HIGH SCHOOL LIFE SCIENCE: BIOCHEMISTRY

Standards Bundle:

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. (SEP: 6; DCI: LS1.C; CCC: Energy/Matter) [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

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. (SEP: 6; DCI: LS1.A; CCC: Structure/Function) [*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.*]

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Sustaining life requires the input of both matter and energy. Photosynthesis combines carbon dioxide and water to form sugar which in turn, can be used to make amino acids and other macromolecules through rearrangement, combining, and adding other elements. Once those amino acids are either consumed or formed through other molecule rearrangement, DNA directs the formation of those proteins. The directions for assembling the amino acids are contained in the order of the bases with each arrangement forming specialized proteins with special functions. These proteins carry out most of the essential jobs within the cells.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- A picture of student prepared slides shows starch vacuoles of potato cells stained with iodine. Plants take carbon dioxide and water in during photosynthesis yet contain starch.
- A plant continues to produce a substance (like sugar in the sugar beets, for example) when it already has more than it will use, or take in and retain more water than it needs for its own purposes (grapes, etc.).
- Peanuts are plants. They contain protein (or show/lab with protein detection). Peanuts are also a source of oil. Photosynthesis only produces carbohydrates.

- Many dogs are allergic to beef or chicken but not deer proteins in their diet.
- Prairie dogs may go months without drinking even one drop of water, yet water is required by every organism for life.
- “You are what you eat.” What do you think about that statement?

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts

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. ● 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. ● Construct the explanation that atoms from sugar molecules may combine with other elements via chemical reactions to form other large carbon-based molecules.	**LS1.A: Structure and Function** ● 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. **LS1.C: Organization for Matter and Energy Flow in Organisms** ● The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. ● As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	**Structure and Function** ● 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. **Energy and Matter** ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

In this standard bundle, students will develop and use models (physical, mathematical or computer models) to demonstrate and explain how all life is dependent on energy and matter. Organisms must obtain energy and matter from other organisms or from the environment around them. By better understanding the flow of matter within an ecosystem, students can see how organisms make biological molecules like sugars, amino acids, proteins, carbohydrates and DNA from simple elements (e.g. nitrogen) and molecules (e.g. carbon dioxide and water). Students will create explanations about how energy and matter are not created or destroyed but recycled within organisms, between organisms, or within different components of ecosystems.

The manufacture of proteins is dependent upon an organism obtaining or manufacturing the required amino acids but also upon the specific sequences of nitrogen base pairs found in DNA molecules. DNA codes for the structures that help organisms carry out functions necessary for life. Short regions within DNA,

called genes, code for the sequence of amino acids, forming the structure of proteins. Proteins are assembled in various forms to create biological molecules with specific functions (e.g. structural, enzymes, and catalysts). The structures created by proteins form specialized cells in organisms,which help them to grow, reproduce, and carry out specific tasks.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

SEP Constructing Explanations and Designing Solutions

- Write an evidence based explanation for the saying "You are what you eat."
- Produce an explanation for the phenomenon that prairie dogs can go for months without drinking a drop of water.
- Given sequences of DNA base pairs, model protein synthesis by creating amino acid sequences. What evidence exists that supports the statement that muscle proteins are unique between different animals?

CCC Structure and Function

- If the DNA molecule is only composed of four possible nitrogen bases, how can thousands of different proteins be formed from such a limited set of fixed shapes?

CCC Energy and Matter

- If a plant only creates carbohydrates from photosynthesis, where do proteins, lipids, and DNA come from?
- Plants need energy to make necessary molecules to grow, repair, and reproduce. Explain how and where they get the energy needed as well as the raw materials/matter needed. Note that they do not directly use light energy.
- How does DNA, a nucleic acid, act as a blueprint for the amino acid sequences that compose proteins?

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Utilize digital resources or physical models** to construct various amino acid *sequences* from a DNA sequence of base pairs in an effort to form a model

protein.

- Determine exactly which amino acids are formed from specific DNA base *sequences* and what would happen if the bases were *changed*.
- **Explain** how scientists can utilize technology to create sequences and "speed read" the DNA code using *sequence* analyzers.
- **Conduct investigations** to demonstrate that organisms are composed of a variety of macromolecules.
- **Ask questions** to determine where molecules other than carbohydrates come from in plants.
- **Communicate information** on how *energy released* in respiration can be used to drive chemical reactions between sugars and other substances, and the products of those reactions can include amino acids and other complex carbon-based molecules.
- **Develop a model** to discuss the *relationship* between the carbon, hydrogen, and oxygen atoms from sugar molecules formed in or ingested by an organism and those same atoms found in amino acids and other large carbon-based molecules.
- **Using evidence**, explain the statement "You are what you eat" or how the food you eat becomes the complex molecules you are composed of.