Effect of Enzymes on Stains

Today, consumers are offered countless options for nearly every product they purchase, even laundry detergent. They can choose powder or liquid detergent, special scents, brighteners, dyes, softeners, and, most importantly, enzymes or no enzymes. To determine whether laundry detergents with enzymes are more or less effective at removing stains, an experiment was conducted using four detergent brands, two of which contained enzymes and two of which did not. It was hypothesized that if each laundry detergent was trying to remove a bloodstain from a white cloth, the detergents containing enzymes would remove the stain most effectively.

In order to understand the impact of enzymes on a bloodstain, one must first recognize the makeup of the bloodstain itself. Major components of blood include phospholipids from the membrane, which are classified as a lipid, and hemoglobin, which is classified as a protein. The synthesized bloodstain used in the experiment, like genuine blood, contained both lipids and proteins. Once the blood is exposed to cloth, "the proteins in blood [...] bind, chemically, to [the] fabric. This is where enzymes come into the mix. Enzymes [...] are designed to react with and break down other proteins," such as the hemoglobin found in blood (Hatch). Protease, a highly specific enzyme, hydrolyzes the proteins and breaks them down into more soluble polypeptides; similarly, lipase causes the blood's phospholipids to undergo hydrolysis, "a chemical process of decomposition involving the splitting of a bond and the addition of [...] water" (Hydrolysis).

Since enzymes themselves are composed of organic molecules, they should increase a detergent's potential to remove the organic bloodstain from the fibers of the shirt, supporting the experimenter's prediction.

However, laundry detergents contain a variety of other ingredients which are necessary in eliminating stains and properly cleaning clothes. Surfactants, a major element found in detergents that serves as an active cleaning agent, have a variety of functions, such as wetting the fabric and loosening soils; these functions depend on the structure of the surfactant molecule, which includes a hydrophilic head that attracts water for rinsing and a hydrophobic tail which repels water and instead attracts grime and oil from the cloth (Laundry 2). The combined effects of surfactants and enzymes allow more stubborn stains to be removed from fibers. The main purpose of builders, another property of detergents, is to complex, or bind to, cations found in water. High concentrations of cations make the water harder, hindering stain removal by setting the stain more deeply into the fabric. Builders soften the water and keep the cations from interfering with the surfactants (Laundry 3). Other components of laundry detergents include dyes, fragrances, and fabric softeners, all of which have more to do with the appeal of the clothing than with the actual stain removal. The three energy types important for effective cleaning are "chemical energy, provided by the [...] detergent," "thermal energy, provided by warm or hot water," and "mechanical energy, provided by a machine or hands" (Soaps). Overall, there are a variety of variables which affect the removal of stains from laundry.

During the experiment, the independent variable manipulated was the brand of laundry detergent and the presence of enzymes in each brand. For each category of enzymes

or no- enzymes, one powder and one liquid detergent was selected. One enzyme-containing detergent was Purex Dirt-Lift Action, a liquid detergent "packed with ingredients to soften hard water and [...] specially formulated with stain fighting enzymes to go deep into fabric fibers to remove ground-in dirt and stains" (Purex). The second enzyme-containing detergent was Gain, a powder detergent which, according to CPID, "does contain enzymes" (Gain). Although neither brand was specific about which enzymes were in their detergent, commonly used laundry detergent enzymes include protease, lipase, and amylase. One enzyme-free detergent was Woolite, a liquid detergent that "does not contain bleach, phosphates, or enzymes" (Woolite). The other enzyme- free detergent was 20 Mule Team Borax, a powder detergent which declares that "absolutely nothing is added. No phosphates, peroxide, chlorine, or other additive chemicals," including enzymes (What is Borax). The dependent variable of the experiment was the effect of each detergent on the bloodstain, measured by the shade of each stained cloth after undergoing washing with a detergent. Control variables of the experiment included the temperature of the water, the amount of laundry detergent added, the size and type of the cloth, the amount of blood added, the number of cloths in each beaker, the time cloth was in detergent, the time spent stirring the detergent solution, and the time spent drying.

After the experiment was conducted, the detergents were ranked based on the shade of the bloodstain on each cloth. According to the results, the most effectively removed bloodstains were from the beaker with the enzyme-containing liquid detergent Purex Dirt-Lift Action; the second-most effectively removed bloodstains were from the control beaker with only water; the third-most effectively removed bloodstains were from the beaker with

the enzyme-free liquid detergent Woolite; the fourth-most effectively removed bloodstains were from the beaker with the enzyme-free powder detergent 20 Mule Team Borax; the least effectively removed bloodstains were from the beaker with the enzyme-containing powder detergent Gain. These results were unable to thoroughly prove or disprove the hypothesis, which stated that detergents containing enzymes would more effectively remove stains than detergents without enzymes. While one enzyme-containing liquid detergent, Purex Dirt-Lift Action, completely removed the bloodstain from the cloth and was ranked highest in stain removal, the other enzyme-containing powder detergent, Gain, left the cloth a medium pink and was ranked lowest in stain removal. This data suggests that enzymes might have had no control over the removal of the bloodstain, although all background research showed otherwise; perhaps there was another explanation for why Purex was so much more successful than Gain. The enzyme-free detergents, liquid Woolite and powder 20 Mule Team Borax, were ranked third and fourth in effectiveness; for both, the cloth became a shade of light pink. While the enzyme-free detergents did not completely fail to remove the stain, they were not entirely successful and, as experimenters predicted, at least one enzyme-containing detergent was much more effective at the removal of the bloodstain. Surprisingly, the control group, which contained only water and should have been least successful in removing the stain, resulted the second most effectively removed bloodstains; this suggests that detergents are completely unnecessary and mechanical and thermal energy are most effective in removing a stain. Because there were no surfactants, builders, or enzymes - all of which should have enhanced the cleaning process - this result is not supported by any background research and does not provide support for the hypothesis. Altogether, the results

of the experiment fail to prove the hypothesis correct.

However, the experiment's inconclusive results can not prove that the hypothesis is wrong and can not prove whether detergents with enzymes and enzyme-free detergent are more effective in removing stains. Regarding the unexpectedly different ranks of the enzyme-containing Purex and enzyme-containing Gain, there are multiple errors that might provide potential explanations. Mistakes might have been made in measuring the amount of detergent added to each beaker; if a larger amount of Purex was in the beaker than Gain, it's surfactants, enzymes, and other ingredients would have been more. Inaccurate information on whether both detergents actually contained enzymes was a huge concern, since there was research that suggested Purex might be enzyme-free. Since only two drops of blood were added to the cloth, the lack of a significant-size stain might have caused it to wash away to easily, especially considering the impact of mechanical and thermal energy on the stain itself. Liquid detergent, like Purex, versus powder detergent, like Gain, might have played a part in the effectiveness of stain removal. The aforementioned errors might have also played a part in the high rank of water, particularly the small stain and the impact of mechanical and thermal energy on removing the stain. In order to improve the experiment and ensure results that better proved or disproved the hypothesis, experimenters should perform multiple trials, researched the detergents and their ingredients more thoroughly, had a larger supply and variety of detergents, added a larger amount of blood to each cloth, and added less thermal and mechanical energy to the cloth.

Experimental Procedure

Materials: Five beakers, Purex Dirt-Lift Action liquid detergent, Gain powder detergent, Woolite liquid detergent, 20 Mule Team Borax powder detergent, five stirring rods, large white cloth t- shirt, synthesized blood with eyedropper, paper towels, hairdryer

Procedure

1) Fill five beakers with 200mL of hot water to provide thermal energy.

2) In Beaker #1, add 10mL of liquid detergent Purex Dirt-Lift Action liquid detergent. In Beaker #2, add 10mL of Gain powder detergent. In Beaker #3, add 10mL of of Woolite liquid detergent. In Beaker #4, add 10mL of 20 Mule Team Borax powder detergent.

3) Stir each beaker vigorously for three minutes.

4) Cut ten 2.54x2.54 cm of cloth from a white t-shirt. Add two drops of blood to each cloth.

5) Put two cloths in each beaker. Stir each beaker for ten minutes to provide mechanical energy.

7) Remove cloths from beaker and carefully organize each on a paper towel under the correct detergent label. Dry each cloth for one minute using a hairdryer on low power.

Detergent Type, Rank of Effectiveness, and Stain Description

Rank of Effectiveness	Detergent Type	Stain Description
1	Purex Dirt-Lift Action	White
2	Control (water)	White (hint of pink)
3	Woolite	Light pink
4	20 Mule Team Borax	Light pink
5	Gain	Medium pink

Works Cited

"Enzymes for Detergent." *Maps Enzymes*. N.p., 2010. Web. 02 Oct. 2014.

"Gain Laundry Detergent Powder." *CPID*. DeLima Associates, 3 Sept. 2008. Web. 02 Oct. 2014.

Hatch, Jonathan. "Get Rid of Blood Stains." *GETRIDOFTHINGS.com*. St. Paul Media, 21 Aug. 2007. Web. 02 Oct. 2014.

"Hydrolysis." *Merriam-Webster*. Merriam-Webster, n.d. Web. 03 Oct. 2014.

"Laundry Detergent Ingredients." *WashWise*. Accord, n.d. Web. 2 Oct. 2014.

"Purex Liquid Laundry Detergent." *Purex*. Henkel Company, n.d. Web. 02 Oct. 2014.

"Soaps & Detergents: Chemistry of Surfactants." *Clean Living*. American Cleaning Institute, 2014. Web. 30 Sept. 2014.

"What Is Borax." *20 Mule Team Borax Detergent Booster MultiPurpose Household Cleaner*. N.p., n.d. Web. 02 Oct. 2014.

"Woolite Detergent." *CPID*. DeLima Associates, 3 Dec. 2009. Web. 02 Oct. 2014.

epic Educational Policy Improvement Center

Work Sample Evaluation

Subject Area: Biology
Task Title: Soapy Enzymes
Student Work Sample Title: Effect of Enzymes on Stains

The document was scored using the *CCR Task Bank Rubric for Scientific Research Plans and Reports.* The final scores are indicated in the following chart.

Scoring Criteria	Insufficient Evidence	Developing	Progressing	Accomplished	Exceeds
Hypothesis Development					**X**
Research Plan					**X**
Results and Interpretation					**X**
Communication				**X**	
Organization				**X**	
Accuracy					**X**

Annotations: The following evidence from the work sample and the reviewer's comments support the scores above. Page and line numbers refer to the original work sample.

Scoring Criteria	Page #	Line #	Commentary about the work sample
Hypothesis Development: *Locating resources in order to develop a thesis or hypothesis*	1	10-20	It is obvious that much research went into this explanation of the concepts and why enzymes may be added to detergents.
	1-3		Multiple references are provided within the text and in the Works Cited page. The chemical bases behind laundry detergents, additives, and cellular components are presented.
	3,45		The student revisits and links the information given in the introduction with the observed results.
Research Plan: *Planning, conducting, and describing an experiment or study*			The student provides an excellent design and well-explained experiment especially in regards to demonstrating the ideas/concepts they aimed at presenting.
	5		Though the student discusses some troubleshooting concepts, it does not detract from the information presented.
Results and Interpretation: *Describing and interpreting results in relation to the hypothesis*			The student provides a chart explaining the results. While conventional scientific writing was used and I could follow the logic, in places it was difficult to read because no sections were provided. The paper needed proper sections.
	3 & 4	18 +	The writer provides a cohesive and very specific discussion of the results and explains the findings quite well. The student makes excellent attempts to scientifically reason the "HOW" and "WHY" the experiment turned out as it did.
	4	4-22	The writer makes a good to attempt to reason the flaws in the experiment and/or the expected results.
Communication: *Using subject appropriate language and considering audience*	All		The student uses excellent scientific writing and explanations of concepts. The discussion links back to introduction and discusses how results demonstrate the expectations. The writer does not spend the whole discussion discussing what could have gone wrong.
	All		The student uses excellent scientific terminology and does very well at linking the concepts.
Organization: *Structuring main ideas and incorporating supporting information*			The student consistently supported the expectations and results of the experiment in their work sample.
			The paper needed separate sections in order to make the evaluation of the writing and to discern the understanding of the concepts shown.
Accuracy: *Attending to detail, grammar, spelling, conventions, citations, and formatting*			The student uses some excellent scientific concepts in the presentation of their graphs
			It would be useful to include section headings in order to separate the ideas presented in the paper.