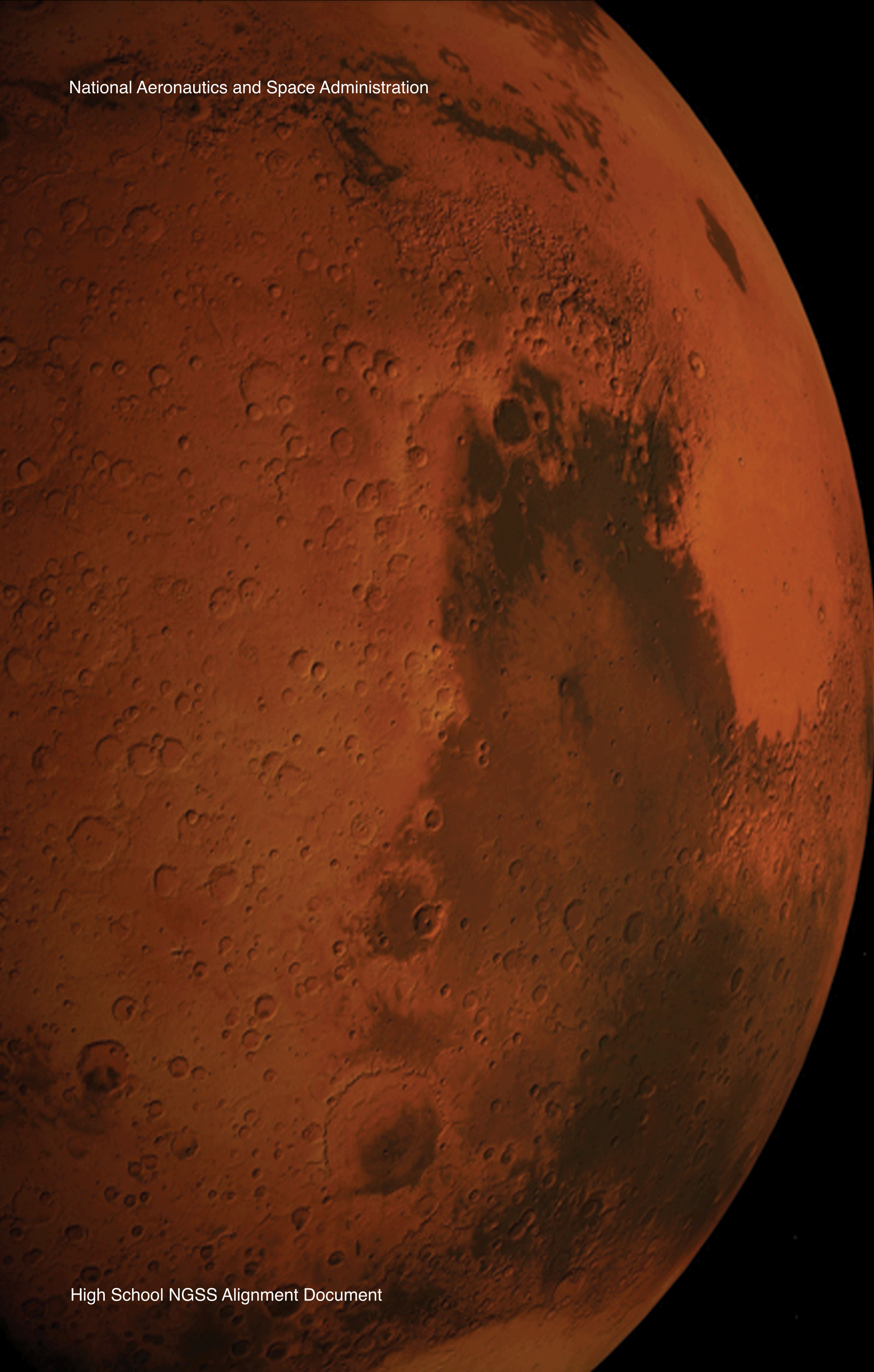
National Aeronautics and Space Administration



red rocks

High School NGSS Alignment Document

Red Rocks

High School Next Generation Science Standards Alignment Document

WHAT STUDENTS DO: Explore red rocks of Earth to explain why Mars is red.

Explore Karijini Gorge in Australia and Oak Creek Canyon in Sedona, AZ searching for clues to the environments that formed the red rocks there. Observe these rock formations at a variety of scales to gather these clues. Finally, apply understanding of red rock formation to answer the question "Why is Mars red?"

NRC FRAMEWORK/NGSS CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES (IO)
HOW AND WHY IS EARTH CONSTANTLY CHANGING? *NGSS Core Question: ESS2: Earth Systems* **How do Earth's major systems interact?** *NGSS ESS2.A: Earth Materials and Systems*	*Students will be able to* **IO1: Interpret evidence in the rocks of Mars at a variety of scales to explain the presence of iron oxide and what it tells us about water in the ancient/present Martian environment.**

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1.0 About This Activity

How Students Learn: Science in the Classroom (Donovan & Bransford, 2005) advocates the use of a research-based instructional model for improving students' grasp of central science concepts. Based on conceptual-change theory in science education, the 5E Instructional Model (BSCS, 2006) includes five steps for teaching and learning: Engage, Explore, Explain, Elaborate, and Evaluate. The Engage stage is used like a traditional warm-up to pique student curiosity, interest, and other motivation-related behaviors and to assess students' prior knowledge. The Explore step allows students to deepen their understanding and challenges existing preconceptions and misconceptions, offering alternative explanations that help them form new schemata. In Explain, students communicate what they have learned, illustrating initial conceptual change. The Elaborate phase gives students the opportunity to apply their newfound knowledge to novel situations and supports the reinforcement of new schemata or its transfer. Finally, the Evaluate stage serves as a time for students' own formative assessment, as well as for educators' diagnosis of areas of confusion and differentiation of further instruction. The 5E stages can be cyclical and iterative.

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2.0 Instructional Objectives, Learning Outcomes, Standards, & Rubrics

Instructional objectives and learning outcomes are aligned with

- Achieve Inc.'s, *Next Generation Science Standards (NGSS)*
- National Research Council's, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*
- National Governors Association Center for Best Practices (NGA Center) and Council of Chief State School Officers (CCSSO)'s, *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and* Technical Subjects
- Partnership for 21st Century Skills, *A Framework for 21st Century Learning*

The following chart provides details on alignment among the core and component NGSS questions, instructional objectives, learning outcomes, and educational standards.

- Your **instructional objectives (IO)** for this lesson align with the NRC Framework and NGSS.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO),** also aligned with the NRC Framework and NGSS.
- You will know the level to which your students have achieved the learning outcomes by using the suggested **rubrics**.

Important Note: This lesson is color-coded to help teachers identify each of the three dimensions of NGSS. The following identifying colors are used: Practices are blue, Cross-Cutting Concepts are green, and Disciplinary Core Ideas are orange.

This color-coding is consistent with the NGSS Performance Expectations and Foundation Boxes.

Quick View of Standards Alignment:

This alignment document provides full details of the way in which instructional objectives, learning outcomes, 5E activity procedures, and rubric assessments were derived through, and align with the Next Generation Science Standards (NGSS). For convenience, a quick view follows:

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HOW AND WHY IS EARTH CONSTANTLY CHANGING?

NGSS Core Question: ESS2: Earth Systems

How do Earth's major systems interact?

NGSS ESS2.A: Earth Materials and Systems

Instructional Objective *Students will be able to*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*
IO1: Interpret evidence in the rocks of Mars at a variety of scales to explain the presence of iron oxide and what it tells us about water in the ancient/present Martian environment.	**LO1a: Collect geologic evidence (make observations) at a variety of scales in present day Karijini Gorge, Oak Creek Canyon, and Mars as a basis for interpretation of their present and past environments.** **LO1b: Generate the list of evidence needed to support a hypothesis as to why Mars is red (oxidized) and explain the importance for collecting this evidence on the macro to micro scale.**	**PRACTICES:** **1. Planning and Carrying Out Investigations** **2. Analyzing and Interpreting Data** **3. Constructing Explanations and Designing Solutions** **4. Engaging in Argument from Evidence** **Scientific Knowledge is based on Empirical Evidence** **DISCIPLINARY CORE IDEAS:** **ESS2.A: Earth Materials and Systems** **Optional Iron Oxidation Lab** **PS1.B: Chemical Reactions** **CROSSCUTTING CONCEPTS:** **1. Patterns** **2. Cause and Effect: Mechanism and Prediction** **3. Scale, Proportion, and Quantity** **4. Structure and Function** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

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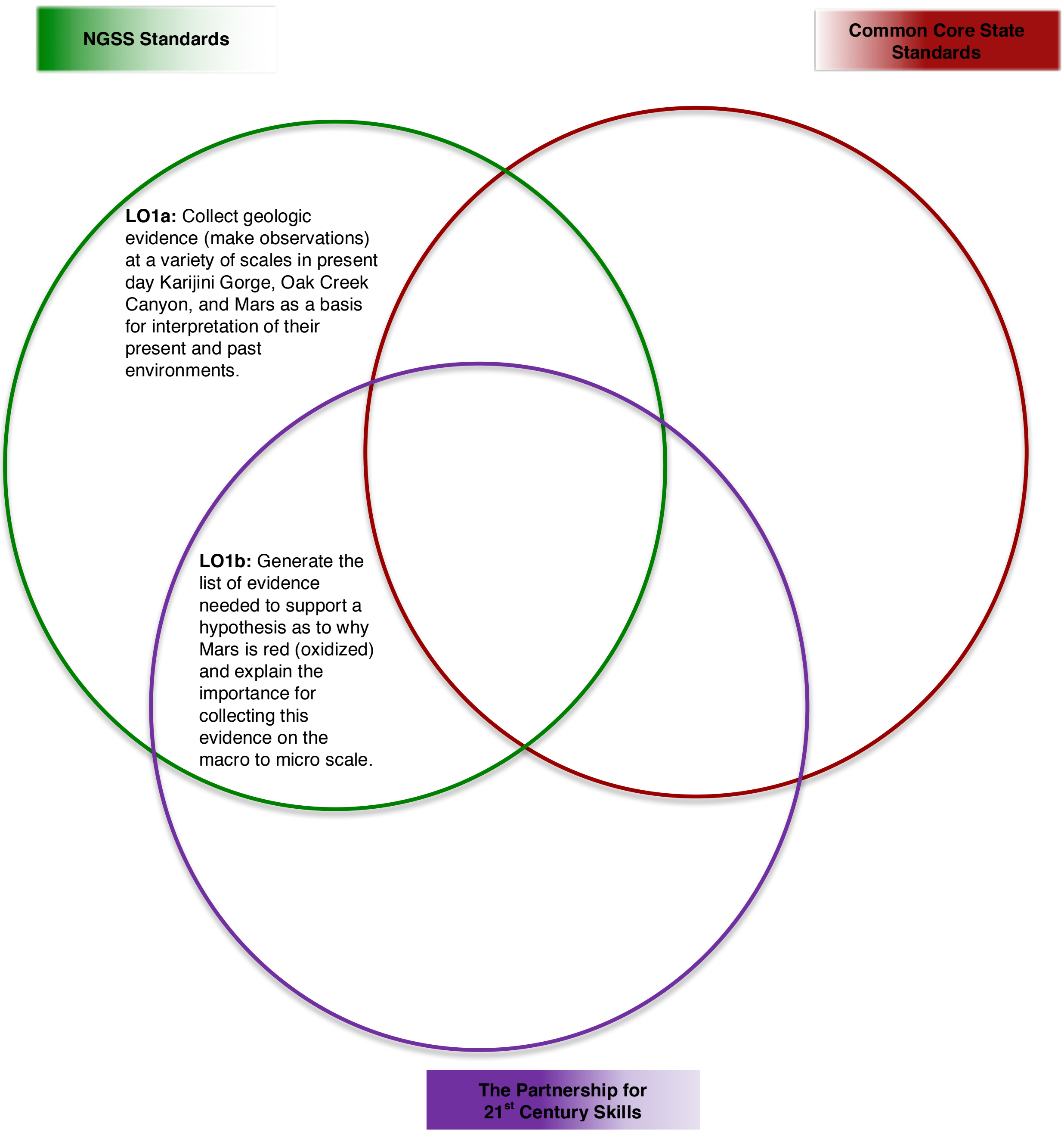
3.0 Learning Outcomes, NRC Framework, Common Core, & 21st Century Skills Connections

The connections diagram is used to organize the learning outcomes addressed in the lesson to establish where each will meet the Next Generation Science Standards, Common Core Standards, and the 21st Century Skills and visually determine where there are overlaps in these documents. See Common Core Alignment Document and 21st Century Skills Alignment Document for details on their specific alignments.



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4.0 Evaluation/Assessment

Use the *(N) Red Rocks Alignment Rubric* as a formative and summative assessment, allowing students to improve their work and learn from mistakes during class. The rubric evaluates the activities using the Next Generation Science Standards (NGSS).

5.0 References

Achieve, Inc. (2013). *Next generation science standards*. Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS.

Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carson Powell, J., Westbrook, A., Landes, N. (2006) *The BSCS 5E instructional model: origins, effectiveness, and applications.* Colorado Springs: BSCS.

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(M) Teacher Resource. Red Rocks NGSS Alignment (1 of 3)

You will know the level to which your students have achieved the **Learning Outcomes**, and thus the **Instructional Objective(s)**, by using the suggested **Rubrics** below.

Related Standard(s)

This lesson supports the preparation of students toward achieving Performance Expectations using the Practices, Cross-Cutting Concepts and Disciplinary Core Ideas defined below: (HS-ESS2-1), (HS-ESS2-2).
If using the iron oxidation lab in class to support this lesson, the following also apply: (HS-PS1-4), (HS-PS1-5), (HS-PS1-6)

Next Generation Science Standards

Instructional Objective	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
IO1: **Interpret evidence in the rocks of Mars at a variety of scales to explain the presence of iron oxide and what it tells us about water in the ancient/present Martian environment.**	**Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Constructing Explanation 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, simulation, 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	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1), (HS-ESS2-2) ****IF USING IRON OXIDATION LAB IN CLASS TO SUPPORT THIS LESSON, THE FOLLOWING ALSO APPLY**** **PS1.B Chemical Reactions** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanation of phenomena. Classification or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Cause and Effect: Mechanism and Prediction:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems

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	the future. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Engaging in Argument from Evidence** Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. **Scientific Knowledge is Based on Empirical Evidence** Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4), (HS-PS1-5) In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)	by examining what is known about smaller scale mechanisms within the system. **Scale, Proportion, and Quantity** Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Patterns observable at one scale may not be observable or exist at other scales. **Structure and Function** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

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(M) Teacher Resource. Red Rocks NGSS Alignment (2 of 3)

Next Generation Science Standards

Learning Outcomes	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
LO1a: **Collect geologic evidence (make observations) at a variety of scales in present day Karijini Gorge, Oak Creek Canyon, and Mars as a basis for interpretation of their present and past environments.**	**Planning and Carrying Out Investigations** Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims. **Scientific Knowledge is Based on Empirical Evidence** Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1), (HS-ESS2-2) ****IF USING IRON OXIDATION LAB IN CLASS TO SUPPORT THIS LESSON, THE FOLLOWING ALSO APPLY**** **PS1.B Chemical Reactions** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4), (HS-PS1-5) In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanation of phenomena. Classification or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Structure and Function** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Scale, Proportion, and Quantity** Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.

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			Patterns observable at one scale may not be observable or exist at other scales. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.
LO1b: **Generate the list of evidence needed to support a hypothesis as to why Mars is red (oxidized) and explain the importance for collecting this evidence on the macro to micro scale.**	**Planning and Carrying Out Investigations** Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. *(Reconnect to 6-8 Practices)* **Scientific Knowledge is Based on Empirical Evidence** Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1), (HS-ESS2-2) ****IF USING IRON OXIDATION LAB IN CLASS TO SUPPORT THIS LESSON, THE FOLLOWING ALSO APPLY**** **PS1.B Chemical Reactions** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4), (HS-PS1-5) In many situations, a dynamic and condition-dependent balance between a	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanation of phenomena. Classification or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Cause and Effect: Mechanism and Prediction:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. **Scale, Proportion, and Quantity**

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		reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)	Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. **Structure and Function** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

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(M) Teacher Resource. Red Rocks NGSS Individual Activity Alignment (3 of 3)

Next Generation Science Standards Activity Alignments (NGSS)

Activity	Phases of 5E Instructional Model	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
Red Rocks Virtual Field Trip Video Intro	**Engage**			
Red Rocks Virtual Field Trip (Karijini and Oak Creek)	**Explore**	**Planning and Carrying Out Investigations** Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims. **Constructing Explanation and Designing Solutions** Apply scientific reasoning, theory, and/or models to link evidence to	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2)	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanation of phenomena. Classification or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Scale, Proportion, and Quantity** Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Patterns observable at one scale

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		the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Scientific Knowledge is Based on Empirical Evidence** Science arguments are strengthened by multiple lines of evidence supporting a single explanation.		may not be observable or exist at other scales. **Structure and Function** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.
OPTIONAL Iron Oxidation Lab	**Explore**	**Planning and Carrying Out Investigations** Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an	**PS1.B Chemical Reactions** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4), (HS-PS1-5) In many situations, a dynamic and condition-dependent balance between a reaction and the reverse	**Structure and Function** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so

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		optimal design solution. **Constructing Explanation 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, simulation, 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. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	reaction determines the numbers of all types of molecules present. (HS-PS1-6)	in the future.
(A) Reading Rock Evidence Worksheet	**Explore Explain**	**Planning and Carrying Out Investigations** Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2)	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanation of phenomena. **Scale, Proportion, and Quantity** Patterns observable at one scale may not be observable or exist at other scales. **Scientific Knowledge Assumes an Order and Consistency in**

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		scientific claims or determine an optimal design solution. **Constructing Explanation 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, simulation, 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. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based on empirical evidence. Science arguments are strengthened by multiple lines of evidence supporting a single explanation.		**Natural Systems** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

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Red Rocks Virtual Field Trip (Mars)	**Elaborate**	**Planning and Carrying Out Investigations** Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Constructing Explanation 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, simulation, 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. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1), (HS-ESS2-2)	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanation of phenomena. Classification or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Cause and Effect: Mechanism and Prediction** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. **Scale, Proportion, and Quantity** Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. **Structure and Function** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

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(B) Red Rocks Evaluation Worksheet	**Evaluate**	**Constructing Explanation 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, simulation, 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. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Engaging in Argument from Evidence** Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based on empirical evidence. Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1), (HS-ESS2-2)	**Patterns** Classification or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. **Cause and Effect: Mechanism and Prediction** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. **Scale, Proportion, and Quantity** Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Patterns observable at one scale may not be observable or exist at other scales. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

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(N) Teacher Resource. Red Rocks NGSS Alignment Rubric

Related Rubrics for the Assessment of Learning Outcomes Associated with the Above Standard(s):

Next Generation Science Standards Alignment (NGSS)

Learning Outcome	Expert	Proficient	Intermediate	Beginner
LO1a: Collect geologic evidence (make observations) at a variety of scales in present day Karijini Gorge, Oak Creek Canyon, and Mars as a basis for interpretation of their present and past environments.	Generates observations for all three locations. Includes more than one observation from each of the macro-micro scales in Karijini/Oak Creek Canyon and only the macro-meso scale on Mars.	Generates observations for all three locations. Includes one observation from each of the macro-micro scales in Karijini/Oak Creek Canyon and only the macro-meso scale on Mars.	Generates observations for all three locations. Includes one observation from the macro-micro scale in Karijini/Oak Creek Canyon and only the macro-meso scale on Mars.	Generates observations.
LO1b: Generate the list of evidence needed to support a hypothesis as to why Mars is red (oxidized) and explain the importance for collecting this evidence on the macro to micro scale.	Generates list of evidence from the macro to micro scale to explain the Martian environment was/is ***not*** like Karijini ***or*** Oak Creek Canyon.	Generates list of evidence to explain the Martian environment was/is ***not*** like Karijini ***or*** Oak Creek Canyon.	Generates list of evidence to explain the Martian environment ***was/is like*** Karijini ***or*** Oak Creek Canyon.	Generates list of evidence to explain the Martian environment ***was/is like*** Karijini ***and*** Oak Creek Canyon.

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