Strand IV: Cell Chemistry and Biotechnology

Enzymes

Teacher Materials

This curriculum-embedded science performance task is related to the content standards and expected performances for high school, as described in the Core Science Curriculum Framework, under Scientific Inquiry, Literacy and Numeracy, Strand IV – Cell Chemistry and Biotechnology.

Targeted Content Standard

10.1 The fundamental life processes depend on the physical structure and the chemical activities of the cell.

Targeted Scientific Inquiry, Literacy and Numeracy Standards

D INQ. 1 Identify questions that can be answered through scientific investigation.

D INQ. 3 Formulate a testable hypothesis and demonstrate logical connections between the scientific concepts guiding the hypothesis and the design of the experiment.

D INQ. 4 Design and conduct appropriate types of scientific investigations to answer different questions.

D INQ. 5 Identify independent and dependent variables, including those that are kept constant and those used as controls.

D INQ. 6 Use appropriate tools and techniques to make observations and gather data.

D INQ. 7 Assess the reliability of the data that was generated in the investigation.

D INQ. 9 Articulate conclusions and explanations based on research data, and assess results based on the design of an investigation.

Learning objective:

Students will be able to identify the best enzyme for juice production and variables that affect the ability of an enzyme to function.

Listed below are the suggested materials for the laboratory exercise. You may use additional materials if they are available.

Materials:

apple sauce	droppers	splash-proof safety goggles
pectinase enzyme	stirring rods	access to a balance
cellulase enzyme	graduated cylinder	paper towels for cleanup
funnels	access to tap water	
filter paper	paper cups	
lab aprons	access to a stopwatch, watch or clock	

Considerations:

Teams of two students are ideal for laboratory work, but circumstances may necessitate teams of three students. Students will need a minimum of 90 minutes to complete this laboratory exercise if you expect their lab reports to be written during class time. You should allow at least 60 minutes of instructional time for the students to design and conduct their experiment and a minimum of 30 minutes for the students to write about their results. As an alternative the students can complete the lab report for homework. A sample scoring rubric is provided for your convenience or you may design one of your own.

A guideline for the quantity of enzyme to be used is provided due to the concern about conserving costly supplies. Once students identify which enzyme or combination produces the greatest quantity of juice, you can encourage them to explore another variable effect on juice production such as change in temperature or pH. This extension relies on the availability of enzyme supply and instructional time. Check with the science supply house of your choice for the availability and cost of the enzymes. Remember the shelf life of the enzymes is six months when refrigerated.

The task can be integrated into a unit on cell chemistry in any high school biology course. The curriculum-embedded task is intended to be used in the course of normal instruction as a formative assessment. The Connecticut Academic Performance Test-Generation III will include some open-ended items that will assess scientific inquiry and communication skills in the same context as this task.

Background Information on the Enzymes Used in This Activity

Cellulase

The enzyme **cellulase** breaks down **cellulose**. Cellulose is a polymer made out of long branching chains of glucose and it is one of the main components of plant cell walls. Cellulose accounts for about 50 percent of all the organic materials on Earth. Unfortunately, humans, like all other mammals, do not contain the enzyme cellulase and therefore can't digest cellulose.

Scientists purified the enzyme cellulase and currently it is used in the food industry for the production of wine and juices. The enzyme is also used in the production of plant-based materials such as paper, light basswood, rayon fibers and photographic films.

Pectinase

The enzyme **pectinase** breaks down **pectin**. Pectin is a complex carbohydrate that is part of the plant cell wall. Pectin acts like "glue," holding plant cell walls together. Pectin is soluble in water, and in a mild acidic environment it becomes sticky. These properties make pectin very useful in the production of jams and jellies. When the enzyme pectinase is added to mashed fruits it breaks down the pectin in the fruit cell walls, thus facilitating the industrial production of fruit juices.

Student Name:_____ Class:_____

Enzymes

Laboratory Investigation
Student Materials

<u>Introduction</u>: Apple Juice

A Connecticut company is in the business of making and selling apple juice. To make apple juice, apple sauce is strained through filters to remove the juice. The company would like your help in testing the impact of different enzymes on the production of the apple juice. You will investigate the ability of these enzymes to remove more juice during this process and decide the most cost effective plan to increase juice production. The following is a list of the enzymes along with their prices:

Pectinase:	$ 50 per liter
Cellulase:	$100 per liter

Enzymes are proteins that catalyze chemical reactions in the cells of all living organisms. Enzymes control many vital functions in the cell, including the release of energy during the breakdown of nutrients into smaller molecules and the synthesis of complex cell materials from the small molecules. In this lab you will work with two plant enzymes – cellulase and pectinase.

Your Task

You and your lab partner will design and conduct an experiment to determine **which enzyme or combination of the two enzymes maximizes juice production.** Once you complete the laboratory investigation, you will evaluate which enzyme will be the most cost effective to use in juice production.

You have been provided with the following materials and equipment. It may not be necessary to use all of the equipment that has been provided.

Suggested materials:

apple sauce
pectinase enzyme
cellulase enzyme
funnels
filter paper
lab aprons
splash-proof goggles
paper towels for cleanup
droppers
stirring rods
graduated cylinder
access to tap water
paper cups
access to a watch or clock with a second
access to a balance

Designing and Conducting Your Experiment

1. In your words, state the problem you are going to investigate. Write a hypothesis using an "If … then … because …" statement that describes what you expect to find and why. Include a clear identification of the independent and dependent variables that will be studied.

2. Design an experiment to solve the problem. Your experimental design should match the statement of the problem and should be clearly described so that someone else could easily replicate your experiment. Include a control if appropriate and state which variables need to be held constant.

3. Review your design with your teacher before you begin your experiment.

4. Conduct your experiment. While conducting your experiment, take notes and organize your data into tables.

Safety note: Students must wear approved safety goggles and follow all safety instructions.

When you have finished, your teacher will give you instructions for cleanup procedures, including proper disposal of all materials.

Communicating Your Findings

Working on your own, summarize your investigation in a laboratory report that includes the following:

- **A statement of the problem you investigated. A hypothesis ("If ... then … because …" statement) that described what you expected to find and why.** Include a clear identification of the independent and dependent variables.

- **A description of the experiment you carried out.** Your description should be clear and complete enough so that someone could easily replicate your experiment.

- **Data from your experiment.** Your data should be organized into tables, charts and/or graphs as appropriate.

- **Your conclusions from the experiment.** Your conclusions should be fully supported by your data and address your hypothesis.

- **Discuss the reliability of your data and any factors that contribute to a lack of validity of your conclusions**. Also, include ways that your experiment could be improved if you were to do it again.