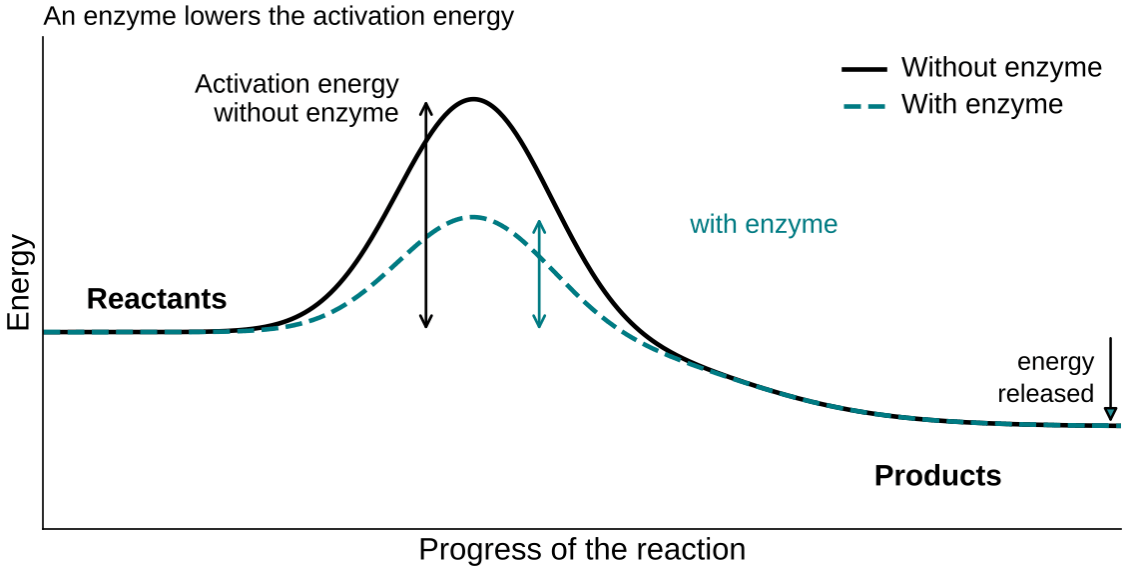
Essential Question

How do enzymes speed up the reactions that keep cells alive?

Activation Energy

- A reaction needs a push to get started
- That push is the activation energy
- Without help, many reactions in cells are too slow
- Heating the cell would also harm it



Enzymes

What Enzymes Are

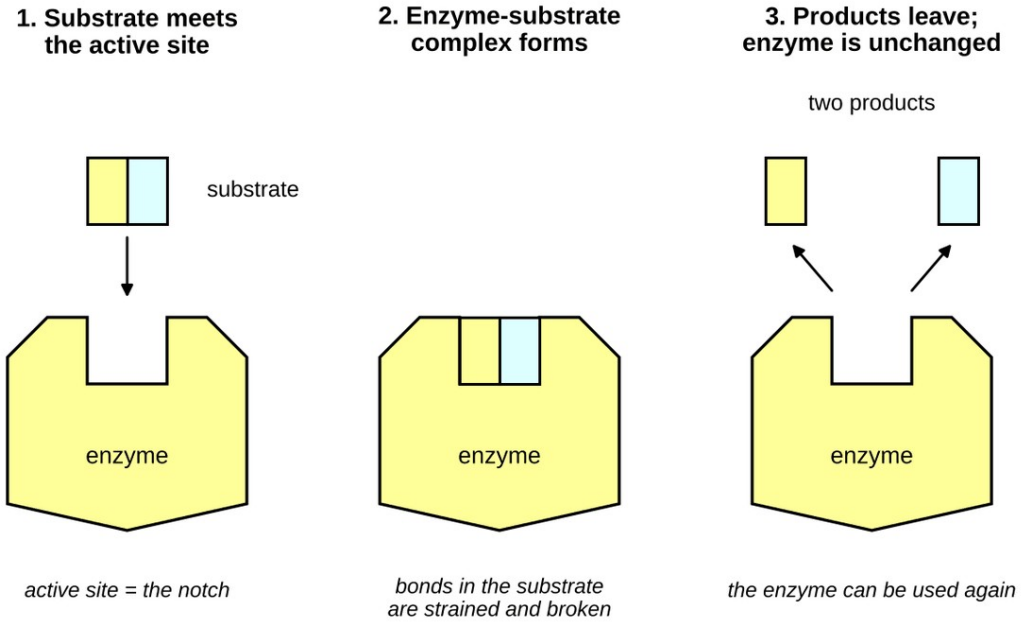
- Enzymes are proteins that act as catalysts
- A catalyst lowers the activation energy
- It is not used up, so it can work again and again
- Each enzyme is specific to one kind of reaction

Enzyme	Substrate	Product	Where it works
Amylase	Starch	Sugars	Mouth, small intestine
Pepsin	Proteins	Short polypeptides	Stomach
Lipase	Fats	Fatty acids and glycerol	Small intestine

Enzymes

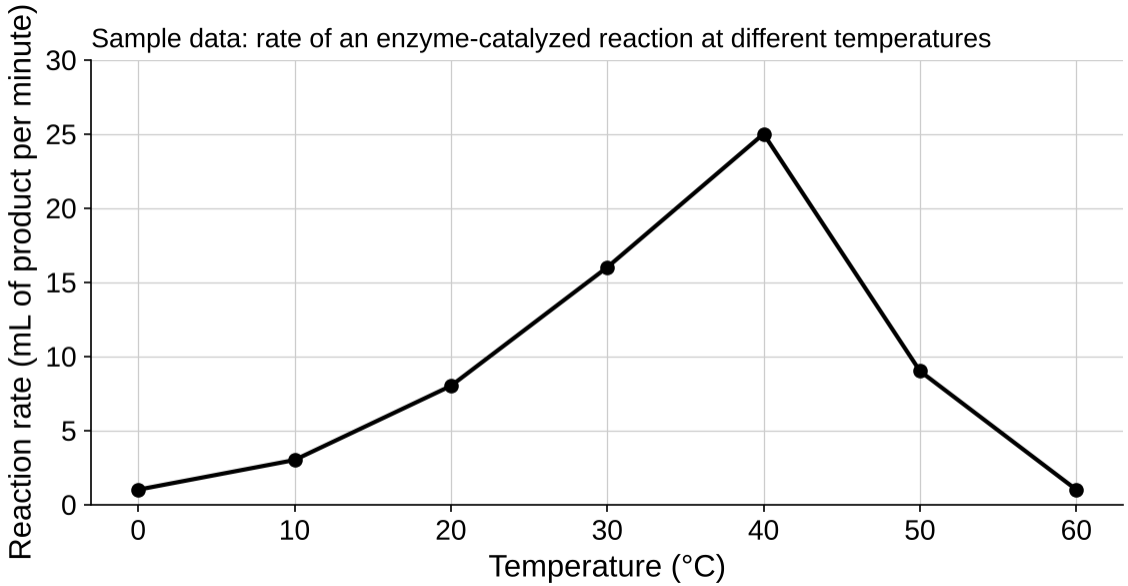
The Active Site

- The active site is a pocket on the enzyme
- The substrate fits into the active site
- The enzyme-substrate complex forms
- Products leave and the enzyme is free to work again



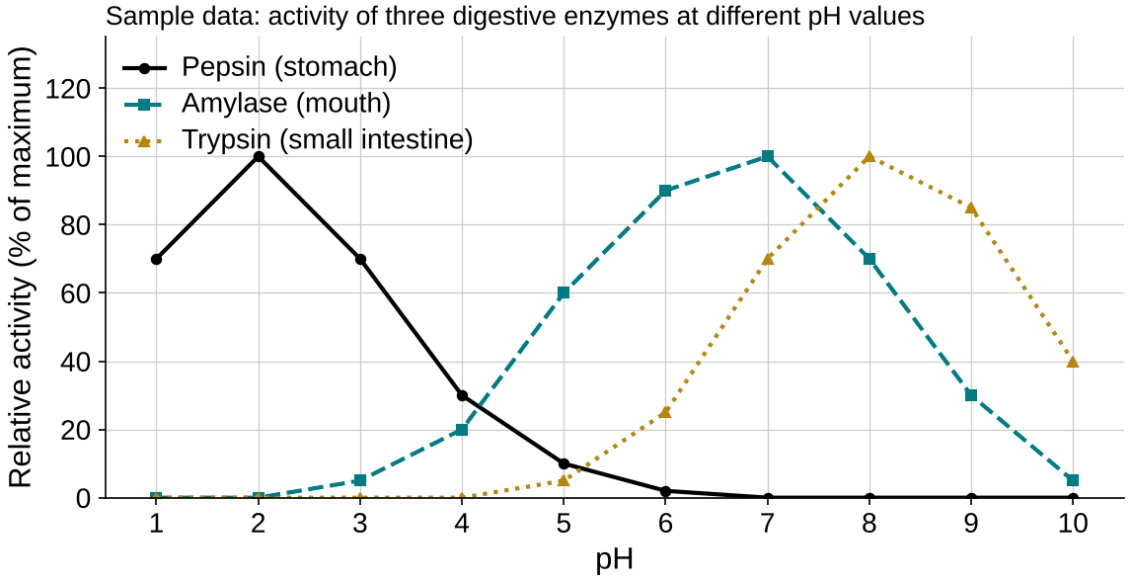
Temperature and Enzyme Rate

- Rate = amount of product ÷ time
- A higher temperature makes molecules collide more often
- Each enzyme has an optimum temperature
- Above it, the enzyme denatures and the rate falls



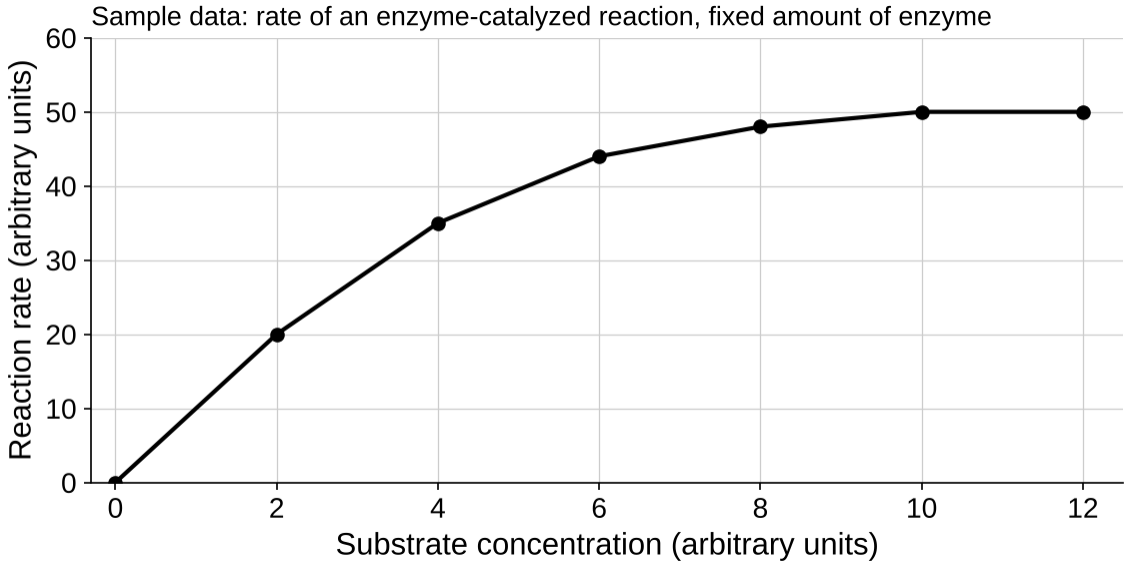
pH and Enzyme Rate

- Each enzyme has an optimum pH
- A change in pH changes the charges on R groups
- This changes the shape of the active site
- Enzymes in different places work at different pH values



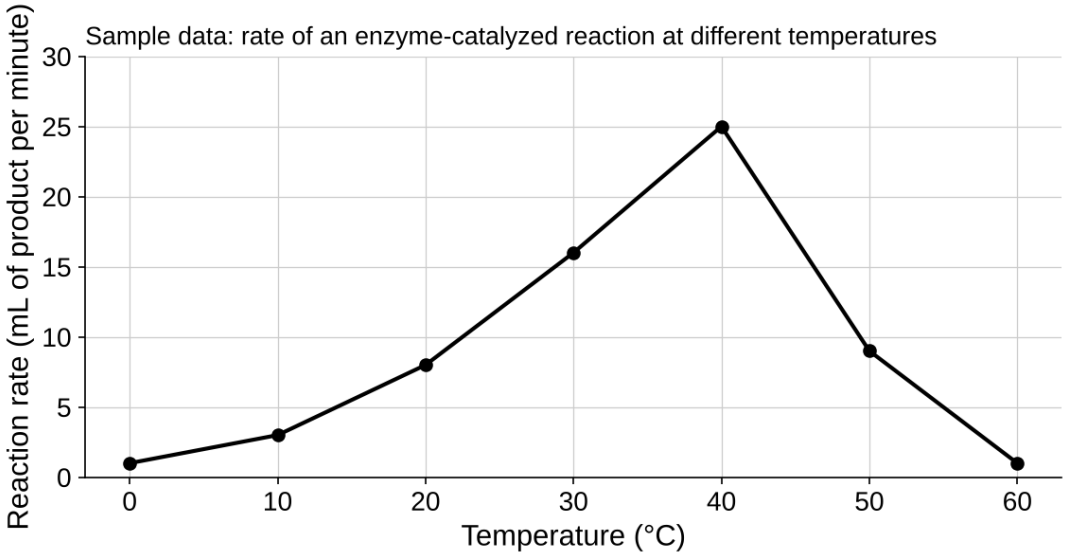
Substrate Concentration

- More substrate means more collisions with active sites
- The rate rises at first
- Then it levels off when all active sites are busy
- Adding more enzyme raises the maximum rate



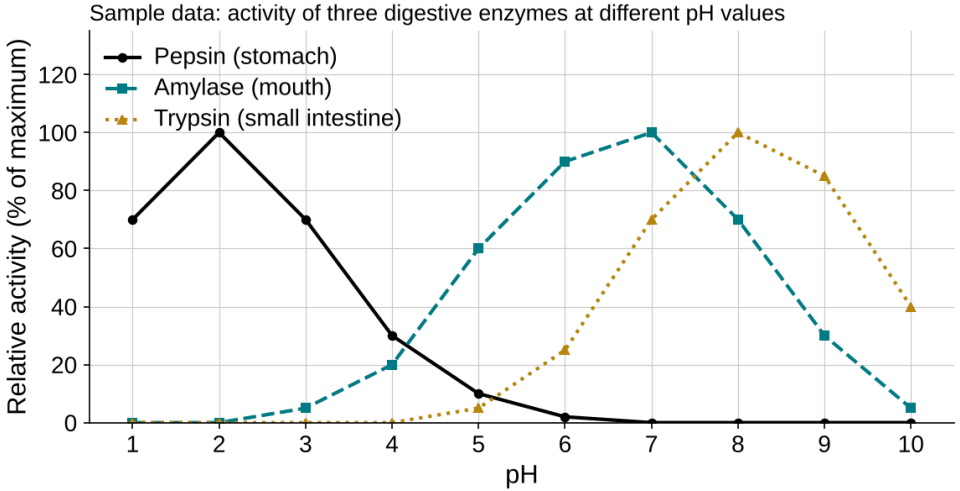
Example: Finding a Reaction Rate

(a) An enzyme produces 12 mL of gas in 4 minutes. What is the rate? (b) Use the temperature graph. At 40°C, how many mL of product would be made in 6 minutes? (c) How many times faster is the rate at 40°C than at 10°C?



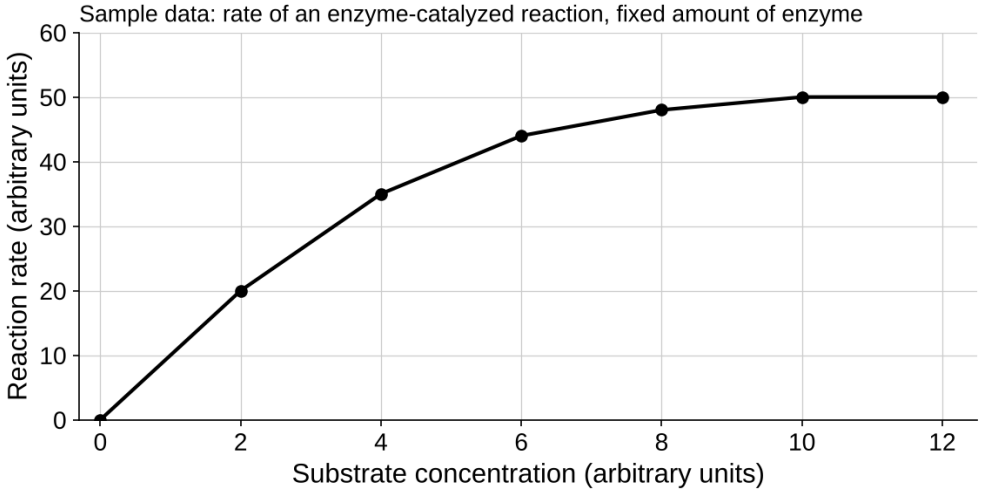
Example: Enzymes at Different pH Values

Use the graph of three enzymes. (a) What is the optimum pH of each enzyme? (b) Which enzyme could digest food in the stomach, where the pH is about 2? (c) Amylase from the mouth is swallowed into the stomach. Explain what happens to it, using the graph and what you know about protein shape.



Example: Substrate and Active Sites

Use the graph of rate against substrate concentration for a fixed amount of enzyme. (a) What is the rate at a concentration of 6? (b) At about what concentration does the rate stop rising? (c) Explain why the rate levels off. (d) How could the cell increase the maximum rate?



Enzymes

Big Ideas

- Enzymes are protein catalysts that lower the activation energy
- A substrate fits into the active site
- Enzymes are not used up
- Temperature, pH, and substrate concentration change the rate
- Rate = amount of product ÷ time