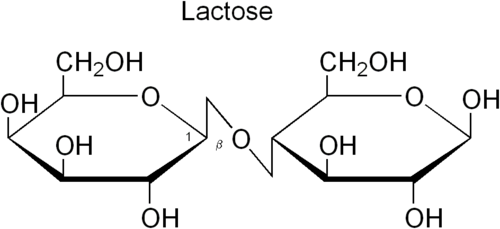
Unit Plan: Lactose Intolerance and Why it Matters: A Socio-biology unit about enzymes and lactose intolerance Kathy Walsh, April 30, 2015.



Introduction: The Bias in traditional Biology Education

Based on previous observations in high schools in Philadelphia and the area nearby, students are told they need to learn about enzymes because Enzymes are important in Biology and they are on the test. The traditional Unit consists of learning about the characteristics and functions of enzymes through a lecture and power point presentation, with a lab to demonstrate how factors like acid or temperature affect enzyme action. Sometimes real world connections are mentioned with cheese making and enzymatic cleaning products. I believe that the emphasis in biology education should be shifted to the health and welfare of people. That is what builds relevance in Biology. The entire experience of learning about this topic was decontextualized and disconnected from people who are intricately tied to this issue, or society. This makes science not relevant to students. Furthermore anytime scientific experimentation and research is mentioned, it is never a person of color. The lack of people in color being shown in science media for students further closes this subject area.

Want to learn how to make biology more meaningful for students!

This unit on lactose intolerance attempts to break through barriers students may have to science due to a lack of relevance and role models. The unit strategically incorporates a social context into the lessons as a method of attracting and maintaining interest of students in high school biology. The Unit contains resources and tools to allow students to reflect on the social context and issues of social justice that intersect with Biology and their lives. Students will be encouraged to critically examine how these issues impact their own lives, and through youth participatory action research (YPAR) seek to use both scientific and sociological research to solve a real-world problem affecting them. As students conduct science experiments they will have scientist mentors who have also struggled with injustice and are uniquely able to offer mentorship. Our students are ready to look at the prejudice and inequities of our society straight on. Equipped with a knowledge of biology and how to investigate and research, we can help them make a better and healthier world.

Questions at the intersection of social justice and Biology that this unit will address:

* How can we develop awareness of injustices promoted or perpetuated by science and society related to a socio-biological issue?
* How can we involve the stakeholders in a biological issue in the design and implementation of solutions?
* How can we use science as a tool to improve health and justice in our communities?

Why Start with Social Justice

Even though it is important for students to learn and understand about enzymes in their biology curriculum it is important to catch their interest and that they understand why the science is important to learn. Rather than front loading the unit with a great deal of scientific information about enzymes, you want to start with the social context to generate student interest and get the YPAR started. This will set up a student-driven “need-to-know” motivation for learning the science. The more the students tell you what they need to find out, the better.

After seeing that through science your students can make positive changes in their lives it will set the stage for engagement in learning of biology for the rest of the year. That is why doing this unit near the beginning of the year is worth the time investment. For the rest of the year, your students will be tuned into the idea of looking at science with a critical social lens. They will want to learn biology because it will help them in their lives.

Two Options for Overall Unit Sequence:

SixWeek Option that includes a YPAR project.

Week 1: Introduction to the Social Context around Lactose Intolerance. Bias analysis of a text book paragraph, Activity to learn about how lactase persistence evolved in particular populations. Start the YPAR project.

Week 2: Scientific Investigations about Lactase; Setting up what other research is needed. Connect with Scientific Mentors.

Week 3: Conduct Research and Collect Data. Learn about Enzymes through experimental inquiry, readings, videos and other resources provided. Connect with mentors.

Week 4: Analyze the data and decide how to present it and to whom. Begin to create the report and presentation of the findings and recommendations. Seek out feedback from the mentors.

Week 5: Complete the first draft of the report and the presentation and Practice it in front of peers and teachers. Conduct self-assessment, peer assessment and get feedback from the mentors. Brush up on scientific background knowledge that may be asked by the audience.

Week 6: Revise the report and/or presentation based on feedback. Give the presentation to stakeholders from the community, including mentors. Publish it online. Seek out further audiences for future presentations in wider communities.

Alternative 3 Week Sequence: (Eliminates the YPAR project)

Week 1: Introduction to the Social Context around Lactose. Conduct Bias Analysis. Learn about how lactase persistence evolved in particular populations

Week 2: Learn about Enzymes through scientific inquiry, readings, videos and other resources. Connect with mentors.

Week3. Brush up and show mastery of scientific concepts. Rewrite the original Text book paragraph on Lactose intolerance in the bias analysis lesson.

More Detailed summaries of lessons.

1. KWL about Lactose Intolerance; Discussion of lactose intolerance vs. Lactose tolerance in different populations and ethnic groups; Examination of data about who is lactose intolerant and who is not in the world; Identify lactase Persistence as a mutation that affects a small portion of the world population; Ask if milk is a necessary food in the diet and whether it is in all diets around the world? Discuss the reason dairy products are so prevalent in this country; Discuss the milk industry and its power; Tie this discussion back to the statistics on lactose intolerance and identify a pattern of dominant groups who are lactase persistent setting up a society that pushes milk on everyone; Ask what they think about this.

Essential Questions:

* What do you notice from the data tables about who is lactose intolerant and who is not?
* Why do you think so many people are lactose intolerant in minority groups?
* Do you think lactose intolerance is a medical disorder or is it normal in human beings?
* What do you think is the dairy industry’s position on this topic?
* If most students at this school were lactose intolerant, would that be an issue? If so in what way?

1. Complete the Lesson: Evolution of Lactase Persistence (lactose Tolerance) in Some Groups of People

Essential Questions:

* What environmental factor caused some groups of people to evolve to be lactase persistent?
* How do groups of people who are 100% lactose intolerant survive and thrive?
* What do you think would happen if all European Americans suddenly became lactose intolerant and everyone else developed lactase persistence? Would that change anything?

1. Bias Analysis: Got Milk? Have students break into groups to read the paragraph, “Got Milk?” and critically analyze it for bias. Have each group present its findings. As a group, generate a list of issues and problems that this bias in our society may have caused to negatively affect their lives.

Essential Questions:

* Which allele (version of the lactase enzyme gene) is considered the norm in our society?
* What is the reality in this country with respect to this allele?
* How is this text book passage biased?

1. Conduct Scientific Experiments on Lactase, under the mentorship of scientists
2. The YPAR Project: Decide as a class which issue or problem to work on collectively to solve through YPAR. (One issue that may come up is the fact that the free lunch program only serves milk as a beverage.) As an example we will go through the YPAR using this issue as an example. Put up the steps in conducting a YPAR project that also include scientific research about enzymes and lactase, in particular. Divide the students into teams to carry out the research in different areas of the issue and then writing the research report. Students share their work in a google document to collaborate.

Examples of possible research group topics but the topics will be originated by the students: Survey of students, community and family members about lactose intolerance in their lives. Research into different ethnic group’s diets and nutrients provided. Research about the dairy industry in this country, Research about the school lunch program policies and decision makers, research about the science of lactase and lactose.

1. Reading: Enzymes as Catalysts.
2. Brush up on knowledge by doing the Interactive Practice and the Quiz.
3. Practice the Presentation. Revise the report and presentation based on feedback.
4. Present.
5. Publish.

Standards Correlations:

Next Generation Science Standards (NGSS)

NGSS LS1.3  Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

NGSS. LS3.1  Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

NGSS.LS1.1  Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

NGSS. LS1.2  Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

NGSS. LS3.1  Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

NGSS. LS3.2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

NGSS. SCI.1.1. Ask a scientific question.

NGSS.SCI. 1.2. Formulate a hypothesis.

NGSS. SCI. 1.3. Define and analyze variables.

NGSS. SCI. 1.4. Plan an investigation.

NGSS. SCI.1.5. Organize and strengthen plan.

NGSS. SCI. 1.6. Conduct and investigation.

NGSS. SCI. 2.1. Analyze and interpret data.

NGSS. SCI. 2.2 Explain and represent relationships between variables.

NGSS. SCI. 2.3. Explain limitations and sources of error.

NGSS. SCI 2.4. Construct evidence-based explanations.

NGSS. SCI.2.5. Receive and Respond to critique

NGSS. SCI.2.6. Follow writing conventions.

NGSS. SCI.6.1. Identify and analyze patterns.

NGSS. SCI.6.2. Evaluate cause and effect.

NGSS. SCI.6.6. Apply knowledge of structure and function.

PA Core Science Standards: (PCSS)

**3.1.10.B1**.**5:**  Explain how mutations can alter genetic information and the possible consequences on cells.

**3.1.10.C2.2:** Explain that mutations can alter a gene and are the original source of new variations in a population.

**3.1.10.A1:** Explain the characteristics of life common to all **organisms.**

**3.1.10.A2:** Explain cell processes in terms of chemical reactions and energy changes.

**3.1.10.A3:** Compare and contrast the **life cycles** of different **organisms.**

**3.1.10.A5:** Relate life processes to sub-cellular and cellular structures to their functions.

**3.1.10.A7:** Describe the relationship between the structure of **organic molecules** and the function they serve in living **organisms.**

**3.1.12.A5:**  Analyze how structure is related to function at all levels of biological organization from **molecules** to **organisms.**

**3.1.12.A7:** Evaluate metabolic activities using experimental knowledge of **enzymes.**

**3.1.12.A9:**Communicate and defend a scientific argument.

Common Core State Standards: (CCSS)

CCSS.Reading Informational texts. ELA.2.8. Evaluate arguments and claims.

CCSS Reading Informational texts. ELA. 2.6. Assess the point of view.

CCSS.Reading Informational texts. ELA. 2.9. Acquire and use academic vocabulary.

CCSS.Writing Informational texts. ELA. 4.1. Introduce the topic

CCSS.Writing Informational texts. ELA.4.2. Develop the subtopics with facts.

CCSS.Writing Informational texts. ELA. Maintain a formal style and objective tone.

CCSS.Writing Informational texts. ELA.4.6. Provide a compelling conclusion.

CCSS.Writing Informational texts. ELA. 4.8. Use technology to share work.

CCSS. Writing Arguments. ELA.3.2. Develop the claim and counterclaims.

CCSS. Writing Arguments. ELA. 3.6. Strengthen writing through revision.

CCSS Conducting Research. ELA.8.1 Construct a primary research question.

CCSS Conducting Research. ELA.8.2. Construct a secondary research question.

CCSS Conducting Research. ELA.8.3. Identify and select diverse, trustworthy sources.

CCSS Conducting Research. ELA. 8.4. Use systems to organize information gathered.

CCSS Conducting Research. ELA. 8.5. Use the research process to build vocabulary

CCSS Conducting Research. ELA. 8.6. Evaluate findings and draw conclusions.

CCSS Giving Presentations. ELA. 7.1. Introduce the presentation.

CCSS Giving Presentations. ELA. 7.2. Present findings and supporting evidence.

CCSS Giving Presentations. ELA. 7.6. Give an effective conclusion.

CCSS. Writing Arguments. ELA. 3.1. Introduce my claim.

Instructional Materials.

1. KWL Unit Starter:

Ask what students know about lactose intolerance and wonder about. Questions and wonderings about the natural world may arise like the following:

1. Why are so many people in my family and my community lactose intolerant?
2. What causes lactose intolerance?
3. Why do some people lactose intolerant?
4. Is lactose intolerance a health problem?

Record the students’ questions and keep them available in the classroom either on a large piece of paper or a place that won’t get erased to be able to refer back to them and add to them throughout the unit.

(Key Vocabulary: Lactose, Lactose intolerance)

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| Facts about Lactose Intolerance   * 75% of all African-American, Jewish, Mexican-American, and Native American adults are lactose intolerant. * 90% of Asian-American adults are lactose intolerant. * Lactose intolerance is least common among people with a northern European heritage-about 12%   <http://www.hopkinsmedicine.org/healthlibrary/conditions/digestive_disorders/lactose_intolerance_85,P00388/>  Overall, about 75 percent of the world's population, including 25 percent of those in the U.S., lose their lactase enzymes after weaning.7 The recognition of this fact has resulted in an important change in terminology: Those who could not digest milk were once called "lactose intolerant" or "lactase deficient." They are now regarded as normal, while those adults who retain the enzymes allowing them to digest milk are called "lactase persistent." <http://www.pcrm.org/health/diets/vegdiets/what-is-lactose-intolerance>  Distribution of Lactose Intolerance in different Human Groups |
| | Human group | Individuals examined | Intolerance (%) | | --- | --- | --- | | [Dutch](http://en.wikipedia.org/wiki/Dutch_people) | N/A | 1 | | [Danes](http://en.wikipedia.org/wiki/Danish_people) | N/A | 4 | | [Europeans in Australia](http://en.wikipedia.org/wiki/Anglo-Celtic_Australian) | 160 | 4 | | [Swedes](http://en.wikipedia.org/wiki/Swedish_people) | N/A | 5-7 | | [Basques](http://en.wikipedia.org/wiki/Basque_people) | 85 | 8.3 | | [British](http://en.wikipedia.org/wiki/Demographics_of_the_United_Kingdom) | N/A | 5–15 | | [Germans](http://en.wikipedia.org/wiki/German_people) | 1805 | 6-23 | | [Swiss](http://en.wikipedia.org/wiki/Swiss) | N/A | 10 | | [European Americans](http://en.wikipedia.org/wiki/European_Americans) | 245 | 12 | | [Tuareg](http://en.wikipedia.org/wiki/Tuareg_people) | N/A | 13 | | [Finns](http://en.wikipedia.org/wiki/Finnish_people) | N/A | 14-23 | | [Belorusians](http://en.wikipedia.org/wiki/Belorusians) | N/A | 15 | | [Russians](http://en.wikipedia.org/wiki/Russians) | N/A | 16 | | [Ukrainians](http://en.wikipedia.org/wiki/Ukrainians) | N/A | 13 | | [Austrians](http://en.wikipedia.org/wiki/Austrians) | N/A | 15–20 | | [Spaniards (non-Basque)](http://en.wikipedia.org/wiki/Spanish_people) | N/A | 15 | | [Northern French](http://en.wikipedia.org/wiki/French_people) | N/A | 17 | | Central [Italians](http://en.wikipedia.org/wiki/Italian_people) | 65 | 19 | | [Mexicans](http://en.wikipedia.org/wiki/Mexican_people) (nationwide) | N/A | 16 - 33 | | [Indians](http://en.wikipedia.org/wiki/Demographics_of_India) | N/A | 20 | | African [Tutsi](http://en.wikipedia.org/wiki/Tutsi) | N/A | 20 | | African [Fulani](http://en.wikipedia.org/wiki/Fulani) | N/A | 23 | | [Bedouins](http://en.wikipedia.org/wiki/Bedouin) | N/A | 25 | | [Portuguese](http://en.wikipedia.org/wiki/Portuguese_people) adults | 102 | 35 | | Southern [Italians](http://en.wikipedia.org/wiki/Italian_people) | 51 | 41 | | [African American](http://en.wikipedia.org/wiki/African_American) Children | N/A | 45 | | [Saami](http://en.wikipedia.org/wiki/Sami_people) (in Russia and Finland) | N/A | 25–60 | | Northern [Italians](http://en.wikipedia.org/wiki/Italian_people) | 89 | 52 | | North American [Hispanics](http://en.wikipedia.org/wiki/Hispanic) | N/A | 53 | | [Balkans](http://en.wikipedia.org/wiki/Balkans) | N/A | 55 | | [Mexican American](http://en.wikipedia.org/wiki/Mexican_American) Males | N/A | 55 | | [Cretans](http://en.wikipedia.org/wiki/Cretans) | N/A | 56 | | African [Maasai](http://en.wikipedia.org/wiki/Maasai_people) | 21 | 62 | | [Southern French](http://en.wikipedia.org/wiki/French_people) | N/A | 65 | | [Greek Cypriots](http://en.wikipedia.org/wiki/Greek_Cypriots) | N/A | 66 | | [Jews, Mizrahi (Iraq, Iran, etc.)](http://en.wikipedia.org/wiki/Mizrahi_Jews) | N/A | 85 | | [Jews, Ashkenazi](http://en.wikipedia.org/wiki/Ashkenazi_Jews) | N/A | 68.8 | | [Jews, Sephardic](http://en.wikipedia.org/wiki/Sephardi_Jews) | N/A | 62 | | [Jews, Yemenite](http://en.wikipedia.org/wiki/Yemenite_Jews) | N/A | 44 | | [Sicilians](http://en.wikipedia.org/wiki/Sicily#People) | 100 | 71 | | [Mestizos of Peru](http://en.wikipedia.org/w/index.php?title=Mestizos_of_Peru&action=edit&redlink=1) | N/A | >90 | | Rural [Mexicans](http://en.wikipedia.org/wiki/Mexicans) | N/A | 73.8 | | [African Americans](http://en.wikipedia.org/wiki/African_American) | 20 | 75 | | [Lebanese](http://en.wikipedia.org/wiki/Demographics_of_Lebanon) | 75 | 78 | | [Alaskan Inuit](http://en.wikipedia.org/wiki/Alaska_Natives) | N/A | 80 | | [Australian Aborigines](http://en.wikipedia.org/wiki/Australian_Aborigine) | 44 | 85 | | African [Bantu](http://en.wikipedia.org/wiki/Bantu_peoples) | 59 | 89 | | [Asian Americans](http://en.wikipedia.org/wiki/Asian_American) | N/A | 90 | | Northeastern [Han Chinese](http://en.wikipedia.org/wiki/Han_Chinese) | 248 | 92.3 | | [Chinese](http://en.wikipedia.org/wiki/Chinese_people) | 71 | 95 | | [Southeast Asians](http://en.wikipedia.org/wiki/Southeast_Asian) | N/A | 98 | | [Thais](http://en.wikipedia.org/wiki/Thai_people) | 134 | 98 | | [Native Americans](http://en.wikipedia.org/wiki/Native_Americans_in_the_United_States) | 24 | 100 |   <http://en.wikipedia.org/wiki/Lactase_persistence> |

2. Evolution of Lactase Persistence (lactose Tolerance) in Some Groups

Lactose intolerance is probably familiar to most of you. Normally, organisms lose the ability to digest milk as they grow to adulthood. This lack of tolerance has little effect on most organisms as there really is no milk source for them as adults. However, the case with *Homo sapiens* is a little different. A ways back in our history, some humans took to raising livestock to supplement their diet and with this change in behavior a new resource became available, along with a benefit for anyone who could exploit it. As you may have surmised, this new resource was milk and all the products which can be made from milk.

Learn how changes in DNA affect lactose tolerance.

* Watch this video: **New Lactose Tolerance Mutation Found** from AMNH <http://www.youtube.com/watch?v=y-WDBbldlwI>
* Use the list of resources below to research and answer the following questions:

Use the resources below to answer the following questions:

1. Does having lactose intolerance mean that you cannot tolerate any lactose at all? How did this situation help lactose tolerant genes increase in the human population? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. What kind of mutation in chromosome 2 was found to convey lactase persistence into adulthood? Are you surprised that such a mutation could cause such a big change? Why or why not? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. Is the new East African mutation the same as previous mutations found in Middle Eastern and European populations? Why is it believed these types of mutations were selected for in human populations? What evidence is there to support this hypothesis? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Resources:

* <http://www.youtube.com/watch?v=y-WDBbldlwI>
* <http://digestive.niddk.nih.gov/ddiseases/pubs/lactoseintolerance/>
* <http://www.elmhurst.edu/~chm/vchembook/546lactose.html>
* <http://www.scientificamerican.com/podcast/episode.cfm?id=africans-did-dairy-seven-millennia-12-06-20>
* <http://www.nutritionecology.org/panel5/intro.html>
* <http://www.stolaf.edu/depts/environmental-studies/courses/es-399%20home/es-399-05/Projects/dairy%20research/socialhistory.html>

(Key Vocabulary: Lactase, enzyme, adaptation, lactase persistence, mutation, chromosome, genes, alleles)

(Standards: NGSS LS1.3, NGSS. LS3.1, NGSS.LS1.1, PCSS 3.10.B1.5, PCSS.3.1.10.C2.2, PCSS. 3.10.A3)



3. Got Milk? Bias Analysis

Directions: Read through the paragraph with your group. Analyze it for bias and present which parts you think might be biased and the reasons.

Look for the following kinds of bias:

a. Invisibility: Are particular ethnic groups not included in the narrative?

b. Stereotyping: Assigning characteristics to all members of a group.

c. Imbalance and Selectivity: Presenting only one interpretation of a situation and omitting other perspectives.

d. Unreality: Glossing over unpleasant facts and events and painting a rosy picture of a situation.

e. Fragmentation and Isolation: When a particular group of people is presented in an isolated way, only interacting with persons like themselves, on the side, rather than a main part of society.

f. Linguistic Bias: Language that that denies the existence of different groups, or portrays particular groups negatively.

g. Cosmetic Bias: Attractive illustrations or photos that presents a favorable false impression.

**Got milk?**

Milk is one of the basic foods needed for good nutrition, especially for growing children. It contains vitamins and [minerals](http://www.ck12.org/earth-science/Minerals) necessary for healthy development. Unfortunately, milk and other dairy products also contains lactose, a carbohydrate that can make some people very ill. Lactose intolerance is a condition in which the lactose in milk cannot be digested well in the [small intestine](http://www.ck12.org/biology/Small-Intestine). The undigested lactose then moves into the [large intestine](http://www.ck12.org/biology/Large-Intestine) where bacteria attack it, forming large amounts of gas. Symptoms of lactose intolerance include bloating, cramps, nausea, and vomiting. Often, the individual will outgrow this problem. Avoidance of foods containing lactose is recommended for people who show signs of lactose intolerance. Since dairy products can provide many vital nutrients, tablets can be taken that provide the needed digestive materials in the small intestine. Lactose-free milk is also readily available.

(Key vocabulary: lactose intolerance, small intestine, large intestine, types of bias, invisibility, fragmentation, stereotyping, imbalance, selectivity, cosmetic bias, unreality, linguistic bias)

(Standards: CCSS. ELA.2.6, 2.8,2.9)

1. YPAR Research Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Research Team \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| Project Description (briefly answer each question) | |
| What is the purpose of this project? |  |
| Why is this project important? |  |
| What sub-topic is your research team studying? |  |
| What do I know about this sub/topic? |  |
| What do I want to know? |  |
| What are some questions you can ask that will guide you your research? Evaluate each question by the following Criteria. |  |
| For each research question, check if it meets the following criteria: | \_\_\_ You can answer it locally by collecting data in your immediate communities.  \_\_\_ You can answer it in a couple of weeks: Will you be able to collect data within the week and a half that we have and complete the research by \_\_\_\_\_\_\_.  \_\_\_ It matters to you and to your community: Does this question impact you a as a human being and others around you? Will the research findings benefit you and others? |
| Decide on your central research question. |  |
| What data collection tools will you use? |  |

5. Research Methods/Tools:

Interviews, Focus Groups, and Surveys

Researchers collect data using a variety of methods. Some of the most common methods, or tools, are: interviews, focus groups, and surveys.

For Exhibition, you will be using one of these methods (or maybe two if you’re an Open Honors student or feeling especially ambitious). Each of these methods has its advantages and its disadvantages.

Most importantly, your research question should determine the method(s) that you use. You’ll see what we mean in a minute.

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| Interviews |

* Can be done face-to-face or over Skype/Facetime or the phone
* Need to record what the interviewee says. Ways to do this:
  + a recording device (e.g., Voice Memos app on an iPhone; Garage Band on a Mac; a handheld audio recorder)
  + take really good typed or hand-written notes; might want to do this with a partner who takes notes while you ask questions
* You will need to transcribe (write down) a few key quotes but definitely not the whole thing
* Probably no more than 3-5 questions
* Questions should be open-ended, not yes or no questions; you want to ask questions where the interviewee will open up and talk

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| * + Good interview questions:     - “Tell me about a time when you felt a teacher was being unfair about the discipline policies at your school.”     - “What do you like about your history classes? What do you dislike? What do you feel is missing?”     - “In what ways are restorative justice practices at BAA working? In what ways are they not working?”   + Not-so-good questions:     - “What is your major at BAA?”     - “Do you like math class?”     - “Is your principal male or female?” |

* Might answer an overarching research question where you only want responses from a few people, but you want them to go into great detail about their experiences
* Example of Exhibition research questions that might use interviews:
  + “What do a sample of different students who participated in restorative justice circles think of the process?”
  + “What are the experiences of two students at BAA compared to two students at Boston Prep in terms of discipline policies?”
* Pros?:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Cons?:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| Focus Groups |

* Similar to interviews, but they’re conducted with groups (usually 3-5 peoples) instead of individuals; unlike interviews, it should be more of a discussion among the participants where they build on each other’s thoughts
* Most likely will need to be done face-to-face; could be done a lunch table or an afterschool group, for example
* Like interviews, you’ll need to record what people say somehow
* Probably no more than 3-5 questions; questions should be open-ended, similar to interviews

|  |
| --- |
| * + Examples of good focus group questions:     - “What do you all think about extended day at BAA? Can one of you start us off? The rest of you can feel free to jump in and add to what’s been said, ok?”     - “You all are in the same AP math course. What are your thoughts about who is accepted into and successful in AP math courses at Boston Latin School and why?”     - “Do you all think that any changes should be made around standardized testing (MCAS, SATs, AP exams, etc.)? If so, what needs to be changed? Who would like to start us off?” |

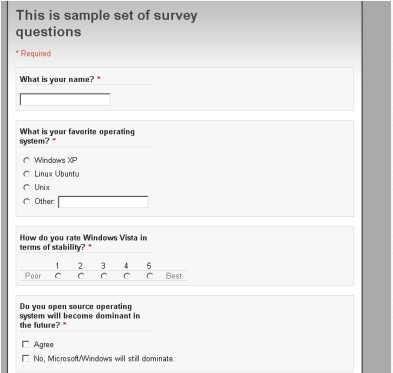
* Might answer an Exhibition research question where you want more than 1-2 people responding, but you still want them to go into some depth about their experiences, especially if they’re shared experiences (e.g., they’re all in the same class or school)
* Example of Exhibition research questions that might use interviews:
  + “What do students at BAA think of late policies and what would they do to change them?”
  + “What are the experiences of students who don’t speak English as a first language in English Language Arts and Humanities classes?”
* Pros?:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Cons?:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |
| --- |
| Surveys |

* Can use an online tool like Google forms or Survey Monkey; a website comparing the two: <http://wic.library.upenn.edu/multimedia/tutorials/surveys.pdf>
* Can be typed up on a Word doc or handwritten, but this is kind of a pain because you have to calculate the data by hand
* Probably no more than 5-10 questions

Most common types of questions:

* + Open-ended (see first question below)
  + Multiple choice (question 2)
  + Likert scale (question 3)
  + Agree/disagree or yes/no (question 4)



* Might answer a research question where you want a lot of responses.
* Examples:
  + “What do students in BPS study in their history classes?”
  + “What do BAA dance majors plan to do after high school?”
* Pros?:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Cons?:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Key vocabulary: action research tools, focus groups, surveys, interviews)

(Standards: CCSS.ELA.8.1, 8.2, 8.3. 8.4)

6. Sources:

Source #1,

Title \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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List 3 things you learned from this source, include at least 1 statistic or research study finding:

* 1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
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Make a connection between the source of information and your topic \_

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* 1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
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(Standards: CCSS.ELA.2.8, 2.6, 2.9, 8.5, 8.6, )

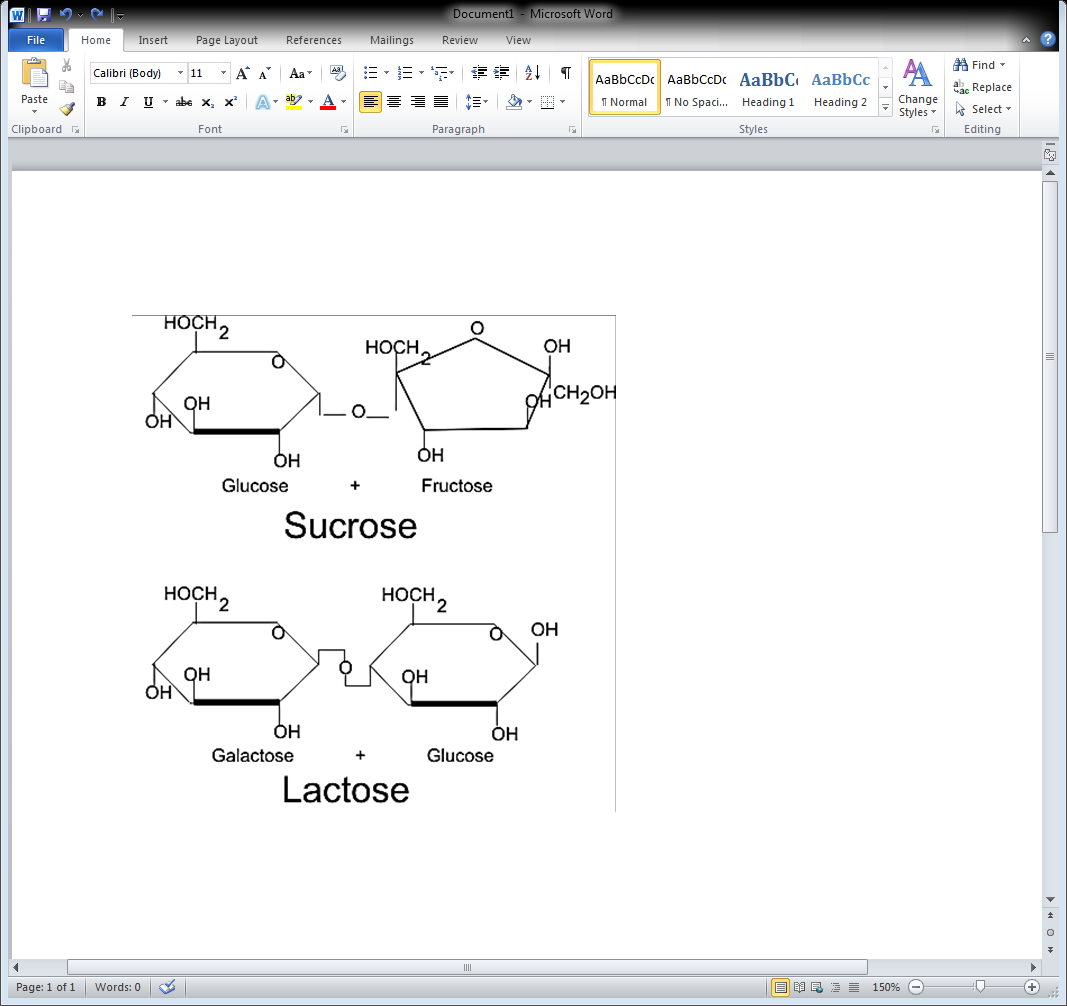
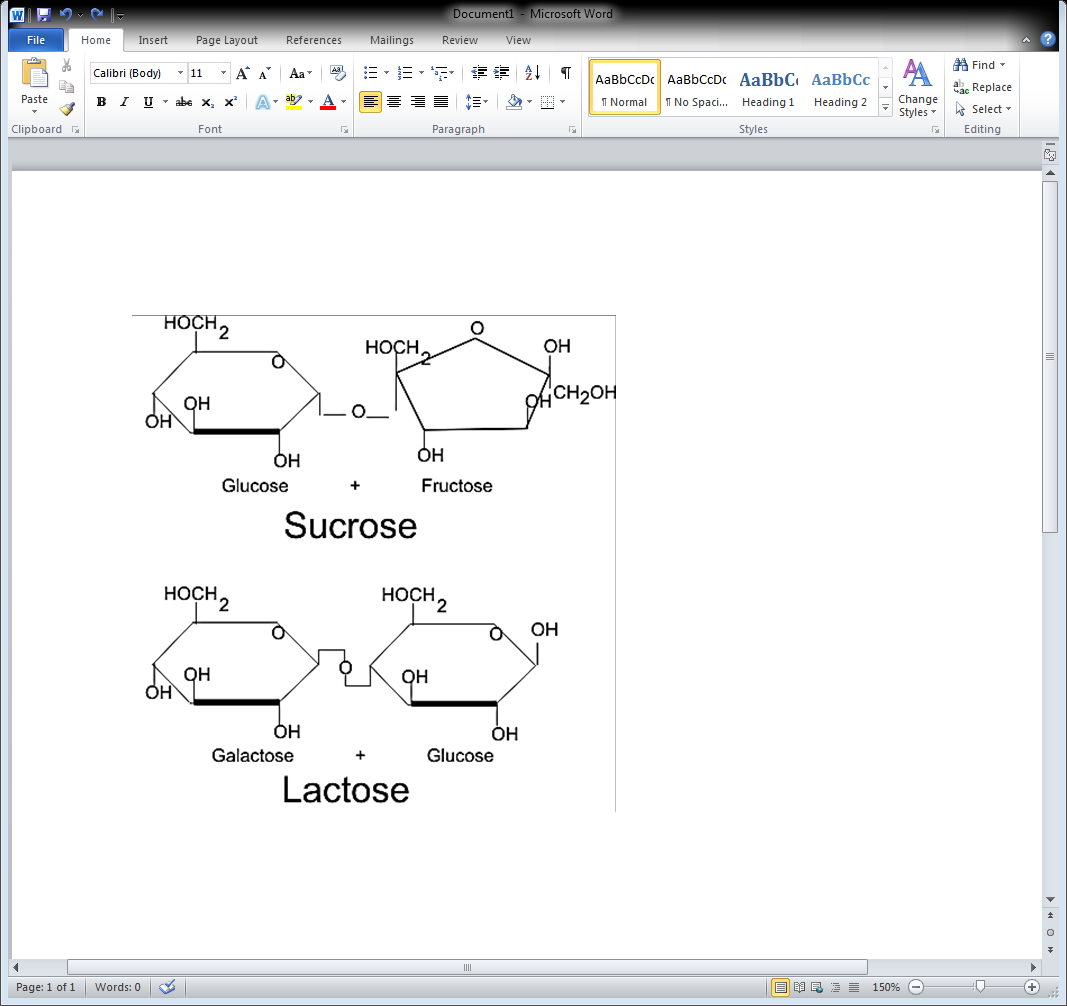
* 1. Lactose Experiments Handout Enzymes Help Us Digest Food[[1]](#footnote-1)

Introduction to Sugars and Enzymes: Background Information

The food we eat contains many different types of molecules, including two types of sugars: monosaccharides and disaccharides. For example, fruits contain the monosaccharides, glucose and fructose, and the disaccharide, sucrose.

★ In the diagrams below: - circle the name of each monosaccharide

- use arrows to indicate the names of the disaccharides.

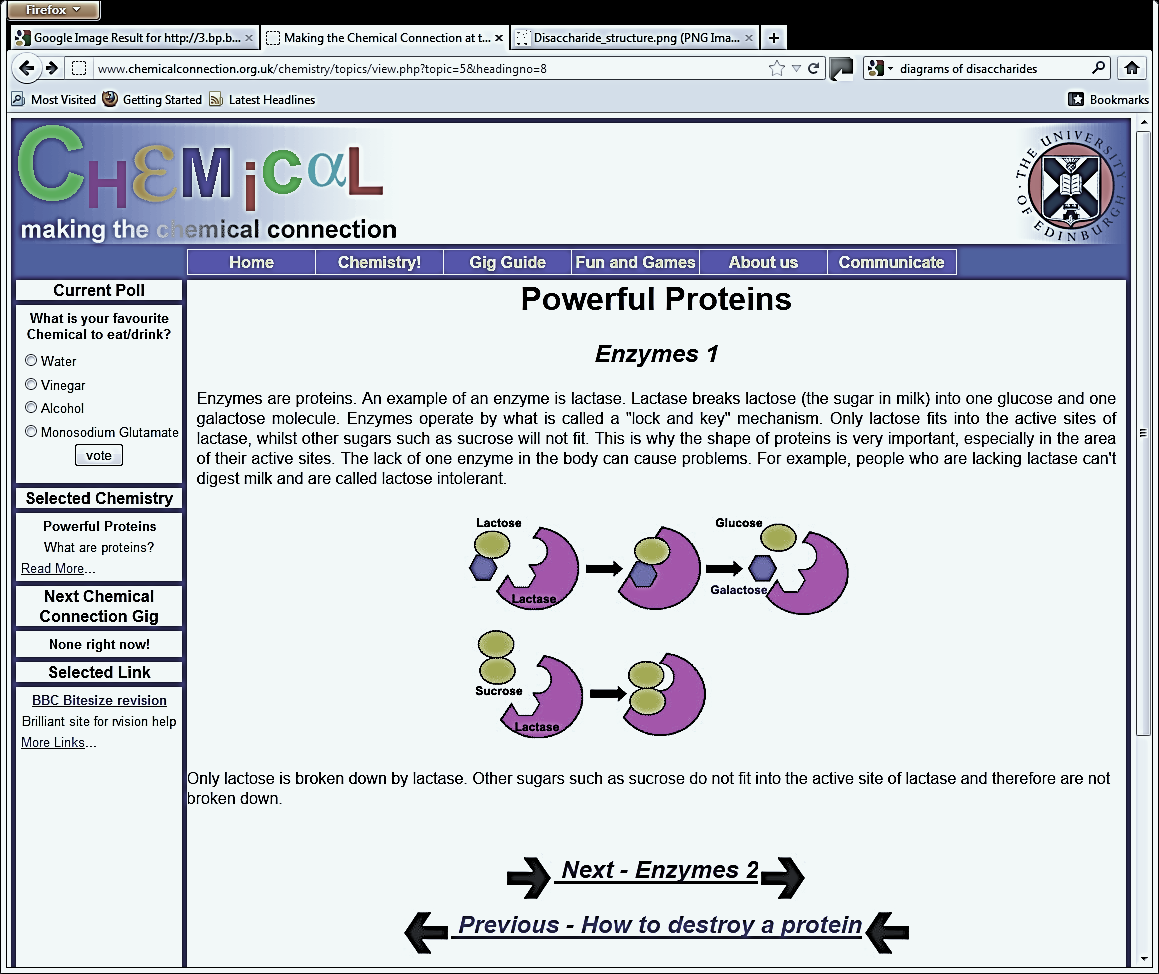
 

★ What is the difference between a monosaccharide and a disaccharide?

Monosaccharides from the food you eat are absorbed from your gut into your blood and carried to all the cells in your body where they are used for energy. Each disaccharide molecule must be broken down or digested into its monosaccharide components before it can be absorbed into the blood.

★ When a sucrose molecule is digested, which monosaccharides are produced?

The digestion of the disaccharide lactose to the monosaccharides glucose and galactose occurs very very slowly unless there is an enzyme to speed up the process. The enzyme that speeds up the digestion of lactose is called lactase.



Lactase and most other enzymes are proteins. Each enzyme has an active site where a substrate molecule binds. For example, the substrate lactose binds to the active site of the enzyme lactase. Notice that the name of the enzyme lactase was created by adding the suffix *–ase* to part of the name of the substrate lactose.

★ Circle the active site in the enzyme in the figure above.An enzyme speeds up a chemical reaction which converts a substrate or substrates to a product or products. The products are released from the enzyme and the enzyme returns to its original state, so the enzyme is ready to act on another substrate molecule. Thus, an enzyme molecule can be reused over and over. For example, a single molecule of the enzyme lactase can speed up the digestion of many many molecules of lactose.

★ The following equation shows the digestion of lactose.

Lactase

Lactose --------- > Glucose + Galactose

Use E to indicate the enzyme, S to indicate the substrate, and P to indicate the products. Circle the molecule that is a protein, and use arrows to indicate the molecules that are sugars.

Experiment 1 - Can the sugar lactose be digested without any enzyme?

To find out whether the enzyme lactase is needed to digest the sugar lactose, you will test whether lactose breaks down to glucose and galactose in two different conditions: (1) with no enzyme and

(2) when the enzyme lactase is present.

★ First, predict what you think will happen. For each column, circle the equation that describes what you think will happen.

|  |  |  |
| --- | --- | --- |
| Prediction with No Enzyme |  | Prediction with the Enzyme Lactase |
| No Enzyme  Lactose -------- > Glucose + Galactose  Or  No Enzyme  Lactose -------- > Lactose  (no glucose produced) | Lactase  Lactose -------- > Glucose + Galactose  Or  Lactase  Lactose -------- > Lactose  (no glucose produced) |

To test whether your predictions are correct, you will use glucose test strips to test whether glucose has been produced.

Procedure

1. One member of your group should prepare Tube 1 with 10 mL of lactose solution.

2. Another member of your group should prepare Tube 2 with 10 mL of lactose solution and 1 mL of lactase solution. Put on a glove, put your thumb on the top of the tube and turn the tube upside down several times to mix the two solutions.

3. Wait 3 minutes to allow time for lactose to break down to glucose and galactose.

4. While you are waiting, both of the experimenters should get a test strip. Notice that the original color of the test strip is aqua. In the next step, if the test strip turns green, olive or brown, this will indicate that glucose is present.

5. After the 3 minute wait, each experimenter should dip a glucose test strip into the solution in his or her tube until the pad is submerged, and then remove the test strip immediately and run the edge of the strip against the rim of the tube to wipe off excess liquid.

Results

★ Wait 1 minute and then record your results in the table below.

|  |  |  |
| --- | --- | --- |
|  | Tube 1 - 10 mL of lactose solution | Tube 2 - 10 mL of lactose solution  + 1 mL of lactase solution |
| Test strip color |  |  |
| Was there any  change in the color  of the test strip? |  |  |
| Conclusion | \_\_\_ no glucose produced  \_\_\_ some glucose produced | \_\_\_ no glucose produced  \_\_\_ some glucose produced |

Interpretation

★ Was the sugar lactose digested without any enzyme?

★ Was the sugar lactose digested when the enzyme lactase was present?

★ Do your results match your predictions? \_\_\_ yes \_\_\_ no

If yes, what conclusion do your results support?

If no, what do you think is the reason for the difference between your predictions and results?

★ In Tube 2, there were over 5000 lactose molecules for each molecule of lactase. How can a single lactase molecule break down many many lactose molecules?

(Standards: PCSS: 3.1.10.A5, 3.1.10.A7, 3.1.12.A5, 3.1.12.A7, NGSS: 2.2, 2.3, 2.4, 2.5, 2.6, 6.1, 6.2, 6.6 )

Experiment 2 - Can the same enzyme digest lactose and sucrose?

To answer this question, you will use your results from Experiment 1 and you will design a second experiment to test whether the enzyme lactase can digest the disaccharide sucrose. For this second experiment you will have available the same supplies as you used in Experiment 1 and also a sucrose solution. Write down your procedures and create a data table. Ask your teacher to check these, and then carry out your experiment and record your results.

Interpretation

★ Did lactase break down sucrose? How do you know?

★ Does the same enzyme digest lactose and sucrose? \_\_\_ yes \_\_\_ no

Your results illustrate a general principle called enzyme specificity. Enzymes act only on specific substrates. In many cases an enzyme can only react with a single kind of substrate. For example, lactase can digest lactose, but not other types of disaccharide sugars.

★ Which part of an enzyme is responsible for this enzyme specificity? (Hint: See the bottom of page 1.)

Because of enzyme specificity, our bodies need lots of different enzymes to digest different types of food molecules. For example, our small intestine has the enzyme lactase to digest lactose and a different enzyme to digest sucrose.

★ What do you think is the name of the enzyme that digests sucrose? (Hint: See the bottom of page 1.)

★ Complete the following equation to show the digestion of sucrose. Include the enzyme and the products.

Sucrose ----------

Experiment 3 - Do we need the enzyme lactase to digest milk?

Some people have trouble digesting milk because their bodies do not make the enzyme needed to digest the sugar in milk. Design an experiment to test whether lactase is needed to digest the sugar in milk. You will have available for this experiment the same supplies as you used in Experiment 1 and milk. Write down your procedures and create a data table. Ask your teacher to check these, and then carry out your experiment and record your results.

Interpretation

★ Is lactase needed to digest the sugar in milk? How do you know?

★ Which sugar does milk contain: glucose, lactose or sucrose? How do you know?

★ Suppose that the cells in a person's body do not make lactase. What do you think would happen to the lactose molecules in the milk that person drinks?

Human babies and the babies of all other mammals depend on milk for their nutrition. All babies produce the enzyme lactase to digest lactose, which is the main sugar in milk.

In contrast, many adults produce very little lactase, so they can only digest very small amounts of lactose. When a person who produces very little lactase consumes large amounts of lactose in a short time period, most of the lactose is not digested in the small intestine and lactose reaches the large intestine where it is digested by bacteria. This can result in symptoms such as diarrhea, flatulence, and discomfort. This condition is called lactose intolerance.

★ Name some foods that might result in discomfort for a person who is lactose intolerant.

People who are lactose intolerant can buy lactose-free milk to gain the benefits of the protein, calcium and vitamin D that milk provides.

★ How do you think lactose-free milk is made?

★ Do you think lactose-free milk contains glucose? \_\_\_ yes \_\_\_ no

If yes, where did the glucose come from?

★ Milk contains many other types of molecules in addition to lactose. The table below shows two types of molecules and an ion that are contained in milk. Enzymes are needed to digest large molecules (e.g. disaccharides) into smaller molecules (e.g. monosaccharides) that can be absorbed into the blood. Small molecules and ions can move into the blood without being digested by enzymes. Complete the second column of the table.

|  |  |
| --- | --- |
| Molecule or ion | Are enzymes needed to digest this type of molecule or ion?  If digestive enzymes are needed, what type of smaller molecule is produced? |
| Calcium (Ca++) |  |
| Proteins |  |
| Water (H2O) |  |

(Standards: NGSS.SCI: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1)

Teacher Preparation Notes for Enzymes Help Us Digest Food

by Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, 2012[[2]](#footnote-2)

Experiments using the enzyme lactase and discussion questions help students to learn about enzyme function, enzyme specificity and the molecular basis of lactose intolerance. Students also learn about scientific method by interpreting evidence to test hypotheses and designing the second and third experiments to answer specific scientific questions about lactase.

It should be possible to complete each of the labs in a single 50-minute laboratory period, especially if you discuss the Introduction to Sugars and Enzymes on pages 1-2 of the Student Handout in the class period before the laboratory period and discuss all but the first two questions on page 6 in the class period after the laboratory period.

Key Points for Students to Learn

Enzymes

* An enzyme is a molecule (usually a protein) that speeds up a specific chemical reaction. Without the enzyme, the reaction typically occurs extremely slowly or not at all.
* Digestive enzymes break down (digest) larger molecules in our food to smaller molecules that can be absorbed into our blood. For example, lactase breaks down the disaccharide lactose into the monosaccharides glucose and galactose.
* An enzyme molecule returns to its original state after acting on the substrate, so each enzyme molecule can be reused over and over again. For example, a single molecule of lactase can break down many many molecules of lactose.
* An enzyme acts only on a specific substrate because only that substrate fits into the enzyme’s active site. For example, lactase digests lactose but not sucrose. Because of enzyme specificity, many different enzymes are needed to digest food (e.g. lactase and sucrase).
* A person who produces very little lactase can only digest very small amounts of lactose at a time, resulting in lactose intolerance. This example illustrates that proteins are not just abstract concepts in biology textbooks, but real parts of our body that have observable effects on our characteristics and health.

Scientific Method

* Designing experiments, including the importance of controls
* Comparing results with predictions
* Interpreting data to draw conclusions

Equipment and supplies:

* Lactose solution: 5 g lactose in 200 mL water (20 mL for each group of 3-4 students)\*
* Sucrose solution 5 g sucrose in 200 mL water (10 mL per group)\*
* Milk (20 mL per group)\*
* Lactase solution: 1 g lactase in 50 mL water (3 mL per group) (Store the lactase in the refrigerator until you make the solution on the day of the activity. When you make the solution you will need to smoosh the lumps and stir a lot.)\*
* Beakers+
* 25 mL graduated cylinders to measure lactose solution, sucrose solution, and milk +
* 1 mL transfer pipet for lactase solution+
* 15 milliliter test tubes\* (2 per group if students will be able to rinse these between uses; otherwise 5 per group) and test tube rack or something else to keep the test tubes upright (1 per group)
* Visually readable glucose test strips (5 per group)
* Gloves (3 per group)
* Permanent markers and tape or labels for labeling test tubes (1 set per group)

\* In order to conserve materials and thus reduce the cost of purchasing lactase, you can use smaller test tubes and correspondingly smaller amounts of each solution. If you do this, you will need to modify the instructions in the Student Handout.

+ If you keep the solutions at your desk, you will need four beakers (for each solution and the milk) and a minimum of three graduated cylinders and one transfer pipette for measuring each of these.

Ordering Information

Possible sources:

* Lactase and lactose from Fisher (Sucrose is table sugar and easily available.)
* Glucose test strips ($4.95/100 strips) from

<http://app.testyourselfathome.com/cf.inventory.php?action=showinvdetail&invid=874&heading=Glucose%20Early%20Diabetes%20Screening&pagetitle=Glucose%20Early%20Diabetes%20Screening>

Teaching Suggestions and Background Information

(Page numbers refer to the primary version of the Student Handout, but the correspondence to the alternative version of the Student Handout should be obvious.)

Page 1 of the Student Handout

If your students are not entirely comfortable with molecular diagrams, you will probably want to make sure they understand the implied carbon and hydrogen atoms, as well as the explicitly shown parts of the molecular structure.

Sucrose is commonly called table sugar and is found in sugar cane, sugar beets, and fruits.

Page 2 of the Student Handout

The prediction question is important, in part to ensure that students understand why testing for glucose is a reasonable method for evaluating whether lactose can be digested without any enzyme.

Glucose test strips are used by people with diabetes to test for glucose in their urine; when glucose is present in the urine this indicates that blood glucose levels are too high, which can be harmful to their health. Note that the glucose test strip does not react with glucose when the glucose is part of the disaccharide lactose or sucrose. The glucose test strip only reacts with the monosaccharide glucose.

Page 3 of the Student Handout

To calculate the number of lactose molecules per lactase molecule for the question near the middle of page 3 of the Student Handout, we used the amount of lactose and lactase solutions added to the tube, the concentrations of lactose and lactase in the solutions, and the molecular weight of lactose (342) and lactase (approximately 150,000-300,000).

You may want to ask your students to suggest improvements in experimental design. For example, in Experiment 1 it might be useful to add 1 mL of water to Tube 1 for greater comparability to Tube 2 or it might be useful to test for glucose production after a longer wait period than the designated 3 minutes in order to see whether, given enough time, lactose might break down without the enzyme lactase.

Students can use the procedures provided for Experiment 1 to help them design the procedures for Experiment 2. The alternative version of the Student Handout (available in the Comments section of the website for this activity) provides specific suggested procedures. You may want to add a class discussion of experimental design and procedures either before the students carry out Experiment 2 or as part of the discussion of the questions on the top of page 4.

Page 4 of the Student Handout

To help students think about what control condition will be needed for Experiment 3, you may want to ask them to think about what result they would expect from their proposed experiment if the sugar in milk is lactose, if it is sucrose, or if it is glucose; you may even want to use the table shown on the top of page 5 of the alternative version of the Student Handout (available in the Comments section of the website for this activity).

Page 5 of the Student Handout

Background Information on Lactose Intolerance

The alleles for the gene for lactase differ in the nucleotide sequence in the regulatory DNA; this difference influences the rate of transcription of the coding DNA and thus influences the rate of production of the protein, lactase.

* Lactase persistence alleles result in substantial production of lactase throughout life.
* The lactase nonpersistence allele results in substantial production of lactase by infants, but very low levels of lactase in adults, resulting in lactose intolerance.

|  |
| --- |
| For virtually all infants and for adults with lactase persistence:  -- in the small intestine:  lactase  lactose -------- > glucose + galactose |
| For about two-thirds of adults worldwide:  -- in the small intestine:  low levels of lactase (lactase nonpersistence) -- > most lactose not digested  -- so, in the colon of the large intestine, lactose is fermented by anaerobic bacteria:  fermentation  lactose ---------------- > short-chain fatty acids + gases (e.g. CO2)  \/ \/ \/  the mixture of water, partially digested \/  food, etc. in the colon is hypertonic flatulence and  – > osmotic influx of water – > diarrhea discomfort  \/ \/  lactose intolerance |

Dairy products are an important source of calcium, as well as protein and some vitamins. People with lactose intolerance can continue to consume dairy products but minimize symptoms by:

* using lactase supplements
* consuming dairy products with reduced lactose due to treatment with lactase (e.g. lactose-free milk) or fermentation by bacteria (e.g. traditionally made cheese or yogurt)
* consuming small amounts of dairy products at multiple times during the day
* adaptation of bacteria in the colon by gradually increasing regular lactose consumption of modest amounts of dairy products

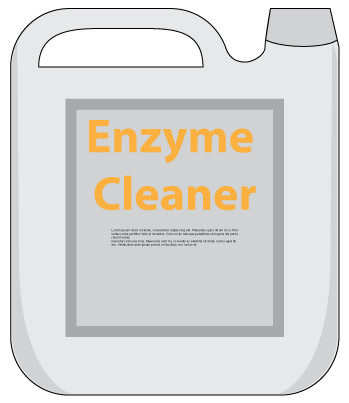
Example of natural selection in humans:

* lactase nonpersistence alleles nearly universal in mammals and early humans
* when some groups of humans began raising dairy animals,

natural selection -- > lactase persistence alleles became more common

* different lactase persistence alleles in European and African herding groups illustrate similar characteristics evolving independently in different populations = convergent evolution

Lactose intolerance is different from a milk allergy which happens when the body's immune system reacts to proteins in milk. (A good summary of milk allergy is available at <http://kidshealth.org/PageManager.jsp?article_set=30372&lic=175&cat_id=20132> .)

* 1. Reading: Enzymes as Catalysts
* Enzymes are catalysts of living things. They speed up biochemical reactions.
* Under the conditions of inside living cells, biochemical reactions would occur too slowly to support life without the help of enzymes.
* Enzymes increase the rate of biochemical reactions by reducing the amount of activation energy needed for reactants (called the substrate) to start reacting.
* More than 1000 different enzymes are necessary for human life, and many help digest food. Two examples of enzymes are amylase and lactase.

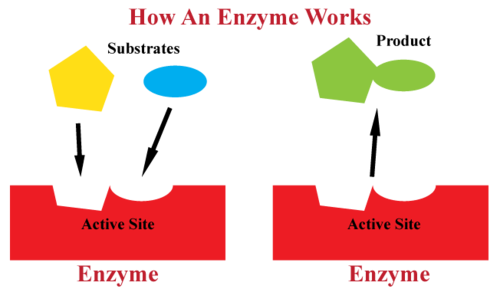
An enzyme cleaner like the one pictured here contains [proteins](http://www.ck12.org/biology/Proteins?referrer=crossref) called enzymes. The enzymes attach themselves to particular stains and help break them down. Different enzymes work on different types of stains, such as grease stains or bloodstains. Removing stains isn’t the only use of enzymes. Enzymes are also essential to life.

### Why Living Things Need Enzymes

Chemical reactions constantly occur inside the [cells](http://www.ck12.org/biology/Cells?referrer=crossref) of living things. However, under the conditions inside cells, most [biochemical reactions](http://www.ck12.org/biology/Biochemical-Reactions?referrer=crossref) would occur too slowly to maintain life. That’s where enzymes come in. **Enzymes** are [catalysts](http://www.ck12.org/physical-science/Catalysts-in-Physical-Science?referrer=crossref) in living things. Like other catalysts, they [speed](http://www.ck12.org/physical-science/Speed-in-Physical-Science?referrer=crossref)up chemical reactions. Enzymes are [proteins](http://www.ck12.org/biology/Proteins?referrer=crossref) that are synthesized in the [cells](http://www.ck12.org/biology/Cells?referrer=crossref) that need them, based on instructions encoded in the cells’ [DNA](http://www.ck12.org/biology/DNA?referrer=crossref).

### How Enzymes Work

Enzymes increase the rate of chemical reactions by reducing the amount of [activation energy](http://www.ck12.org/physical-science/Activation-Energy-in-Physical-Science?referrer=crossref) needed for reactants to start reacting. One way this can happen is modeled in the **Figure** [below](http://www.ck12.org/physical-science/Biochemical-Compound-Classification-in-Physical-Science/lesson/Enzymes-as-Catalysts/#x-ck12-TVNfUFMtRW56eW1lcw..). Enzymes aren’t changed or used up in the reactions they catalyze, so they can be used to [speed](http://www.ck12.org/physical-science/Speed-in-Physical-Science?referrer=crossref)up the same reaction over and over again. Each enzyme is highly specific for the particular reaction is catalyzes, so enzymes are very effective. A reaction that would take many years to occur without its enzyme might occur in a split second wth the enzyme. Enzymes are also very efficient, so waste products rarely form.



**Q:** This model of enzyme action is called the lock-and-key model. Explain why.

**A:** The substrates (reactants) fit precisely into the active site of the enzyme like a key into a lock. Being brought together in the enzyme in this way helps the reactants react more easily. After the product is formed, it is released by the enzyme. The enzyme is now ready to pick up more reactants and catalyze another reaction. You can see an animated version of this model at the following URL.

<http://www.youtube.com/watch?v=V4OPO6JQLOE>

As we have learned more about enzymes we have adjusted our models. The newer model of enzyme action is called the induced fit model.

Explore More: Watch the video and answer the questions. How Enzymes Work as Catalysts <https://www.youtube.com/watch?v=870MWm0peRI>

1. What kind of energy is needed for a chemical reaction to start? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. How do enzymes cause a chemical reaction to start? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. What is the part of the enzyme that must fit with the substrate during a reaction? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. A pair of scissors is a good analogy for an enzyme. Identify the active site of the scissors enzyme, its substrate, and the chemical reaction it catalyzes. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. How does the induced fit theory differ from the lock-and-key model of enzyme action?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Review:

1. What are enzymes? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Why are enzymes needed to catalyze chemical reactions in living things?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. How do enzymes speed up biochemical reactions? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Identify examples of two digestive enzymes? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   1. YPAR: Writing an Original Research Paper



You have spent the last two weeks developing a research question, and conducting research related to that question. We are now in phase two of the YPAR process in which you, as young researchers, will take time to articulate the knowledge you have gathered and gained to understand and examine the problem that inspired your research. You will be using your voice as a writer to explain to a broader audience about your research question and what you have discovered through conducting original research. Your paper will be divided into the following five sections:

Introduction (Due \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

* What's the problem you're trying to address?
* Why did you choose this problem? Do you have personal connections?
* How will it help your community to solve this problem?
* What's your research question that you're trying to answer?

Literature Review/Background information (Due\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

* Where's your evidence that this is a problem? What have others written/researched about your issue/problem? (newspaper articles, statistics, scholars’ opinions, research studies)

Methodology (Due \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

* How/when/where did you collect data?
* What was the experience like?  Any difficulties/obstacles you had to overcome?

Data and Analysis (\_Due\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

* Present the raw data (percentages, bar graph, key quotes, common themes in the interviews)
* Analysis -- does your data answer your research question?  If so, what is it telling you?
  + You should do this by pulling out the themes and patterns you observe in your research question.

Recommendations

* What can be changed and why?  Who can do it?  When could it be done by?
* Why is it important to you and the community that this takes place?  How might this improve the educational experiences for young people and the community as a whole?

First draft due \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_at the beginning of class

Before Writing

Step 1: State the problem and research question

The problem(s) I see in BAA/BPS is: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Therefore, my research question is: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 2: Figure out how you feel about your research question and the related problem you chose.



Complete this sentence about the topic: I feel \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ when I think about this topic.

This will influence to your tone in writing.

Step 3: What larger human value(s) or universal human experience(s) or need(s) does this topic connect to?

List it/them:

This will influence to your purpose in writing.

Step 4: What exactly do you want to communicate about the topic and to whom do want to communicate it?

Complete these prompts:

- The ultimate message/perspective I want to communicate about this topic is that…

- The audience I want to communicate this message/perspective to is…\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

- After reading my research paper, I want my audience to … think/feel/do….\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\*\*Before typing, sign into your google drive, title a new document “Original Research Paper” and share the document with [kwalsh645@gmail.com](mailto:kwalsh645@gmail.com)\*\*

10. Writing your introduction

Introduction: *This is where you introduce your audience to the problem. The introduction is an important place for you to use your VOICE as a writer. You should draw the reader in by identifying the problem, showing its importance, and identifying the research question that you hope will help solve the problem. Your introduction should address the following questions:*

* What's the problem you're trying to address?
* Why did you choose this problem? Do you have personal connections?
* How will it help your community to solve this problem?
* What's your research question that you're trying to answer?

What to focus on as you write…

1. Think about a personal story, statistic, or observation you’ve made that will draw your audience in and introduce the problem that your research seeks to address.
2. Use descriptive language that demonstrates the tone you wish to communicate to the reader. Don’t be afraid to use imagery, metaphors and other figurative language.

NOTE: Thesaurus.com is a great website for helping you make more effective word choice.

1. Use strong transition words to make your writing flow. Your introduction should not sound like a list of responses to the question above.

Sample introduction

Across the United States millions of school children and teenagers consume school lunch. Often times the “food” provided for this essential meal is far from fresh. Children stand in long lines to receive processed meat, pizza, or tatter tots that are low on vitamins and high on fat and calories. In fact, many school lunchrooms do not have actual cooking utensils because the “food” arrives in a box and is simply heated in a microwave. Despite these unpleasant facts, according to the Huffington Post, “last year 21 million students relied on school lunch as their primary meal of the day” (Dosomething.org 1). This means millions of do not receive nutritious sustenance. Is this how schools should nourish the young people they are supposed to serve?

As a public school educator, I have seen what comes out of the cafeteria and have been increasingly concerned about the health of my students. I believe everyone deserves access to healthy food: fresh fruits and vegetables, whole grains, and meat that is free of chemicals. To me, access to healthy food is a human right and one that schools, public institutions build to serve all young people, should guarantee to students. After all, food does not just feed our physical bodies, it feeds our creativity, our curiosity, and our ability to stay focused and engaged. At a school like Boston Arts Academy that is about artistic, academic and personal development, adequate nourishment is essential. Yet only those students whose family can afford to pack a healthy lunch, get the necessary nourishment they need in a day. Based on my observations of this disturbing reality, I was interested in learning what students felt about the quality of food they receive in school. Thus my research questions are: What do students think of the school lunches at BAA? How, if at all, can they be improved?” My hope is that through my research I will gain important knowledge about students’ perspective on what they eat in school, as well as their suggestions for how to make lunchtime a truly positive experience.

1. First, make a general statement about how your topic relates to society:

|  |
| --- |
|  |

1. What is the problem of you and your topic?

|  |
| --- |
|  |

1. Why is this a problem that relates to broader society?

|  |
| --- |
|  |

1. Write a few scientific facts that supports your position on this issue?

|  |
| --- |
|  |

1. What is your personal connection to this topic

|  |
| --- |
|  |

11. Enzymes as Catalysts Interactive Practice

Instructions: Go to the following website and complete the interactive web practice.

<http://www.ck12.org/physical-science/Biochemical-Compound-Classification-in-Physical-Science/asmtpractice/Enzymes-as-Catalysts-in-Physical-Science-Practice/>

12. Enzymes as Catalysts Quiz to Prepare for the Presentation

1. What is a catalyst?

2. Catalysts in living things are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

3. True or false: Enzymes work by providing activation energy.

4. True or false: Enzymes are used up in the reactions they catalyze.

5. Explain the lock-and-key model of enzyme action.

6. The human enzyme that helps digest starch is

a) pepsase. c)amylase.

b) starchase d) glucase

7. Which of the following statements about enzymes if false?

a) Enzymes are highly specialized for the reactions they catalyze.

b) Enzymes are very effective at speeding up reactions.

c) Enzymes are very efficient at catalyzing reactions.

d) Enzymes usually result in the formation of waste products.

8. The human enzyme that helps digest proteins in the stomach is named \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

9. True or false: About 100 different enzymes are needed for human life.

10. Enzymes are

a) proteins. c) made in the cells where they are needed.

b) encoded in DNA. d) all of the choices.

.

Enzymes as Catalysts Quiz Answer Key

1. What is a catalyst?

A catalyst is a substance that speeds up a chemical reaction.

2. Catalysts in living things are called enzymes

3. True or false: Enzymes work by providing activation energy. false

4. True or false: Enzymes are used up in the reactions they catalyze. false

5. Explain the lock-and-key model of enzyme action.

Reactants fit precisely into the active site of the enzyme like a key into a lock. Being brought together in the enzyme in this way helps the reactants react more easily. After the product is formed, it is released by the enzyme.

6. A human enzyme that helps digest starch is c

a) pepsase.

b) starchase.

c) amylase.

d) glucase.

7. Which of the following statements about enzymes if false? d

a) Enzymes are highly specialized for the reactions they catalyze.

b) Enzymes are very effective at speeding up reactions.

c) Enzymes are very efficient at catalyzing reactions.

d) Enzymes usually result in the formation of waste products.

8. The human enzyme that helps digest proteins in the stomach is named pepsin

9. True or false: About 100 different enzymes are needed for human life. false

10. Enzymes are: d

a) proteins.

b) encoded in DNA.

c) made in the cells where they are needed.

d) all of the above

Assessment based on standards:

Students will be assessed by using competencies (skill sets) tied to the Standards. Students will compile their work into a digital portfolio. They will receive timely feedback comments via google documents as they submit work and can always revise their work along the way. This unit was designed to be team-taught with both science and other content areas. All teachers would be involved in helping students to revise and strengthen their work. Here is an example rubric for the student presentation. Students would use the rubric to evaluate themselves, and their peers for both formative and summative assessments.

Presentation Assessment:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Area | Not yet | Developing | Proficient | Exemplary |
| How well did I introduce my presentation? ELA.7.1 | Hooks the audience by using a short story, question, an interesting fact or example that helps the audience to see how the presentation is important. | Hooks the audience by using a short story, question, an interesting fact or example that shows how my presentation is important or interesting | Hooks the audience by using a short story, question, an interesting fact or example that is relevant to the central message(s) of my presentation and connects to the audience. | Hooks the audience by using a an interesting story, provocative question or reference that helps engage my audience intellectually and leaves them eager to listen |
| How Well did I present my findings and supporting evidence? ELA.7.2 | Uses descriptors, facts, and details to highlight main ideas r themes.  Uses transition words to introduce key ideas. | Uses relevant descriptions, facts and details and makes clear connections between central messages and supporting details. | Selects relevant descriptions, and important details to make strong support for my claim and cite relevant evidence and use valid reasoning as I present connections between central messages and supporting details. | Uses several kinds of supporting evidence (illustrations, statistics, quotations that strengthen my central message.  I can identify counter-claims. |
| How well did I conclude my presentation? ELA.7.6 | I provide a closing statement in which I restate my main ideas | I provide a closing statement in which I restate my main ideas and leave the audience with something to think about. | In my conclusion I rephrase my central message or claim and explain the connection between the main ideas and a larger theme or an essential questions. | In my conclusion I provide a synthesis of my central message and supporting ideas/ evidence and connect to other themes and leave the audience with suggested next steps. |

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1. Partially adapted from “Lactase Investigation” in the School District of Philadelphia Biology Core Curriculum, by Drs. Ingrid Waldron and Jennifer Doherty, Department of Biology, University of Pennsylvania, © 2012. Teachers are encouraged to copy this Student Handout for classroom use. An alternative version, Word files (which can be used to make changes if desired), Teacher Preparation Notes, comments, and links to our other hands-on activities are available at <http://serendip.brynmawr.edu/sci_edu/waldron/> , with additional activities available at <http://serendip.brynmawr.edu/exchange/bioactivities> . [↑](#footnote-ref-1)
2. These Teacher Preparation Notes and the related Student Handouts are available at http://serendip.brynmawr.edu/sci\_edu/waldron/#enzymes. [↑](#footnote-ref-2)