This scope and sequence document was developed to assist teachers with the implementation of the Louisiana Student Standards for Science. This tool is not full curriculum and will need to be further built out by science educators. It has been designed to help in the initial transition to the new standards.

This document is considered a "living" document, as we believe that teachers and other educators will find ways to improve it as they use it. Please send feedback to classroomsupporttoolbox@la.gov so that we may use your input when updating this tool.

About the Sample Scope and Sequence Tools

The Louisiana Student Standards for Science represent the knowledge and skills needed for students to successfully transition to postsecondary education and the workplace. The standards call for students to:

- Apply content knowledge
- Investigate, evaluate, and reason scientifically
- Connect ideas across disciplines

This scope and sequence document is designed to assist teachers, schools, and districts with the development of instructional resources that align with the Louisiana Student Standards for Science. This scope and sequence is only a sample; it does not illustrate the only appropriate sequence to teach the standards or the only possible ways to bundle the standards. The bundles can be reorganized around different phenomenon, including phenomenon specific to Louisiana or to a region in Louisiana.

Based on the instructional shifts, this tool uses phenomena to drive 3-dimensional science instruction. The incorporated phenomena are observable events that occur in the universe and can be explained by science. They establish the purpose for learning and help students to connect their learning to real-world events.

- The standards are bundled into units.
- The units are built around an anchor phenomenon.
- One unit has been built out further to contain a series of investigative phenomena, which have been sequentially organized to reinforce one another and build toward the performance expectations.

Throughout each unit, students should have multiple opportunities to apply the science and engineering practices, make sense of the crosscutting concepts, and develop a deep understanding of disciplinary core ideas.

Building out the Science Scope and Sequences for Classroom Instruction

How to Use the Anchor and Investigative Phenomena[1]

1. Explore the anchor phenomenon
2. Attempt to make sense of the phenomenon
3. Identify related phenomena
4. Develop questions and next steps
5. Explore investigative phenomena to help make sense of the anchor phenomenon
6. Communicate scientific reasoning around the anchor phenomenon

Instructional Process

Choosing an Anchor Phenomenon

Students should be able to make sense of anchoring phenomenon, but not immediately, and not without investigating it using sequences of the science and engineering practices. With instruction and guidance, students should be able to figure out, step-by-step, how and why the phenomenon works. [2]

A good anchor phenomenon[3]:

- ☐ is too complex for students to explain or design a solution for after a single lesson.
  - The explanation is just beyond the reach of what students can figure out without instruction.
  - Searching online will not yield a quick answer for students to copy.
- ☐ can be a case (pine beetle infestation, building a solution to a problem), something that is puzzling (why isn't rainwater salty?), or a wonderment (how did the solar system form?).
- ☐ has relevant data, images, and text to engage students in the range of ideas students need to understand. It should allow them to use a broad sequence of science and engineering practices to learn science through first-hand or second-hand investigations.
- ☐ will require students to develop an understanding of and apply multiple performance expectations while also engaging in related acts of mathematics, reading, writing, and

[1] adapted from How do we bring 3-dimensional learning into our classroom?

[2] Using Phenomena

[3] Qualities of a Good Anchor Phenomenon

communication.

- ☐ is observable to students. "Observable" can be with the aid of scientific procedures (e.g., in the lab) or technological devices to see things at very large and very small scales (telescopes, microscopes), video presentations, demonstrations, or surface patterns in data.

Choosing Investigative Phenomena

Students should be able to make sense of investigative phenomenon, but not immediately, and not without investigating it using sequences of the science and engineering practices. With instruction and guidance, students should be able to figure out, step-by-step, how and why the phenomenon works.[4]

A good investigative phenomenon:

- ☐ helps students make sense of one or two parts of the anchor phenomenon.
- ☐ has relevant data, images, and text to engage students in the range of ideas students need to understand.
- ☐ can be understood or explained by students using the science and engineering practices.

Investigating the Phenomena

When a phenomenon is introduced, whether anchor or investigative, students should have the opportunity to make observations, discuss current understandings, and pose questions about the phenomenon. Once questions are compiled, it may be helpful to categorize questions as follows:

- Questions that can be investigated by our class
- Questions that can be investigated but not with our current resources and equipment
- Questions that can be researched
- Questions that cannot be answered (due to current technologies or scientific limitations)

Other Useful Questions When Designing a Sequence of Learning[5]

- How do we kick off investigations in a unit?
- How do we work with students to motivate the next step in an investigation?
- How do we help students use practices to figure out the pieces of the science ideas?
- How do we push students to go deeper and revise the science ideas we have built together so far?
- How do we help students put together pieces of the disciplinary core ideas and crosscutting concepts?

[4] Using Phenomena

[5] Questions to Guide the Development of a Classroom Culture That Supports "Figuring Out"

Biology Science Standards Overview

The Biology course focuses on the study of From Molecules to Organisms: Structures and Processes, Ecosystems: Interactions, Energy and Dynamics, Heredity: Inheritance and Variation of Traits, Biological Evolution: Unity and Diversity.

	Science and Engineering Practices									
Crosscutting Concepts		Asking Questions and Defining Problems	Developing and Using Models	Planning and Carrying Out Investigations	Analyzing and Interpreting Data	Using Mathematics and Computational Thinking	Constructing Explanations and Designing Solutions	Engaging in Argument from Evidence	Obtaining, Evaluating, and Communicating Information	**All Domains**
	Patterns				HS-LS4-1 HS-LS-3					
	Cause and Effect	HS-LS3-1					HS-LS4-2 HS-LS4-4	HS-LS3-2 HS-LS4-5		
	Scale, Proportion and Quantity				HS-LS3-3	HS-LS2-1			HS-LS1-8	
	Systems and System Models		HS-LS1-2 HS-LS1-4							
	Energy and Matter		HS-LS1-5 HS-LS1-7			HS-LS2-4	HS-LS1-6			
	Structure and Function						HS-LS1-1			
	Stability and Change			HS-LS1-3			HS-LS2-7	HS-LS2-6		

Overview of Sample Units

	Unit 1 Evolution	Unit 2 Genetics & Heredity	Unit 3 Ecosystems	Optional From Molecules to Organisms	Optional From Molecules to Organisms	Optional Genetics & Heredity
Anchor Phenomenon	Why don't antibiotics work like they use to?	How can Science help make our lives better?	How do small changes make big impacts on ecosystems?	Why would a marathon runner become disoriented during a race, then go into a coma shortly after running a race?	Why do vaccines only kill some viral strains?	Why do some people with the sickle cell trait have immunity to malaria?
Standards	HS-LS3-1 HS-LS4-1 HS-LS4-2 HS-LS4-3 HS-LS4-5 HS-LS4-4* HS -LS1-8*	HS-LS1-1 HS-LS1-4 HS-LS3-1 HS-LS3-2 HS-LS3-3	HS-LS1-2 HS-LS1-3 HS-LS1-4 HS-LS1-5 HS-LS1-6 HS-LS1-7 HS-LS2-1 HS-LS2-4 HS-LS2-6 HS-LS2-7	HS-LS1-2 HS-LS1-3 HS-LS1-7	HS-LS1-1 HS-LS1-2 HS-LS1-3 HS-LS1-8*	HS-LS1-4 HS-LS3-1 HS-LS3-2 HS-LS3-3 HS-LS4-3* HS-LS4-4*
Resources	Bend I: Addie Bend II: Juncos	Bend I: DMD Bend II: CRISPR	Bend I: Serengeti Bend II: Trees	Marathon Runner	Louisiana Scope and Sequence	Louisiana Scope and Sequence

**HS-LS4-4 6 and HS-LS1-8 are not fully addressed by the Inquiry Hub Evolution unit. These performance expectations can be addressed by incorporating the Louisiana Biology Sample Scope and Sequence units as needed.*

From Molecules to Organisms

About the Standards

Performance Expectations

- HS-LS1-1 From Molecules to Organisms: Structures and Processes: 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.
- HS-LS1-2 From Molecules to Organisms: Structures and Processes: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- HS-LS1-3 From Molecules to Organisms: Structures and Processes: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis in living organisms.
- HS-LS1-8 From Molecules to Organisms: Structures and Processes: Obtain, evaluate, and communicate information about (1) viral and bacterial reproduction and adaptation, (2) the body's primary defenses against infection, and (3) how these features impact the design of effective treatment.

Science and Engineering Practices

- 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 natural world operate today as they did in the past and will continue to do so in the future.
- Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Crosscutting Concepts

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales
- Feedback (negative or positive) can stabilize or destabilize a system.
- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

From Molecules to Organisms

Putting the Standards into Practice

Sample Anchor Phenomenon: The 2014 Ebola breakout killed approximately 11,000 people. Although a vaccine was created to combat the virus, the vaccine did not effectively kill all strains of the virus.

Explore the anchor phenomenon

Resources: A number of resources for the anchor phenomenon are included below. Teachers should screen the resources and pull photos, quotes, and data that are appropriate to share with high school students. These resources are not appropriate to be given to students as they are due to length, content, or accessibility of the content.

The New York Times: Ebola Virus: A Village Devastated
The New York Times: Burial Boys of Ebola Virus Outbreak 2014
National Geographic: Meet the Fearless Ebola Hunters of Sierra Leone
Ebola Virus: Film Reveals Horror in Liberia
CDC's Ongoing Work to Contain Ebola in West Africa
2014 Ebola Outbreak in West Africa-Case Counts
2014 Ebola Outbreak in West Africa Distribution Map
Map: Cases of Ebola Virus Disease in Africa (1976-2017)
Outbreaks Chronology: Ebola Virus Disease
Map: Outbreak Democratic Republic of the Congo (2017)
The History and Science of Ebola
Bat-Filled Tree May Have Been Ground Zero For the Ebola Epidemic
Hunting for Ebola Among the Bats of the Congo
CDC: Facts About Bushmeat and Ebola

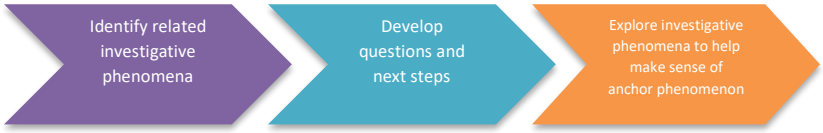
Questions students may pose that could be used for future learning or investigations:

Try to make sense of the anchor phenomenon

- How did the cultural practices in small West African countries contribute to the spread of Ebola in 2014?
- Why were the bodies of people that died from Ebola dangerous to West African villagers?
- How are the traditional burial practices of West African villagers different from our burial practices?
- What types of trainings do the "Burial Boys of Ebola" go through to ensure that the Ebola infection isn't spread to villagers?
- Where did the 2014 Ebola breakout originate? What African villages were hit the hardest by the disease?
- How did other animals, such as bats, contribute to the Ebola breakout in 2014?
- Why did the Ebola breakout rapidly spread? What factors contributed to the rapid spread?
- Can the virus spread from people to animals?
- What is the most effective way to eliminate the transmission of Ebola from person to person?

Teachers should provide Investigative Phenomena based on student observations, questions, and the Characteristics of Quality Investigative Phenomenon.

Sample Investigative Phenomena



Sample 1: Holly Jones is a healthy young woman. However, her body becomes a battlefield when she becomes infected with influenza invaders.

Discovery Education: An Inside Look: The Flu
The Immune System and Primary Immunodeficiency Disorders

Sample questions and activities for students to investigate:

Develop a model of the cells and organs that make up the immune system. Use your model to support your responses to the following prompts:

- Describe the function of each immune cell.
- How are the cells and organs of the immune system interconnected?
- How do immune cells become specialized to carry out different functions of the immune system?
- How do the structures of the cells allow them to carry out essential functions of the immune system?

Develop a model to illustrate the organization and relationships between the different components of the immune system. Use your model to support your responses to the following prompts:

- What is a system? What are the major components of the immune system? How is the immune system organized and developed?
- How does the scale of each component of the immune system change as the hierarchical structural organization become more complex?
- What are the overall differences between the innate immune system and the adaptive immune system?
- List 2 to 3 components of the immune system. How do the different components of the immune system work together to provide a defense against infections?
- What role do cytokines play in the immune system?

Develop a model to illustrate how the influenza virus entered Holly's body. Summarize how Holly's immune system responded to the infection. Use evidence from scientific literature and your model to support your response.

Make a claim supported by evidence to explain how you think the Ebola virus entered West African villagers in 2014. How do you think the immune system reacts to the virus?

3-D learning opportunities:

SEP: Develop and use a model; Obtain, evaluate, and communicate information

DCI: HS.LS1A.a; HS.LS1A.b;

CCC: Systems and system models; Structure and Function; Scale, proportion and quantity

Student Wonderings About the Phenomenon:

How did viruses contribute to the Ebola breakout in 2014? How did the virus enter the human body?

Why did so many people die of Ebola infections if the Immune system provides a defense against infections?

Were the immune systems of people living in Small West African villages comprised due to sanitation practices?

Why did West African villages experience such a large rate of Ebola infections?

Sample 2: A person can be infected with Ebola up to 21 days before suddenly experiencing symptoms.

What Does Ebola Actually Do?
Science Daily: Ebola's Secret Weapon Revealed
Dendritic Cells
BBC News: Why Ebola is so Dangerous
Ebola Virus Proteins
How the Ebola Virus Jams Immune System Signals and Kills
Study Reveals How Ebola Blocks Immune System
Washington Post: Ebola's Catastrophic Effect On the Body

Sample questions for students to investigate:

Develop a model based on evidence to illustrate how the Ebola virus enters immune cells, such as macrophages and dendritic cells.

- Use a model of the Ebola virus and its proteins to describe the structure of the virus.
- Why is the structure of the Ebola virus difficult for host cells to identify?
- How do Ebola viruses gain access to host cells? Where do Ebola viruses go after they gain access to host cells?

Develop a model to illustrate DNA replication, transcription, and translation.

- Where do DNA replication, transcription, and translation take place in cells?
- Describe the processes of DNA replication, transcription, and translation.
- How do Ebola viruses replicate using a cell's protein expression mechanisms?
- How do Ebola viruses impact replication, transcription and/or translation?
- How are the function of cytokines (proteins), such as interferons, impacted by Ebola infections?

What is a "cytokine storm"? How does a cytokine storm cause a positive feedback in one's immune system?

Construct an explanation supported by reliable and valid information that the Ebola virus disrupts the normal function of immune cells by disrupting protein synthesis.

3-D learning opportunities:

SEP: Obtain, evaluate, and communicate; Construct explanations; Develop and use models

DCI: HS.LS1A.c; HS.LS1E.a; HS.LS1E.d; HS.LS1E.e

CCC: Structure and function; Stability and change

Students Wondering About the Phenomenon:

How is the feedback loop that occurred with Holly (flu case) different from the one that is caused by a "cytokine storm"?

Has the immune system of any human overcome an Ebola infection?

How were some people able to fight off the infection in 2014?

Sample 3: The Ebola virus causes cell to cell infections, which translates to full-body symptoms, including severe nausea and vomiting, bleeding from the eyes or mucus membranes, chest pain and shortness of breath, and/or bumpy red rashes on the neck or torso.

Ebola Virus: How It Infects People, and How Scientists Are Working to Cure It
Discover Magazine: Too Close to Ebola
Scientific America: Infection Secrets of Ebola Explained
Washington Post: Ebola's Catastrophic Effect On the Body

Sample questions for students to investigate:

Use a model to illustrate the organization and relationships between different components of systems in the human body. Use your model to support your responses to the following prompts:

- What is a system? What are the major components of systems in the human body? How are the systems organized and developed?
- What are the overall differences between the systems in the body?
- List 2 to 3 components of different systems in the human body. How do the systems work together to maintain homeostasis? How are the human body systems interconnected with one another?
- Describe 2 to 3 feedback mechanisms that are present in the human body. How do these mechanisms help the body maintain its internal conditions?

Is the Ebola infection an example of a positive or negative feedback? Use evidence to support your response.

How do the scale, proportion, and quantity of an Ebola infection change as patients shift from the incubation period to the advanced symptoms period? In your response, describe how the cell to cell infection eventually causes systemic changes in the human body.

3-D learning opportunities:

SEP: Plan and conduct an investigation; Develop and use a model

DCI: HS.LS1A.d; HS.LS1A.b

CCC: Stability and change; Systems and system models; Scale, proportion, and quantity

Students Wondering About the Phenomenon:

How does the Ebola virus elicit full body symptoms if the virus infects cells, which cannot be seen without a microscope?

Does the Ebola virus infect other cells in the human body or just cells of the immune system?

How are other systems in the human body interconnected to the immune system?

How are other human body systems impacted by the Ebola virus?

Sample 4: Ebola vaccines may provide immunity against some infections.

Washington Post: Ebola's Catastrophic Effect On the Body
WHO: Ebola Vaccines, Therapies, and Diagnostics
WHO: Final Trial Results Confirm Ebola Vaccine Provides High Protection Against disease
CDC Ready to Vaccinate 6,000 Against Ebola in Sierra Leone
The New York Times: Many in West Africa May Be Immune to Ebola Virus

Sample questions for students to investigate:

How do vaccines provide immunity to infections?
How does the immune system respond when a person receives a vaccination?
How are viral and bacterial infections different from one another?
How are antibiotics and vaccines different from one another?

3-D learning opportunities:

SEP: Obtain, evaluate, and communicate information

DCI: HS.LS1E.c; HS.LS1E.b; HS.LS1E.c; HS.LS1E.d

CC: Scale, proportion and quantity

Sample Anchor Phenomenon Reflections

Communicate scientific reasoning around the anchor phenomenon

- Construct an explanation supported by 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.
- Use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- Describe how feedback mechanisms maintain homeostasis in living organisms.
- Obtain, evaluate, and communicate information about (1) viral and bacterial reproduction and adaptation, (2) the body's primary defenses against infection, and (3) how these features impact the design of effective treatment.

Genetics and Heredity

About the Standards

Performance Expectations

- HS-LS1-1 From Molecules to Organisms: Structures and Processes: 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.
- HS-LS3-1 Heredity: Inheritance and Variation of Traits: Formulate, refine, and evaluate questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
- HS-LS3-2 Heredity: Inheritance and Variation of Traits: 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 Heredity: Inheritance and Variation of Traits: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Science and Engineering Practices

- 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 natural world operate today as they did in the past and will continue to do so in the future.
- Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.
- Apply concepts of statistics and probability (e.g., determining function fits to data and correlation coefficient for linear or nonlinear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Crosscutting Concepts

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects
- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Genetics and Heredity

Putting the Standards into Practice

Sample Anchor Phenomenon: Sickle cell anemia is more common in African Americas and approximately 1 in 13 blacks have the sickle cell trait. Although the disease can be deadly, people with the trait tend to have immunity to malaria.

Explore the anchor phenomenon

Resources: A number of resources for the anchor phenomenon are included below. Teachers should screen the resources and pull photos, quotes, and data that are appropriate to share with high school students. These resources are not appropriate to be given to students as they are due to length, content, or accessibility of the content.

Malaria: Mosquito Host
Malaria: Human Host
The New York Times: How One Child's Sickle Cell Mutation Helped Protect the World From Malaria
Mystery Solved: How Sickle Hemoglobin Protects Against Malaria
Evolution of Sickle Cell Malaria

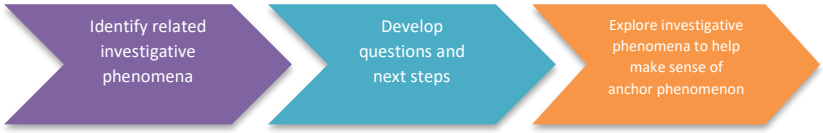
Questions students may pose that could be used for future learning or investigations:

Try to make sense of the anchor phenomenon

Why is sickle cell anemia more common in African Americans?
What is sickle cell anemia?
Is sickle cell anemia considered to be deadly?
How is sickle cell anemia and the sickle cell trait different from one another?
What is malaria and how does it impact the immune system?
Is malaria and Ebola infections similar to one another?
How do people become infected with malaria?
How do the sickle cell trait provide immunity to people with malaria?
How do people get the sickle cell trait?

Teachers should provide Investigative Phenomena based on student observations, questions, and the Characteristics of Quality Investigative Phenomenon.

Sample Investigative Phenomena



Sample 1: The hemoglobin of a child that is of African descent is altered. However, the child doesn't suffer from severe health complications because there are two copies of every gene and at least one gene functions properly.

A Case Study of the Effects of Mutation: Sickle Cell Anemia
Genomes and SNPs in Malaria and Sickle Cell Anemia (Part 3, Malaria and Sickle Cell Anemia)
Understanding the Distinction Between Genes, DNA, and Chromosomes
How Can a Mutation in DNA Affect Protein Synthesis?
How Can a Point Mutation Cause Protein Synthesis to Stop?
CDC: Sickle Cell Trait
CDC: What You Should Know About Sickle Cell Trait
Sickle Cell Trait

Sample questions for students to investigate:

Develop a model to illustrate the relationships between genes, DNA and chromosomes. Use evidence from your model and other sources to respond to the following questions:

- What questions do you have about your model?
- What are the differences between genes, DNA, and chromosomes?
- What is the role of DNA and chromosomes in coding the instructions for traits that are passed from parents to offspring?
- What is the role of DNA in coding the instructions for hemoglobin genes?

Develop a model to illustrate how hemoglobin mutations affect protein synthesis. Use evidence from your model and other sources to respond to the following questions and prompts:

- What questions do you have about your model?
- Describe the different types of mutations that can take place during DNA replication.
- How are the DNA and protein sequences of people with the sickle cell trait different from people with normal sequences?
- How do DNA mutations affect protein synthesis?
- What type of mutation cause the sickle cell trait? How do DNA mutations impact the expression of hemoglobin genes? What impact does this mutation have on people if only one gene is abnormal?
- How do mutations affect the activation of genes and gene regulation?

3-D learning opportunities:

SEP: Engage in argument from evidence; Develop and use a model; Ask questions

DCI: HS.LS1A.c; HS.LS3A.a; HS.LS3B.b

CCC: Cause and effect

Students Wondering About the Phenomenon:

What causes mutations in hemoglobin genes?

Is it possible for both hemoglobin genes to be mutated? How will this impact the expression of hemoglobin genes?

Sample 2: Blood disorders, such as sickle cell and hemophilia, are passed down from parents to their offspring. According to Hemophilia: The Royal Disease, the descendants of Great Britain's Queen Victoria suffered from a blood disorder. Her eighth son had severe hemorrhages and a cut or bump could be deadly. Eventually, at the age of thirty-one he died from a minor fall.

Live Science: What is Meiosis?
Meiosis
National Heart, Lung, and Blood Institute: Hemophilia
Gene Ed: Hemophilia
National Center for Case Study Teaching in Science: The Royal Disease

Sample questions for students to investigate:

Develop a model to illustrate the stages of meiosis. Use evidence from your model to respond to the following questions:

- Describe the stages of meiosis.
- Describe the process of recombination. How does this process increase genetic variation?
- How do errors during meiosis, including errors in DNA replication, recombination and segregation, impact the person made from the gamete?
- How are DNA mutations, found in parental DNA sequences, passed from the parents to their offspring?

How are blood disorders, such as hemophilia and sickle cell anemia, different from one another?

3-D learning opportunities:

SEP: Develop and use a model

DCI: HS.LS3B.a

CCC: Cause and effect

Students Wondering About the Phenomenon:

Is the sickle cell trait and hemophilia always passed down from parents to offspring?

What is the probability that a couple will have children with the sickle cell trait? Will all of their children have the trait?

Why is hemophilia prevalent in the descendants of Great Britain? Is the sickle cell trait just as prevalent in the descendants of African descent? Why is the trait so prevalent in African Americans?

How can a couple stop the sickle cell trait or hemophilia from being passed down to their children?

Is it possible to get screened for genetic disorders before having children?

Sample 3: Blood samples of people carrying the sickle cell trait in East Africa reveal that people living near the coast have higher frequencies of the trait in comparison to people that don't live near the coast.

The Making of the Fittest: Natural Selection in Humans
PhET: Natural Selection Lab Simulation
CDC: Protective Effect of Sickle Cell Trait Against Malaria-Associated Mortality and Morbidity
The Making of the Fittest: Natural Selection in Humans – Testing A Hypothesis (worksheet)
The Making of the Fittest: Natural Selection in Humans - Nature of Science (worksheet)

Sample questions for students to investigate:

Describe the data that Dr. Allison collected in West Africa. How did Dr. Allison use that data to develop a hypothesis about the connection between malaria and the sickle cell trait?

What patterns did Dr. Allison identify during his studies in West Africa? In your response, discuss the quantitative and qualitative patterns that Dr. Allison collected during his research.

Describe the process of natural selection. How did the data that Dr. Allison collect support the theory that natural selection occurred in West African populations?

Why are there higher frequencies of the sickle cell trait in areas where malaria is more prevalent?

How did environment factors affect the expression of sickle cell traits in West Africa?

Make a claim supported by quantitative and qualitative data that the sickle cell trait is prevalent among people of African descent due to the presence of malaria in East African communities. In your response, explain how this phenomenon is an example of natural selection and how it leads to adaptations.

3-D learning opportunities:

SEP: Analyzing and interpreting data; Engage in argument

DCI: HS.LS3B.c; HS.LS4.B.a; HS.LS4B.c; HS.LS.4C.a; HS.LS.4C.b

CCC: Patterns

Students Wondering About the Phenomenon:

Why are people that are born in malaria communities at a disadvantage if they have two copies of the sickle cell gene or two copies of the normal gene?

Are people that are born in communities without the presence of malaria at the same risks if they have two copies of the normal gene or two copies of the sickle cell gene?

Sample 3: From time to time, hemoglobin genetic mutations cause issues. When two people of African descent meet and start a family, some of their children inherit two copies of the mutated hemoglobin.

TEDEd: How Mendel's Pea Plants Helped Us Understand Genetics
Sickle Cell Disease - The Invisible Illness
CCD: Did You Know There's More Than One Way to Inherit Sickle Cell Disease?
CDC: Sickle Cell Disease
The Making of the Fittest: Natural Selection in Humans –Genetics, Probability, Pedigree, Chi-Square

Sample questions for students to investigate:

Develop a Punnett square model to determine the phenotype and genotype of one's offspring if both parents have the sickle cell trait. Use evidence from the model to support your response to the following questions:

- What is the probability that the couple's offspring will be homozygous recessive, homozygous dominant, and heterozygous?
- What is the probability that the couple will have offspring with the sickle cell trait and sickle cell anemia?

Develop a Punnett square model to illustrate traits that are codominant, incomplete dominant, and polygenic. Use evidence from the model to explain how these traits are different from one another.

3-D learning opportunities:

SEP: Analyzing and interpreting data; Develop and use a model

DCI: HS.LS3A.b

CCC: Cause and effect; Scale, proportion, and quantity

Students Wondering About the Phenomenon:

How would a Punnett square look if one parent had the sickle cell trait and the other parent had sickle cell anemia?

How does sickle cell anemia impact the human body?

Are sickled red blood cells dangerous to people that do not live in areas where malaria is prevalent?

Sample 4: According to the American Society of Hematology, "As a young child, Alexandria, endured near-constant feelings of exhaustion and general sickness, which turned into severe pain at night." Eventually, she experienced a "silent stroke".

The Function of Red Blood Cells
Sickle Cell Anemia: A Patient's Journey
Sickle Cell Disease
National Heart, Lung, and Blood Institute

Sample questions for students to investigate:

How are old or damaged red blood cells replaced and removed from the body? What role do stem cells and bone marrow play in this process?

Describe how oxygen levels in the human body trigger feedback mechanisms, which leads to erythropoiesis.

Describe how erythropoiesis helps to maintain homeostasis in the circulation of red blood cells.

Develop a model to illustrate the stages of mitosis. Use your model to respond to the following questions or prompts:

- Describe each stage of mitosis.
- How is mitosis and meiosis different from one another? How do disruptions in the cell cycles of mitosis and meiosis lead to diseases?
- Why are red blood cells unable to undergo mitosis like other somatic cells?

Learning Sequence aligned with Secondary DCIs: Develop a model of the cells and organs that make up the cardiovascular system. Use your model to support your responses to the following prompts:

- Describe the structure and function of red blood cells.
- How are the cells and organs of the cardiovascular system interconnected?
- How do the structures of the red blood cells allow them to carry out essential functions of the cardiovascular system?
- What is a system? What are the major components of the cardiovascular system? How is the cardiovascular system organized and developed?

3-D learning opportunities:

SEP: Develop and use a model

DCI: HS.LS1B.a; HS.LS1B.b; HS.LS1B.c;

Secondary DCIs: HS.LS1A.b and HS.LS1A.d

CCC: Stability and change; Systems and system models; Structure and Function

Students Wondering About the Phenomenon:

Can diseased bone marrow be replaced?

Is there a cure for sickle cell anemia?

Sample 5: Researchers have developed a solution to sickle cell anemia.

National Geographic: A Child Prodigy, A Painful Disease, And A Life-Changing Treatment
Alberta Woman Cured of Sickle Cell Disease Thanks to Sister's Stem Cells
What Is Sickle Cell Anemia? Stem Cell Transplant Cures Canadian Woman
The Function of Red Blood Cells
Bone Marrow (Hematopoietic) Stem Cells

Sample questions for students to investigate:

What is the hematopoietic system? What role does this system play in producing blood cells?

How does bone marrow differentiate into many types of cells?

How are stem cells harvested from bone marrow and umbilical cords?

How do stem cells maintain complex organisms?

How do stem cells work together to meet the needs of an organism?

3-D learning opportunities:

SEP: Asking questions

DCI: HS.LS1B.b; HS.LS1B.c

CCC: Systems and system models

Students Wondering About Phenomenon:

Can bone marrow transplants cure other genetic disease such as hemophilia?

Sample Anchor Phenomenon Reflections

Communicate scientific reasoning around the anchor phenomenon

- 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.
- Describe the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
- Make a claim supported by 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.
- Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.