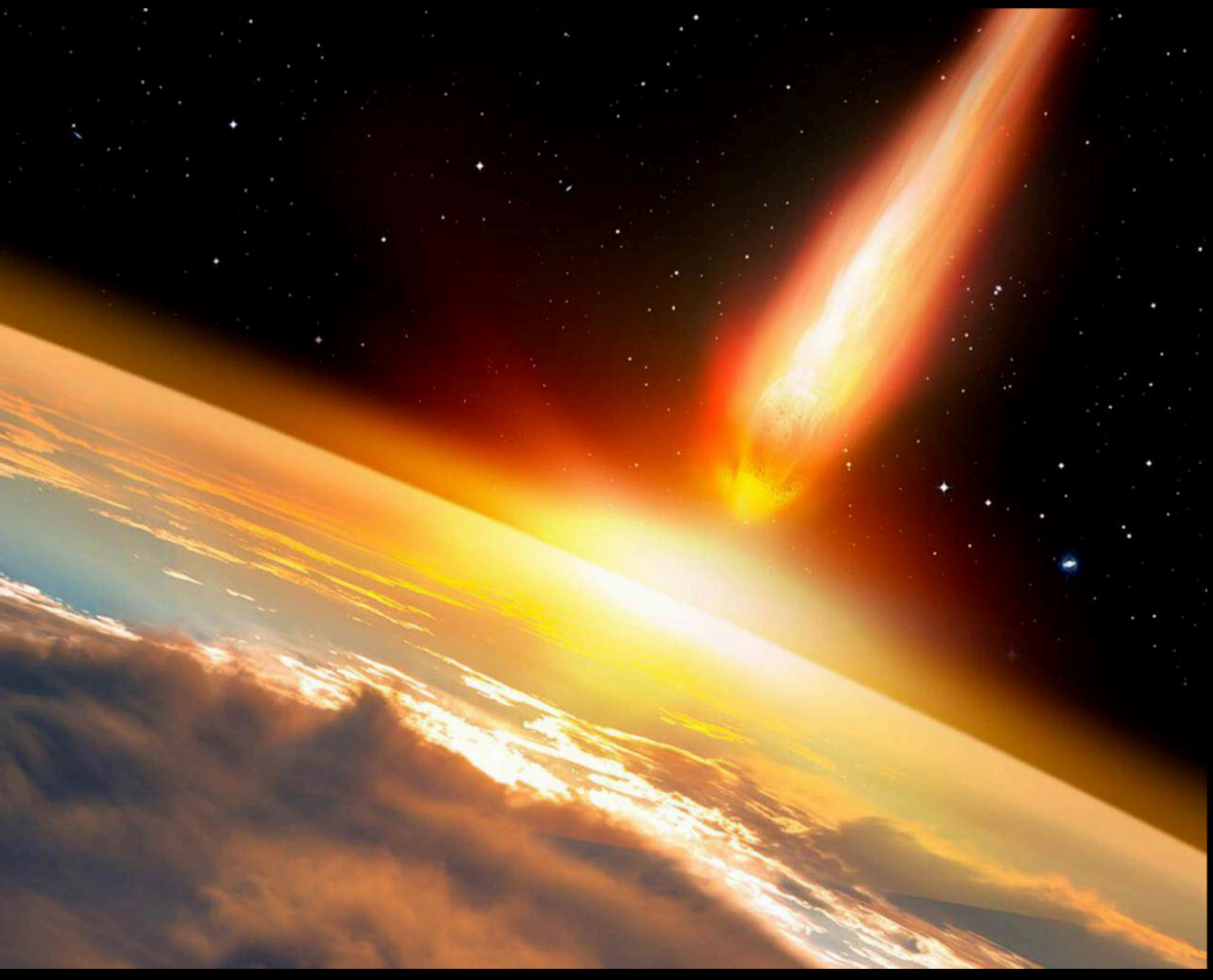
National Aeronautics and Space Administration

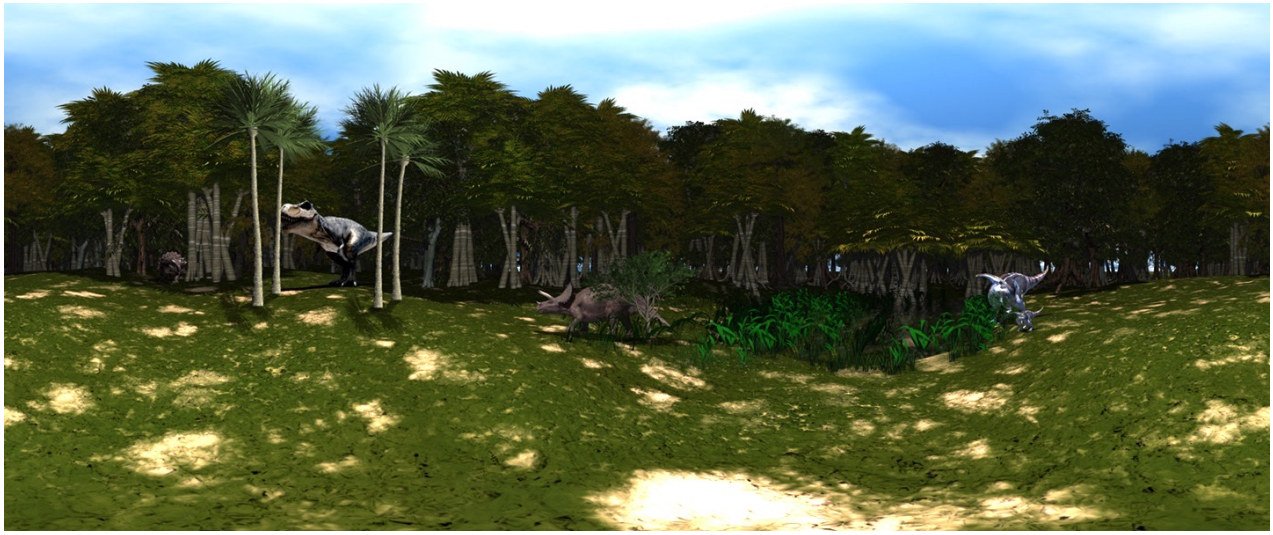


dino doom

NRC Framework High School Alignment Document

Dino Doom

High School NRC Framework for Science Education Alignment Document



WHAT STUDENTS DO: Explore the extinction event at the KPg boundary.

Students will explore sites around the world searching for clues to the mass extinction event that occurred 66 mya. They will collect evidence from each site to tell a piece of the KPg story. Finally, students will combine all of the evidence to explain how natural events impact life on Earth.

NRC FRAMEWORK/NGSS CORE & COMPONENT QUESTIONS

HOW AND WHY DO ORGANISMS INTERACT WITH THEIR ENVIRONMENT AND WHAT ARE THE EFFECTS OF THESE INTERACTIONS?

NRC Core Question: LS2: Ecosystems: Interactions, Energy, and Dynamics

How do organisms interact with the living and nonliving environments to obtain matter and energy?

NRC LS2.A: Interdependent Relationships in Ecosystems

What happens to ecosystems when the environment changes?

NRCC LS2.C: Ecosystem Dynamics, Functioning, and Resilience

INSTRUCTIONAL OBJECTIVES (IO)

Students will be able to

IO1: Construct an explanation, using empirical and observational data from the rock record, for the impact of a natural event on the carrying capacities of an ecosystem and the natural selection that results from limited resources.

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HOW CAN THERE BE SO MANY SIMILARITIES AMONG ORGANISMS YET SO MANY DIFFERENT KINDS OF PLANTS, ANIMALS, AND MICROORGANISMS?

NRC Core Question: LS4: Biological Evolution: Unity and Diversity

How does the environment influence populations of organisms over multiple generations?

NRC LS4.C: Adaptation

HOW AND WHY IS EARTH CONSTANTLY CHANGING?

NRC Core Question: ESS2: Earth Systems

How do Earth's major systems interact?

NRC ESS2.A: Earth Materials and Systems

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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

- 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*

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

- Your **instructional objectives (IO)** for this lesson align with the NRC Framework.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO),** also aligned with the NRC Framework.
- 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 the NRC Framework. 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 NRC Framework for K-12 Science Education.

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 NRC Framework for K-12 Education. For convenience, a quick view follows:

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HOW AND WHY DO ORGANISMS INTERACT WITH THEIR ENVIRONMENT AND WHAT ARE THE EFFECTS OF THESE INTERACTIONS?

NRC Core Question: LS2: Ecosystems: Interactions, Energy, and Dynamics

How do organisms interact with the living and nonliving environments to obtain matter and energy?

NRC LS2.A: Interdependent Relationships in Ecosystems

What happens to ecosystems when the environment changes?

NRC LS2.C: Ecosystem Dynamics, Functioning, and Resilience

HOW CAN THERE BE SO MANY SIMILARITIES AMONG ORGANISMS YET SO MANY DIFFERENT KINDS OF PLANTS, ANIMALS, AND MICROORGANISMS?

NRC Core Question: LS4: Biological Evolution: Unity and Diversity

How does the environment influence populations of organisms over multiple generations?

NRC LS4.C: Adaptation

HOW AND WHY IS EARTH CONSTANTLY CHANGING?

NRC Core Question: ESS2: Earth Systems

How do Earth's major systems interact?

NRC ESS2.A: Earth Materials and Systems

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Instructional Objective *Students will be able to*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*
IO1: Construct an explanation, using empirical and observational data from the rock record, for the impact of a natural event on the carrying capacities of an ecosystem and the natural selection that results from limited resources.	**LO1a: Investigate the patterns in fossil data over time that aid in the discovery of significant events in Earth's history.** **LO1b: Investigate the global patterns in chemical composition data over time that aid in the discovery of significant events in Earth's history.** **LO1c: Determine the size of the impact crater, using the global patterns of iridium in the rock record, to search for the location of the impact potentially responsible for changes to the environment.** **LO1d: Investigate the global patterns of living organisms, before and after the KPg boundary, to identify the significant changes to life on Earth.**	**PRACTICES:** 1. Planning and Carrying Out Investigations 2. Analyzing and Interpreting Data 3. Using Mathematics and Computational Thinking 4. Constructing Explanations and Designing Solutions 5. Obtaining, Evaluating, and Communicating information **DISCIPLINARY CORE IDEAS:** LS2.A: Interdependent Relationships in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS4.C: Adaptation ESS2.A: Earth Materials and Systems **CROSSCUTTING CONCEPTS:** 1. Patterns 2. Cause and Effect: Mechanism and Prediction

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4.0 Evaluation/Assessment

Use the *(N) Dino Doom 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

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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National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

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(M) Teacher Resource. Dino Doom NRC 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.

NRC Framework for K-12 Science Education

Instructional Objective	Science and Engineering Practices Benchmark by Grade 12	Disciplinary Core Idea Grade Band Endpoints	Crosscutting Concepts
IO1: **Construct an explanation, using empirical and observational data from the rock record, for the impact of a natural event on the carrying capacities of an ecosystem and the natural selection that results from limited resources.**	**Constructing Explanation and Designing Solutions** Construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking it to models and evidence. Offer causal explanations appropriate to their level of scientific knowledge.	**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. **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	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)* **Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.

		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. **LS4.C: Adaptation** Natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes	

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		the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost. **ESS2.A: Earth Materials and Systems** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	

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(M) Teacher Resource. Dino Doom NRC Alignment (2 of 3)

NRC Framework for K-12 Science Education

Learning Outcomes	Science and Engineering Practices Benchmark by Grade 12	Disciplinary Core Idea Grade Band Endpoints	Crosscutting Concepts
LO1a: Investigate the patterns in fossil data over time that aid in the discovery of significant events in Earth's history.	**Planning and Carrying Out Investigations** Engage in investigations that range from those structured by the teacher—in order to expose an issue or question that they would be unlikely to explore on their own to those that emerge from students' own questions to those that emerge from students' own questions. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	**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. **LS4.C: Adaptation** Natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)* **Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.

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		Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost. **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic	

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		events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	
LO1b: **Investigate the global patterns in chemical composition data over time that aid in the discovery of significant events in Earth's history.**	**Planning and Carrying Out Investigations** Engage in investigations that range from those structured by the teacher—in order to expose an issue or question that they would be unlikely to explore on their own to those that emerge from students' own questions to those that emerge from students' own questions. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	**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. **LS4.C: Adaptation** Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost.	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)* **Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.

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		ESS2.A: Earth Materials and Systems The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	
LO1c: **Determine the size of the impact crater, using the global patterns of iridium in the rock record, to search for the location of the impact potentially responsible for changes to the environment.**	**Using Mathematics and Computational Thinking** Express relationships and quantities in appropriate mathematical or algorithmic forms for scientific modeling and investigations. Use grade-level-appropriate understanding of mathematics and statistics in analyzing data. **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	**ESS2.A: Earth Materials and Systems** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)* **Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.
LO1d: **Investigate the global patterns of living organisms, before and after**	**Planning and Carrying Out Investigations** Engage in investigations that range from those structured by the teacher—in order to expose an issue	**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	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)*

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the KPg boundary, to identify the significant changes to life on Earth.	or question that they would be unlikely to explore on their own to those that emerge from students' own questions to those that emerge from students' own questions. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	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. **LS4.C: Adaptation** Natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment,	**Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.

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		whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost. **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	

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(M) Teacher Resource. Dino Doom NRC Individual Activity Alignment (3 of 3)

NRC Framework Activity Alignments				
Activity	**Phases of 5E Instructional Model**	**Science and Engineering Practices Benchmark by Grade 12**	**Disciplinary Core Idea Grade Band Endpoints**	**Crosscutting Concepts**
Dino Doom Virtual Field Trip Video Intro	**Engage**			
Dino Doom Virtual Field Trip	**Explore**	**Planning and Carrying Out Investigations** Engage in investigations that range from those structured by the teacher—in order to expose an issue or question that they would be unlikely to explore on their own to those that emerge from students' own questions to those that emerge from students' own questions. *(Reconnect to 6-8 Practices)* **Using Mathematics and Computational Thinking** Express relationships and quantities in appropriate mathematical or algorithmic forms for scientific modeling and investigations.	**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. **LS4.C: Adaptation** Natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)* **Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.

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		Use grade-level-appropriate understanding of mathematics and statistics in analyzing data. **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost. **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	

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			The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	
(A) Story of Fossils (Section 1) Recording Sheet	**Explore** **Explain**	**Planning and Carrying Out Investigations** Engage in investigations that range from those structured by the teacher—in order to expose an issue or question that they would be unlikely to explore on their own to those that emerge from students' own questions to those that emerge from students' own questions. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	**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. **LS4.C: Adaptation** Natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)* **Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.

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			survive and reproduce in that environment. Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost. **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events,	

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			ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	
(B) Origin of Iridium (Section 2) Recording Sheet	**Explore** **Explain**	**Planning and Carrying Out Investigations** Engage in investigations that range from those structured by the teacher—in order to expose an issue or question that they would be unlikely to explore on their own to those that emerge from students' own questions to those that emerge from students' own questions. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	**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. **LS4.C: Adaptation** Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost.	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)* **Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.

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			ESS2.A: Earth Materials and Systems The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	
(C) Determine the Diameter of the Asteroid (Section 3) Recording Sheet **(D) Locating the Crater (Section 4) Recording Sheet**	**Explore** **Explain**	**Using Mathematics and Computational Thinking** Express relationships and quantities in appropriate mathematical or algorithmic forms for scientific modeling and investigations. Use grade-level-appropriate understanding of mathematics and statistics in analyzing data. **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	**ESS2.A: Earth Materials and Systems** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)* **Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.
(E) Mass Extinction	**Explore** **Explain**	**Planning and Carrying Out Investigations**	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**	**Patterns** Recognize, classify, and

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(Section 5) Recording Sheet **(F) Adaptation and Recovery (Section 6) Recording Sheet**		Engage in investigations that range from those structured by the teacher—in order to expose an issue or question that they would be unlikely to explore on their own to those that emerge from students' own questions to those that emerge from students' own questions. *(Reconnect to 6-8 Practices)* **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	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. **LS4.C: Adaptation** Natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can	record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)* **Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.

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Last edited: April 16, 2018

			change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost. **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	

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KPg Food Web	**Elaborate**	**Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships. **Obtaining, Evaluating, and Communicating information** Use words, tables, diagrams, and graphs (whether in hard copy or electronically), as well as mathematical expressions, to communicate their understanding or to ask questions about a system under study. Read scientific and engineering text, including tables, diagrams, and graphs, commensurate with their scientific knowledge and explain the key ideas being communicated.	**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.	**Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.
		Constructing Explanation and Designing Solutions Construct their own explanations of phenomena using their knowledge of accepted scientific theory and	**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	**Patterns** Recognize, classify, and record patterns in the phenomena they observe. *(Reconnect to K-5 Crosscutting Concepts)*

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(G) Dino Doom Evaluation	**Evaluate**	linking it to models and evidence. Offer causal explanations appropriate to their level of scientific knowledge.	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. **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. **LS4.C: Adaptation** Natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. Natural selection leads to adaptation—that is, to a population dominated by organisms that	**Cause and Effect: Mechanism and Prediction:** Argumentation starting from students' own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study.

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			are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost. **ESS2.A: Earth Materials and Systems** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	

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(N) Teacher Resource. Dino Doom NRC Alignment Rubric

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

NRC Framework for Science Education Alignment

Learning Outcome	Expert	Proficient	Intermediate	Beginner
LO1a: Investigate the patterns in fossil data over time that aid in the discovery of significant events in Earth's history	Accurately describes the diversity and size of forams, including adaptations of some and the extinction of others at the 66 mya mark.	Describes the diversity ***or*** size of forams, including adaptations of some and the extinction of others at the 66 mya mark.	Describes the diversity ***or*** size of forams, including the adaptations of some ***or*** the extinction of others at the 66 mya mark.	Discusses adaptation and/or extinction.
LO1b: Investigate the global patterns in chemical composition data over time that aid in the discovery of significant events in Earth's history.	Accurately describes the iridium **ratio** found at and around the 66 mya mark, including the type of rock, at a variety of global locations.	Describes the iridium **spike** found at and around the 66 mya mark, including the type of rock, at a variety of global locations.	Describes the iridium ratio ***or*** spike found at and around the 66 mya mark, including the type of rock.	Claims there is an iridium spike at 66 mya.
LO1c: Determine the size of the impact crater, using the global patterns of iridium in the rock record, to search for the location of the impact potentially responsible for changes to the environment.	Identifies the process used to find the diameter of the asteroid and crater, then correctly narrows the possible locations to three based on diameter, and to the most probable site of impact based on age.	Identifies the process used to find the diameter of the asteroid and crater, then narrows to the possible locations, and to the most probable site of impact based on age.	Identifies the process used to find the diameter of the asteroid and crater, then narrows to the possible locations based on diameter.	Identifies the process used to find the diameter of the asteroid and crater.
LO1d: Investigate the global patterns of living organisms, before and after the KPg boundary, to identify the significant changes to life on Earth.	Accurately describes the difference between the characteristics of organisms that survived the extinction and those that did not, and explains the significance of this extinction event.	Describes the characteristics of organisms that survived the extinction and includes a description of the significance of this extinction event.	Describes the characteristics of organisms that survived the extinction and those that did not.	Describes the characteristics of organisms that survived the extinction.

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