Overview: The purpose of this task is to enable students to visualize how enzymes function as catalysts and describe the lock and key mechanism of an enzyme by conducting laboratory investigations on the enzyme action of detergents. This task may be differentiated for various student levels ranging from student-developed procedures to teacher directed procedures.

Standards (Content and Characteristics):

SB1. Students will analyze the nature of the relationships between structures and functions in living cells.
   b. Explain how enzymes function as catalysts.

SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.
   a. Follow correct procedures for use of scientific apparatus.
   b. Demonstrate appropriate techniques in all laboratory situations.
   c. Follow correct protocol for identifying and reporting safety problems and violations.

SCSh6. Students will communicate scientific investigations and information clearly.
   a. Write clear, coherent laboratory reports related to scientific investigations.
   b. Write clear, coherent accounts of current scientific issues, including possible alternative interpretations of the data.
   c. Use data as evidence to support scientific arguments and claims in written or oral presentations.

SCSh8. Students will understand important features of the process of scientific inquiry.
   Students will apply the following to inquiry learning practices:
   a. Scientific investigators control the conditions of their experiments in order to produce valuable data.
   b. Scientific researchers are expected to critically assess the quality of data including possible sources of bias in their investigations’ hypotheses, observations, data analyses, and interpretations.
Enduring Understanding:

Most cell functions involve chemical reactions that utilize enzymes that either break down or synthesize compounds.

Essential Question(s):

How do enzymes function as catalysts?

How does the lock and key mechanism of an enzyme work?

Pre-Assessment:

Enzyme Function Activity Directions:
1. Spit out gum or candy.
2. Take a couple of swallows of water.
3. Give each student an unsalted soda cracker.
4. They should take half the cracker and simply put it in their mouths.
5. **Do not chew**!
6. Over time, the bland cracker taste should become sweet tasting.
7. Have the students discuss or write a possible explanation for the change.

*Teacher Notes: Saliva contains the enzyme amylase. Amylase functions to breakdown carbohydrate into sugar. Over time, the bland cracker taste should become sweet tasting. Have the students discuss or write a possible explanation for the change.*

<table>
<thead>
<tr>
<th>Outcome/Performance Level Indicator</th>
<th>BASIC</th>
<th>INTERMEDIATE</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain how enzymes function as catalysts and describe the lock and key mechanism of an enzyme.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groups will be given specific directions to carry out the procedures for the lab entitled Detergents and Enzymes. Scaffolded questions may be imbedded with the procedure to create a thought map that may enable the student to make appropriate</td>
<td>Groups will be assigned to develop a controlled experiment based on the research question provided by the teacher. For example, students may be asked “how effective are different detergents at breaking down protein?” <em>Teacher Note: Groups must</em></td>
<td>Each group will develop a research question and design an experiment to examine the function of enzymes in detergents to be approved by the teacher. <em>Teacher Note: Groups must</em></td>
<td></td>
</tr>
</tbody>
</table>

Georgia Department of Education
Kathy Cox, State Superintendent of Schools
Biology • 9-12 • Energy Transformations Differentiated Task
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# Energy Transformations

**Differentiated Task**

August 9, 2007

### Page 3 of 15

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**Materials**

- 4 - test tubes/ bathroom sized plastic cups
- 1 package of gelatin
- 2 - 250 mL beaker
- distilled water
- hot plate
- 10% laundry detergent solution

**Teacher Notes:**

*Gelatin will serve as a source of protein. Hot plates are recommended, as students will be stirring to keep the gelatin from scorching. Ten percent (10%) laundry detergent solution can be made by dissolving 10 grams of detergent in 90 mL of water.*

**Technology**

Students may create graphs of data using graphing software. This activity may be modified using computer based data collection tools.

**Resources**

- Enzymes
  
- Video Segments
  
  Enzymes (01:37)
  

**Safety**

Be sure to follow all chemical, heat, eyewear, and glassware safety rules that are specified by your teacher and in all general laboratory experiences, along with all teacher instructions.

**Homework/Extension**

- Students will use given puzzle pieces labeled as substrate, enzyme, and binding site to
- Students will use unlabeled puzzle pieces to represent the substrate, enzyme, and binding site to
- Students will create a puzzle using the terms substrate, enzyme, and binding site to
### Instructional Tasks

<table>
<thead>
<tr>
<th>Accommodations for ELL Students</th>
<th>Accommodations for Students with Specific Disabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Pair with a same language buddy to assist</td>
<td>● Review and Implement IEP accommodations for specific student needs</td>
</tr>
<tr>
<td>● Modify language requirements for written assessments</td>
<td>Other accommodations may include:</td>
</tr>
<tr>
<td>● Pair with more advanced native language speaking partner (allow for translation in native language for comprehension) as needed</td>
<td>● Provide directions for the lab on tape</td>
</tr>
<tr>
<td>● Provide paragraph summary template (fill in the blank format)</td>
<td>● Provide a template for students to complete the lab (fill in the blank)</td>
</tr>
<tr>
<td>● Provide bilingual support using word to word translation such as dictionaries, and glossaries</td>
<td>● Oral examination</td>
</tr>
<tr>
<td>● Modify language requirements for written assessments</td>
<td>● Word Prediction software for Lab Report</td>
</tr>
<tr>
<td>● Pair with more advanced native language speaking partner (allow for translation in native language for comprehension) as needed</td>
<td>● Proof reading checklist for lab report</td>
</tr>
<tr>
<td>● Provide bilingual support using word to word translation such as dictionaries, and glossaries</td>
<td>● Extended time for written lab report if needed</td>
</tr>
<tr>
<td>● Visual aids/graphic organizers used during the lab for sequence and clarification</td>
<td>● Use a template to create a graph</td>
</tr>
<tr>
<td>● Provide directions for the lab on tape</td>
<td></td>
</tr>
</tbody>
</table>
### Instructional Tasks Accommodations for Gifted Students

<table>
<thead>
<tr>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Research enzyme disorders and create a multimedia presentation that connects an enduring understanding back to the lab</td>
</tr>
<tr>
<td>- Create a medicine that would be helpful with lactose intolerance</td>
</tr>
<tr>
<td>- Create a graph using computerized graphing software</td>
</tr>
</tbody>
</table>

- Modify language requirements for written assessments
- Modify language requirements for written assessments
Detergent Enzyme Lab

Most laundry detergents today contain enzymes in order to be more effective at removing stains. The most difficult stains are proteins and, therefore, the detergents will contain a class of enzymes called proteases. Provide a variety of detergent brands and types. The variety of detergents will allow for a simple inquiry lesson to be designed. This activity can be modified to create different levels of inquiry. Select the level at which you are comfortable and your students will be successful. Remember to increase the levels as the semester/year progresses in order to place more responsibility on the students. This will also increase the level of understanding and ultimately will assess student knowledge through performance tasks.

Materials (per group)

- 4 - test tubes/ bathroom sized plastic cups
- 1 package of gelatin
- 2 - 250 mL beaker
- distilled water
- hot plate
- 10% laundry detergent solution

Teacher Notes:

1. Gelatin will serve as a source of protein.
2. Hot plates are recommended as students will be stirring to keep the gelatin from scorching.
3. 10% laundry detergent solution can be made by dissolving 10 grams of detergent in 90 mL of water

Procedures for varying levels of inquiry

Advanced Level:

- Groups will design experiments to determine how effective different detergents are at breaking down protein. Groups must submit the experimental design to the teacher prior to the start of the experimentation. Teacher should ensure the experiment is safe and viable (one variable, a control).
- Some of the designs will include:
  - Different types of detergents (cold water formulas vs. room temperature water formula, liquids vs. powders, or different types of the same brand).
  - Temperature (remind students they can only change one variable, if they use temperature they must use a single detergent). Students will place test tubes in different temperatures; remember the gelatin will begin to “melt” at body temperature.
  - pH (remind students they can only change one variable, if they use pH they must use a single detergent). Students would increase/decrease pH of the detergent
Students need to design a data table on which they will record their data. Students will conduct the experiment and record data. They will use their data to draw conclusions. Students need to be prepared to share their experimental design and results with the class. Classmates need to be prepared to comment on validity of experiment/conclusions and sources of error as a part of the formal lab report.

Suggested preparation of available materials:

Prepare the Gelatin
- Add 50 mL of water to a 250 mL beaker and bring this to a boil.
- Use a balance to measure out 2 grams of gelatin on a piece of paper towel. Remember when you are massing something using a triple beam balance or digital balance you must take the mass of the paper towel into account.
- Slowly add the gelatin to the beaker of boiling water as the beaker remains on the hot plate. Use a stirring rod to make sure all the gelatin dissolves. Stir while the beaker is on the hot plate to avoid scorching the gelatin.
- Using tongs or hot mitts, remove the beaker when the entire gelatin sample is dissolved.
- Pour approximately 10 mL (divide it as evenly as possible) of gelatin in each of the four test tubes or bathroom sized cups. Cover and allow them to cool overnight.

Prepare the Detergent
- Using a balance, measure out 10 grams of powdered detergent and place it in a 250 mL beaker.
- Using a graduated cylinder, add 90 mL of distilled water to the beaker and stir until most of the detergent dissolves.
- If the detergent is liquid, measure 10 mL of the detergent with a graduated cylinder and then add it to the beaker with 90 mL of distilled water.
- Label the beaker with the name of the detergent and the type of enzyme (if known).
- TEACHER NOTE: you may want to alter the pH of a couple of the detergents by splitting the sample and adding HCl or NaOH to mimic the protease action of the human stomach. This will need to be shared with the students. Groups will need to be assigned specific materials for this to show valid results.

Intermediate Level:
- Groups will be assigned one of the specific variations of the lab stated above. One group could serve as the control for all the other groups (they just add water to their tubes and place them under the same conditions as the others).
- Student groups will complete the experiment as directed and develop all recording documents to record observations and data.
Student groups will share their experiment and results with classmates. Classmates will need to comment on validity of conclusions and identify sources of error as a part of the formal lab report.

Prepare the Gelatin
- Add 50 mL of water to a 250 mL beaker and bring this to a boil.
- Use a balance to measure out 2 grams of gelatin on a piece of paper towel. Remember when you are massing something using a triple beam balance or digital balance you must take the mass of the paper towel into account.
- Slowly add the gelatin to the beaker of boiling water as the beaker remains on the hot plate. Use a stirring rod to make sure all the gelatin dissolves. Stir while the beaker is on the hot plate to avoid scorching the gelatin.
- Using tongs or hot mitts, remove the beaker when the entire gelatin sample is dissolved.
- Pour approximately 10 mL (divide it as evenly as possible) of gelatin in each of the four test tubes or bathroom sized cups. Cover and allow them to cool overnight.

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- Label the beaker with the name of the detergent and the type of enzyme (if known).
- TEACHER NOTE: you may want to alter the pH of a couple of the detergents by splitting the sample and adding HCl or NaOH to mimic the protease action of the human stomach. This will need to be shared with the students. Groups will need to be assigned specific materials for this to show valid results.

Basic Level:

Prepare the Gelatin
- Add 50 mL of water to a 250 mL beaker and bring this to a boil.
- Use a balance to measure out 2 grams of gelatin on a piece of paper towel. Remember when you are massing something using a triple beam balance or digital balance you must take the mass of the paper towel into account.
- Slowly add the gelatin to the beaker of boiling water as the beaker remains on the hot plate. Use a stirring rod to make sure all the gelatin dissolves. Stir while the beaker is on the hot plate to avoid scorching the gelatin.
- Using tongs or hot mitts, remove the beaker when the entire gelatin sample is dissolved.
- Pour approximately 10 mL (divide it as evenly as possible) of gelatin in each of the four test tubes or bathroom sized cups. Cover and allow them to cool overnight.
Georgia Performance Standards Framework for Biology 9-12

Prepare the Detergent

- Using a balance, measure out 10 grams of powdered detergent and place it in a 250 mL beaker.
- Using a graduated cylinder, add 90 mL of distilled water to the beaker and stir until most of the detergent dissolves.
- If the detergent is liquid, measure 10 mL of the detergent with a graduated cylinder and then add it to the beaker with 90 mL of distilled water.
- Label the beaker with the name of the detergent and the type of enzyme (if known).
- TEACHER NOTE: you may want to alter the pH of a couple of the detergents by splitting the sample and adding HCl or NaOH to mimic the protease action of the human stomach. This will need to be shared with the students. Groups will need to be assigned specific materials for this to show valid results.

Setting up the experiment

- Mark the level of the solid gelatin with a marking pencil in each of the four tubes.
- Select 3 detergents and label the test tubes with the names of the detergents to be tested.
- The fourth tube should be labeled as the control.
- To the control, add 15 drops of distilled water.
- Add 15 drops of the appropriate detergent to the labeled tubes and replace the cover.
- Make sure the tubes are labeled with a mark to indicate the group.
- Allow the tubes to sit for 24 hours. (TEACHER NOTE: select one of each detergent type and a control to be place in a refrigerator to see the effect different temperatures have on enzyme action. A set could also be placed in a very warm area (not to exceed 85 degrees as optimum enzyme action should be body temperature and gelatin will “melt” above 85 F). Collect class data if groups manipulate different variables.
- Measure the amount of liquefaction using a ruler and record in data table.
- Allow the tubes to sit for an additional 24 hours and record the results.

Students will complete a formal lab report. Their conclusions should include the following:

- The purpose of the tube with water.
- The most effective detergent (include any alterations such as temperature or pH).
- The least effective detergent.
- Identification of the enzyme involved, even if one was not listed on the package (protease is a good response!)
- Sources of error.
- Identification of the manipulated and responding variables
- Why detergents were effective at dissolving proteins (do we care???)
- A detailed explanation of why enzymes are important to chemical reactions based on data collected from the lab.
Lab Reports

Laboratory experiences are an important part of science education. These experiences in the classroom allow students the opportunity to practice the processes of scientific inquiry in order to promote scientific literacy and problem solving skills necessary to develop an understanding of scientific concepts. Skills employed while doing lab include reading, writing and critical thinking as well as the appropriate use of laboratory equipment, precision and accuracy of measuring and organizing data.

Lab Focus Question:
What is the purpose of this lab? Why is the lab being done? The lab group is responsible for developing an appropriate lab focus question.

Lab Procedure:
You are expected to write a descriptive paragraph explaining how the lab was conducted. You may not use any personal pronouns such as I, we, us, etc. The narrative should contain only that information a reader would need to be able to explain how the lab was conducted. Be sure to include all equipment and/or solutions, chemicals, etc., needed to complete the lab. Make sure that no “understood” procedures are included (i.e. materials were gathered).

Lab Questions:
You are expected to answer all questions in a lab. The questions should be answered in complete sentences and be correct. Calculations, when required, are clearly shown. Specific formulas or equations for reaction during the lab are shown.

Safety:
All safety procedures are expected to be followed and all safety equipment is expected to be worn while anyone in the lab is still working.

Work Ethic:
Group works together cooperatively, is continually on-task and all members of group are participating. There is no horseplay or wasted time.

Format:
Blue or black ink is recommended with no whiteout. Proper spelling and grammar is followed and no 1st or 3rd person personal pronouns are used. Conclusion is written in such a way that lab focus question is easily identifiable. All sections are written in proper paragraph form, (remember, one sentence is not a paragraph).

Conclusion:
The conclusion should be written in paragraph form and should answer the lab focus question using data obtained as supporting evidence. Be sure to identify the data as either qualitative or quantitative or both. Also, explain how the skills and concepts studied in today’s lab are relevant in today’s society.
A sample Rubric for lab reports is attached below that allows for self, peer and teacher evaluation.

### Laboratory Report Rubric

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Teacher</th>
<th>Peer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lab Focus Question:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present and relevant to the topic</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Present and closely related to the topic</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Absent or not directly related to the topic</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Lab Procedure:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Written as a descriptive paragraph with relevant steps and materials included</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Written as a list with relevant steps and materials included</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>OR Written as a paragraph but missing relevant steps and or materials</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Absent or more than 50% of relevant steps and or materials missing</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Lab Results:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All results are clearly written; proper units are used when necessary</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Results are present, some without proper units or some results are missing</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>No results are included OR less than 50% of the results are included</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Lab Questions:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Answered in complete sentences, calculations, when required are clearly shown; specific formulas or equations for reactions during the lab are shown</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Answers not in complete sentences, most calculations, formulas or equations are shown OR less than 80% of these are shown correctly</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Answers, calculations formulas and/or equations missing OR less than 50% of these are shown directly.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Safety:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All safety procedures were observed; all safety equipment was used correctly; group was not cited for a safety violation</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Safety procedures were observed, safety equipment was used; group cited for ONE safety violation.</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Safety procedures were not observed; safety equipment was not used; group was cited for more than one safety violation.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Lab Conclusion:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Written in paragraph form answering the lab focus question using data as supporting evidence, also explains how the information discovered in the lab is applicable in today’s society, data is identified as either qualitative or quantitative</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Paragraph format absent but lab focus question is addressed using appropriate data OR paragraph format present and application to today’s society is missing OR data is not properly identified as qualitative or quantitative</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Paragraph format absent, lab focus question is not addressed using appropriate data and application to today’s society is missing and data is not identified as qualitative or quantitative</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Format:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neatly presented, uses appropriate grammar, and adheres to format.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Neatly presented, few grammar mistakes, minor format mistakes</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Neatness absent, frequent grammar mistakes, does not follow format</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
### Work Ethic:

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Group is on task; no horseplay; works cooperatively; all members actively participate</td>
</tr>
<tr>
<td>3</td>
<td>Group is redirected one time; 80% of members work cooperatively and actively participate</td>
</tr>
<tr>
<td>0</td>
<td>Group is redirected more than one time, 50% of members work cooperatively and actively participate.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Score</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Total points earned = Lab grade
The Enzyme Action of Detergents Template

Introduction

The introduction should total one paragraph. State the Purpose of the lab by answering the following two questions as STATEMENTS. Do not write the questions and answer them. Just answer these two questions as complete STATEMENTS to form a paragraph. (1) Why did you do this lab? (2) Discuss the importance of enzymes (3) What were you looking to find or confirm?

Hypothesis

Create a hypothesis statement based on the following research question. How do detergents break down enzymes?

Materials

LIST all materials used in this experiment.

Procedures

In paragraph form write step by step what you did to conduct this lab.

Results

Write a paragraph describing what you observed (seen happen) such as changes. Use the observations from your table to write this results paragraph. Do not explain why things happened in this section.

Conclusion

In paragraph form EXPLAIN WHY your observations occurred. Just answer these two questions as complete STATEMENTS to form a paragraph. Do not write the questions and answer them. (1) Explain how enzymes function as catalysts (2) Explain the lock and key mechanism of an enzyme.
Substrate's role in Enzyme Function

Inhibitor's role in Enzyme Function

Thought Map
Describe the enzyme's role in the lock and key mechanism

____________________
____________________
____________________

Outcome of lock and key mechanism

______________________________
______________________________
______________________________

______________________________
______________________________
______________________________