*Unit 5 - Cell Specialization and Homeostasis

Content Area: **Science**
Course(s): **Biology CP, Biology Honors, STEM Biology Honors**
Time Period: **February**
Length: **15 Blocks**
Status: **Published**

Unit Summary

Students formulate an answer to the question "*How do the structures of organisms enable life's functions?" S*tudents investigate explanations for the structure and functions of cells as the basic unit of life, of hierarchical organization of interacting organ systems, and of the role of specialized cells for maintenance and growth. The crosscutting concepts of *structure and function*, *matter and energy*, and *systems and system models* are called out as organizing concepts for the disciplinary core ideas. Students use *critical reading*, *modeling*, and *conducting investigations*. Students also use the science and engineering practices to demonstrate understanding of the disciplinary core ideas.

This unit is based on HS-LS1-1, HS-LS1-2, HS-LS1-3, and HS-LS1-4.

Updated from Model Curriculum 6.26.17

Enduring Understandings

- The genes within an organism's DNA code for proteins that carry out essential cell functions
- Differential expression of genes allows for cell specialization, and systems of specialized cells within multicellular organisms carry out essential life functions
- Feedback mechanisms allow individual cells and multicellular organisms to maintain a stable internal environment (homeostasis) as the external environment changes

Essential Questions

- How are the instructions for a living thing encoded in DNA?
- If all cells within an organsim have exactly the same set of instructions then why are there different types of cells?
- How do groups of specialized cells work together to carry out essential body functions?
- How do cells and organisms maintain homeostasis in a constantly changing external environment?
- How does a trillion-celled organism develop from a single cell?

Student Learning Objectives (PE, SEP, DCI, CCC) & Aligned Standards

Performance Expecations

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.*[Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]* **(HS-LS1-1)**

Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.*[Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.]* **(HS-LS1-2)**

Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.*[Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.]* **(HS-LS1-3)**

Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.*[Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.]***(HS-LS1-4)**

Science and Engineering Practices

Constructing Explanations and Designing Solutions

- Construct 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. (HS-LS1-1)

Developing and Using Models

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-2)

Planning and Carrying Out Investigations

- **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. (HS-LS1-3)**

Disciplinary Core Ideas

LS1.A: Structure and Function

- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)
- 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 (negative feedback) what is going on inside the living system. (HS-LS1-3)
- Regions of DNA called genes determine the structure of proteins, which carry out the essential functions of life through systems of specialized cells. The sequence of genes contains instructions that code for proteins. (LS1.A)
- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
- Groups of specialized cells (tissues) use proteins to carry out functions that are essential to the organism. (LS1.A)

Crosscutting Concepts

Systems and System Models

- 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. (HS-LS1-2)

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)

HS-LS1	From Molecules to Organisms: Structures and Processes
HS-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.
HS-LS1-2	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
HS-LS1-1.LS1.A	Structure and Function
HS-LS1-1.LS1.A.1	Systems of specialized cells within organisms help them perform the essential functions of life.
HS-LS1-3	Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS1-1.LS1.A.2	All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.
HS-LS1-1.6	Structure and function.
HS-LS1-4	Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
CCC.4	Systems and system models.
	Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
SEP.2	Developing and Using Models
SEP.2.c	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.
HS-LS1-2.LS1.A.1	Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
CCC.7	Stability and change.
SEP.3	Planning and Carrying Out Investigations
	For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.
SEP.3.b	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.
SEP.6	Constructing Explanations and Designing Solutions
SEP.6.b	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.
SCI.9-12.4.3	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.
SCI.9-12.7.3	Feedback (negative or positive) can stabilize or destabilize a system.

Concepts & Formative Assessment

Part A: *How does the structure of DNA determine the structure of proteins, and what is the function of proteins?*

Concepts

- Systems of specialized cells within organisms help them perform the essential functions of life.
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.
- 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

their functions and/or solve a problem.

Formative Assessment

Students who understand the concepts are able to:

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
- Construct an explanation, based on 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, for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
- Conduct a detailed examination of the structure and function of DNA.

Part B: *What do you mean they say that people are made of a system of systems?*

Concepts

- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- 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.

Formative Assessment

Students who understand the concepts are able to:

- Develop and use a model based on evidence to illustrate hierarchical organization of interacting systems that provide specific functions within multicellular organism.
- Develop and use a model based on evidence to illustrate the interaction of functions at the organism system level.
- Develop and use a model based on evidence to illustrate the flow of matter and energy within and between systems of an organism at different scales.

Part C: *How do feedback mechanisms maintain homeostasis?*

Concepts

- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.
- Feedback mechanisms maintain a living system's internal conditions within certain limits, and they mediate behaviors, allowing the system to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or

discourage (negative feedback) what is going on inside the living system.
- Feedback (negative or positive) can stabilize or destabilize a system.

Formative Assessment

Students who understand the concepts are able to:

- Plan and conduct an investigation individually and collaboratively to produce evidence that feedback mechanisms (negative and positive) maintain homeostasis.
- In the planning of the investigation, decide on the types, amount, and accuracy of the data needed to produce reliable measurements, consider limitations on the precision of the data, and refine the design accordingly.

Resources

Membrane Channels Simulation: Students begin by asking questions that arise from demonstrations with aromatic sprays and they will articulate the movement of particles from areas of high concentrations to lower concentrations. The students will then ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. Students will develop, revise, and /or use a model based on evidence to illustrate and/or predict the relationship between systems or between components of a system using a computer simulation. Students will then communicate scientific and/or technical information or ideas in multiple formats (including orally, graphically, and textually).

Membrane Diffusion: Collaboratively, students will analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine an optimal design solution. Students can then work either collaboratively or independently to use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Structure and Function: Stem Cell: Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

DNA Transcription and Translation Simulation: Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Growth and Development: Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Mitosis: Develop and/or use a model to generate data to support explanations, predict phenomena, analyze systems, and/or problems.

Embryonic Development: Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Suggested Assessments

- Students construct an explanation for the development of a complex multicellular organism from a fertilized egg.
- Demonstrate how cells of a system work together to carry out a specific function (groups pick a system and explain how specialized tissues work together to achieve a specific task - see PE HS-LS1-2, "an example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system")
- Diffusion and osmosis lab (how do cells/organisms deal with osmotic stress???)
- Model a feedback loop for maintaining body temp, blood sugar levels, etc…
- Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis (see PE HS-LS1-3 - modify exercise and respiration lab)

Connecting with English Language Arts Literacy and Mathematics

English Language Arts/Literacy

- Write an explanation that supports how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
- Draw evidence from informational texts to support how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
- Conduct short as well as more sustained research to determine how feedback mechanisms maintain homeostasis.
- Gather applicable information from multiple reliable sources to support claims that feedback mechanisms maintain homeostasis. Use advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Mathematics

- Write a function that describes a relationship between the role of cellular division and differentiation

and the production and maintenance of complex organisms.

Modifications

Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.

Research on Student Learning

Preliminary research indicates that it may be easier for students to understand that the cell is the basic unit of structure (which they can observe) than that the cell is the basic unit of function (which has to be inferred from experiments). Research also shows that high-school students may hold various misconceptions about cells after traditional instruction (NSDL, 2015).

References

Adapted from the New Jesery NGSS Science Model Curriclum

Connections to NJSLS

English Language Arts

Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.9-12.7** (HS-LS1-3)

Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **WHST.11-12.8** (HS-LS1-3)

Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. **SL.11-12.5** (HS-LS1-2)