This material is based on work supported by the National Science Foundation under Grant No. DUE 9987332.

TxCETP Course Component

Alien Enzyme Function

(Roswell Revisited)

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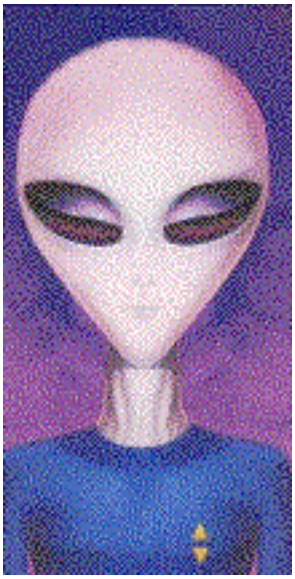
Student Edition



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I. Introduction

Overview:
This inquiry-based lab module is designed to give students practical experience designing experiments in an investigative manner while also teaching valuable content knowledge concerning enzyme function and chemical digestion and developing their communication skills. Students are given unknown enzymes and must determine what substrate, pH, and temperature allow the enzymes to work best. They must also explain the "how and why" of their results. Connections are made not only to TEKS, but also to the National Science Education Standards (National Research Council, 1996). You can use this module before or after a unit on digestion/ enzymatic function. You may modify as you wish to fit your individual course needs.

Prerequisites:
Prior to this lab students should have an understanding of the following concepts: human digestive anatomy and physiology, an overview enzyme function and metabolism, and experimental design.

Objectives:
The student should be able to:

- explain how enzymes function,
- predict the effect of substrate, pH, and temperature on enzyme structure and activity,
- name 3 characteristics of enzymes and explain how they function in degradation reactions,
- describe the function of bile in digestion, and
- explain how temperature and pH differences affect enzyme activity.

Connections to TEKS:
112.43: B1; C1, A&B; C2, A-D; C3, A; C4, B; C9, A&C

Connections to NSES:
Teaching Standards (B), (D), & (E); Content Standard A

Instructional Game Plan:
This is a group project designed to be used in a biology laboratory for high school students. Students may work in groups of 2-4.

Estimated Time:
Approximately 4 hours. Students will need a period to plan their experiment and another to execute it in the lab setting.

Activities:
Students must complete a pre-lab assignment concerning digestive anatomy and physiology, plan and design an experiment to investigate enzyme function as related to digestion, and compile a report that summarizes their findings.

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II. Activities with Assessment and Evaluation

Instructions:

TASK #1: Complete the pre-lab assignment and turn it in prior to coming to lab.

TASK #2: Work with your team members and use the planning form to determine how you will approach the experiment given below. Have your instructor check it before proceeding to the experimental design.

TASK #3: Implement your experiment, record and analyze your data, draw your conclusions, and compile a report.

Evaluation Overview:

Each individual student is responsible for completing the pre-lab assignment. Each group will turn in the planning form and a lab report.

- Each student will receive an individual grade based on the correctness of the pre-lab assignment (25%).
- All members of the group will receive the same grade on the planning form and the lab report (50%).
- Each member of the group will be graded anonymously by their peers in their lab group (25%).

Evaluation Specifics:

1. Complete the pre-lab assignment on a separate piece of paper with your name only.
2. Place the names of the team members on your planning form/lab report. Turn it in on completing your experiment.
3. Place your name on the peer evaluation form. Turn it in upon completing your experiment.

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Task # 1: Pre-Lab Assignment

Complete the following questions using your textbook and/or lecture notes and turn it in prior to coming to lab.

1. Define the function of each of the following digestive terms: digestion, secretion, absorption, elimination, oral cavity, esophagus, stomach, gastric secretions, small intestine, intestinal secretions, large intestine, pancreas, liver, gallbladder, and bile/bile salts.

2. What are the differences between chemical and mechanical digestion?

   What is the ultimate purpose of digestion?

3. What are the 4 major macromolecules that comprise all body components? What purposes do they serve in the body?

   What are the component monomers of these macromolecules?

4. What is an enzyme? What do enzymes do? How do they work?

   What do they need to operate efficiently?

   What controls enzyme activity?

   What is their role in digestion?

5. Give some examples of enzymes that breakdown carbohydrates, lipids (triglycerides), and proteins into their component monomers. Where are these enzymes manufactured?

6. What is the function of the bile? Where are the bile salts produced?

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Terms of Interest:
These terms may help you in your experimental investigation; use as you see fit.

Gastrointestinal Tract:
- Oral cavity
- Pharynx
- Esophagus
- Stomach
- Small intestine:
  - Duodenum
  - Jejunum
  - Ileum
- Large Intestine:
  - Cecum and appendix
  - Colon:
    - Ascending
    - Transverse
    - Descending
    - Sigmoid
  - Rectum
  - Anal canal

Accessory organs:
- Tongue
- Teeth
- Muscles of mastication and swallowing
- Salivary glands:
  - Parotid glands
  - Submaxillary glands
  - Sublingual glands
- Pancreas
- Liver and gallbladder

Other terms:
Peristalsis, emulsification, reactants, products, pH, enzyme, substrate, catalyst, enzyme substrate complex, monomers, bile, bile salts; catabolism, anabolism, metabolism, monosaccharides, disaccharides, polysaccharides, glycerol, fatty acids, amino acids, proteins, starches and sugars, triglycerides/lipids, substrate, catalyst, modulators

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Task #2

Work with your team members and use the planning form to determine how you will approach the experiment given below. Have your instructor check it before proceeding to the experimental design. Use the Alien Enzyme Function Planning & Lab Report Form which follows Task #3.

The Scenario:

An alien vessel has crashed landed (again?) in the desolate ranch land surrounding Roswell, New Mexico. The government is quick to recover the wreckage before certain pesky agents arrive from the FBI. In doing so the recovery team discovers the bodies of two extraterrestrial aliens among the wreckage. The humanoid aliens (see picture on first page) have obviously perished as a result of their injuries. As a member of a secret government research team, you are charged with investigating the physiology of the aliens before the bodies begin to decay. Another team has previously determined that the aliens are indeed carbon-based life forms and have anatomical structures similar to humans; however, it is unknown whether their physiology is similar to ours. In order to learn more about the normal physiology of these aliens, your team is responsible for investigating the function of enzymes isolated from the alien bodies. The previous team isolated two enzymes (dubbed X & Q) from the aliens in two locations from what appears to the alien's digestive tract. Enzyme X was isolated from a rudimentary stomach-like pouch. Enzyme Q was isolated from the upper 1/3 of a tube-like structure similar to a human's small intestine. It is believed that the aliens' enzymes work similar to those of humans. It is your team's task is to determine what substrate the enzymes work on and at what temperature and pH they work best.

Design an experiment that would determine for each of the unknown enzymes the correct substrate, pH, and operating temperature. Since the aliens are carbon-based, it is assumed they have similar physiological needs in regards to basic macromolecules of life such as carbohydrates, lipids, and proteins. The substrates that are available to you for testing are egg white and diary cream.

Materials Available:

15 ml test tubes (12-24 per group)	Droppers
Test-tube racks	Litmus cream (dairy cream + powdered litmus)
Water bath (37° C)	Boiled egg white
Water bath (100° C)	Distilled water
Ice bath (~0° C)	Concentrated Hydrochloric Acid (HCL)
Graduated Cylinders	0.25% Sodium Hydroxide (NaOH)
Polyethylene funnels	Unknown Enzyme X (5% pepsin)
pH (Hydrion) paper	Unknown Enzyme Q (2% pancreatic lipase/pancreatin)

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Task # 3

Implement your experiment, record and analyze your data, draw your conclusions, and compile a report. Use the Alien Enzyme Function Planning & Lab Report Form which follows.

Special Instructions, Laboratory Procedures, & Information:

- Remember to determine the following: what is known based on the given information; what is already known that would be useful; what information is still needed and how to get it; what some possible solutions might be; and how to differentiate among them.
- Use equal amounts of unknown and substrate solutions (3ml) in all tubes.
- Egg slices should be no more than 0.5 cm^2.
- pH paper gives a measure of the acidity/alkalinity of a solution.
- All tubes should be incubated for at least an hour.
- Litmus remains blue for alkaline solutions; turns pink/red for acidic solutions.
- Bile salts emulsify fat.
- HCl is acidic, NaOH is basic, and distilled water is neutral.
- You should record data both before and after incubation.
- Remember to eliminate as many sources of bias as possible.

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III. Planning & Lab Report Form

Instructions:

Answer the following on separate pages. Be sure to complete the planning form and have your instructor approve of your design before proceeding to the experiment and report.

Planning Form:

1. How will you answer the proposed questions? (You will need to provide a general written overview followed by a graphical representation of the experiment.)

2. How will you know if you have determined the correct substrate, pH, and temperature for each of the unknown enzymes (be as specific as possible)? Some considerations follow:
    - What assumption(s) are you making?
    - What is your hypothesis? What is the alternative hypothesis?
    - What are your predictions?
    - What is/are the independent variable(s)? What are you manipulating?
    - What is/are the dependent variable(s)? What are you measuring?
    - What is/are the experimental group(s)?
    - What is/are the control group(s)?

3. Procedures:
    - Outline your procedures carefully and specifically, so that others could easily replicate your experiment.

Report:

1. Data Collected/Observations:
    - Describe your collected data (results), how you limited the bias, the equipment you used, and the duration of your sampling.
    - Organize your data into a legible form using graphs, tables, charts, etc. Be sure to write everyone's name on the page.

2. Data Analysis:
    - Describe how you analyzed your data (graphs, tables, charts, statistical tests, etc.).
    - What patterns or trends did you notice?

3. What are your Conclusions?
    - Summarize your conclusions based on your data.

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Summary Report:

The commanding officer in charge of the investigation demands that you report your findings in a form that he, a "non-scientist," will understand. Summarize your findings in a report or presentation addressed to the non-scientist making sure to address his questions.

1. What the similarities of alien enzyme function and human enzyme function? What are the differences?
2. What are the optimum temperature, pH, and substrate for enzyme X and for enzyme Q?
3. What can you infer from your results regarding the alien's
   - diet and
   - digestive function?

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IV. Peer Evaluation Form[2]

NAME: _____ GROUP: _____

Use this form to ***anonymously*** evaluate your lab partners in their ability, usefulness, and helpfulness with the planning form, experimental procedures, and the report. Please write the names of your group members in the spaces below and give them the scores you believe they earned. Do not include yourself. There are 25 points available to evaluate each of your group members. Be fair in your assessments. If someone worked harder than the rest of the group award them more points. If not, award them less. The average of your individual scores from your peers will be used to determine your grade for this portion of the exercise.

There are some rules in assigning points:

- You cannot give more than 25 points.
- You do not have to assign all of your points.
- Don't give students a grade that they don't deserve.

	Group Members	Score
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____

If you gave someone less than 15 points, please indicate your reasoning below.

If you gave someone more than 23 points, please indicate your reasoning below.

If you were to assign points to yourself, what do you feel you deserve? Why?

[2] Adapted from: Herried, C.H. (2001). When justice peeks: evaluating students in case study teaching. J*ournal of College Science Teaching, 30*, 7, 430-433.

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V. Grading Rubric

Name(s); Section #; Score_____

POINT VALUE	**0**	**.25**	**.5**	**.75**	**1**
Introduction					
Planning From is complete.					
Graphical representation is present.					
Planning Form is logical					
1 Statements of question(s) under investigation is/are clear, and correct.					
2 Hypotheses are clear and causal.					
3 Provides logical argument for why question and hypothesis(es) are being investigated.					
Methods					
4 Experimental design is described completely and clearly.					
5 Steps/procedures are justified.					
6 Experimental and control variables and assumptions are correctly chosen and justified.					
7 Methods provide for appropriate test of selected hypothesis.					
Results					
8 Data are presented without causal interpretation or implications.					
9 Data are summarized and displayed appropriately in graphs or tables.					
10 Trends in data are made clear in text without repeating the information in tables or graphs.					
11 Figures and tables are properly numbered, captioned, and are referred to in the text.					
12 Figures and tables can be properly interpreted without reference to the text.					
Discussion					
13 Questions and hypotheses stated in introduction are addressed.					
14 Conclusions are supported by the data.					
15 Alternative explanations are discussed.					
16 Speculations are clearly stated as such and logically derived from data.					

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POINT VALUE	**0**	**.25**	**.5**	**.75**	**1**
17 Additional hypotheses are generated.					
18 Unexpected results are interpreted without unnecessary reference to experimenter error.					
19 Appropriate comparisons to textbook(s) are made and properly cited.					
20 Interpretations and information presented are correct given sources available to student.					
General					
21 Writing is clear and free of grammar, spelling, and punctuation errors.					
22 Presentation (optional) is concise and informative.					
Extra Credit (+1 point each)					
1 Data are analyzed statistically. (x3)					
2 Appropriate comparisons to literature are made and properly cited.					
3 Methods are illustrated by images or graphics.					
4 Additional experiments are designed.					
5 Additional experiments are completed.					
Subtotal:					
TOTAL:					

Adapted from & used by permission from: Russell, C.P. & French, D.P. (2001). Biological Investigations: A Laboratory Resource Guide. Harcourt College Publishers

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VI. Bibliography

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VII. Appendix

Digestion of fat with pancreatic lipase and bile salts.

1. Add litmus powder to dairy cream until a blue color is produced. Preincubate the litmus cream and a 1% pancreatin solution at 37° C for 5 minutes. Prepare a series of test tubes as follows.

Tube 1	**Tube 2**
3 ml cream	3 ml cream
+	+
3 ml pancreatin	3 ml water

Tube 3	**Tube 4**
3 ml cream	3 ml cream
+	+
3 ml pancreatin	3 ml water
+	+
3 ml bile salts	pinch bile salts

2. Incubate all tubes in a 37° C water bath for 1 hour, or until a color change occurs in one tube. Blue litmus will turn pink in an acid environment. Test the pH using pH paper, and not the odor of each tube.

Gastric Digestion of Protein

1. Place thin slices of cooked egg white in four test tubes. It is important to make these slices the same size (about 0.5 cm^2) and as thin as possible.

2. Add the following to the tubes and determine the pH of each tube:

Tube 1	**Tube 2**
3 ml pepsin (5% soln)	3 ml pepsin (5% soln)
+	+
3 ml HCL (0.5%)	3 ml water

Tube 3	**Tube 4**
3 ml HCL (0.5%)	3 ml pepsin (5% soln)
+	+
3 ml water	3 ml NaOH (0.25%)