

Effects of environmental factors on catalase and lipase



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Abstract

Enzyme is a biological catalyst, which is used to speed up a chemical reaction by lowering the activation energy barriers. The functions of the enzyme are directly related to its structure, and hence, denaturation will occur if its shape is altered. There are optimal conditions where it supports enzymes in its most active structure, such as the best temperature, pH, and concentration of enzymes and substrates that will produce the most reaction rate. These variations of environmental factors are use to conduct experiments to examine the effects it have on catalase and lipase.

The Effect on Catalase and Lipase From Variation in Environmental Factors

Introduction:

Most enzymes are protein, which is a macromolecule with a unique three dimensions configuration that acts as a catalyst. A catalyst is a chemical agent that speeds up a chemical reaction by lowering the activation energy, the initial energy needed to drive a reaction, barriers without being consume in the process. An enzyme can lower the activation energy when catalyzes a reaction by enable the reactant molecules called substrates to absorb enough energy to reach the transition state with minimum thermal assistance.

Since enzymes are proteins, they are very sensitive to their environmental factors, such as temperature, level of pH, and concentration of enzyme and substrate in an enzyme-substrate mixture, that may affect the enzymes or its reaction rate. This is because of its specific amino acid sequence that gives each enzyme a certain shape, which is the reason that the function of

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an enzyme is directly related to its structure. The structure of the enzyme allows only a specific substrate to bind into its active site, an area where substrates bind to the enzyme, so that the catalysis may occur. Its structure is so vital that slight changes in it will cause the enzyme to be less efficient and reducing the reaction rate. Extreme alteration will cause denaturation in an enzyme, where it can no longer function. However, there are optimal conditions where it favors the most active shape for each enzyme to function the best under.

Each enzyme has a different optimal temperature and optimal pH level where they work best in that produce the most product molecules by having the greatest reaction rate due to the number of molecular collisions and conversion of reactants. Most enzyme's optimal pH is of the range 8 and optimal temperatures is around 37.5°C because it is the average internal temperature of a human body. As the temperature rise, the enzyme reaction rate will also increase until a certain temperature and above that temperature, the reaction rate will decrease. This is due to heat making molecules move rapidly and cause the substrates to collide with the active sites more often to convert reactants to products. However, too much heat will cause the bonds in the enzyme to break and alter its shape, which will cause the enzyme to be denatured. The same idea is apply to the pH levels; if a solution that is intensely acidic or basic will cause the bond in enzyme to break, alter its shape, and become denatured (Campbell et al., 2008).

Concentration of enzyme and substrates also affect the reaction rate but it does not affect the structure of the enzyme. If the substrate concentration is constant, then the reaction rate is also constant. But if the substrate

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concentrations increase, then the reaction rate will increase until it reaches a point where the enzymes are saturated, meaning the enzymes are all currently working on substrates and it is limited by the number of enzymes. Also, when the substrates are constant and the enzymes concentration increases, then the reaction rate will also increase.

In this experiment, the actual experiment analyzing catalase and the simulation experiment analyzing lipase will be use to evaluate the effect given by variation in environmental factors. Catalase is enzymes that convert the harmful byproduct of metabolism, hydrogen peroxide, into oxygen and water and is found in all living cells. The enzyme catalase binds to the substrate, hydrogen peroxide, and catalyst the chemical reaction to produce water and oxygen. Whereas, lipase is enzymes that breaks down lipids or other fats into absorbable form and is found in the pancreas or the small intestine. The enzyme lipase binds to its substrate, fats, and catalyzes the reaction to split it into glycerol and fatty acids. Catalase is predicts to work best in the temperature of 37. 5°C, under the pH of 8, and when the the enzyme concentration and substrate concentration is high. While, lipase is predicts to work best in the temperature of 37. 5°C, under the pH of 5, and when the substrate concentration is high.

Methods:

For this experiment over enzymes, we used catalase, which were extracted from a yeast solution, to demonstrate how the enzyme-catalyzed reactions rates were affected by different enzyme concentrations, substrate concentrations, temperatures, and pH. The rate of chemical reaction was measured by the pressure of oxygen that was produced.

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To accurately measure the increase of pressure of O₂, we connected the completed arrangement of Vernier Gas Pressure Sensor to the Vernier LabPro interface, which was then connected to the laptop that carried the Logger Pro computer software program. From the Logger Pro program, we opened the file " 06B Enzyme (Pressure)" from the Biology with Computer folder. Once all of the equipment was setup and running, we obtained a clean, large test tube and collected the enzyme. The enzyme was placed at the bottom of the test tube and the test tube was dried. The stopper valve was in a closed position before the rubber stopper was inserted and tightly secured onto the test tube. We then drew the diluted H₂O₂ into a syringe and connected it to the rubber stopper assembly. Next, we open the valve of the apparatus to inject the peroxide solution, which was immediately closed and the collect button was clicked on the Logger Pro program. Throughout this 3 minute data collection process, we made sure that the rubber stopper was still intact to ensure accurate data reading. Once it had ended, we clicked store latest run in the Logger Pro software. Then, we removed the rubber stopper assembly, discarded the contents of the test tube, and cleaned and dried the test tube and the rubber stopper. When the data collected for the set of experiment had finished, we clicked on the graph where it began to increase and dragged it over to where the graph look non-linear, then clicked the Linear Fit icon once the wanted area was highlighted, and recorded the equation of the line and its slope to determined the rate of the reaction into the data table. We used these same processes for the general procedures for all sets of the experiments.

To test the effect of enzyme concentration, we used fifteen milliliters of H₂O and fifteen milliliters of 3% H₂O₂ in this experiment. We obtained one drop of enzyme solution at the bottom of the clean, large test tube, as stated in the general procedures. Then we drew up six milliliters of the substrate solution and continued to follow the general procedures to acquire the rate of reaction. The rest of experiments on enzyme concentration used the same methods as stated but only changed from one drop of enzyme to two, three, four, and then five drops of enzyme solution. We then recorded the data for this set of experiments in table one.

Then to test the effect of substrate concentration, we used one milliliter of H₂O and five milliliters of 3% H₂O₂ in this experiment. Three drops of enzyme solution are obtained and placed at the bottom of the test tube. We then drew up six milliliters of the substrate solution and continued to follow the general procedures to acquire the rate of reaction. The same methods are applied for the rest of the experiments on substrate concentration, except that the one milliliter of H₂O with five milliliters of 3% H₂O₂ are to be replaced by two, three, four, and five milliliters of H₂O with four, three, two, and one milliliter of 3% H₂O₂, respectively, for each experiment. We then recorded the data for this set of experiments in table two.

Furthermore, to test the effect of temperature on the enzyme reaction rate, we used three milliliters of H₂O and three milliliters of 3% H₂O₂. We drew up the solutions into the syringe and placed it in ice water for three minutes; the temperature of ice was then recorded only in this experiment. Then we placed the test tube that contained three drops of enzyme solution into the Erlenmeyer flask that was half filled with ice water, where it was chilled for <https://assignbuster.com/effects-of-environmental-factors-on-catalase-and-lipase/>

three minutes. When the syringe was done acclimated for three minutes in ice water, it was removed and connected to the rubber stopper and we continued to follow the general procedures to acquire the rate of reaction. For the rest of the set of experiments on temperature, we repeated the same methods except the ice water are replaced by room temperature, 30°C water bath, 40°C water bath, 50°C water bath, and 60°C water bath with each experiment. We then recorded the data for this set of experiments in table three.

Finally, to test the effect of pH on the enzyme reaction rate, we used three milliliters of the pH 3 solution and three milliliters of 3% H₂O₂. We then obtained three drops of enzyme and placed it at the bottom of the test tube, such as stated in the general procedures, drew up the solutions into the syringe, and continued to follow the general procedures to acquire the rate of reaction. The same methods were used to carry out the rest of the set of experiments on pH, except the pH 3 solutions was substituted by the solutions of pH 5, pH 7, pH 9, and pH 11. We then recorded the data for this set of experiments in table four.

Results:

Figure 1. Results of the actual experiment on the effect of substrate concentration on the reaction rate of the enzyme catalase, using computer software Logger Pro to evaluate on a three minutes interval per trial. As the substrate increase in the solutions, the reaction rate of catalase decreases.

Figure 2. Results on the effect of substrate concentration in the simulation of the enzyme lipase, using the program “ Enzyme Investigation.” The effects

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are based on the constant variables of temperature at 37.5°C, pH of 9, and the enzyme concentration of 1×10^{-6} moles per liter.

Figure 3. Results of the actual experiment on the effect of temperature on the reaction rate of the enzyme catalase, using the computer software Logger Pro and evaluate each experiment on a three minutes interval. The effects are based on the constant variables of 0.5 mL of substrate concentration and 3 drops of enzyme solutions. As indicated, catalase's optimal temperature is 30°C.

Figure 4. Results on the effect of temperature on the rate of reaction in the simulation of the enzyme lipase, using the program Enzyme Investigation. The reaction rates of lipase varying from different temperature are based on the constant variables of pH of 9, substrate concentration of 0.01 moles per liter, and the enzyme concentration of 1×10^{-6} moles per liter. As indicated, lipase's optimal temperature is between 37-38°C.

Figure 5. Results of the actual experiment on the effect of pH on the reaction rate of the enzyme catalase, using the computer software Logger Pro and evaluate each experiment on a three minutes interval. The reaction rate of catalase varying from pH level of 3 to 11 are based on the constant variables of 3mL of 3% H₂O₂ and 3 drops of enzyme concentrations.

Figure 6. Results on the effect of pH on the rate of reaction in the simulation of the enzyme lipase, using the program "Enzyme Investigation." The reaction rate of lipase varying from pH level of 1 to 14 are based on the constant variables of temperature at 38°C, substrate concentration of 0.01 moles per liter, and the enzyme concentration of 1×10^{-6} moles per liter.
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Figure 7. Results of the actual experiment on the effect of enzyme concentration on the reaction rate of the enzyme catalase, using the computer software Logger Pro and evaluate each trial on a three minutes interval. As indicate, the more drops of enzymes is provide into the solutions of 15 mL of H₂O and 15 mL of 3% H₂O₂, the reaction rate increases.

Discussion:

As discussed in the Introduction, the optimal conditions for most enzymes are in the environment of around human body temperature, which is 37.5°C, and with the pH level of around 8 because enzymes work best in a slightly basic solution. Also, increases in enzyme concentration should always increase the rates of reaction; this is verified through the actual experiment of catalase, which is illustrated in figure 7. While increases in substrate concentration will also give a rise to the rate of reactions, it will gradually come to a point where it reaches the saturation point and “ any further increase in substrate concentration produces no significant change in reaction rate,” which is demonstrate in figure 2 (Royal Science of Chemistry).

In previous predictions, the enzymes catalase and lipase are both thought to have optimal temperatures around 37.5°C. The optimal pH of catalase is 8, while lipase is 7. Figure 4 suggests that the prediction for lipase optimal temperature is correct. The rates of reaction for the enzyme lipase continue to increase as the temperature rise until it reach its highest at 37.5°C, then the reaction rate begin to drop after 38°C until it come to a stop at 60°C.

This is due to the increasing temperature, increases enzyme reaction rate up until the point where the enzymes is denatured when the temperature

continues to rise above its optimal temperature, as explained in the <https://assignbuster.com/effects-of-environmental-factors-on-catalase-and-lipase/>

introduction. For catalase however, the predictions prove false for the figure 3 suggests that the optimal temperature for catalase is 30°C and not at 37.5°C. The reaction rate begins to drop after 30°C, due to denaturalization of enzyme.

On the other hand, the predictions for the optimal pH conditions of both catalase and lipase prove false. In figure 5, it suggests that the optimal pH conditions of catalase are at 11, not 8, and is continue to rise as the solution is becoming more basic. The data suggests that catalase works best in a very basic solution and not just slightly basic as predicted, but it does show that the reaction rate is decreasing as the solution gets acidic. As predicted, catalase does not work well in acidic solution and as it gets too acidic, catalase will begin to be denatured (Vasquez et al, 2008). Figure 6 suggests that the optimal pH level for lipase is at 9, and not 7. As the solution continue to be more acidic or basic, the reaction rate begin to slow and decreases until it comes to a stop when lipase is completely denatured and stop functioning.

The prediction that the increase in substrate concentration will also increase in the reaction rate of catalase is indicate by figure 1 as false. Figure 1 show that the reaction rate decreases as the substrate concentration increases. This may be due to the enzymes had already reach the saturated point. Figure 2, however, verify that the predictions of increase in substrate concentration also increase the reaction rate for lipase.