NGSS Connections

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Lab/Activity: Looking into Lactase
Grade Level: High School

Performance Expectations: Students' ability to complete the following performance expectation(s) will be supported by participation in this activity.

HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
HS-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.
HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Dimension	NGSS Code or citation	Corresponding student task in activity
Disciplinary Core Idea	LS1.A Structure and Function • Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (through negative feedback) what is going on inside the living system.	Students explore how enzyme function is affected by changes in pH and temperature. Students explore how different areas of the GI tract and different foods consumed might alter the response of an enzyme taken orally.
	LS3.B Variation of Traits • In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a good source of genetic variation. Environmental factors can also cause mutations in genes, and variable mutations are inherited.	During the pre-laboratory activities, students explore global distribution of lactase persistence (and, inversely, lactase intolerance). They also discuss how lactase persistence is actually a genetic mutation and is inherited. Students discuss a segment of a video which explains one hypothesis of how and why the lactase persistence mutation persisted in certain populations.

	• Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors.	
Practices	Planning and Carrying Out Investigations • Plan an investigation individually and collaboratively and in the design, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. • Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meets the goals of the investigation.	Students identify the independent and dependent variables in both investigations of this lab. Students plan and conduct investigations to test how temperature and pH affect enzyme function. We offer the lab in two versions. In the Structured version, students are supported in developing their protocols through use of a 'steps' activity where all the steps of the investigation are written on separate pieces of paper and students must decide in what order to conduct the steps. In the Guided version, students are supported in developing their protocols with 'hints' that guide them as they write their own protocols, do a peer review of the protocols and revise them, then complete the investigation by following their self-written protocols
	Constructing Explanations • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the	Students construct a scientific explanation about the temperature and pH ranges where lactase is functional. They are asked to provide evidence, primarily from the data they collected in their investigations, and to describe the reasoning that supports their claims.

	natural world operate today as they did in the past and will continue to do so in the future.	
Crosscutting Concept	Cause and Effect • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller-scale mechanisms.	Students explore how changes in temperature and pH can affect an enzyme's ability to function.
	Scale, Proportion and Quantity • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.	Students use an indirect measure of enzyme function (glucose test strips) to explore how temperature and pH affect the lactase enzyme.
	Structure and Function • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.	Students explore how the shape of the intestinal villi support the function of enzyme production and nutrient absorption. In some classes, students explore how the physical structures of enzymes allow them to function and how changes to the protein shape can affect the ability of the protein to function.
	Stability and Change • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	Students learn that some environmental conditions can alter the shape and functionality of an enzyme. Sometimes the changes are temporary, other times the changes are permanent (denaturation).

Nature of Science

Scientific investigations use a variety of methods.

- Scientific investigations use diverse methods and do not always use the same set of procedures to obtain data.
- Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.

Connections to Common Core State Standards

English Language Arts/Literacy	Mathematics
RST.9-10.3	Practice.MP1
RST.9-10.9	Practice.MP3

RST.11-12.3 RST.11-12.7	