Looking into Lactase

This unit will introduce students to lactose intolerance. Students will develop questions about a case of a girl with symptoms of stomach pains, gas, and diarrhea. Throughout the unit, students will analyze pieces of evidence to answer their questions and eventually come to understand the mechanism of lactose intolerance.

# STANDARDS ALIGNMENT

**NGSS CONNECTIONS**

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

**TEKS CONNECTIONS**

**B.6D:** recognize that gene expression is a regulated process

**B.6E:** identify and illustrate changes in DNA and evaluate the significance of these changes

# LEARNING OBJECTIVES

**Students will know:**

* Carbohydrates (monosaccharides and polysaccharides)
* Mutations in a gene can change gene function
* Mutations in regulatory regions can change gene expression
* Enzyme substrate relationship

**Students will understand:**

* Monosaccharides are building blocks of polysaccharides
* Enzymes can break down polymers into monomers
* Enzymes are specific to a substrate
* Gene expression is regulated

**Students will be able to:**

* Analyze data to determine if Maria had an allergic reaction
* Analyze data to determine milk types based on glucose data and response to specific enzymes
* Analyze RT-PCR data to determine the expression of *LCT* in Maria
* Collect data about lactase’s activity in different environments to determine where in the body lactase is usually expressed.

# UNIT PLAN

## Phenomena

Students should be introduced to the story of Maria, a girl who recently started having symptoms of diarrhea, gas, and stomach pains. They will also be given the food she consumed that day in addition to her family’s medical history. After reading Maria’s story, students are encouraged to ask questions about what is causing Maria’s symptoms.

* [What’s Going On?](https://drive.google.com/file/d/1agRfx0XKuDLf6-Wpwe0gCM4ANnaCc_xU/view?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Phenomena can be provided in the form of print outs for groups of students or read out loud to the class as a whole.    Students can analyze the provided information on their own, discuss questions in small groups, and share out their questions with the class as a whole. | Phenomena can be shown as a screen share in a presentation or on their own. They can also be provided to students before the session.    If possible, breakout rooms can be used to allow for student discussion of questions that they think of.    Students could also submit questions via a chat window or interactive platform like Pear Deck. | Phenomena can be provided on the school LMS in the form of an assignment or Google Doc.    Students can discuss questions they have via a forum in the LMS or group Google documents. |

Common questions might include:

* Did she eat anything else that could have caused this?
* Could she be allergic to something in the milk or the other foods?
* Was the milk expired?
* What kind of milk was it?
* When does her mother get these symptoms?
* Did she get a disease from her mom’s side of the family?

Students will be guided through pieces of evidence to help them make sense of the questions they have asked.

## 

## Evidence

### *Could it be allergies?*

* Students will be given blood count data for Maria and two control groups. Students will be asked to determine the differences between the normal and allergic samples and draw conclusions about Maria’s situation
  + [Allergic Response Data](https://drive.google.com/file/d/1Xc3_1u-FmcgKLuPJvY2fzxITuVgtjCc7/view?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Students can work in pairs or small groups to view the data and form their conclusions. | If possible, breakout rooms and a Jamboard of the handout can be used to allow for student discussion as they view the data and form their conclusions. | Groups could be assigned to a Google Doc to work together to understand the provided data and form their final conclusions. |

### What type of milk was in the fridge?

* Students will analyze the differences between soy and cow milk and will use a computer model to compare the molecular structures of sucrose and lactose.
  + [Milk Comparison](https://drive.google.com/file/d/1z1BoQ2NGLIDgr4K5oVfTeentG2JJuvRl/view?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Worksheet can be provided to students.    The questions provided can also act as a discussion/debrief after students have completed the compare/contrast. | Students can be tasked with answering the 2 questions on the worksheet in breakout rooms and then sharing answers with the class. Students could collaborate in the form of a group Google Doc.    Students could also submit questions in via a chat window or interactive platform like Pear Deck. | Students can work alone on their worksheet or could work on a collaborative group Doc to highlight and note similarities and differences between the molecules. |

### How are these sugars digested?

* Students analyze data about glucose concentration of milk samples and enzyme use in order to determine which sample contained which milk type. Students learn about enzymes and their functions.
  + [Sugar Breakdown](https://drive.google.com/file/d/1z9vTg535h5q-NGUMdNyXC4kVVOmxQQRS/view?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Data can be provided to the students in the form of a worksheet.    Students can work in pairs or small groups and can review the answers with the class as a whole afterward. | Handout can be provided to the class as homework and class time can be used to review the worksheet and to discuss the final questions.    Students can take a poll on the last question using Mentimeter, Pear Deck, or a polling feature of the video conferencing platform. Poll data should be shown in real time to the students. | Handout can be provided to the class as homework and a forum on the LMS should be used to discuss the final question.    Students can take a poll on the last question using Poll Everywhere or Google Forms. Poll data should be shown in real time to the students. |

### Is lactose intolerance caused by a mutation in the LCT gene?

* Students learn about the lactase gene (*LCT)* and analyze RT-PCR data to see if Maria is expressing lactase.
  + [Lactose intolerance gene?](https://drive.google.com/file/d/1-xvftlqGX_tSa3ABg4PgCRld-vm697LU/view?usp=sharing)

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### How is gene expression regulated?

* Students learn that Maria has a mutation in a gene upstream of *LCT*. Students learn about gene expression in eukaryotes and how a mutation in a regulatory element can change a gene’s expression.
  + [Gene Regulation in Eukaryotes](https://drive.google.com/file/d/1vwBbOYPep1qQVJ1ajMb_tbRVkiQd39GB/view?usp=sharing)

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### Where in the body is Maria’s expression of LCT turned off?

* Students use a simulation to see what conditions (pH and temperature) allow for the highest enzymatic rate. Students will compare this information to data about temperature and pH throughout the human body to determine where lactase expression is usually turned on.
  + [Gene Regulation for Specialized Cells](https://drive.google.com/file/d/14qgIVL_Sl3EhhIQVt5IbUdLyrTttNA9R/view?usp=sharing)
  + [Temperature and pH Accepted Values](https://drive.google.com/file/d/1oIUyCaLCeALcb8t2hAhoCcrBSgDCsvCv/view?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Students should work in pairs to complete the simulation and graph their results.  After all groups have completed, the class can discuss the results and final thoughts. | In breakout rooms, students can work in small groups to complete the simulation and graph their results.  After all groups have completed, the class can discuss the results and final thoughts using polling software through the video conferencing platform or through a service like Poll Everywhere or Mentimeter. | Students should work in pairs to complete the simulation. One person focusing on the temperature and the other on the pH. They can work in a shared google doc to collaboratively collect data. |

## Conclusions

* Students construct a claim backed up by evidence and reasoning to answer the following question:
  + [Why did Maria get sick after having cow’s milk?](https://drive.google.com/file/d/1kNcyQKCivJRimxQ1uFrnLfvZTsY0eFtD/view?usp=sharing)

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| In classroom | Synchronous online | Asynchronous online |
| Students can work on this individually, then in pairs or small groups.    Groups should present their argument to the other groups and students should provide feedback on the presented argument. | Students can work on this individually, then in pairs or small groups via a shared Google Doc. This should be done before the synchronous session.    Groups should present their argument to the other groups and students should provide feedback on the presented argument.    As a class, ask students to answer the question again via a platform like a chat window or Pear Deck. | Students can work on this individually, then in pairs or small groups via a shared Google Doc.    Groups should create a document (Google Doc, Slides, or video) of their argument to be shared with other classmates. Classmates will review the argument and provide feedback.    As a class, ask students to answer the question again via Google Quiz or LMS forum. |

**Additional resources**

* [Enzyme Fact Sheet](https://drive.google.com/file/d/1nkKWYl9uZ3dxbzBbVresKORN7oNf4_ha/view?usp=sharing)
* [Evolution of Lactose Tolerance](https://drive.google.com/file/d/1CLsr-Gku_6Rv1qH_ZS4ck7yMWrROLk8W/view?usp=sharing)
* [Enzyme Quick Check](https://drive.google.com/file/d/1zUjbGLFexdUB72hjQNEFcAXXqoVdkG03/view?usp=sharing)
* Looking into Lactase Videos: [Part One](https://vimeo.com/413139495) and [Part Two](https://vimeo.com/413203082)
  + [Handout](https://drive.google.com/file/d/1Fncy3k_iXaHIBwuNGV_tuOX-djZYzdo5/view?usp=sharing)
* [Map of Lactase Persistence](https://drive.google.com/file/d/1xDfAk842EpmgBbfLmsBvdl9IyQDNmIsm/view?usp=sharing)
* [Lactase Persistence Data](https://drive.google.com/file/d/15Fi67QpolsZGakTmZRZ4k8jo80_z_8uA/view?usp=sharing)