**Subject area/course**: Science/Biology

**Grade level/band**: 11-12

**Task source**: Educational Policy Improvement Center (EPIC)

**Soapy Enzymes**

**TEACHER'S GUIDE**

1. **Task overview**:

This task provides students with an opportunity to perform guided scientific inquiry. Students will work with a partner or group to design and conduct an experiment to determine if a detergent containing enzymes is more effective than a detergent that does not contain enzymes in removing blood stains. Students design a qualitative experiment to determine the visual appearance of the stained fabric. At the conclusion of the experiment, students write an individual report summarizing their experimental findings. Students organize and apply their knowledge about the structure and function of biomolecules in a real-world context.

1. **Aligned standards:**
2. **Primary Common Core State Standards**

[CCSS.ELA-Literacy.WHST.11-12.2](http://www.corestandards.org/ELA-Literacy/WHST/11-12/2/) Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

[CCSS.ELA-Literacy.W.11‐12.7](http://www.corestandards.org/ELA-Literacy/W/11-12/7/) Conduct short as well as more sustained research projects to answer a question (including a self-­‐generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

1. **Secondary Common Core State Standards**

[CCSS.ELA-Literacy.RST.11-12.9](http://www.corestandards.org/ELA-Literacy/RST/11-12/9/) Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

[CCSS.ELA-Literacy.WHST.11-12.1d](http://www.corestandards.org/ELA-Literacy/W/11-12/1/d/) Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

1. **Critical abilities**

Research: Conduct sustained research projects to answer a question (including a self-generated question) or solve a problem, narrow or broaden the inquiry when appropriate, and demonstrate understanding of the subject under investigation. Gather relevant information from multiple authoritative print and digital sources, use advanced searches effectively, and assess the strengths and limitations of each source in terms of the specific task, purpose, and audience.

Experimentation and Evaluation: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Evaluate hypotheses, data, analysis, and conclusions, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

1. **Other standards**

NGSS Cross-Cutting Concept [Structure and Function](http://www.nap.edu/openbook.php?record_id=13165&page=96): [Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.](http://www.nap.edu/openbook.php?record_id=13165&page=96)

NGSS DCI [LS1.A: Structure and Function](http://www.nap.edu/openbook.php?record_id=13165&page=143%22) [Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)](http://www.nap.edu/openbook.php?record_id=13165&page=143)\*

\*This task helps build an understanding of how proteins, specifically enzymes, function in biotic systems

1. **Time/schedule requirements:**

Students should be given the assignment before their lab time so that they can work with their lab groups to do background research and have a preliminary experimental design planned. This preparation should take about an hour or two and should be completed out of class as homework.

A three-hour lab block should be sufficient to perform the experiment(s), depending on how well prepared the students are when they come to lab. If lab time is not organized into a sustained three-hour block, consider having students break down their experimental activities to best fit time constraints. An additional lab block could be used to allow the students to pose additional questions and design and conduct the experiments to answer them.

Students may need as much as five hours to write their final individual report. The report could be due about one week after students complete their experiments.

1. **Materials/resources:**
* This web site provides a list of ingredients in many readily available detergents: <http://www.pinstripesandpolkadots.com/detergentchart.htm>
* This web site defines detergent ingredients by function: <http://www.pgproductsafety.com/productsafety/ingredients/household_care/laundary_fabric_care/Tide/Tide_Ultra_Stain_Release.pdf>
* Suggested materials to have on hand for student use:
	+ A white shirt that can be cut into small pieces (suggestion 1 inch by 1 inch squares)
	+ A sample of hemoglobin dissolved in buffer to mimic blood stains, which can be purchased from a supply company such as Sigma-Aldrich.
		- If you are not able to get hemoglobin, you may choose another protein in a buffer solution, or another common stain such as juice or oil.
	+ Several laundry detergents, including at least one that contains enzymes (e.g., Tide Original) and one that does not.
	+ Transfer pipettes or Pasteur pipettes to apply drops of hemoglobin to the fabric
	+ Several test tubes that will hold at least 10 mL
	+ Parafilm or stoppers for the test tubes
	+ 10 and 100 mL graduated cylinders for making dilutions
	+ Solutions of hydrochloric acid and sodium hydroxide to adjust the pH of the detergent solutions
	+ pH meters or pH paper
	+ If you want students to attempt a quantitative analysis, a spectrophotometer capable of reading at a wavelength where hemoglobin absorbs and cuvettes for that instrument
	+ Heat guns or hair dryers to dry fabrics or a low temperature drying oven
1. **Prior knowledge:**

Students should be able to:

* Describe the structure of proteins and lipids, including phospholipids.
* Define the terms hydrophobic and hydrophilic.
* Describe how enzymes work.
* Perform simple dilution calculations.
* Complete Internet searches related to structure and function of detergents.
* If a quantitative analysis is requested, students should have prior knowledge about spectroscopic theory and operation of a spectrophotometer. This could be acquired in a prior laboratory session.
1. **Connection to curriculum:**

This activity fits into the curriculum of an introductory cell/molecular biology class at the conclusion of a unit on proteins and lipids.

1. **Teacher instructions:**
* This activity can be introduced by having the students brainstorm about claims made for consumer products that are exaggerated or inaccurate.
* Students should be given the task several days before they are asked to perform the experiment in order to do background research and design a draft experimental protocol with their group.
* Students should be provided with small pieces of white fabric, a hemoglobin solution to mimic bloodstains, and at least two detergents – one containing enzymes and one that does not contain enzymes. More detergents would be better.
* Also, provide students a list of materials that they will have available in the laboratory at the time of the experiment.
* Students should work with a lab partner or partners so they can discuss the potential pitfalls of their tentative experimental design and brainstorm to refine their procedure before beginning.
* Encourage students to discuss their proposed procedure and emerging results with you during the execution of the experiment.
* The teacher may ask students to consider the following as they design their experiments:
	+ How much hemoglobin sample (the protein that makes blood red) should I use to stain my test fabric and how will I apply it to the cloth?
	+ How long will I let the stain sit on the fabric? Does the time of exposure make a difference? Is this an experiment I would like to perform?
	+ How will I wash the stained fabric consistently?
	+ What can I use for a qualitative measure of how efficient the detergent was at removing the stain? Should I dry the fabric before evaluation?
	+ Can I quantitatively measure the amount of hemoglobin removed by the soap sample? (Note: Teacher must decide whether or not to ask students to attempt this, depending on their experience with spectroscopy. Students may be given a wavelength where hemoglobin can be measured, or asked to determine the best wavelength. If students attempt to measure the hemoglobin removed with the soap, they should consider the question of what to use for an instrumental blank in the spectrophotometer.)
	+ How many replicates should I use for each test condition so that I have faith in my results?
1. **Student support:**

The following suggestions are examples of scaffolding that can be used to meet the diverse student needs within the classroom.

* Provide class time for research on students’ topics.
* Provide students with the rubric to be used to score their final product.
* Provide definitions of new vocabulary words ahead of time.
* Depending on students’ familiarity with experimental design, review and give examples of independent, dependent, and control variables in order to help students design a rigorous experiment.
* For the final product, all learners will benefit from peer assistance while brainstorming their topics, as well as a peer or teacher review of their papers before final submission.
* Some students will have good research skills, but some will need guidance in the determination of appropriate sources and where to look for them. It is important to spend class time in review of what constitutes an appropriate source in advance of students’ independent work time.
1. **Extensions or variations:**
* Students could present the results of their research to the class via an oral or multimedia presentation.
* If there is a particularly interesting and/or controversial topic, a debate could be organized where students choose sides on the topic and defend their views.
* If you wish, each student group could write a one-paragraph executive summary of their experimental findings to share with their peers, especially if the groups attempted to answer different questions.
* If time permits and the students have experience with spectroscopy, they can attempt to measure the amount of hemoglobin extracted into the detergent. Spectra available for most hemoglobin samples show a maximum absorbance of approximately 425 nm. Sigma reports that hemoglobin is soluble at a level of 20 mg/mL in 100 mM phosphate buffer. This concentration should produce a dark stain on a white fabric.
* If they have time, students might try this test at different pHs to determine the effectiveness of their detergents at different levels of acidity or basicity. (Provide acids and bases with which to adjust the pH if you ask students to consider this question.)
* If you have additional time, you might repeat your experiment at different temperatures to mimic the effectiveness of detergents in cold, warm, or hot water. What effect would you expect temperature to have on the effectiveness of enzymes? Let students know how much time they have to complete their experiments.
1. **Scoring:**

Student work can be scored using the College and Career Ready (CCR) Task Bank Scoring Rubric.