The power of pineapple: an enzyme lab story

How do pH, heat, and the concentration of enzymes impact the enzymatic activity of protease in breaking down gelatin?

Gelatin is derived from animal hides, bones, and cartilage. To obtain gelatin, these materials are crushed, treated with strong acids and bases, and then boiled for several hours to extract the protein collagen, which is converted into gelatin. The resulting protein extract is subsequently dried and flavored to produce the familiar gelatin-based snacks.

In this laboratory activity, gelatin will be examined through its interaction with enzymes. Enzymes are specialized proteins that function as biological catalysts, accelerating chemical reactions—such as digestion—by reducing the activation energy required for those reactions to occur.

While the human body produces many enzymes, certain foods contain enzymes that actively interact with biological tissues. For instance, the tingling or burning sensation experienced after eating pineapple is caused by bromelain, a protease enzyme. Bromelain begins breaking down proteins in the tissues of the mouth, demonstrating enzymatic activity firsthand.

Ohio Standards

- Biology: B.C.2: Cellular processes
- Chemistry: C.IM.1: Chemical reactions

Anatomy and Physiology

- AP.T.3: Lymphatic and immune system
- AP.AE.1: Digestive system

Student prior knowledge

Students should understand that gelatin is made from collagen, a protein extracted from bones, skin, and cartilage of animals. Proteins are large molecules, and enzymes are specialized proteins that accelerate chemical reactions by lowering the activation energy. Some enzymes, called proteases, break down proteins during digestion. Certain foods, like pineapple, contain proteases such as bromelain, which can break down proteins and cause a tingling sensation in your mouth. Because gelatin is made of protein, adding protease enzymes can break it down or prevent it from setting properly.

Suggested timeline

Two 45-minute class periods

Materials

Per groups of 2–3 students:

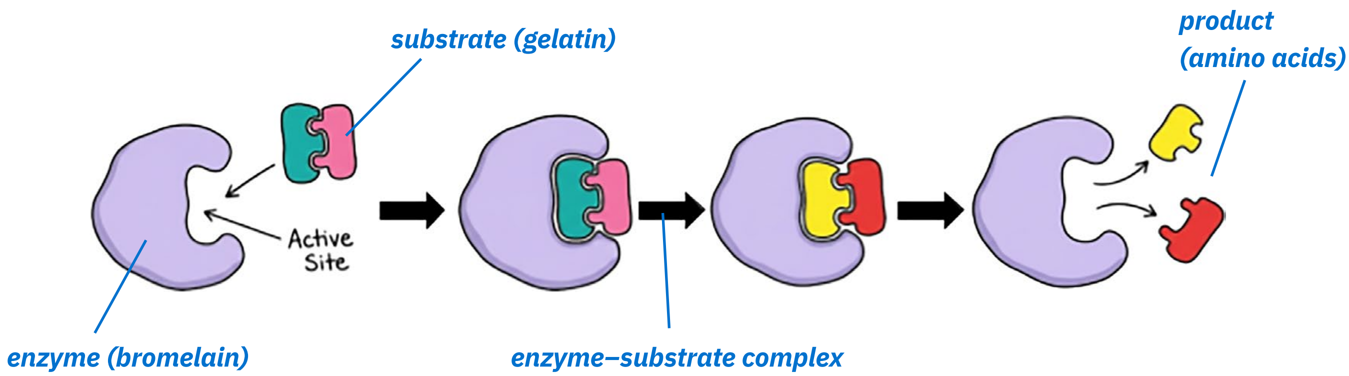
- A sleeve of saltine crackers, enough for one per student (check dietary restrictions of students before handing out)
- 1 Petri dish with prepared gelatin
- 1 straw
- 1 flat toothpick
- 1 Sharpie marker
- 1 metric ruler
- Separate dropper for each solution
- 7 solutions:
  - 25% *fresh* pineapple juice
  - 50% *fresh* pineapple juice
  - frozen pineapple juice (thawed)
  - canned pineapple juice
  - pineapple juice (pH 1)
  - pineapple juice (pH14)
  - distilled water

Teacher preparation

At least a day in advance, prepare a desired number of Petri dishes with about 15 mL of gelatin (make according to the box directions). Prepare the various solutions of pineapple required for the lab; thaw a can of frozen pineapple juice. **Safety precaution:** Check for dietary restrictions (saltine crackers). No known alternatives.

Procedure

1. Ask the students what a saltine cracker tastes like.
2. Give each student a cracker and have them place a piece of it on their tongues and keep it there for 20 seconds. They can finish eating it after the 20 seconds is up.
3. Did the taste of the cracker change over the 20 seconds?
4. What happened to the cracker?
5. What do they think occurred?
6. In groups of two, have students brainstorm the answers to the following questions:
    a. Knowing that the names of enzymes end in "-ase", what do you predict is the substrate of protease?
    b. Based on the background information about gelatin, what effect might proteases such as bromelain have on the gelatin?
    c. Do you think that protease performs hydrolysis or dehydration synthesis on its substrate? Why?
    d. Ask students to create a diagram using the terms active site, substrate, enzyme, enzyme–substrate complex, and product, or use the diagram below and ask students to label **substrate, enzyme, enzyme–substrate complex,** and **product.**



7. Have the students follow the directions on the student document.
8. Once their wells are filled, have them place them in a space where they cannot be disturbed.
9. Students should answer the post-lab questions for day 1.
10. Check dishes and record data on day 2; answer post-lab questions.

Suggested wrap-up

Relate the lab to the immune response. Have students discuss what a normal body temperature range is and how that changes when there is an illness. Why is this important? They can also discuss why organs used in transplantations are stored on ice.

Differentiation

- For students who cannot handle gelatin, use pectin; use papaya as the alternative to pineapple.
- Students may cut out the diagram from their student document to model the action of enzymes.

Extensions

Students can do further research on the enzymes in the human body and their pH and temperature requirements. Students can research or do extension labs on different types of laundry detergents and their effect on various stains. They can also change the concentrations or temperatures of the detergent solutions.

Support information

- Animation of the induced fit model
  youtu.be/nVd4BdeuJYU
  Discussion of the control of metabolism through enzyme regulation
  labxchange.org/library/items/lb:LabXchange:3b90856b-911c-32a9-83ed-7c10616c99e8:html:1
- Factors Affecting Enzyme Activity
  https://bio.libretexts.org/Courses/Prince_Georges_Community_College/PGCC_Microbiology/07%3A_Microbial_Metabolism/7.01%3A_Introduction_to_Metabolism_and_Enzymes/7.1.01%3A_Factors_Affecting_Enzyme_Activity

Career connections

- **Biochemist/Enzymologist:** Studies enzyme structure, function, and kinetics in labs.
- **Enzyme Engineer/Protein engineer:** Modifies enzymes for specific industrial or therapeutic uses (directed evolution, synthetic biology).
- **Computational Scientist:** Uses AI/ML to design and predict enzyme performance.
- **Molecular Biologist:** Works on gene expression and protein production.
- **Food Chemist:** Develops enzymes for baking, brewing, and dairy.
- **Pharmaceutical researcher:** Creates enzymes for drug targets (therapeutics) or diagnostic tests (PCR enzymes, biosensors).
- **Process Engineer:** Produces enzymes for detergents, biofuels, and sustainable processes.
- **Analytical Chemist:** Designs enzymatic ingredients for skincare.
- **Process Development Scientist/Technician:** Optimizes large-scale enzyme production and stability.
- **Quality Control/Assurance:** Ensures enzyme products meet standards.