CPHS Biology Unit 2: Matter and Energy Transformations in Organisms and Ecosystems

CONTENT AREA: Biology	GRADES: 9-12	UNIT: 2 of 8
Pacing:		
Performance Expectations: NJSLS-S-HS-LS1-5, NJSLS-S-HS-LS1-6, NJSLS-S-HS-LS1-7, NJSLS-S-HS-LS2-3, NJSLS-S-HS-LS2-4, NJSLS-S-HS-LS2-5		
Evidence Statement(s): NJSLS-S-HS-LS1-5, NJSLS-S-HS-LS1-6, NJSLS-S-HS-LS1-7, NJSLS-S-HS-LS2-3, NJSLS-S-HS-LS2-4, NJSLS-S-HS-LS2-5		
Essential Question: How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems? How do organisms interact with the living and non-living environment to obtain matter and energy?		
21st Century Skills: 9.2.8.B.3, 9.2.8.B.4		
Career Ready Practices: CRP4, CRP6, CRP7		
Technology:		
Technical Terms (Suggested)	**Core Instructional Materials**	**Assessment Statement**
*All terms should be taught in context rather than in isolation. These terms should be addressed after conceptual understanding.	NJSLS-S-HS-LS1-5 NJSLS-S-HS-LS1-6 NJSLS-S-HS-LS1-7 NJSLS-S-HS-LS2-3 NJSLS-S-HS-LS2-4 NJSLS-S-HS-LS2-5	
Modifications		

English Language Learners	Special Education	At Risk	Gifted & Talented
Scaffolding Word walls Sentence/paragraph frames Bilingual dictionaries/translation Think alouds Read alouds Highlight key vocabulary Annotation guides Think-pair-share Visual aides Modeling Cognates	Word walls Visual aides Graphic organizers Multimedia Leveled readers Assistive technology Notes/summaries Extended time Answer masking Answer eliminator Highlighter Color contrast	Teacher tutoring Peer tutoring Study guides Graphic organizers Extended time Parent communication Modified assignments Counseling	Curriculum compacting Challenge assignments Enrichment activities Tiered activities Independent research/inquiry Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks Self-directed activities

5E Model	
<u>Performance Expectation: NJSLS-S-HS-LS1-5</u> Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.	
Engage: Anticipatory Set 1 Day	Begin lesson by showing a short video clip on photosynthesis. http://www.schooltube.com/video/dc732e59026d90ab949d/ After showing this video ask the class what plants need to survive and what do plants provide to the environment? Have students try to create a basic chemical equation of photosynthesis.
Exploration: Student Inquiry 2 Days	Arrange students in groups of 3 to 4 students. Procedure: 1. Fill the large, clear container 3/4 of the way full with the room-temperature, dechlorinated tap water. 2. Add 1 g of sodium bicarbonate to the water and stir until dissolved. This is the CO_2 source for the plant that is being used. 3. Cut 8 to 12 sprigs of the plant to a length of about 20 cm. 4. Place the cut sprigs into the mouth of the funnel. 5. Invert the funnel and place it into the container of water, trapping the aquatic plant inside the funnel. 6. Make sure the stem of the funnel is completely submerged in the water. If it's not, add more room temperature, dechlorinated water to the container until the funnel stem is covered. 7. Wrap a rubber band about 1/4 of the way down the test tube several times. This allows the test tube to sit inside the stem of the funnel without falling all the way into it. 8. Submerge the test tube into the water in the container, filling it completely. 9. Invert the test tube in the water and place it over the stem of the funnel while it is still submerged. Make sure no air bubbles are trapped in the test tube. 10. Place a fluorescent light source near the container and turn it on. 11. Create another set-up and place it in the dark. 12. Leave the setups undisturbed for 24 hours. 13. Observe the oxygen that is trapped in the test tubes after 24 hours. **Simple lab**: bromothymol blue and elodea (test tube) - yellow to blue indicator Chromatography lab: extract pigments Possible lab: live yeast, dead yeast, plant, animal - phenol red indicator Spinach chad lab from AP Biology labs. For more information, see ology http://www.carolina.com/teacher-resources/Interactive/using-aquatic-plants-to-demonstrate-photosynthesis/tr28607.tr Video of experiment http://www.carolina.com/teacher-resources/Video/photosynthesis-activities-video/tr11204.tr?question=photosynthesis
Explanation: Concepts & Practices	<u>In these lessons:</u> Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. <u>Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):</u> LS1.C: Organization for Matter and Energy Flow in Organisms:

	The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
Elaboration: Extension Activity	Let students research other organisms besides plants that use photosynthesis. What are some problems that photosynthesizers are facing today? What are possible solutions to these problems? Write an essay. lab: color filters/ determine best wavelength for maximum photosynthesis (groups) How do farmers maximize photosynthesis? Group project
Evaluation: Assessment	

5E Model

Performance Expectation: NJSLS-S-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.

Engage: Anticipatory Set 1 day	Begin lesson by showing the following video which describes the molecules important to life. https://www.opened.com/video/chemical-compounds-in-cells-rap/5634965 After the video ask the class to list different foods that they eat. Have a student or yourself list the different foods on the board. Then ask students to classify the different foods into the different types of biological molecules. Students can write them down and can be collected for class participation
Exploration: Student Inquiry 2 day	Arrange students in groups of 3. Students responsible to bring in food products. Benedict's solution is used to test for simple sugars, such as glucose It is a clear blue solution of sodium and copper salts. In the presence of simple sugars, the blue solution changes color to green, yellow, and brick-red, depending on the amount of sugar. The molecular formula for glucose is ($C_6H_{12}O_6$). Sugar contains the elements carbon, hydrogen and oxygen. 1. Mix small amount of each food sample with water to make a test liquid. 2. To a test tube, add 20 drops of liquid to be tested. 3. Label each test tube with tape and a marker. 4. Add 10 drops of Benedict's solution to each test tube. Carefully heat the test tubes by suspending in a hot water bath at about 70 degrees celsius for three minutes. 5. Note any color change. If sugar is present solution will turn green, yellow, or brick-red, depending on sugar concentration. **Food Test 2: Protein Test - Biuret solution** Biuret solution is used to identify the presence of protein. Biuret reagent is a blue solution that, when it reacts with protein, will change color to pink-purple. Proteins are large organic molecules that contain the elements carbon, hydrogen , oxygen, nitrogen, and sometimes sulfur Like sugar, proteins also contain carbon. Carbon is sometimes referred to as the element of life because it is found in organic compounds. 1. To a test tube, add 20 drops of liquid to be tested. 2. If testing more than one liquid, label each test tube with a marker. 3. Add 3 drops of Biuret solution to each test tube. Shake gently to mix. 4. Note any color change. Proteins will turn solution pink or purple. **Food Test 3: Complex Carbohydrate (starch) – Iodine solution** Iodine solution is used to test for the presence of complex carbohydrates. Iodine is a yellowish liquid that turns dark purple or black when it reacts with complex carbohydrates. Complex carbohydrates are very large energy rich organic molecules that contain carbon hydrogen and oxygen. Many sugar molecules chained together would form a complex carbohydrate. 1. Apply a drop of iodine directly to each food sample. 2. Note any color change. Starch will turn iodine dark purple or black. Give examples of foods that contain Carbohydrates? Give examples of foods that contain proteins?

Explanation: Concepts & Practices 3 days	In these lessons: Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): 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.
Elaboration: Extension Activity 2 days	Construct a menu for a fictitious restaurant. Students will include appetizers, main course and desserts. They will list the food offerings and list the complex molecules that they are composed of. https://www.youtube.com/watch?v=-uwDfLS749k
Evaluation: Assessment	

5E Model	
Performance Expectation: NJSLS-S-HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.	
Engage: Anticipatory Set	https://www.youtube.com/watch?v=8Kn6BVGqKd8 Demo or class lab: peroxide and yeast with thermometer
Exploration: Student Inquiry	Rube Goldberg apparatus. Online metabolism activity: https://www.wisc-online.com/learn/natural-science/life-science/mby2604/metabolic-pathways http://msp.ehe.osu.edu/wiki/index.php/MSP:MiddleSchoolPortal/Energy_Transfers_and_Transformations:_Sparking_Student_Interest#Energy_Transfers_.26_Transformations:_Sparking_Student_Interest_-_Introduction Form student groups of three. Distribute a packet entitled “Plants Respire Too!” http://c.ymcdn.com/sites/my.aspb.org/resource/group/a9372bf4-9ae4-4d0b-ad0c-595c9dfc3543/12labs/05_respiration_and_energy.pdf Procedure: 1. Obtain 100 mL of water. Test the pH (using pH paper test strips) of this solution. Record in your lab notebook. 2. Place 3 test tubes in a test tube rack and label each with the date, plant material, and your name. Add 10 mL of water to each of the 3 test tubes. Then add 3

	drops of phenol red pH indicator into each test tube and record the color. 3. Test tube 1 will be your control. Do not place any plant material in this tube. Place this test tube in a beaker or container to hold the test tube upright. Place a stopper in the tube. 4. Pat dry the germinating seeds that have NOT been boiled. In test tube 2, add enough germinating pea seeds to fill one half of the tube, making sure the seeds are in the liquid. Place this test tube in a beaker or container to hold the test tube upright. Place a stopper in the tube. 5. Pat dry germinating seeds that have been boiled. In test tube 3, add enough BOILED germinating pea seeds to fill one half of the tube, making sure the seeds are in the liquid. Place this test tube in a beaker or container to hold the test tube upright. Place a stopper in the tube. 6. Let these tubes sit quietly for 30 minutes. Observe and record the color of the liquid in the tubes. Pour a small amount of the liquid from each tube into small clear containers and place a piece of pH test strip in each solution. Leave for 2 minutes, and then record the pH of each solution. Pour the liquids back into the correct test tubes and put stoppers back into the tubes. 7. Let these test tubes sit overnight. 8. Pour some of the liquid from each test tube into smaller clear containers. Note any color changes in the liquids. Check and record the pH of the liquids by placing pH paper strips in each and leaving for several minutes. For a full write up, see http://c.ymcdn.com/sites/my.aspb.org/resource/group/a9372bf4-9ae4-4d0b-ad0c-595c9dfc3543/12labs/05_respiration_and_energy.pdf
Explanation: Concepts & Practices	In these lessons: Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): LS1.C: Organization for Matter and Energy Flow in Organisms As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
Elaboration: Extension Activity	Athletics - carbo loading and long distance running, weight lifting and protein, fat intake for mountain climbers, (Compare energy metabolism with final macromolecules: nucleic acids.nucleotides and the importance of fresh fruits and vegetable sauces for growing babies as they go through mitotic division during growth). Comparisons in energy use between endotherms and ectotherms.
Evaluation: Assessment	

5E Model	
Performance Expectation: NJSLS-S-HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.	
Engage: Anticipatory Set	Begin the lesson by showing students how to make dough rise. Teacher can demonstrate this with yeast water and flour. Why does the dough get bigger? Is it alive? where does the air come from.
Exploration: Student Inquiry	On the first day of the activity, students set up the yeast-molasses respiration chambers. It is best to start this activity on a Monday, so it can be monitored throughout the week. For the next 3-4 days, students take a few minutes of class time to observe their chambers and measure the heights of the carbon-dioxide bubbles within. On the last day, when most of the bubbles are at the maximum measurable height, students make graphs that show how the heights of the gas bubbles changed over the duration of the experiment. For more details, refer to https://www.teachengineering.org/view_activity.php?url=collection/duk_/activities/duk_cellresp_mary_act/duk_cellresp_mary_act.xml Investigating Questions Ask students the following questions either while they make daily observations and measurements and/or during the concluding discussion. ● Are all of the small gas bubbles produced by the yeasts trapped in the inverted test tube? ● Is the size of the bubble inside the inverted test tube an accurate representation of the amount of yeast respiration that occurred? ● Did the trapped gas bubble grow at a uniform rate each day? If not, why not? ● How do we know that the bubbles produced in the test tube were made of carbon dioxide? ● Did this experiment have a control? If not, what could be used as a control?
Explanation: Concepts & Practices	In these lessons: Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): LS2.B: Cycles of Matter and Energy Transfer in Ecosystems Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. Energy drives the cycling of matter within and between systems.
Elaboration: Extension Activity	*Concluding Discussion*: Once the activity is done, lead a class discussion to share and compare results and conclusions. See details in the Procedure and Investigating Questions sections. Listen to student answers to gauge their level of comprehension. *Writing Problem*: At activity end, present to students the following scenario and ask them to write and turn in their responses for grading. Review their answers to assess their depth of comprehension. Several loaves of bread that a baker made this morning did not rise as they should have. The result was flat, dense loaves that he cannot sell. He suspects a problem with the yeast, since he knows that it is the yeast that makes the bread dough rise. All of the yeast he used came from his one large supply. *How can you help the baker determine if his yeasts are functioning properly?*

	Make Yogurt: Like yeasts, some bacteria respire anaerobically. Yogurt is produced when bacteria break down lactose, the sugar contained in milk, to obtain energy for their cellular activities. Lactic acid is produced as a by-product, and this is what gives plain yogurt its tart taste. Plain yogurt is easy to make and does not require a lot of class time, although it does require a warm (about 40 ºC or 100 ºF) location for several hours. Have students conduct an Internet search to find a recipe that the class could make. Afterwards, students might enjoy bringing in flavorings and toppings for when they taste the finished product. Assign students to research the difference between sourdough and conventional bread. *Alcohol production*: research anaerobic respiration and beer/wine production.
Evaluation: Assessment	

5E Model	
Performance Expectation: NJSLS-S-HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.	
Engage: Anticipatory Set	https://www.youtube.com/watch?v=q52qtdrvah8
Exploration: Student Inquiry	Online food web simulation: https://www.learner.org/courses/envsci/interactives/ecology/food_web.php http://www.ck12.org/earth-science/Flow-of-Matter-in-Ecosystems/lesson/Flow-of-Matter-in-Ecosystems/
Explanation: Concepts & Practices	In these lessons: Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
Elaboration: Extension Activity	**Student-Designed Experiments** Biomagnification: literacy articles with questions and pyramid kit Have students construct their own food webs on a poster or online as a group project which shows relative biomass and energy flow at different trophic levels. Students may construct a vocabulary list, increase their knowledge of geography, while increasing their understanding of biological magnification and scientific methodology while dissecting the following article: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3844145/ http://www.vtaide.com/png/foodwebS.htm
Evaluation: Assessment	

5E Model	
<u>Performance Expectation: NJSLS-S-HS-LS2-5</u> Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	
Engage: Anticipatory Set	https://www.youtube.com/watch?v=jRduc0pzQ_4 Additional/Optional anticipatory set information can be obtained via NOAA at: http://coralreefwatch.noaa.gov/satellite/education/ These resources focus on bleaching of coral, as a means of understanding CO_2 cycling into the hydrosphere.
Exploration: Student Inquiry	Carbon Cycle Project: https://west.madison.k12.wi.us/files/west/carboncycleproject.pdf
Explanation: Concepts & Practices	<u>In these lessons:</u> Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. <u>Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas):</u> **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** ● Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.
Elaboration: Extension Activity	Having students create diagrams to illustrate the processes of photosynthesis and cellular respiration assists in their understanding. If a student team is struggling, consider combining it with a team that is grasping the concepts more quickly. Having students work together allows them to help each other and emphasizes collaborative learning. Allowing students to find answers collectively also causes them to explain results to each other, which can greatly improve comprehension while engaging them in learning. Students may create an “Exit Slip” question on an index card. The following day the teacher will elaborate on concepts covered in class based on the curiosity of individual students. Have students work on group global warming presentations: Presentation guidelines and rubric: https://docs.google.com/document/d/13cr5zMhynyPtnbC-UGmsh0mZE1ulOCgN7MNBfaYAn0k/edit?usp=sharing Presentation template: https://docs.google.com/presentation/d/1cQQKAylYO4wAd6PW_Adio-7pe2dv36JW67BTglfK9_o/edit?usp=sharing
Evaluation: Assessment	

How do organisms obtain and use energy they need to live and grow? ***How do matter and energy move through ecosystems?*** Students construct explanations for the role of energy in the cycling of matter in organisms and ecosystems. They apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and develop models to communicate these explanations. They relate the nature of science to how explanations may change in light of new evidence and the implications for our understanding of the tentative nature of science. Students understand organisms' interactions with each other and their physical environment, how organisms obtain resources, change the environment, and how these changes affect both organisms and ecosystems. In addition, students utilize the crosscutting concepts of matter and energy and Systems and system models to make sense of ecosystem dynamics. (p. 2, Life Science Topics Storyline).		
#	**STUDENT LEARNING OBJECTIVES**	**CORRESPONDING PEs and DCIs**
1	**Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** *[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]* [Assessment Boundary: Assessment does not include specific biochemical steps.]	**NJSLS-S-HS-LS1-5**
2	**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.** *[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.]	**NJSLS-S-HS-LS1-6**
3	**Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.** *[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.]* [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]	**NJSLS-S-HS-LS1-7**
4	**Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** *[Clarification Statement: Examples of models could include simulations and mathematical models.]* [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]	**NJSLS-S-HS-LS2-5**
5	**Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** *[Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.]* [Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.]	**NJSLS-S-HS-LS2-3**
6	**Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** *[Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.]* [Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.]	**NJSLS-S-HS-LS2-4**
7	Use visual representations to illustrate how interactions among living systems and with their environment result in the movement of matter and energy.	LS1.C

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices **Developing and Using Models** (pp. 56-59, NRC, 2012) Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. ● Use a model based on evidence to illustrate the relationships between systems or between components of a system. (NJSLS-S-HS-LS1-5),(NJSLS-S-HS-LS1-7) ● Develop a model based on evidence to illustrate the relationships between systems or components of a system. (NJSLS-S-HS-LS2-5) **Using Mathematics and Computational Thinking**(pp. 64-67, NRC, 2012) Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical representations of phenomena or design solutions to support claims. (NJSLS-S-HS-LS2-4) **Constructing Explanations and Designing Solutions** (pp. 67-71, NRC, 2012) Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on valid and reliable evidence obtained from a variety of	**Disciplinary Core Ideas** **LS1.C: Organization for Matter and Energy Flow in Organisms** (pp. 147-148, NRC, 2012) ● The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (NJSLS-S-HS-LS1-5) ● 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. (NJSLS-S-HS-LS1-6) ● As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (NJSLS-S-HS-LS1-6),(NJSLS-S-HS-LS1-7) ● As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (NJSLS-S-HS-LS1-7) **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** (pp. 152-154, NRC, 2012) ● Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (NJSLS-S-HS-LS2-3) ● Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures,	**Crosscutting Concepts** **Systems and System Models** (pp. 91-94, NRC, 2012) ● 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. (NJSLS-S-HS-LS2-5) **Energy and Matter** (pp. 94-96, NRC, 2012) ● 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. (NJSLS-S-HS-LS1-5), (NJSLS-S-HS-LS1-6) ● Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (NJSLS-S-HS-LS1-7),(NJSLS-S-HS-LS2-4) Energy drives the cycling of matter within and between systems. (NJSLS-S-HS-LS2-3) - ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** (pp. 96-101, Appendix H) ● Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (NJSLS-S-HS-LS2-3)

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. (NJSLS-S-HS-LS1-6),(NJSLS-S-HS-LS2-3)	and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (NJSLS-S-HS-LS2-4) ● Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (NJSLS-S-HS-LS2-5) **PS3.D: Energy in Chemical Processes** (pp. 128-130, NRC, 2012) ● The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. *(secondary to NJSLS-S-HS-LS2-5)*	

Connections to other DCIs in this grade-band:
HS.PS1.B (NJSLS-S-HS-LS1-5),(NJSLS-S-HS-LS1-6),(NJSLS-S-HS-LS1-7),(NJSLS-S-HS-LS2-3),(NJSLS-S-HS-LS2-5); **HS.PS2.B** (NJSLS-S-HS-LS1-7); **HS.PS3.B** (NJSLS-S-HS-LS1-5),(NJSLS-S-HS-LS1-7),(NJSLS-S-HS-LS2-3),(NJSLS-S-HS-LS2-4); **HS.PS3.D** (NJSLS-S-HS-LS2-3),(NJSLS-S-HS-LS2-4); **HS.ESS2.A** (NJSLS-S-HS-LS2-3); **HS.ESS2.D** (NJSLS-S-HS-LS2-5)

Articulation of DCIs across grade-bands:
MS.PS1.A (NJSLS-S-HS-LS1-6);**MS.PS1.B** (NJSLS-S-HS-LS1-5),(NJSLS-S-HS-LS1-6),(NJSLS-S-HS-LS1-7),(NJSLS-S-HS-LS2-3); **MS.PS3.D** (NJSLS-S-HS-LS1-5),(NJSLS-S-HS-LS1-6),(NJSLS-S-HS-LS1-7),(NJSLS-S-HS-LS2-3),(NJSLS-S-HS-LS2-4),(NJSLS-S-HS-LS2-5); **MS.LS1.C** (NJSLS-S-HS-LS1-5),(NJSLS-S-HS-LS1-6),(NJSLS-S-HS-LS1-7),(NJSLS-S-HS-LS2-3),(NJSLS-S-HS-LS2-4),(NJSLS-S-HS-LS2-5); **MS.LS2.B** (NJSLS-S-HS-LS1-5),(NJSLS-S-HS-LS1-7),(NJSLS-S-HS-LS2-3),(NJSLS-S-HS-LS2-4),(NJSLS-S-HS-LS2-5); **MS.ESS2.A** (NJSLS-S-HS-LS2-5); **MS.ESS2.E** (NJSLS-S-HS-LS1-6)

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (NJSLS-S-HS-LS1-6),(NJSLS-S-HS-LS2-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (NJSLS-S-HS-LS1-6),(NJSLS-S-HS-LS2-3)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (NJSLS-S-HS-LS1-6),(NJSLS-S-HS-LS2-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (NJSLS-S-HS-LS1-6)
SL.11-12.5	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. (NJSLS-S-HS-LS1-5),(NJSLS-S-HS-LS1-7)

Mathematics -

MP.2	Reason abstractly and quantitatively. (NJSLS-S-HS-LS2-4)
MP.4	Model with mathematics. (NJSLS-S-HS-LS2-4)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (NJSLS-S-HS-LS2-4)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (NJSLS-S-HS-LS2-4)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (NJSLS-S-HS-LS2-4)