Next Generation Science Standards Alignment

MISSION TO MARS (PHOTOSYNTHESIS)

Biology

High School Science

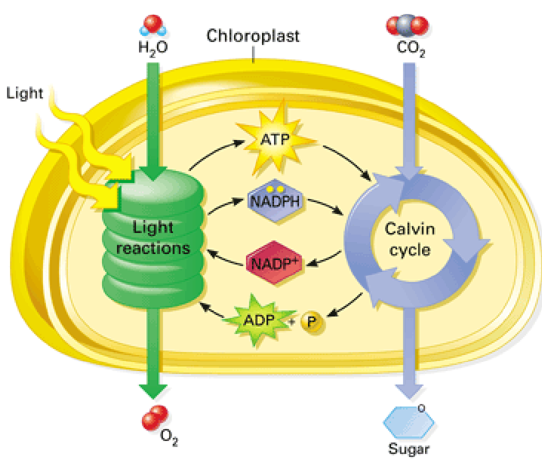

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TABLE OF CONTENTS

OVERVIEW
NPS NEXT GENERATION SCIENCE UNIT

The NPS science units require a contextual understanding of scientific knowledge, how it is acquired and applied, and how science is connected through a series of concepts that help further understanding of the world through the nexus of the three NGSS dimensions: (1) Science and Engineering Practices, (2) Crosscutting Concepts, and (3) Disciplinary Core Ideas. Performance expectations require students to demonstrate all three dimensions through contextual application of the three dimensions. Each unit includes goals (enduring understandings/essential questions/aligned standards), methods (varied instructional approaches, differentiated strategies/resources, scaffolded guiding questions), materials (inclusive of instructional supports - rubrics, teacher background information, common misconceptions, as well as multimedia materials), and assessment (a variety of methods and materials in order to determine learners' level of knowledge, skills, and engagement.)

The ***Mission to Mars*** unit begins with a summary followed by aligned standards, a culminating assessment overview, and the lesson pace and sequence. Each lesson constructs new ideas built on old ideas and addresses science misconceptions. Activities naturally integrate math and/or literacy CCSS for every lesson. Next Generation Science and Common Core language is infused so that the shifts are clear. Each lesson concludes with suggested modes of obtaining qualitative feedback (formative assessments) to determine whether students have met performance expectations and objectives of the lesson. This data should be used during class and/or teacher reflection to modify and elevate instruction.

The unit concludes with an effective performance task that places the student in an authentic learning experience. Students are given real world situations that require real world performance and/or products. The standards for acceptable performance are clearly articulated within the culminating assessment. Additionally, the accompanying aligned rubric specifically and clearly identifies criteria for proficiency, including sufficient guidance for interpreting student performance while requiring the evaluator to give effective feedback. Culminating assessments have a direct link to the unit performance expectations, essential questions, and enduring understandings. It, at minimum, requires students to:

- solve a problem (preferably through design) and design a solution
- analyze information
- develop and use data to communicate information
- use research to communicate their understanding (can be provided by teacher within the unit or obtained by student through independent research)
- emphasize engineering design performance expectations of the grade band

Newark Public Schools

Unit Summary

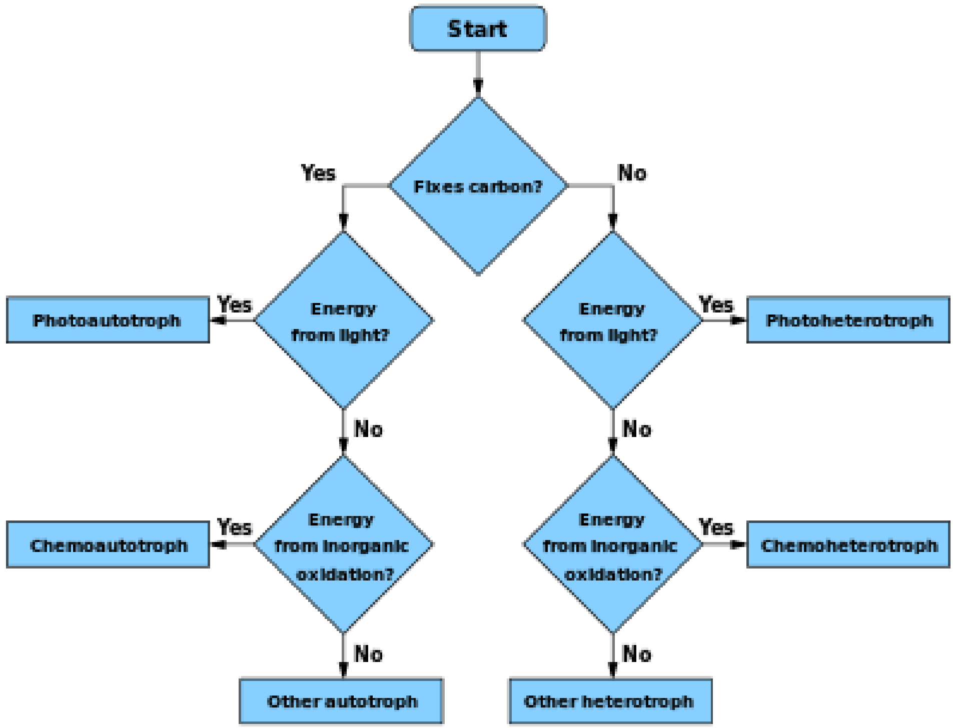
AUTHENTIC SCIENTIFIC INQUIRY ● COMMON CORE SHIFTS

Unit: Mission to Mars (Photosynthesis)
Content Area/ Target Course: Life Science/Biology
Grade Level: High School
Unit Summary: This unit focuses on the concept of photosynthesis. Through a series of learning episodes, students will construct a conceptual understanding of the process of photosynthesis and its role in the relationship between plants and animals. Students will ultimately be able to describe how animals rely on plants for their survival. In addition, students will have the opportunity to research the topics of Deforestation and Global Warming to provide a context for photosynthesis. **NGSS:** HS-LS1-5, HS-LS1-7, HS-LS2-1, HS-LS2-5, HS-ETS1-1, HS-ETS 1-4 **NJCCCS:** 5.3.12.A.1; 5.3.B.12.1,3,4; 5.3.12.C.1 **Primary Literacy Connections::** RI.9-10.1, 8; RST.9-10.1,3,7,9; RST.11-12.1,7-8; WHST.9-10.2,4,7-9; WHST.11-12.2,4,7,9; SL.9-10.4 **Primary Math Connections:**HSS-IC.2, HSS-IC.6, HSS-ID.5, HSS-ID.6
Culminating Assessment
Students are asked to view a scene from the movie, Mission to Mars, in which scientists on the rescue mission find their buddy, Luke, living successfully in a greenhouse on Mars. They must complete the following task: Imagine that you are one of those scientists, but when you arrive, you find the plants dying and Luke is having a difficult time breathing. You have 26 hours to figure out what is going wrong before the plants, Luke AND all of you die. The key is the plants…your task is to figure out why the plants are dying. In detail, recommend how to fix the problem in the greenhouse and develop a model of your solution. Students' final projects should: • demonstrate proficiency of the unit's enduring understandings • effectively solve the problem • demonstrate reasonable analysis of information • develop and use data to communicate information • use research to communicate their understanding emphasize engineering design performance expectations of the grade band

Lesson Pace & Sequence

PE/CPI	Lessons	Suggested Teaching Periods
Pre-Assessment 5.3.12.C.1 5.3.12.B.1 5.3.12.B.3	**Section A: Interactions and Interdependence - A Review** **Sample Lesson Activity:** **Assess Prior Knowledge:**Using the flowchart below and photo cards (Appendix D), have students: 1) Work in small groups to formulate a working definition of the terms autotroph and heterotroph. 2) Classify images of a variety of organisms as either autotrophs or heterotrophs based upon their definitions. 3) Compose a paragraph describing/detailing the relationships between autotrophs and heterotrophs. 4) Present their paragraphs orally.	1-2

Teacher Notes :



Literacy: Life's Greatest Inventions: Photosynthesis **Lexile:**1090

Sample CCSS Tasks:
Guiding Questions:

- How do plants (autotrophs) benefit animals (heterotrophs)?
- How do animals (heterotrophs) benefit plants (autotrophs)?
- How are plants (autotrophs) different from animals (heterotrophs)?

Life's Greatest Inventions: Photosynthesis

- What is the author's overall attitude towards photosynthesis?
- Using the text, create a Venn diagram comparing the types of life that existed on earth prior to photosynthesis and the types of life that existed after photosynthesis.
- Using the text in the article, write a word equation to describe the early version of photosynthesis.
- According to the article, how did the evolution of microbes that were able to utilize oxygen pave the way for the evolution of complex life and its colonization of land?

Suggested Formative Assessments

- Responses to reading materials
- Journals/ Responses to lesson activities
- Appropriate use of introductory terms
- Formal Assessments can be found in TG

Teacher Notes :

HS-LS1-5 HS-LS2-5 5.3.12.A.1 5.3.12.B.4 5.3.12.C.1	**Section B: Plants - An Overview** **Characteristics of Plants** **Sample Lesson Activity:** ▪ **Compare & Contrast:** Have students create a Venn diagram comparing and contrasting the structures of different plantspecimen. **Leaf Structure** **Sample Lesson Activities:** ▪ **Observe, Examine & Sketch:** Have students observe, examine under a microscope, and create labeled sketches of a variety of leaves. ▪ **Compare, Discuss & Hypothesize:** Have students compare their leaf sketches to a diagram of a leaf and discuss the function of each labeled part of the diagram and hypothesize its role in the process of photosynthesis. ▪ **Quick Lab: Have students examine stomata under a microscope using a simple technique involving clear nail polish.** ▪ **Using Models: Using Models: Have students use pairs of two elongated balloons to model the action of stomata. Have students draw diagrams showing how their balloon model is similar to the action of guard cells.** ▪ **Sense Making:** Have students construct a concept map that relates the structure of a leaf with its function. ▪ **Sense Making:** Have students review the structure and function of a leaf and use that information to write an operational definition that explains what a leaf is in their own words. **Plant Pigments** **Sample Lesson Activity:** ▪ **Plant Pigments Paper Chromatography Lab:** Have students complete True Colors - Plant Pigments (Appendix D) **Needs of plants** **Sample Lesson Activities:** **Assess Prior Knowledge:** Have students to recall their observations of patterns of plant growth in parks and backyards and make inferences about their observations. Facilitate a class discussion based upon their observations and inferences. **Applying Concepts: Have students grow their own seedlings. Challenge students to experiment with the presence/absence of specific plant requirements to observe their effects on growth. Note: Time must be allotted for students to care for and observe their plants.** **Problem Solving: Have students complete Plantastic Voyage** (Appendix D)	2

Teacher Notes :

	<u>Literacy</u>: In Living Color, **Lexile:** 1340, The Glory of Leaves, **Lexile:** 1120 **<u>Sample CCSS Tasks</u>:** **<u>Guiding Questions</u> :** ▪ *How does the structure of a leaf enable it to carry out photosynthesis?* ▪ *How does gas exchange take place in a leaf?* ▪ *Why are leaves green?* ▪ *What wavelengths of light are most important?* ▪ *What do plants need to survive?* ▪ *Where do plants get the energy they need to produce food?* In Living Color ▪ Explain what the author means by saying "Form rarely meets function so spectacularly as in our forests each autumn." ▪ Using the text, create a T-chart of the pro(s) and con(s) of elevated CO_2 levels to "autumnal senescence." ▪ Using the text, create a flowchart of the events that cause leaves to go from green to a "wide range of yellow, orange, and brown hues." ▪ Based upon current research, how does the author explain the two new theories that seek to answer the question of "why some trees manufacture the red pigments and others don't?" ▪ Using the text, create a diagram illustrating the recycling of nutrients within a forest. The Glory of Leaves ▪ Based on the text, how did chloroplasts evolve to their current state? ▪ What evidence does the author provide to support the claim that climate, competition and defense are the "evolutionary saws and scissors" that "can explain much of the diversity of leaves? ▪ What is the author's overall view of leaves? **<u>Suggested Formative Assessments</u>** • Laboratory Report • Responses to reading materials • Journals/ Responses to lesson activities • Appropriate use of terms • Formal Assessments can be found in TG	

Teacher Notes :

HS-LS1-5 HS-LS2-5 HS-LS1-7 5.3.12.B.4	**Section C: Photosynthesis - An Overview** **Sample Lesson Activities:** ▪ **Assessing Prior Knowledge:** Have students complete a Photosynthesis KWL (Appendix D) ▪ **Writing in Science:** Have students use the internet or library resources to research a historical photosynthesis experiment and its scientist(s) and write a summary describing how the experiment contributed to the modern understanding of photosynthesis. Completed summaries can be presented orally to the class. ▪ **Quick Lab:** Have students use a sprig of Elodea to investigate the process and products of photosynthesis. ▪ **Data Analysis:** Have students examine a light absorption graph for chlorophyll a and chlorophyll b and determine optimal regions of the color spectrum for each. ▪ **Sense Making:** Have students create a labeled drawing of the process of photosynthesis using the Photosynthesis Cast of Characters: http://www.explorebiology.com/documents/LE/Photosynthesis.pdf. ▪ **Sense making: Have students write a paragraph, using their own words, that explains how plants produce high-energy sugars through the process of photosynthesis.** ▪ **Make Connections: Have students create a two-column chart listing the parts of leaf (from their sketch or a diagram) and a description of its specific role in the process of photosynthesis.** ▪ **Sense Making:** Have students review the lyrics and perform Rock and Roll of Photosynthesis. (Appendix D) Literacy: Photosynthesis **Lexile:** 1430 **Sample CCSS Tasks:** Guiding Question(s): ▪ What is the overall equation for photosynthesis? ▪ What is the role of light and chlorophyll in photosynthesis? Photosynthesis ▪ Using the textual evidence from the article, identify and list at least two types of organisms that are able to perform photosynthesis besides plants. ▪ According to the author, why is “water-splitting” photosynthesis “by far the most complex” version of photosynthesis?	2

Teacher Notes :

	Suggested Formative Assessments • KWL Chart • Laboratory Report • Responses to reading materials • Writing Assignment • Journals/ Responses to lesson activities • Appropriate use of terms • Formal Assessments can be found in TG	
HS-LS1-5 HS-LS1-7 HS-LS2-1 HS-LS2-5 5.3.12.A.1 5.3.12.B.4	**Section D: Photosynthesis - In-Depth** **Sample Lesson Activities:** ▪ **Compare & Contrast: Have students create a Venn diagram of the relationships among grana, thylakoids, photosystems and the stroma in a chloroplast and their roles in the process of photosynthesis.** ▪ **Making Connections: Have students draw and label a diagram that answers the following questions: 1) Where within the structure of a leaf does each stage/reaction of photosynthesis occur? 2) How does the structure of a leaf allow it to obtain energy and materials for photosynthesis?** **Light-Dependent Reactions** **Sample Lesson Activities:** ▪ **Make Connections: Have students discuss work in small groups to respond to the following questions: 1) Does light radiate in waves or particles? 2) What process do you think is most responsible for the increase in percentage of oxygen in the atmosphere over time? Facilitate a whole class discussion based upon students' responses.** ▪ **Experiment: Have students observe two healthy potted plants and have them predict what would happen to one of the plants if it did not receive any light for a week. Conduct an experiment to test their predictions.** ▪ **Demonstration:** Have students complete The Flying Photosynthetic Circus (Appendix D) **Calvin Cycle (Light-Independent Reactions)** **Sample Lesson Activities:** ▪ **Research and Present:** Have students research the biochemical discovery of Melvin Calvin and prepare a presentation to explain how Calvin used Carbon-14 to identify the sequence of light-independent reactions in photosynthesis. ▪ **Sketch, Label & Annotate:** Have students create a labeled sketch of the Calvin cycle with detailed annotations for each step. ▪ **Read & Respond:** Have students complete Calvin Cycle (Light	5

Teacher Notes:

Independent Reactions of Photosynthesis) after reading information from their textbook. (Appendix D)

Light-Dependent Reactions and the Calvin Cycle
Sample Lesson Activities:

- **Compare & Contrast: Have students compare the reactants and products of the light-dependent reactions and the Calvin cycle.**
- **Sense Making: Have students construct a flowchart that illustrates the steps of photosynthesis with as much detail as possible.**
- **Sense Making:** Have students imagine that they are an oxygen atom and two of their friends are hydrogen atoms, together making up a water molecule. Have students describe the events and changes that happen to them and their friends as they journey through the light-dependent and Calvin cycle of photosynthesis. Descriptions should include illustrations.

Literacy: Plants in Candyland, **Lexile:** 1130

Sample CCSS Tasks:
Guiding Questions :

- How do plants convert light energy into chemical energy?

Plants in Candyland

- What does the author mean when he says that sunlight "is not homogenous?"
- Using the text, create a sketch of a chlorophyll molecule based on the description provided within the text.
- How does the author explain the analogy of a plant to a quantum computer?

Suggested Formative Assessments

- Laboratory Report
- Responses to reading materials
- Journals/ Responses to lesson activities
- Appropriate use of terms
- Formal Assessments can be found in TG

Teacher Notes :

HS-LS1-5 HS-LS1-7 HS-LS2-1 HS-LS2-2 HS-LS2-5 5.3.12.B.4	**Section E: Factors Affecting Photosynthesis** **Sample Lesson Activities:** ▪ **Data Analysis: Have students analyze multiple graphs of the rates of photosynthesis of plants under varying conditions (i.e. light intensity, CO_2 levels, and temperature) and draw conclusions about the effects of various factors.** ▪ **Interview & Report: Have students interview a staff member at a local arboretum, conservatory, nursery, etc. about factors that limit or enhance plant growth and make an oral report about their findings.** ▪ **Design an Experiment:** Have students design and conduct an experiment investigating how different colors of light affect starch synthesis during photosynthesis. **Research & Present: Have students complete the Photosynthesis Research Project on their own time and make oral presentations.** (Appendix D) Literacy: A Desert Shrub's Crystallized Protein Sheds Light on Photosynthesis **Lexile:** 1300, Red Means Grow **Lexile:** 1110 **Sample CCSS Tasks:** **Guiding Questions:** ▪ What factors affect the rate at which photosynthesis takes place? A Desert Shrub's Crystallized Protein Sheds Light on Photosynthesis ▪ According to the author, what is the role of rubisco in the process of photosynthesis? ▪ What does the author say about why plants stop growing in high temperatures? ▪ Based on the article, why is crystallization significant to the study of proteins? ▪ According to the author, why was creosote chosen for the study described in the text? ▪ In a follow-up investigation, besides the desert, what other location does the author suggest to look for an activase? Red Means Grow ▪ Using the text, explain why "Red Means Grow." ▪ Take a position on the impact of humans on the rainforest. Cite evidence from the text to support your position. ▪ In the undisturbed rainforest, what encourages more growth, the amount of sunlight or the amount of rain? Justify your response with textual evidence.	5

Teacher Notes :

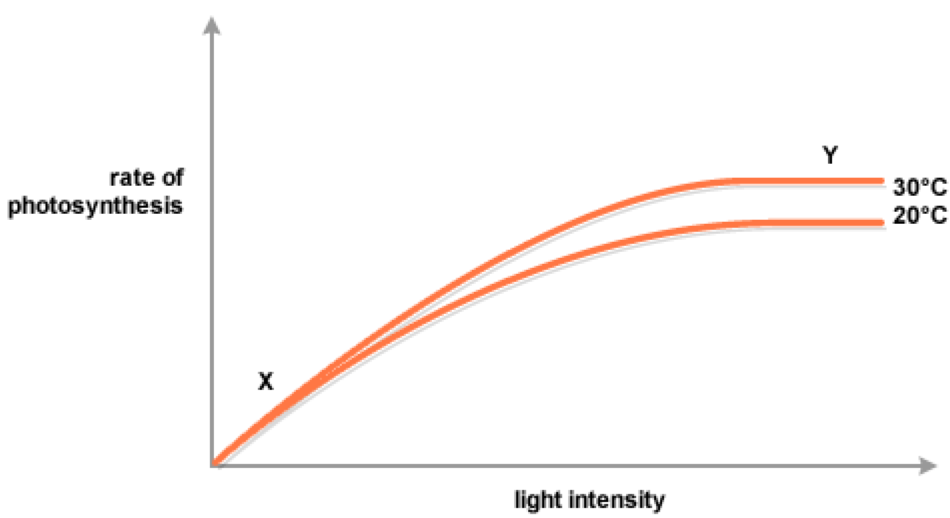
Mathematics: Measuring the Rate of Photosynthesis: The Floating Leaf Disk Assay for Investigating Photosynthesis
http://www.elbiology.com/labtools/Leafdisk.html
HSS-ID.6, HSS-IC.2
Limiting Factors of Photosynthesis
http://www.bbc.co.uk/bitesize/higher/biology/cell_biology/photosynthesis/revision/5/

The Limiting Factors of Photosynthesis

There are three main limiting factors in photosynthesis:

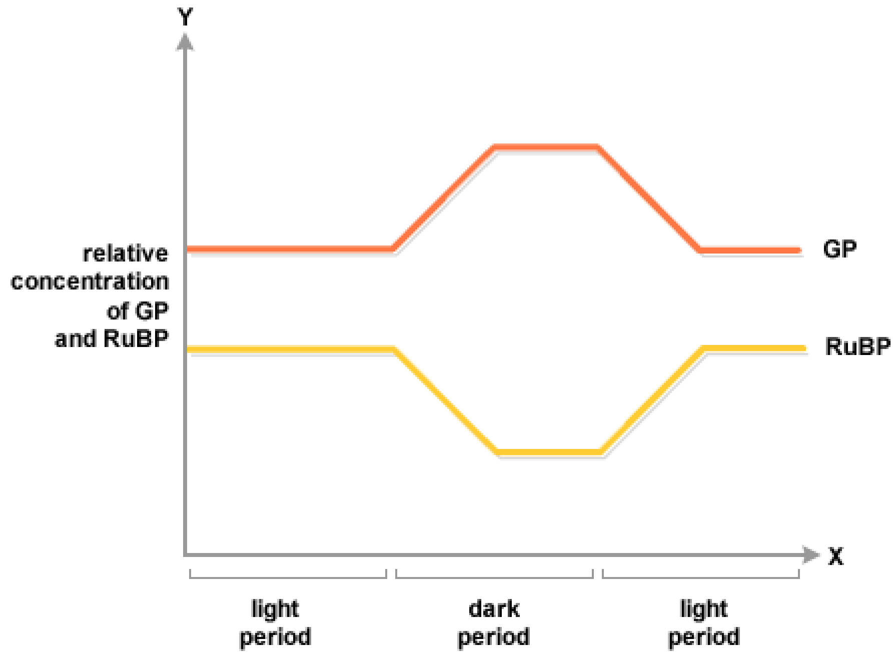
- Lack of carbon dioxide: If there is no carbon dioxide available RuBP cannot be converted into GP. As a result, the RuBP starts to build up and no more glucose will be produced.
- Low temperatures: These limit photosynthesis since the enzymes controlling the reactions are below their optimum temperature.
- Lack of light: In the absence of light neither the ATP or the $NADPH_2$ will be produced and so the GP cannot be converted into glucose. This results in the GP building up and the RuBP being used up.

Demonstrate your understanding of limiting factors of photosynthesis by analyzing the data below and answering the following questions:



- What is the factor which is limiting the rate of photosynthesis at point X on the graph?
- Account for the increase in the rate of photosynthesis when the temperature is raised from 20 degrees C to 30 degrees C.
- Name an environmental factor other than temperature which may be limiting the rate at point Y.

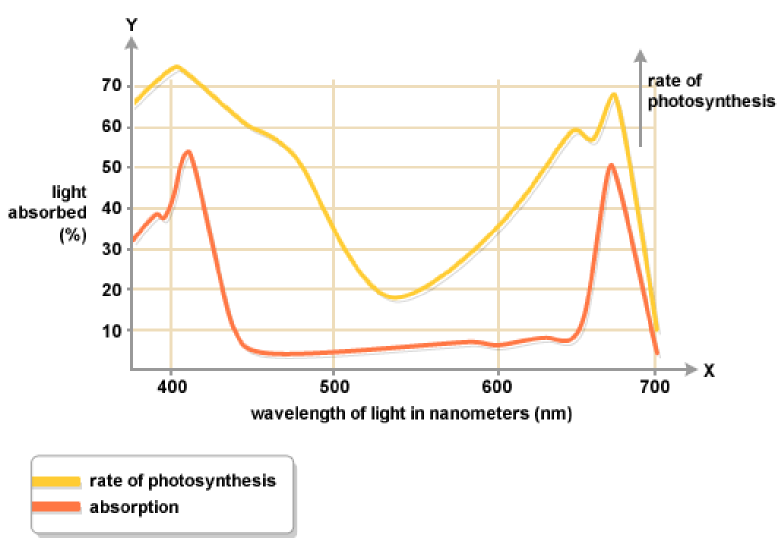
Teacher Notes:



What evidence from the graph supports the statement that GP can be converted to RuBP in the light?

The graph shows the absorption spectrum of chlorophyll a and the rate of photosynthesis over the same range of wavelengths.

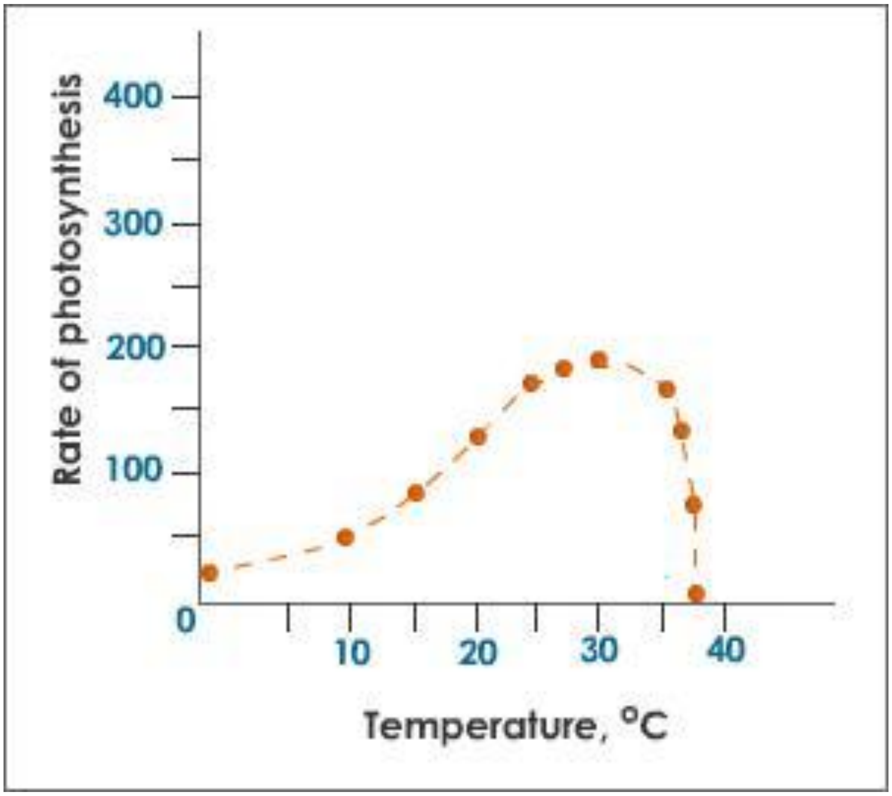
Absorption and Action Spectra



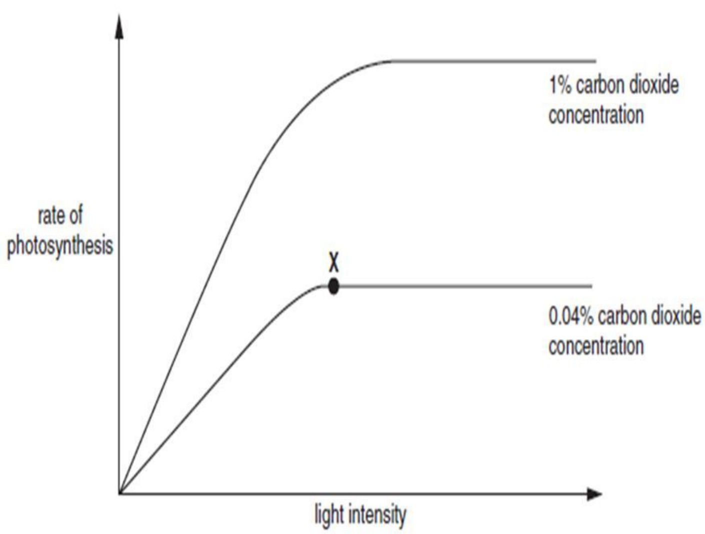
Teacher Notes:

What evidence on the graph indicates that chlorophyll a is not the only pigment involved in photosynthesis?

Rate of Photosynthesis



What can you infer from the data presented in the graph above?
HSS-IC.B.6



Teacher Notes:

	The graph shows how the rate of photosynthesis in a plant varies with light intensity at two different carbon dioxide concentrations. The temperature is keptconstant at 20 °C. Which factor is limiting the rate of photosynthesis at point **X**? HSS-ID.5 **Suggested Formative Assessments** • Investigative Project • Responses to reading materials • Journals/ Responses to lesson activities • Appropriate use of introductory terms • Formal Assessments can be found in TG	
HS-LS1-5 HS-LS1-7 HS-LS2-1-5 HS-ETS1-1 HS-ETS 1-4	**Putting It All Together** Sample Culminating Assessment: Students are asked to view a scene from the movie, Mission to Mars, in which scientists on the rescue mission find their buddy, Luke, living successfully in a greenhouse on Mars. They must complete the following task: Imagine that you are one of those scientists, but when you arrive, you find the plants dying and Luke is having a difficult time breathing. You have 26 hours to figure out what is going wrong before the plants, Luke AND all of you die. The key is the plants…your task is to figure out why the plants are dying. In detail, recommend how to fix the problem in the greenhouse and develop a model of your solution. Students' final projects should: • demonstrate proficiency of the unit's enduring understandings • effectively solve the problem • demonstrate reasonable analysis of information • develop and use data to communicate information • use research to communicate their understanding • emphasize engineering design performance expectations of the grade band	2

Bolded lessons identify areas of important relevance for the culminating assessment.

Resources: Holt Biology,Holt, Rinehart, and Winston.
Internet Resources
Photosynthesis Podcast:http://youtu.be/g78utcLQrJ4
Dawn of the Plantimals
Supercrops!
Additional Text Selections: Tweaking Photosynthesis, The Color of Plants on Other Worlds, The Artificial Leaf, Sun + Water = Fuel, Hydrogen Fuel Edges a Bit Closer
Lexile Analyzer: www.lexile.com
Sample Quiz Questions: ***http://www.proprofs.com/quiz-school/story.php?title=plant-revision***

Teacher Notes:

Teacher Notes: The lesson titles and sample activities are meant to serve as examples of how teachers can move students towards mastery of the identified standard(s). Many of the activities can be done in class or for homework. Teachers can select and modify according to the needs of their students.

Prompt Guiding Questions: Present the guiding questions to the students at the end of section A for section A only. For each additional section, at appropriate times, present guiding questions so that students do not solely focus on the answers to all questions at once. Continue to monitor student progress and mastery by assessing their answers to guiding questions and activities.

Science Misconceptions: In high school, the following misconceptions may still persist among students:

- Plants get their food from the environment rather than manufacturing it internally. Food for plants is taken in from the outside.
- Soil supplies most of the “raw materials” for photosynthesis. (Students have difficulty accepting that plants make food from water and air and that this is their only source of food)
- Water and minerals are food for plants.
- Soil is the plant’s food. People put food (fertilizer) in the soil for plants to eat.
- Respiration and photosynthesis are not seen as energy transfer processes.
- Plants take their food in through the roots and then store it in their leaves. Plants convert energy from the sun directly into matter.
- Plants change water and carbon dioxide into sugar (instead of plants convert carbon dioxide from air and hydrogen atoms from water into sugar.
- Plants only give off oxygen.
- Photosynthesis is a plant process and respiration is an animal process.

Photosynthesis Research Project: The topics of Deforestation and Global Warming can be discussed during this unit to provide a context for photosynthesis. It is important to address the question most students ask (“why do I need to know this?”) in a way that provides an application of photosynthesis that is relevant to their everyday lives. These topics relate very closely to photosynthesis and are social topics that are often discussed in the media. By exposing the students to the scientific background of these issues the students will gain a better understanding of the issues, therefore enabling them to give a rationale for their stance on these political issues. These skills prepare them to be thoughtful and critical members of society.

Student Self-Assessment Suggestions: 1) After guidance, have students create peer editing checklists and/or a self-assessment checklist for the culminating activity (rubric is provided.) Ensure that the students focus on asking questions about specific points, such as the presence of examples to support the ideas discussed or written. 2) Have students reflect on previous understandings after laboratory activities or pre-post assessment activities. 3) Have students begin a portfolio of their work.

Differentiated Instructional Strategies: Lexile leveled material/resources should be adapted for individual student’s needs. Higher level lexile articles may require teacher assistance. ELL& special needs students may benefit from pictorial representation of vocabulary and concepts.

Teacher Notes :

Unit Vocabulary

Vocabulary terms cannot be introduced until students have achieved conceptual understanding. Teachers should teach the concepts without the technical language and then only add technical language AFTER the students have an idea to hang it on. Technical terms must be "labeled" after inquiry based activities and in conjunction with student conceptual understanding as STC lesson structure indicates (constructivist approach to teaching science/7E model.) (http://www.project2061.org/publications/designs/ch7intro.htm) **Students must be required to use technical language after "labeling" in order to reinforce their understanding of concepts and content thereby making communication easier.**

Vocabulary		
Autotroph	Spongy Mesophyll	Thylakoid
Heterotroph	Stoma (Stomata)	Photosystem
Adenosine Triphosphate	Guard Cell	Stroma
(ATP)	Photosynthesis	$NADP^+$
Angiosperm	Pigment	Light-dependent Reactions
Mesophyll	Chlorophyll	ATP Synthase
Palisade Mesophyll	Grana (Granum)	Calvin Cycle

Sample CCSS Culminating Assessment

Mission to Mars

1. Task Context

View clip from *Mission to Mars:* http://youtu.be/vPME0VssWqY (Suggested Start: 1:30; Suggested End: 8:00)

2. Task Explanation

You have just seen a scene from the movie, Mission to Mars, in which scientists on the rescue mission find their buddy, Luke, living successfully in a greenhouse on Mars. Imagine that you are one of those scientists, but when you arrive, you find the plants dying and Luke is having a difficulttime breathing. You have 26 hours to figure out what is going wrong before the plants, Luke AND all of you die. The key is the plants…your task is to figure out why the plants are dying.

3. Hypothesize

Hypothesis: What could cause the plants to die that also makes it difficult for Luke to breathe.
The answer can include anything, but the explanation must make sense.

4. Data Review

While you have been hypothesizing about what could go wrong, your colleague has been doing research and has found the environmental data that Luke has been collecting over the past two weeks. Examine the data provided. Then follow the directions to complete your task and save the plants and your lives!

Table 52: Week 52 in Mars Greenhouse

Environmental data at 12:00 p.m. (noon)…all seems normal.

Temp. (°C)	Light (nm)	CO2 (%of air)	Water intake rate	Stomatal opening factor	Photosynthesis rate
25	1500	0.03	1.0	1.0	100
25	1500	0.03	1.0	1.0	100
25	1500	0.03	1.0	1.0	90
25	1500	0.03	0.9	1.0	100
25	1500	0.03	0.9	0.9	90
25	1500	0.03	0.8	0.9	90
25	1500	0.03	0.8	0.8	80

Table 53: Week 53 in Mars Greenhouse

Environmental data at 12:00 p.m. (noon)…Something is wrong.

Note from Luke: I don't think the urine/water recycler is working properly…need to check that out.

Temp. (°C)	Light (nm)	CO2 (%of air)	Water intake rate	Stomatal opening factor	Photosynthesis rate
25	1500	0.03	0.8	0.9	70
25	1500	0.03	0.6	0.8	50
25	1500	0.03	0.5	0.6	30
25	1500	0.04	0.5	0.4	20
25	1500	0.06	0.4	0.2	10
25	1500	0.08	0.3	0.1	0
25	1500	0.1	0.1	0.1	0

5. Data Analysis

For each of the columns in Tables 52 and 53, write a sentence which describes the trend of the data.

Example: *"The temperature in the greenhouse remained constant at 25°C for weeks 52 and 53."*

- Light:
- CO2:
- Water intake:
- Stomatal opening factor:
- Photosynthesis rate:

6. Graphing

On the graph paper provided, graph the data of the photosynthetic rate and one other factor which YOU think is affecting the photosynthetic rate. Each graph should have a title, labeled axis and a key.

7. Explanation of the Problem

Having examined the data, reassess your hypothesis and determine whether or not it was accurate or if it should be revised. Make a statement of your inferences as to what is killing the plants. Fully describe the factor(s), primary and secondary, causing the plant death and Luke's breathing problem. Be sure to support this with data; reference the data tables provided and the graphs you created. Write a detailed explanation of how the factor(s) affects the photosynthetic rate. Include as much detail as you can on the process of photosynthesis.

8. Proposed Solution to the Problem

In detail, recommend how to fix the problem in the greenhouse, explain why you came to those conclusions and develop a model of your solution.

Mission to Mars
Rubric

	4	3	2	1
Data Analysis	• Accurately describes trends for both week of data • Trends are supported with specific numeric data • All factors are described fully and correctly	• Accurately describes trends for one or both weeks • Trends are supported with general data • Factors are described correctly	• Trends for both weeks are discussed • Trends are not supported with data • Some factors are correctly described	• Incorrect trends are discussed OR trends not discussed at all • Trends not supported with data OR supported with incorrect data • Most factors described incorrectly
Graphs	• PS rate plotted accurately • Correct Factor Plotted • Title and axis labeled properly on both graphs	• PS rate plotted accurately • Related Factor Plotted • Title and axis labeled properly on both graphs	• PS rate plotted • Incorrect factor plotted • Title or label may be missing on one graph	• PS rate plotted incorrectly • Incorrect factor plotted • Title or label may be missing on one or both graphs
Explanation & Proposed Solution	• Factor(s) causing plant death and Luke's breathing problem is fully described and supported with data • Detailed explanation of how factor affects PS rate • Details of PS process are included • Recommendation to fix the greenhouse problem is correct • Reasoning behind the proposed solution is entirely scientifically accurate • Model of solution is appropriate and scientifically accurate	• Factor(s) causing plant death and Luke's breathing problem is identified and supported with data • Explanation of how factor affects PS rate is included • Some details of PS process are stated, but needs clarification • Recommendation to fix greenhouse problem is related to the actual correction needed. • Reasoning behind the proposed solution is mostly scientifically accurate • Model of solution is appropriate, but not entirely scientifically accurate	• Factor(s) causing plant death and Luke's breathing problem is stated, but not supported with data • Explanation of how factor affects PS rate is limited • Details of PS process are missing OR limited • Recommendation for correction is misleading • Reasoning behind the proposed solution contains some scientific inaccuracies. • Model of solution is scientifically inaccurate	• Factor(s) causing plant death and Luke's breathing problem is not clearly identified OR incorrectly identified • Explanation of how factor affects PS rate is incorrect • Details of PS process are incorrect or missing • Recommendation is incorrect or missing • Reasoning behind the proposed solution is scientifically inaccurate or missing • Model of solution is inappropriate or missing

Teacher Feedback:	

APPENDIX A –Unit Framework

Unit: Title of Unit		
Content Area/Target Course: Science content around which the unit's standards are primarily aligned; grade level of the unit; primary unit content		
Grade Level: Grade band by which the unit is aligned		
Unit Summary: Includes a clear and explicit purpose for instruction that builds students' ability to reason in a scientific context through engagement in authentic work of the science disciplines and the practices of science and engineering of the unit. Next Generation Science Standards alignment is evident. **NGSS:** Primary alignment to Next Generation Science Standards **NJCCCS:** Primary alignment to 2009 NJ State Standards for Science **Primary Literacy Connections:** Primary alignment to ELA Common Core State Standards **Primary Math Connections:** Primary alignment to Math Common Core State Standards		
Culminating Assessment		
An effective performance task places the student in authentic learning experiences. Students are given real world situations that require real world performance and/or products. The standards for acceptable performance are clearly articulated within the culminating assessment. Additionally, the accompanying aligned rubric specifically and clearly identifies criteria for proficiency, including sufficient guidance for interpreting student performance while requiring the evaluator to give effective feedback. Culminating assessments have a direct link to the unit performance expectations, essential questions, and enduring understandings.It should, at minimum, require students to: • solve a problem (preferably through design) and design a solution • analyze information • develop and use data to communicate information • use research to communicate their understanding (can be provided by teacher within the unit or obtained by student through independent research) • emphasize engineering design performance expectations of the grade band		
Lesson Pace & Sequence		
PE/CPI	**Lessons**	**Suggested Teaching Periods**
Performance Expectations/ Cumulative Progress Indicator	• Construct new ideas on top of old ideas (provide sequence) and address science misconceptions. • Naturally integrate math and/or literacy CCSS for every lesson. • InfuseNGSS and common core language so that the shifts are clear. • Suggested modes of receiving qualitative feedback (formative assessments) used to determine whether students have met performance expectations and objectives of the lesson. This data should be used during class and/or teacher reflection to modify and elevate instruction.	Suggested pacing based on a 40 minute class period
<u>Unit Vocabulary</u>		
Vocabulary terms cannot be introduced until students have achieved conceptual understanding. Teachers should teach the concepts without the technical language and then only add technical language ***<u>after</u>*** the students have an idea to hang it on. Technical terms must be "labeled" after inquiry based activities and in conjunction with student conceptual understanding as STC lesson structure indicates (constructivist approach to teaching science/7E model.) (http://www.project2061.org/publications/designs/ch7intro.htm) Students must be required to use technical language after "labeling" in order to reinforce their understanding of concepts and content thereby making communication easier.		

APPENDIX B –Unit Next Generation Science Standards& Common Core Standards

Performance Expectations (PE)
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.] **HS-LS1-5**
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.] **HS-LS1-7**
Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, or population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.] **HS-LS2-1**
Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.] **HS-LS2-2**
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.] **HS-LS2-3**
Use a mathematical representation 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.] **HS-LS2-4**
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.] **HS-LS2-5**
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. (Analyze complex real-world problems by specifying criteria and constraints for successful solutions.) **HS-ETS1-1**
Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.) **HS-ETS1-4**
NGSS Disciplinary Core Ideas
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. (**HS-LS1-5**) As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (**HS-LS1-6**),(**HS-LS1-7**) As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another and

APPENDIX B –Unit Next Generation Science Standards & Common Core Standards

release energy to the surrounding environment and to maintain body temperature. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. (**HS-LS1-7**)

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. (**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, 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. (**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. (**HS-LS2-5**)

PS3.D: Energy in Chemical Processes

The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to **HS-LS2-5**)

LS2.A: Interdependent Relationships in Ecosystems

Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (**HS-LS2-1**),(**HS-LS2-2**)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (**HS-LS2-2**),(**HS-LS2-6**)

NGSS Science and Engineering Practices

Developing and Using Models

Use a model based on evidence to illustrate the relationships between systems or between components of a system. (**HS-LS1-5**),(**HS-LS1-7**)

Develop a model based on evidence to illustrate the relationships between systems or components of a system. (**HS-LS2-5**)

Using Mathematics and Computational Thinking

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. (**HS-LS2-4**)

Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (**HS-LS2-1**)

Constructing Explanations and Designing Solutions

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. (**HS-LS1-6**),(**HS-LS2-3**)

APPENDIX B –Unit Next Generation Science Standards& Common Core Standards

Connections to Nature of Science

Scientific Knowledge is Open to Revision in Light of New Evidence

Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (**HS-LS2-3**)

Engaging in Argument from Evidence

Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (**HS-LS2-6**)

Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (**HS-LS2-8**)

Constructing Explanations and Designing Solutions

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.

Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (**HS-ETS1-2**)

Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (**HS-ETS1-3**)

NGSS Cross Cutting 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-LS2-5**)

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. (**HS-LS1-5**), (**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.(**HS-LS1-7**),(**HS-LS2-4**)

Energy drives the cycling of matter within and between systems. (**HS-LS2-3**)

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-LS2-8**),(**HS-LS2-6**)

Scale, Proportion, and Quantity

The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (**HS-LS2-1**)

Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (**HS-LS2-2**)

Stability and Change

Much of science deals with constructing explanations of how things change and how they remain stable. (**HS-LS2-6**),(**HS-LS2-7**)

NJCCCS	Content Statements
5.3.C.12.1 5.3.B.12.1 5.3.B.12.3 5.3.B.12.4 5.3.A.12.1	▪ Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms. ▪ As matter cycles and energy flows through different levels of organization within living systems (cells, organs, organisms, communities), and between living systems and the physical environment, chemical elements are recombined into different products. ▪ Continual input of energy from sunlight keeps matter and energy flowing through ecosystems. ▪ Plants have the capability to take energy from light to form sugar molecules containing carbon, hydrogen, and oxygen. ▪ Cells are made of complex molecules that consist mostly of a few elements. Each class of molecules has its own building blocks and specific functions.

APPENDIX B –Unit Next Generation Science Standards & Common Core Standards

	•
CPI#	**Cumulative Progress Indicator (CPI)**
5.3.12.A.1	Represent and explain the relationship between the structure and function of each class of complex molecules using a variety of models.
5.3.12.B.1	Cite evidence that the transfer and transformation of matter and energy links organisms to one another and to their physical setting.
5.3.12.B.3	Predict what would happen to an ecosystem if an energy source was removed.
5.3.12.B.4	Explain how environmental factors (such as temperature, light intensity, and the amount of water available) can affect photosynthesis as an energy storing process.
5.3.12.C.1	Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem.
CCSS	**Common Core Literacy Standards**
RI.9-10.1	Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
RI.9-10.8	Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient to identify false statements and fallacious reasoning.
RST.9-10.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
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.
RST.9-10.3	Follow precisely a complex multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
RST.11-12.7	Integrate and evaluate multiple sources of information present in diverse formats and media in order to address a question or solve a problem.
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
WHST.9-12.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
WHST.9-12.7	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.9-10.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research.
SL.9-10.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

APPENDIX B –Unit Next Generation Science Standards & Common Core Standards

CCSS	Common Core Math Standards
HSS-IC.2	Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. *For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model*?
HSS-IC.6	Evaluate reports based on data.
HSS-ID.5	Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
HSS-ID.6	Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.

APPENDIX B –Unit Next Generation Science Standards & Common Core Standards

Performance Expectations (PE)
Performance expectations simply clarify the expectations of what students will know and be able to do be the end of the unit grade band. Additionally, they include a student's ability to apply a practice to content knowledge; thereby focusing on understanding and application as opposed to memorization of facts devoid of context. (NGSS Appendix A, p. 1)
NGSS Disciplinary Core Ideas (DCIs)
Specifically, a core ideas for K-12 science instruction should: 1. Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline. 2. Provide a key tool for understanding or investigating more complex ideas and solving problems. 3. Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge. 4. Be teachable and learnable over multiple grades at increasing levels of depth and sophistication. That is, the idea can be made accessible to younger students but is broad enough to sustain continued investigation over years. (NGSS Appendix A, p. 3)
NGSS Science and Engineering Practices (SEPs)
Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science. Participation in these practices also helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students' knowledge more meaningful and embeds it more deeply into their worldview. The eight practices of science and engineering that the Framework identifies as essential for all students to learn and describes in detail are listed below: 1. Asking questions (for science) and defining problems (for engineering) 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations (for science) and designing solutions (for engineering) 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information (NGSS Appendix F, p. 1-2)
NGSS Cross Cutting Concepts (CCCs)
Crosscutting concepts have value because they provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas. (Framework p. 233) 1. ***Pattern:***Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them. 2. ***Cause and effect:*** *Mechanism and explanation*. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts. 3. ***Scale, proportion, and quantity:*** In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

APPENDIX B –Unit Next Generation Science Standards & Common Core Standards

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.
5. ***Energy and matter:*** *Flows, cycles, and conservation.* Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. ***Structure and function.***The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. ***Stability and change:*** 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. (NGSS Appendix G, p. 1)

APPENDIX B –Unit Next Generation Science Standards & Common Core Standards

NJCCCS	**Content Statements**
Standard/Strand	New Jersey's Core Curriculum Content Standards (CCCS) describe expectations for all students by the end of a variety of grades and in different subjects. They are the road map that guides the development of each district's curriculum and the State's standards-based assessments.
CPI#	**Cumulative Progress Indicator (CPI)**
Standard/Strand/ Indicator	The cumulative progress indicators (CPIs) break the CCCS into smaller grade groupings to better guide expectations and judge progress. Consequently, the CPIs for each subject and grade are good barometers to assess each student's progress in the general education curriculum and identify academic strengths and weaknesses.

CCSS	**Common Core ELA Standards**
Anchor Standard and Strand	Unit primary literacy options that: • give students the lens of language with which to focus and clarify their thinking. • allow students to extend their learning beyond the classroom, presenting them with relevant, challenging, age-appropriate reading selections and research activities with which they can enhance literacy skills.
CCSS	**Common Core Math Standards**
Anchor Standard and Strand	Unit primary math options that: • provide a focus and coherence of math standards stressing conceptual understanding of key ideas that naturally integrate within the unit.

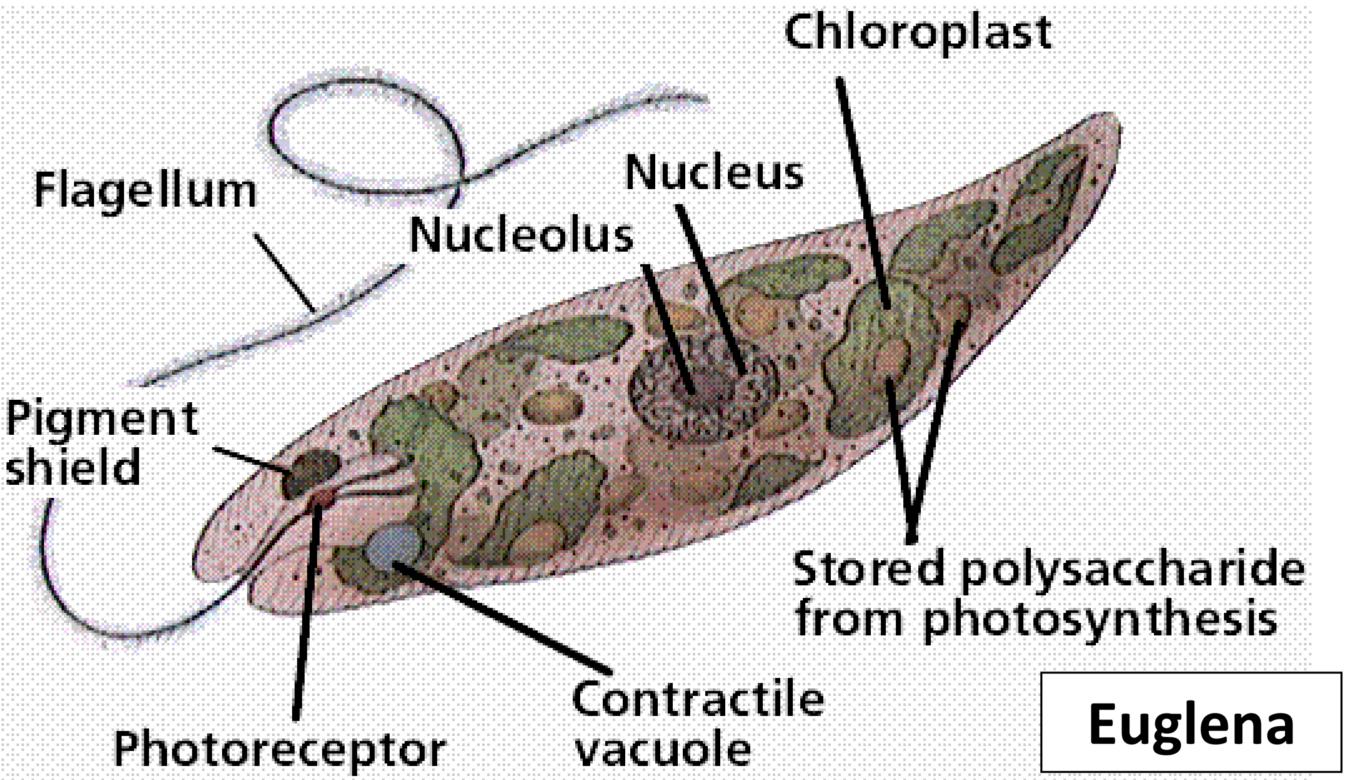
APPENDIX C –Unit Essential Questions & Enduring Understandings

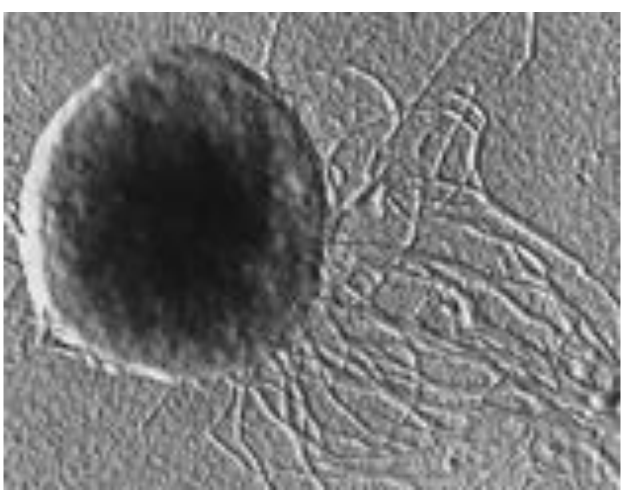
Unit Essential Questions	Unit Enduring Understandings
▪ What do all living things have in common? ▪ How is matter transformed, and energy transferred/transformed in living systems? ▪ In what ways do organisms interact within ecosystems?	▪ Living organisms have a variety of observable features that enable them to obtain food and reproduce. ▪ All organisms transfer matter and convert energy from one form to another. ▪ All animals and most plants depend on both other organisms and their environments for their basic needs.

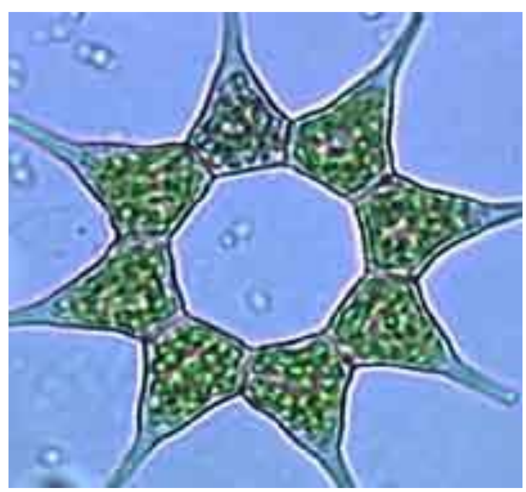
Unit Essential Questions	Unit Enduring Understandings
Designed to engage student interest, promote and guide inquiry into the important ideas of the unit. Essential questions: • Have no simple "right" answer. • Address conceptual or philosophical foundations. • Can be differentiated to meet student needs. • Raise other important questions. • Naturally and appropriately recur. • Stimulate vital, ongoing discussion and rethinking.	Frame the big ideas that give meaning and importance to the unit elements. Enduring understandings: • Summarize the core processes and relevant ideas that are central to the unit. • Have lasting value beyond the classroom. • Unpack areas of the unit where students may struggle to gain understanding or demonstrate misunderstandings and misconceptions.

APPENDIX D–Activity Pages

Section A Photocards







***Venenivibrio stagnispumantis*–**From the

Protists - Many protists appear to be both plant

Kingdom Eubacteria,needs certain gases and specific temperaturesto obtain energy for growth and development.

and animal. Like plants, they are green, and can create their own food. However, like animals, they have moving body parts and are able to move around their environments.

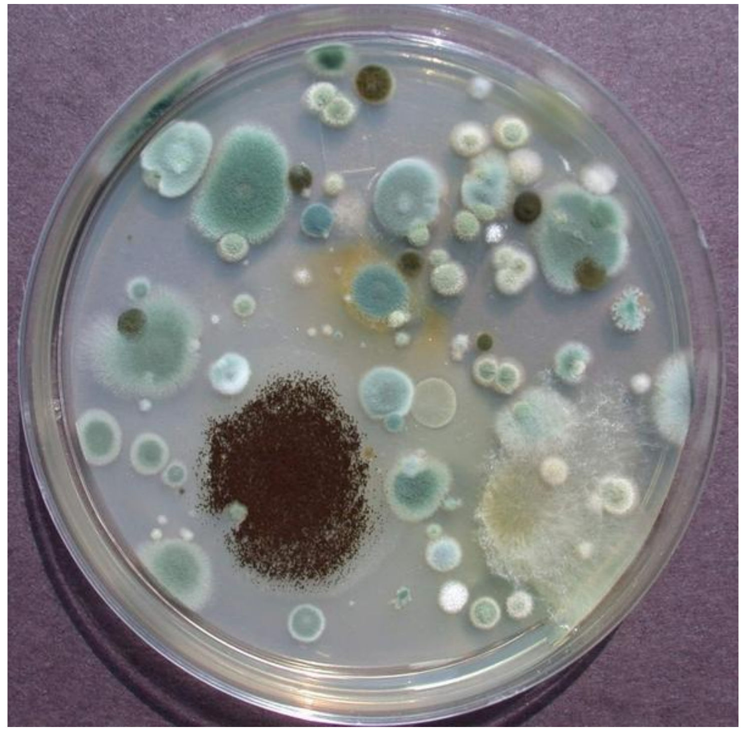
APPENDIX D–Activity Pages

Fungi

Kingdom Animalia

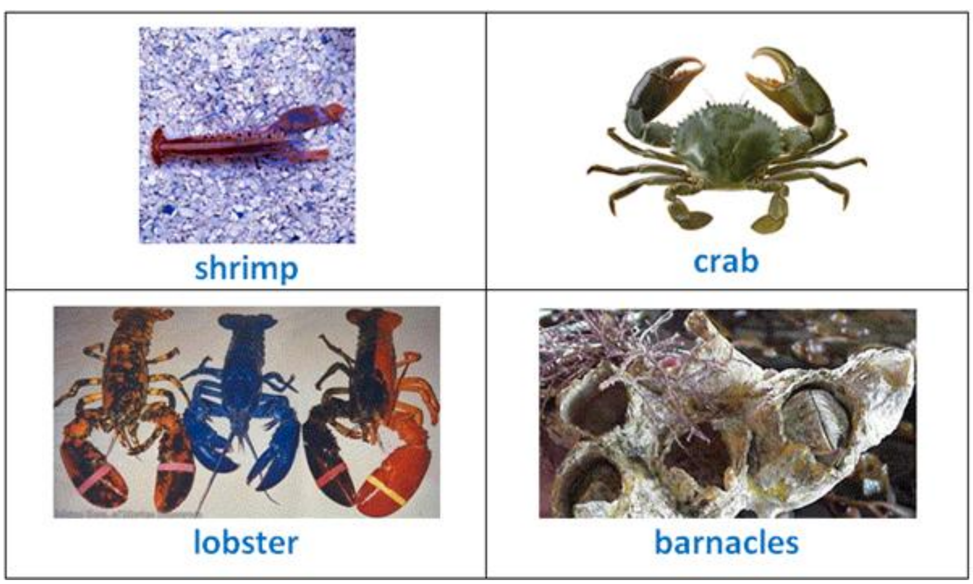
Venus Flytrap- The Venus flytrap (*Dionaeamuscipula*) is probably the best known of the more than 600 species of carnivorous plants, which absorb nutrients from prey rather than through their roots.

APPENDIX D–Activity Pages



Red Algae– This macroscopic marine plant contains chloroplasts although it does not appear green.

Mold – Typically, molds secrete enzymes, from the hyphal tips. These enzymes degrade starch, cellulose and lignin into simpler substances which can be absorbed by the hyphae. In this way molds play a major role in causing decomposition of organic material, enabling the recycling of nutrients throughout ecosystems.



Crustaceans - Many crustaceans are scavengers, feeding on scraps and dead creatures. Crabs, shrimp, and prawns search for food mainly at night and hide in crevices by day. Some crabs and lobsters are active predators, seizing prey in their powerful claws. Barnacles filter tiny creatures from the water using their hairy legs. Woodlice munch on plant remains.

Name: ____ **Date:** ____________________________

PHOTOSYNTHESIS KWL

Fill in the following KWL chart. In the K box write down what you know about photosynthesis. In the W box write down questions you have about Photosynthesis (what you would like to know). This chart will be returned to you at the end of the unit to complete the L box. In this box you will write what you have learned throughout the unit and see if your questions have been answered.

K (What you know)	
W (What you want to know)	
L (What you learned)	

Name: ____ Date: ________________

Photosynthesis Research Project

[Adapted from Dayna Wilhelm Photosynthesis Unit - Blacksburg High School -Mr. Wilkins' Biology Courses]

Task: *Design a brochure about one of the two current "Hot Topics" related to photosynthesis, either Deforestation or Global Warming.*

Content: *Be sure to include the following items in your brochure:*

- Complete introduction of the topic including definition
- Connection to photosynthesis (how this topic is related to photosynthesis)
- Description of how topic affects society.
- Personal Recommendations of the students.
- Inclusion of one scientist and a description of their contribution to the topic.

Methods: *You are allowed to use the following resources:*

- Scientific Journal Articles
- Newspaper Articles
- Books
- Internet

Notes:

- You must compare at least two points of view within your brochure. You also must include citations from at least one:
  - newspaper article and one scientific journal. The final product should be constructed using Microsoft Word or Publisher.
  - Make sure that all pictures obtained from the Internet are cited. Original artwork can also be used!

Grading: *You will be graded using the following rubric:*

Criteria	Possible Points	Points Earned
Complete introduction of the topic including definition	10	
Connection to photosynthesis (how this topic is related to photosynthesis)	25	
Description of how topic affects society • 2 viewpoints presented	20	
Recommendations • Scientifically foundational • Supported by Research	10 5	
Inclusion • one scientist and a description • their contribution to the topic	5 5	
Citations • Included references for pictures/information • newspaper citation • scientific journal citation	5 2.5 2.5	

Comments: **Final Grade:** _________

June 2013 Newark Public Schools Next Generation Science Unit

Name: ____ Date: ________________

True Colors: Plant Pigments

[Adapted from Dayna Wilhelm Photosynthesis Unit - Blacksburg High School -Mr. Wilkins' Biology Courses]

We can see the pigments that capture the light using a method called paper chromatography. In paper chromatography, the solvent (acetone) moves up the paper carrying with it the dissolved substances (plant pigments). The pigments are carried along at different rates because they are not equally soluble in the solvent and are attracted in different degrees to the paper.

Materials (per pair):

- Strips of filter paper Coin
- Acetone Pencil
- 150-mL beaker Metric ruler
- Cover for the beaker Fresh spinach leaf
- Coleus leaf (or other red leaf)

Procedure:

1. Using a pencil, draw a base line 1.5 cm from the bottom of the strip of paper.
2. Place the spinach leaf over the line and use the coin to rub the leaf onto the paper. (The teacher will demonstrate.)
3. Repeat for the Coleus leaf.
4. Add enough acetone to cover the bottom of the beaker (no more than 1cm).
5. Lower the filter paper into the beaker. Be careful to keep the paper in an upright position. Cover the beaker. Do not disturb the beaker for approximately 15 minutes or until the solvent is about 1cm from the top of the strip of paper.
6. When the solvent is about 1 cm from the top of the paper, remove the paper and mark the farthest point of the solvent's progress (front line) with your pencil before this line evaporates.

Hypothesis and Rationale: *What do you think is going to happen and why?*

Observations: *Use the space below to draw a sketch of your chromatogram. Use appropriate colors.*

Possible colors:

- faint yellow-carotenes
- yellow-xanthophyll
- bright green-chlorophyll a
- yellow green-chlorophyll b
- red-anthocyanin.

Using your data and the other partner group's data to fill in the following table:

	Line	Color Observed	Probable Pigment
Spinach	1		
	2		
	3		
	4		
	5		
Coleus	1		
	2		
	3		
	4		
	5		

Questions:

1. Photosynthesis begins with the absorption of light, specifically the white light. What is white light composed of? *We can use a device called a prism to answer this question.*

2. What colors did you observe through the prism? *List all of them (there should be 7)*

3. What pigments did you observe in the spinach leaf?

4. What pigments did you observe in the coleus leaf?

5. How are the two leaves different?

6. Which of these leaves can carry out photosynthesis? Please explain your answer.

7. When you look outside in the Fall you see many vibrant colors like red, yellow, orange, and yellow.

8. Where do you think these colors were during the summer?

9. How can they suddenly appear in autumn?

10. Why are leaves green?

Plantastic Voyage

[Taken from Miller, Kenneth R. and Levine, Joseph. (2006). Prentice Hall Biology. Boston: Pearson Prentice Hall.]

You are a part of a team that is planning a space mission that will send astronauts into space for two years. As part of their food, the astronauts will be growing yam plants, *Dioscoreacomposita*. Your job is to develop a plan to help plants grow in the spacecraft.

Defining Your Problem: In your own words state the problem at hand.

Organizing Information: Research the types of conditions that these plants would need. What requirements would the plants have for moisture? Soil conditions? Light Intensity? Day Length?

Creating a Solution: Make a detailed scale drawing of a container for growing 10 of these plants. (*Dioscorea* plants are vines; assume that each is 10cm long and .5cm wide). Determine what material(s) you will use for your container. Also record your team's ideas taking into account what plants need to survive.

Presenting Your Plan: Prepare a presentation for your classmates as if they were the managers of the space mission. Describe how your team solved the problem, the sources of information you used, the design itself, and what you learned during the project.

The Flying Photosynthetic Circus

[Adapted from Dayna Wilhelm Photosynthesis Unit - Blacksburg High School -Mr. Wilkins' Biology Courses]

Purpose: *The purpose of this lesson is to investigate how the chloroplast converts energy from light into chemical energy (ATP). The focus of this lesson will be on the light reactions.*

Objectives:

- Students will be able to identify the thylakoid membrane as the location of key proteins involved in the light reactions.
- Students will be able to define electron transport chain.
- Students will be able to describe the light reactions in photosynthesis.
- Students will be able to describe how the concentration gradient of H^+ role in the production of ATP.

Materials:

Tennis can lids	Cards that can be flipped ADP to ATP
Three tennis balls	Cards that can be flipped $NADP^+$ to NADH
One balloon	Labeled cards for roles (electron carrier, sun, etc.)

Classroom Management/Safety:

- Students will do this activity outside or in a common area in the school large enough to handle the movement involved.
- Tennis balls can hurt. It will be emphasized that the students pass the tennis balls rather than throw them. Kooshballs may be substituted to limit bruises.

Engage: *Students will be told that they will be acting today. Roles will be assigned. These roles are:*

- Sun
- P_{680}
- P_{700}
- Water molecules/Hydrogen
- Primary electron acceptor for Photosystem I
- Primary electron acceptor for Photosystem II
- Electron Carriers for Photosystem II

Explore: *The class will find a place to spread out and act out the light reactions.*

Explain: *The students will act out the light reactions as the teacher reads the "story" on the activity sheet.*

Elaborate: *The class will return to the classroom. A short animation will be shown to illustrate what they just acted out. Special emphasis will be placed on what happens to the Hydrogen atoms and the products that are made from the light reactions.*

Evaluation: *Students will turn in their Activity sheets in for a class participation grade. This will serve as an exit slip.*

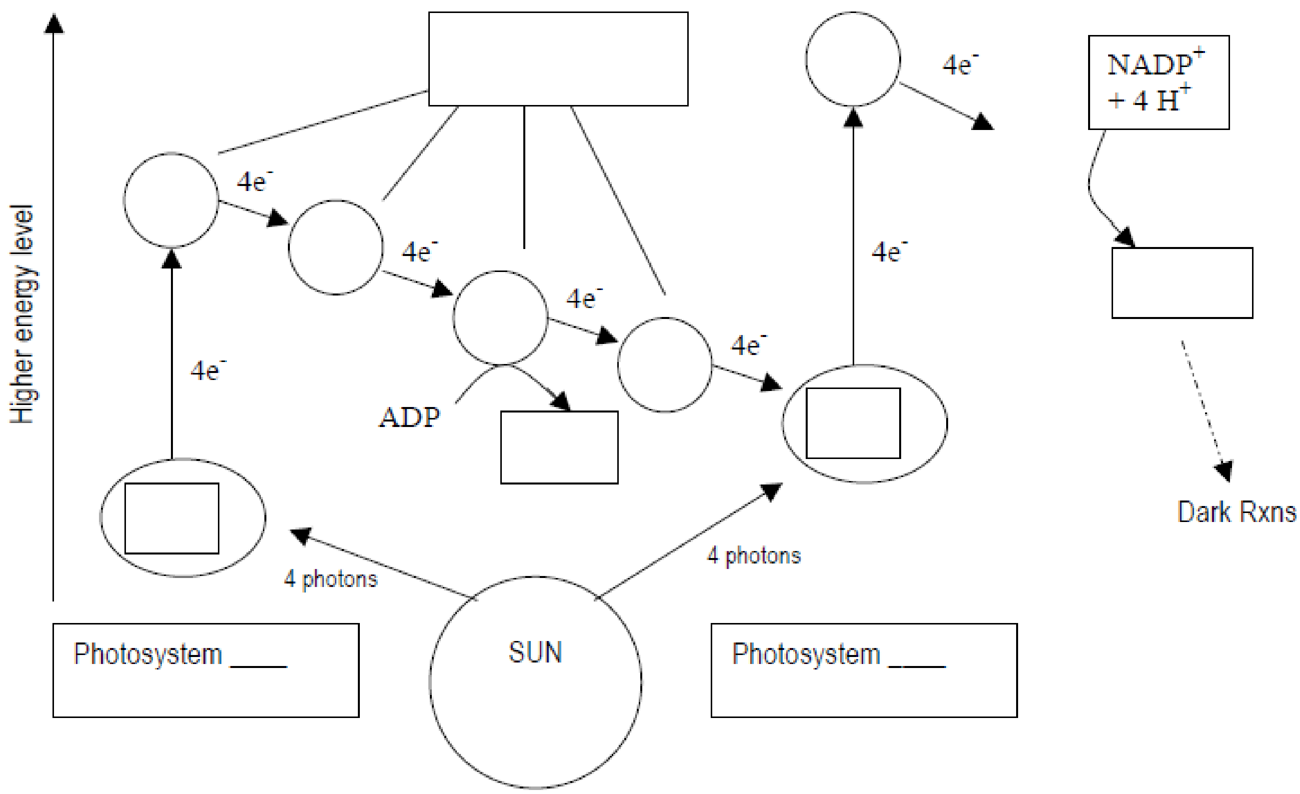
Name: ____ **Date:** _______________________

The Flying Photosynthetic Circus

Story Line:

The sun hits P_{680} with 4 photons (tennis can lid). P_{680} becomes excited and throws 4 electrons (tennis balls) to a higher energy level (up in the air). The electron acceptor II catches the electrons and begins to pass them down the chain to the other electron carriers. One ATP is produced. In the meantime, P_{680} grabs four electrons from the two molecules of water to replace the ones lost. The oxygen (balloon) is released and 2 protons for each of the two molecules of water are freed to join $NADP^+$. At the same time the sun hits P_{700} throws up 4 electrons just in time to grab the electrons that have been passed down the chain of electron carriers. The electrons from P_{700} are caught by the primary electron acceptor in Photosystem I. These electrons are passed on to $NADP^+$ which along with the 4 protons from the water molecules become NADPH and enters the dark reaction.

Fill in the squares/rectangles with the names of the different molecules involved.



Answer the following questions on the back of this sheet:

1. Where are these molecules located?
2. What factor(s) would limit this process?
3. Was this activity helpful in helping you understand the process? Why?

Newark Public Schools Next Generation Science Unit