AP Biology
2000 Student Samples

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1 D1

BIOLOGY

SECTION II

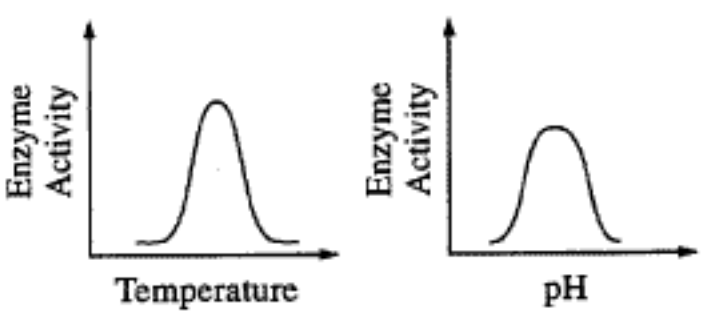
Time—90 minutes

4 Questions

Directions: Answer all questions. Write your answers on the pages following the questions in the pink booklet.

Answers must be in essay form. Outline form is NOT acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write.

1. The effects of pH and temperature were studied for an enzyme-catalyzed reaction. The following results were obtained.



a) How do (1) temperature and (2) pH affect the activity of this enzyme? In your answer, include a discussion of the relationship between the structure and the function of this enzyme, as well as a discussion of how structure and function of enzymes are affected by temperature and pH.

b) Describe a controlled experiment that could have produced the data shown for either temperature or pH. Be sure to state the hypothesis that was tested here.

a. As the results from the experiment show, the enzyme has both an optimal temperature and an optimal pH. Deviation from this optimum results in a decrease in enzyme activity and efficiency. Enzymes are proteins whose unique structure allow them to catalyze chemical reactions. ~~They have primary struct~~ The sequence of amino acids, presense or absense of alpha helixes and beta

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pleated sheets, the types of bonds (ionic, covalent, disulfide, etc.) and the aggregation with an other ~~enzyme~~ protein all effect an enzyme's ability to perform. This unique structure results in an active site, an area that is conducive to the reactants of a particular reaction. Each enzyme is very specific and can catalyze only one reaction. Its active site is only open to one substrate (reactant). This is known as the lock and key theory of enzyme specifity. By temporarily hydrogen bonding to the substrate, the enzyme puts the reactants in positions which enhance the probability of a reaction occuring. When heat is applied to an enzyme, the movement of substrate increases and the substrates are more likely to come in contact with the enzyme's active site. This increases enzyme activity. However if too much heat is applied, the enzyme will denature, its shape will change, and the substrate will no longer be able to fit in the active site, decreasing enzyme activity. The same is true for pH. If the pH is too acidic, the influx of H^+ may affect the bonds of the enzyme, as may an influx of OH^- if the pH is too basic. This will

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also affect the shape of the enzyme's active site and adversely influence its ability to catalyse a reaction.

b. A controlled experiment could have been produced to show the effects of temperature on enzyme activity. The hypothesis would be that enzymes work best at a warmer temperature, but if the temperature is too hot, the enzyme will denature and its activity rate will decrease. In order to do this an enzyme and substrate must be Choosen. A good enzyme would be catalase, which increases the rate at which hydrogen peroxide (H_2O_2) breaks down into water (H_2O) and oxygen (O_2). For the control, the enzyme and substrate would be placed in room temperature. Numerous beakers of enzyme and substrate would be allowed to sit for different time intervals, The reactions could be stopped by the addition of a strong acid to the beakers. This would denature the enzymes and stop the conversion of H_2O_2 into H_2O and O_2. ~~A graph could then be plotted of enzy~~ In order to determine how active the enzyme was, a titration could be used. A titration is the introduction of an indicator chemical

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mat allows one to visualize the endpoint of a reaction. ~~A~~ The amount of H_2O_2 remaining could be determined and plotted on a graph. To check the affects of temperature on enzyme activity, the experiment could be run several times more, but each time with a different temperature, some colder and some warmer, By comparing these various graphs to the graph of the control, it would be possible to determine the affects of heat on enzyme activity

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IC1

BIOLOGY

SECTION II

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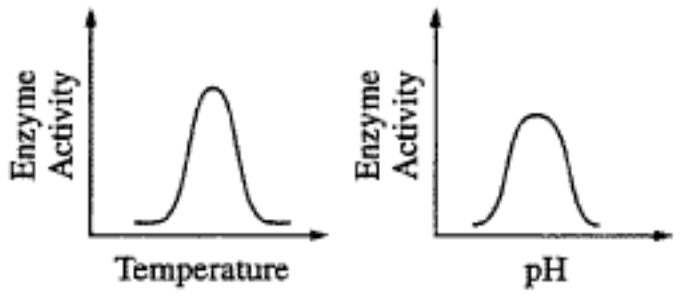
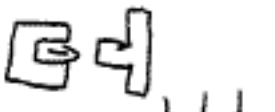


a) How do (1) temperature and (2) pH affect the activity of this enzyme? In your answer, include a discussion of the relationship between the structure and the function of this enzyme, as well as a discussion of how structure and function of enzymes are affected by temperature and pH.

b) Describe a controlled experiment that could have produced the data shown for either temperature or pH. Be sure to state the hypothesis that was tested here.

The graphs shown, indicate a mound shaped distribution meaning that as temperature or pH levels increase, the enzyme activity will also increase. This is reversed once a peak, maximum potential, is reached. Then the further increase of temperature or pH level will hinder Enzymatic activity. An enzyme is produced to fit the ~~need~~ needs of one function. Each enzyme can only bond with it respective substrate. This model, often called the lock and key model, allows for only slight variations in order

The two match up at the binding site only with each other



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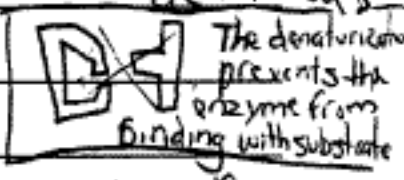
to allow the enzyme to fit properly with the substate. Enzymes have natural habitats within an organism which include an ideal temperature and pH level. At lower or higher temperatures the enzyme loses its ability to bind to its substrate thus as the temp decreases or increases outside of the enzymes ideal range, more and more enzymes become inactive. pH levels have similar effects, enzymes can only tolerate specific (often small) ranges of pH, thus once the range of effective pH levels is left, the enzyme becomes denatured, the altering of the enzyme into an ineffective shape. It is possible to restore the shape but only if the alteration is minimal (thus the ideal range) So in order for an enzyme to begin a reaction in an organism, it is ideal for the organism to be able to maintain proper pH levels and body temp (homeostasis)



B The Hypothesis of the experiment is that temperature does have an effect on the activities of an enzyme. In order to reveal the data curve for temperature effects on Enzyme activity an experment can be conducted. Using several beakers possibly four. An experimenter would place an equal amount of substrate into the beakers. Then it would be necessary to heat or cool each beaker to a specified °C perhaps 10°C, 20°C 30°C and 40°C. Then the experimenter can add an equal amount of enzyme (the one corresponding to the choosen substrate) and pour them into their beakers. Allowing for the reaction to occur, after a set amount of time (maybe 2 minutes) an acid should be added in order to cease all reactions via denaturization. The experimenter can then measure the products of the reaction to

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determine the amount of enzymatic activity in each respective temperature.

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BIOLOGY

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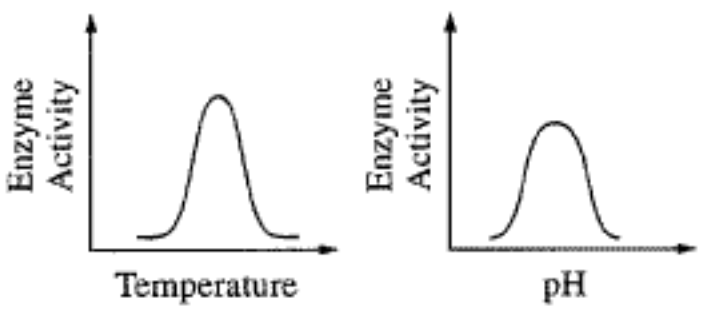

a) How do (1) temperature and (2) pH affect the activity of this enzyme? In your answer, include a discussion of the relationship between the structure and the function of this enzyme, as well as a discussion of how structure and function of enzymes are affected by temperature and pH.

b) Describe a controlled experiment that could have produced the data shown for either temperature or pH. Be sure to state the hypothesis that was tested here.

a) Enzymes are proteins that catalyze biological reaction. Although they are unable to make a reaction occur that would not normally occur in nature, they substantially lower the necessary activation energy for the reaction. This greatly increases the reaction rate. Enzymes are also usually highly specific, which means that each enzyme catalyzes one or maybe a few chemical reactions.

There are two different theories as to how an enzyme functions. The first is known as the lock-and-key model,

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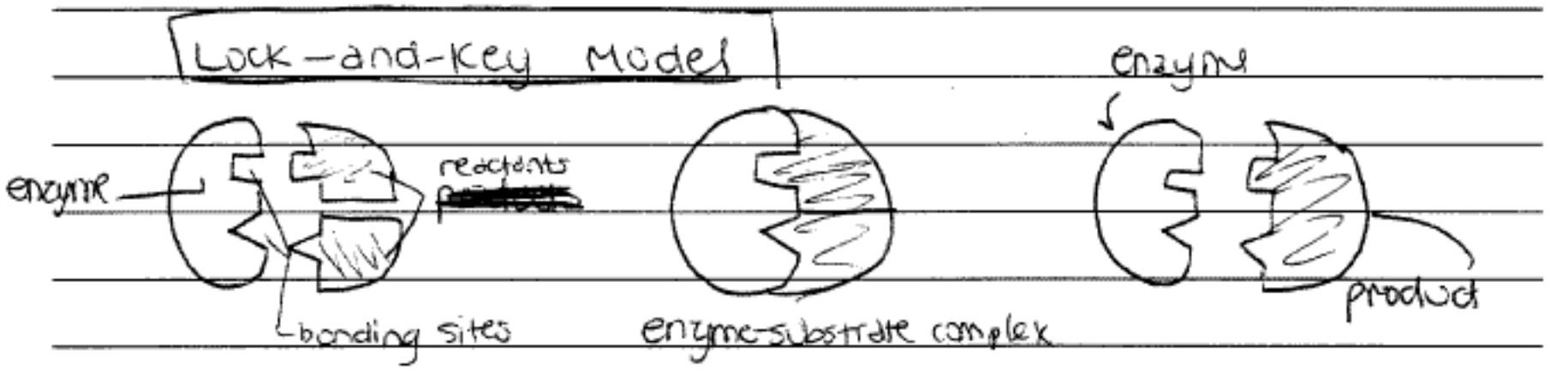
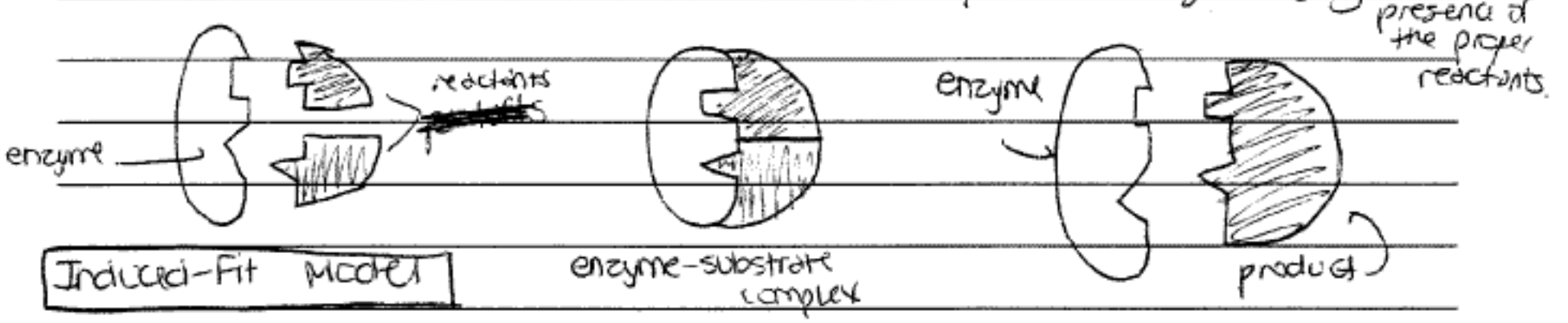
as shown below. Note that the structure of the enzyme remains essentially unchanged.



Another theory is based on the induced-fit model. This is currently thought to be the most likely model of an enzyme, as shown below. Note that the conformation of the protein changes slightly in the presence of the proper reactants.



Enzymes are affected by a variety of factors, including temperature and pH. Most enzymes work most effectively at between 20-30°C and 6-8 pH. When enzymes are exposed to temperature or pH extremes, it affects their tertiary bonding structure and may even permanently denature the enzyme. However, some enzymes such as pepsin function at pH or temperature ~~etc~~ extremes. Pepsin is most effective at low (acidic) pH's as are found in the stomach.

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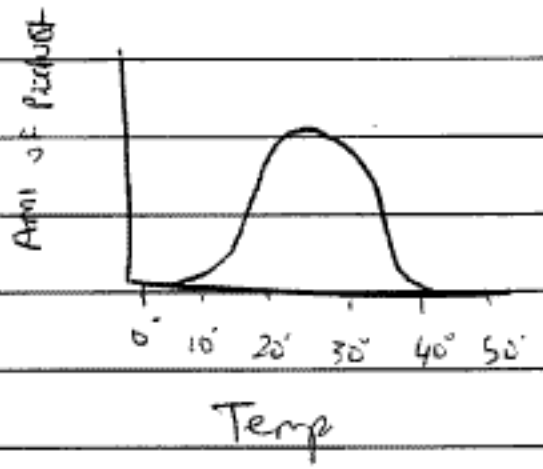
b) The hypothesis is that enzymes are most effective at temperatures between 20° and 30°C. In order to test this, an experiment could be designed in which potatoes and the enzyme amylase are ~~mixed together~~ combined in solutions of varing temperatures ranging from 0°C to 50°C. This, there would be setups for 0°, 5, 10°, 15, 20°, 25°, 30°, 35, 40°, 45° and 50°. Potatoes contain starch, and amylase is a enzyme that breaks this down. After a specified time period constant for all temperatures the amount of product could be measured and the data processed ~~to obtain a curve~~ & graphed. This experiment should serve to reinforce the aforementioned hypothesis and produce the following CURVE:



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1A1

BIOLOGY

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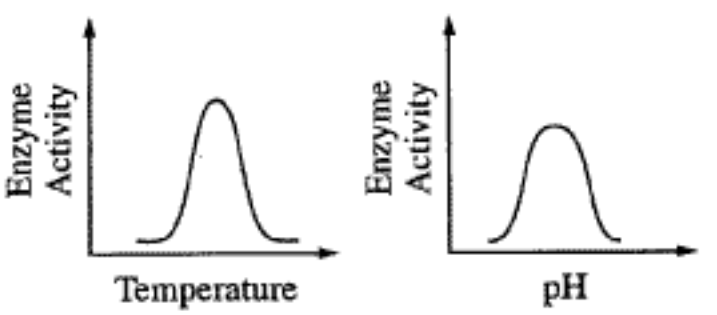

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A1 It seems to me that the enzyme is affected well by temperature. There is a rise as the enzyme catalysis reaches its optimum temperature and then a fall as temperatures get so hot that they actually inhibit catalysis. A2 As for pH it also has an optimum pH but it seems to be lower than the optimum temperature. The optimum pH is in the middle so it might be an

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enzyme whose optimum pH is around 7 (not acid or basic but neutral). As the pH scale rises its enzyme activity increases but only until it reaches the middle because when it does it starts going down again as the enviroment gets too basic.

(B) My experiment would consist on testing for the optimum temperature for the enzyme lactase on the catalyst lactose found in ordinary cows milk.

I would keep the milk in different beakers. Exactly 5 beakers each filled with 500 ML of milk. Beaker #1 would be at 40° F. Beaker #2 would be set at 55° F. Beaker #3 would be at Room Temperature ≈ 70° F. Beaker #4 @ 85° F. Beaker #5 @ 100° F. I would grind up 1(one) Lactaid® Lactase caplet into each Beaker. Then I'd test for glucose content in each in 5 min. The one with the highest content would be the optimum Temp.

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