speed at which the enzyme can convert the substrate into product, release it, and then bind with another substrate molecule.

However, as more and more substrate is converted

into product, there are fewer and fewer substrate molecules to bind with enzymes. Enzyme molecules may be 'waiting' for substrate molecules to hit their active sites. As fewer and fewer substrate molecules are left, the reaction gets slower and slower, until it eventually stops. The rate of an enzyme-controlled reaction is always fastest at the beginning. This rate is called the initial rate of reaction. You can measure the initial rate of the reaction by calculating the slope of a tangent to the curve, as close to time 0 as possible. An easier way of doing it is simply to read off the graph the amount of oxygen given off in the first 30 seconds. In this case, the rate of oxygen production in the first 30 seconds is 2.7 〖cm〗^3 of oxygen per 30 seconds, or 5.4 〖cm〗^3 per minute.

If the method used for measuring the progress of an enzyme-controlled reaction involves a colour change, a colorimeter can be used to measure the colour change quantitatively. A colorimeter is an instrument that measures the colour of a solution by measuring the absorption of different wavelengths of light. The greater the absorption, the greater the concentration of the substance causing the colour.

If you do this over a period of time, you can plot a curve of 'amount of starch remaining' against 'time'. You can then calculate the initial reaction rate in the same way as for the catalase/hydrogen peroxide reaction described previously. It is even easier to observe the course of this reaction if you mix starch, iodine solution and amylase in a tube, and take regular readings of the colour of the mixture in this one tube in a colorimeter. However, this is not ideal, because the iodine interferes with the rate of the reaction and slows it down. Figure 2 shows the effect of temperature on the rate of activity of a typical enzyme. At low temperatures, the reaction takes place only very slowly. This is because molecules are moving relatively slowly. In other words, their kinetic energy is relatively low. Substrate molecules will not often collide with the active site of the enzyme. As temperature rises, the kinetic energy of the molecules increases and so the enzyme and substrate molecules move faster. Collisions happen more frequently, so that substrate molecules enter the active site more often. Also, when substrate and enzyme molecules collide, they do so with more energy. This makes it easier for bonds to be formed or broken so that the reaction can occur. Figure 2:



As temperature continues to increase, kinetic energy increases so the speed of movement of the substrate and enzyme molecules also continues to increase However, above a certain temperature, the enzyme molecule vibrates so much that some of the bonds holding the enzyme molecule in its precise shape begin to break. This is especially true for hydrogen bonds. The enzyme's active site begins to lose its shape and therefore its activity: it is said to be denatured. At first, the substrate molecule fits less well into the active site of the enzyme, so the rate of the reaction begins to slow down. Eventually the substrate no longer fits at all and the reaction stops (the rate becomes zero). The temperature at which an enzyme catalyses a reaction at the maximum rate is called the optimum temperature. Most human

enzymes have an optimum temperature of around 40 °C. By keeping our body temperatures at about 37 °C, we ensure that enzyme-catalysed reactions occur at close to their maximum rate. Enzymes from other organisms may have different optimum temperatures. Some enzymes, such as those found in bacteria which live in hot springs, have much higher optimum temperatures. Some plant enzymes have lower optimum temperatures, depending on their habitat.

Most enzymes work fastest at a pH of somewhere around 7, that is, in fairly neutral conditions. Some, however, have a different optimum pH. For example, pepsin, an enzyme found in the acidic conditions of the stomach, has an optimum pH of about 1.5. Pepsin is a protease, an enzyme that catalyses the digestion of proteins. pH is a measure of the concentration of hydrogen ions in a solution. The lower the pH, the higher the hydrogen ion concentration. Hydrogen ions are positively charged, so they are attracted to negatively charged ions and repelled by positively charged ions. Hydrogen ions can therefore interact with any charged R groups on the amino acids of enzyme molecules. This may break the ionic bonding between the R groups, which affects the three-dimensional structure of the enzyme molecule. The shape of the active site may change and therefore reduce the chances of the substrate molecule fitting into it. A pH which is different from the optimum pH can cause denaturation of an enzyme.When investigating pH, you can use buffer solutions. Buffer solutions each have a particular pH and maintain that pH even if the reaction taking place would otherwise cause the pH to change. You add a measured volume of the buffer to your reaction mixture.

Medical science has greatly benefited from enzyme research. For example, DNA polymerase and reverse transcriptase are key enzymes used in PCR (Polymerase Chain Reaction) and RT-PCR tests — vital tools for detecting viral infections such as COVID-19 and HIV. New enzyme-based biosensors are being developed to detect diseases more rapidly and accurately. These biosensors use enzyme reactions to identify specific biomarkers in blood or saliva samples, providing real-time diagnostic results. In gene editing, CRISPR-Cas enzymes have revolutionized biotechnology. Since 2024, advanced forms of CRISPR enzymes (such as Cas12 and Cas13) have been used not only for genome modification but also for precise detection of genetic mutations associated with cancer and inherited diseases.

Modern environmental research has introduced enzymes as eco-friendly tools for sustainability. In 2024, researchers discovered an enzyme called PETase, which breaks down polyethylene terephthalate (PET) — the main component of plastic bottles — into harmless monomers. This offers a potential biological solution to the global plastic pollution problem. Other enzymes, such as lipases and cellulases, are being used in the production of biofuels from agricultural waste. These enzymes accelerate the breakdown of cellulose and fats, allowing for efficient conversion into ethanol or biodiesel. In the food industry, enzymes continue to play a vital role. Proteases and lipases are used in cheese and yogurt manufacturing, amylases in bread production, and pectinases in fruit juice clarification. Recent innovations include genetically modified yeast that can produce specific enzymes to improve the flavor and nutritional value of fermented foods.

The future of enzyme science lies in the combination of bioinformatics, nanotechnology, and machine learning. Researchers are exploring enzyme–nanoparticle hybrids that can catalyze reactions faster and with higher precision. These hybrid systems could be used in drug delivery, detoxification, and renewable energy generation. By 2025, enzyme research is expected to contribute significantly to green chemistry, bioremediation, and molecular medicine. As our understanding deepens, enzymes continue to demonstrate their remarkable ability to sustain life — both naturally and through human innovation.

REFERENCES

1. BAKHSHULLAYEVICH, T. B., MURODOVICH, T. M., & KABULOVICH, K. B. (2020). Biotechnology of Biological and Chemical Treatment of Water From Refinery. JournalNX, 6(10), 295-296. 10. the Factory of Bukhara Oil
2. Baxtiyor, T. (2020). Biotechnology of biological and chemical treatment of water from the factory of bukhara oil refinery. Центр научных публикаций (buxdu. Uz), 1(1).

3. Nelson, D. L., & Cox, M. M. (2017). Lehninger Principles of Biochemistry (7th ed.). W. H. Freeman and Company.
4. Berg, J. M., Tymoczko, J. L., & Gatto, G. J. (2019). Biochemistry (9th ed.). W. H. Freeman and Company.
5. Voet, D., Voet, J. G., & Pratt, C. W. (2018). Fundamentals of Biochemistry: Life at the Molecular Level (6th ed.). Wiley.
6. Garrett, R. H., & Grisham, C. M. (2016). Biochemistry (6th ed.). Cengage Learning.
7. Stryer, L. (2015). Biochemistry (8th ed.). W. H. Freeman and Company.
8. Dixon, M., & Webb, E. C. (1979). Enzymes. Academic Press.
9. Alberts, B. et al. (2022). Molecular Biology of the Cell (7th ed.). Garland Science.
10. Singh, R., & Kumar, M. (2020). "Advances in Enzyme Technology: Recent Developments and Applications." Biotechnology Advances, 45, 107586.
11. Tournier, V. et al. (2020). "An engineered PET depolymerase to break down and recycle plastic bottles." Nature, 580, 216–219.
12. Jinek, M. et al. (2012). "A Programmable Dual-RNA–Guided DNA Endonuclease in Adaptive Bacterial Immunity." Science, 337(6096), 816–821.
13. Husenov, B., Rakhmonov, R., & Barotov, A. (2022). Some species of carnivorous plants. Journal of the Pedagogical Institute of Bukhara State University, 2(2).
14. Akhmedovich, F. M., & Amonovich, D. Y. (2021). Clinical criteria for the manifestation of atopic dermatitis in schoolchildren, depending on age. Central Asian Journal of Medical and Natural Science, 2(5), 335–339.
15. Rakhmatov, O. B., & Yusupov, D. A. (2021). Distribution of patients with atopic dermatitis in the Bukhara region according to age and gender. Scientific Progress, 2(6), 1718–1729.
16. Makhmudov, F. A., Latipov, I. I., Ozodov, J. H., & Yusupov, D. A. (2020). Vitiligo extent tensity index (VETI) score: a new definition, assessment, and treatment evaluation criteria in vitiligo. New Day in Medicine, (1), 276–279.
17. Yusupov, D. A. (2023). Determining the combined effectiveness of the "Fatiderm-M" mud mask and "Disderm" cream in acne disease. Scientific Journal of Applied and Medical Sciences, 2(2), 212–218.
18. Ozodov, J. H., Sultonov, S. O., & Yusupov, D. A. (2022). Age and gender segregation of leishmaniasis patients in the Bukhara region. Eurasian Medical Research Periodical, 7, 62–68.
19. Husenov, B., Quvonchbek, N. M., Iroda, S., & Yulduz, O. (2022). Morphology, anatomy, and medicinal properties of Althaea (mallow). Journal of the Pedagogical Institute of Bukhara State University, 2(2).
20. Qobil o'g'li, H. B., & Rashitovich, R. J. (2023). Biology of insectivorous plants. Scientific Journal of Agrobiotechnology and Veterinary Medicine, 2(3), 19–23.
21. Qobil o'g'li, H. B., Xasan o'g'li, N. M. Q., & Shodiyevna, S. I. (2023). Reproduction and heredity of plants. Scientific Journal of Agrobiotechnology and Veterinary Medicine, 2(3), 11–18.