**Overview**: The following rubrics can be used to assess the individual project: a self-guided tour of an arena. Each rubric is aligned to one section of the *Individual Project Criteria for Success*, located on the Culminating Project Student Instructions. \*If student provides no assessable evidence (e.g., “I don’t know” or leaves answer blank), then that student response cannot be evaluated using the rubric and should be scored as a zero.

Below we provide an alignment table that details the dimensions assessed for each criterion.

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|  | **Student Criteria for Success** | **Science and Engineering Practice** | **Disciplinary Core Idea** | **Crosscutting Concept** |
| 1 | * Geographic Features   + Identify the geographic features in your arena based on its location.   + Explain how plate motions led to the geographic features in your arena.     - Describe the patterns in data from Task 1 that provide evidence for past plate motions. | **Analyzing and Interpreting Data**   * Analyze and interpret data to provide evidence for phenomena. | **ESS2.B: Plate Tectonics and Large-Scale System Interactions**   * Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth’s plates have moved great distances, collided, and spread apart. | **Patterns**   * Patterns in rates of change and other numerical relationships can provide information about natural systems. |
| 2 | * Natural Resources * Identify the natural resources available in your arena. * Explain how geoscience processes and current human activities affect which resources are available in your arena.   + Use evidence from Task 2 to support your explanation. | **Constructing Explanations**   * Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) 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. | **ESS3.A: Natural Resources**   * Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, freshwater, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. | **Cause and Effect**   * Cause and effect relationships may be used to predict phenomena in natural or designed systems. |
| 3 | * Non-Living Things   + Draw a model (including arrows and labels) that shows how matter and energy are cycled within your arena ecosystem. | **Developing and Using Models**   * Develop a model to describe phenomena. | **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems**   * Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. | **Systems and System Models**   * Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. |
| 4 | * Non-Living Things   + Explain how you can track the flow of energy through your arena’s ecosystem. | N/A | **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems**   * Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. | **Energy and Matter**   * The transfer of energy can be tracked as energy flows through a natural system. |
| 5 | * Living Organisms * Describe how the contestant challenge works: Explain how each plant or animal leads the contestant to the next plant or animal.   + In your contestant challenge, you should use at least two different organism interactions, based on patterns you observed in Task 4. | **Constructing Explanations**   * Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. | **LS2.A: Interdependent Relationships in Ecosystems**   * Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. | **Patterns**   * Patterns can be used to identify cause and effect relationships. |
| 6 | * Human Impact * Describe the potential effects on the entire ecosystem if budget constraints result in the removal of one major resource from your arena.   + Give examples of populations of organisms that may be affected in order to explain why removing a resource can result in a chain of effects. | N/A | **LS2.A: Interdependent Relationships in Ecosystems**   * Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. * In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. * Growth of organisms and population increases are limited by access to resources. | **Systems and System Models**   * Systems may interact with other systems; they may have sub-systems and be a part of a larger complex system. |
| 7 | * Human Impact   + Describe data from Task 5 that allows you to predict this outcome. | **Analyzing and Interpreting Data**   * Analyze and interpret data to provide evidence for phenomena. | **LS2.A: Interdependent Relationships in Ecosystems**   * Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. * In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. * Growth of organisms and population increases are limited by access to resources. | **Cause and Effect**   * Cause and effect relationships may be used to predict phenomena in natural or designed systems. |

**Rubric 1**: Student describes patterns in data as evidence to explain how plate motions have led to the geographic features in the arena.

* Dimensions Assessed: SEP – Analyzing and Interpreting Data, DCI – ESS2.B: Plate Tectonics and Large Scale System Interactions, CCC - Patterns

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student **inaccurately** explains how plate motions have led to the geographic features in the arena. | Student describes **no** patterns in data as evidence to **generally** explain how plate motions have led to the geographic features in the arena. | Student describes **partial** patterns in data as evidence to **accurately** explain how plate motions have led to the geographic features in the arena. | Student describes **multiple** patterns in data as evidence to **accurately** explain how plate motions have led to the geographic features in the arena. |
| **Look Fors:**   * Student shows what continent the arena is located on, but identifies geographic features that are not relevant to the location. For example, a student shows the arena on the east coast of South America, but identifies coal deposits as a geographic feature, which is incorrect. Because geographic features are incorrect, the explanation is inaccurate. * OR student identifies relevant geographic features, but explanation of why they are present is inaccurate or missing. | **Look Fors:**   * Student shows what continent the arena is located on and identifies geographic features relevant to the location. See Look-For examples in the *Advanced*. * Student accurately explains that plate motions caused these geographic features, but references no data from Task 1 as evidence. | **Look Fors:**   * Student shows what continent the arena is located on and identifies some or all geographic features relevant to the location. For example, if a student shows their arena on the east coast of South America, they might identify mountain ranges and glacial deposits as the geographic features present. * Student accurately explains that plate motions caused these geographic features, but references only one pattern in data from Task 1 as evidence. For example, a student may explain the presence of glacial deposits on the southern tips of South America and Africa, which implies the continents were previously joined. Student does not use data to explain other features. | **Look Fors:**   * Student shows what continent the arena is located on and identifies all geographic features relevant to the location. For example, if a student shows their arena on the east coast of South America, they might identify mountain ranges and glacial deposits as the geographic features present. * Student accurately explains that plate motions caused the geographic features and references multiple patterns in data from Task 1 as evidence. For example, a student may explain the presence of mountain ranges with the map from Task 1 that showed mountain ranges on the coasts of South America and Africa, where continents were previously joined. |

**Rubric 2**: Student uses evidence and cause-and-effect relationships to explain why only certain resources are available in the arena.

* Dimensions Assessed: SEP – Constructing Explanations, DCI – ESS3.A: Earth’s Natural Resources, CCC – Cause and Effect

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student **inaccurately** explains why only certain resources are available in the arena. | Student uses **no** evidence, but does use cause-and-effect relationships to **generally** explain why only certain resources are available in the arena. | Student uses **accurate** evidence and cause-and-effect relationships to **partially** explain why only certain resources are available in the arena. | Student uses **accurate** evidence and cause-and-effect relationships to **completely** explain why only certain resources are available in the arena. |
| **Look Fors:**   * Student identifies at least one relevant resource available in their arena, but does not accurately explain why it is present because of past and current geoscience processes.   OR   * Student identifies a resource in their arena that is irrelevant because of its location. For example, coal in an arena location on Antarctica. | **Look Fors:**   * Student identifies at least one relevant resource available in their arena. For example, coal. * Student provides a general explanation that resources are available because of past geoscience processes and current human extraction, but gives no specific evidence related to the resource they identify. Students may or may not include the human impact component. * For example, “My arena has a lot of coal because certain earth processes make it only available in some regions of the world.” | **Look Fors:**   * Student identifies at least one relevant resource available in their arena. For example, oil. * Student accurately uses cause and effect relationships (related to geoscience processes and current human activity) and evidence from Task 2 in order to explain why certain resources are available in the arena. However, some aspects are missing in their explanation, such as the current human impact component. * For example, “My arena has a fair amount of oil because it is right next to a plate boundary. In Task 2, the article said that oil fields are present where one plate subducts under another, creating ocean basins that fill with tiny dead organisms, which eventually become oil.” | **Look Fors:**   * Student identifies at least one relevant resource available in their arena. For example, oil. * Student accurately uses cause and effect relationships (related to geoscience processes and current human activity) and evidence from Task 2 in order to explain why certain resources are available in the arena. * For example, “My arena has a fair amount of oil because it is right next to a plate boundary. In Task 2, the article said that oil fields are present where one plate subducts under another, creating ocean basins that fill with tiny dead organisms, which eventually become oil. However, humans are harvesting too much oil at a rate too fast to replenish, so there is less oil in the arena than there could be.” |

**Rubric 3**: Student develops a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

* Dimensions Assessed: SEP – Developing and Using Models, DCI – LS2.B: Cycles of Matter and Energy Transfer in Ecosystems, CCC – Systems and System Models

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student develops an **incomplete** model to **inaccurately** describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. | Student develops a **partial** model to **partially** describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. | Student develops a **mostly complete** model to **partially** describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. | Student develops a **complete** model to **accurately** describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. |
| **Look Fors:**   * Student develops an incomplete model with only a few relevant living and nonliving components present. Connections are limited or not present.   OR   * Student develops an incomplete model that describes interactions between living and nonliving things with many inaccuracies. For example, “The animals drink water to make energy.” | **Look Fors:**   * Student develops a model with some, but not all relevant living and nonliving components. For example, student may omit the sun and decomposers. * Some components are accurately connected using arrows or another symbol in order to show some interactions within the system. * Model accurately describes (using labels) some, but not all interactions—such as inputs, processes, outputs—and energy and matter flows within their arena ecosystem. For example: Plants use carbon dioxide and water to grow, releasing oxygen. Animals eat these plants and use the oxygen to create their own energy, releasing water and carbon dioxide, which cycles back to be used by plants.” This is missing the energy input from the sun, as well as the role of decomposers. | **Look Fors:**   * Student develops a model with all relevant living and nonliving components (oxygen, carbon dioxide, sunlight, water, soil, plants, animals, decomposers). * Most components are accurately connected using arrows or another symbol in order to show most interactions within the system. * Model accurately describes (using labels) most, but not all interactions—such as inputs, processes, outputs—and energy and matter flows within their arena ecosystem. For example: Plants use carbon dioxide and water to grow, releasing oxygen. Animals eat these plants and use the oxygen to create their own energy, releasing water and carbon dioxide, which cycles back to be used by plants. This description is missing the energy input from the sun, as well as the role of decomposers. | **Look Fors:**   * Student develops a model with all relevant living and nonliving components (oxygen, carbon dioxide, sunlight, water, soil, plants, animals, decomposers). * All components are accurately connected using arrows or another symbol in order to show interactions within the system. * Model accurately describes (using labels) all interactions—such as inputs, processes, outputs—and energy and matter flows within their arena ecosystem. For example: Plants use energy from the sun, as well as carbon dioxide from air and water from soil, to grow. This creates oxygen. Animals eat these plants and use the oxygen to create their own energy, releasing water and carbon dioxide, which cycles back to be used by plants. Decomposers recycle nutrients from dead plants and animals back into the soil to be used by plants.” |

**Rubric 4**: Student explains how they can track the flow of energy through the arena ecosystem.

* Dimensions Assessed: DCI – LS2.B: Cycles of Matter and Energy Transfer in Ecosystems, CCC – Energy and Matter

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student **inaccurately** explains how they can track the flow of energy through the arena ecosystem. | Student **generally** explains how they can track the flow of energy through the arena ecosystem. | Student **partially** explains how they can track the flow of energy through the arena ecosystem. | Student **completely** explains how they can track the flow of energy through the arena ecosystem. |
| **Look Fors:**   * Student inaccurately explains how energy flows in an ecosystem. * For example, “Plants get their energy from the soil, so they can grow. Animals make their own energy by eating.” | **Look Fors:**   * Student generally explains how energy flows in an ecosystem, but doesn’t specifically track the flow of energy within the arena ecosystem. * For example, “All of the ecosystem’s energy comes from the sun, which is transferred when organisms eat one another.” | **Look Fors:**   * Student accurately but only partially tracks the flow of energy within the arena ecosystem from sunlight to various plants, animals, and decomposers. * For example, “Energy from the sun provides all the energy for the arena ecosystem. Plants capture it so they can make their own food. Then animals eat the plants, which gives them energy.” Decomposers and other animals are missing from this explanation. | **Look Fors:**   * Student accurately and completely tracks the flow of energy within the arena ecosystem from sunlight to various plants, animals, and decomposers. * For example, “Energy from the sun provides all the energy for the arena ecosystem. Plants capture it so they can make their own food. Then animals eat the plants, which gives them energy. Then carnivorous animals eat those animals for energy. Various plants and animals use this energy to survive, grow, and do daily activities. When they die, they are consumed by decomposers, which use them for energy.” |

**Rubric 5**: Student uses patterns of interactions among organisms to explain a contestant challenge within the arena ecosystem.

* Dimensions Assessed: SEP – Constructing Explanations, DCI – LS2.A: Interdependent Relationships in Ecosystems, CCC – Patterns

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student uses **no** patterns of interaction among organisms to **inaccurately** explain a contestant challenge within the arena ecosystem. | Student uses **one** pattern of interaction among organisms to **partially or completely** explain a contestant challenge within the arena ecosystem. | Student uses **multiple** patterns of interactions among organisms to **partially** explain a contestant challenge within the arena ecosystem. | Student uses **multiple** patterns of interactions among organisms to **completely** explain a contestant challenge within the arena ecosystem. |
| **Look Fors:**   * Student describes a contestant challenge that does not include any types of organism interactions. For example, “The contestant will follow a path of wildflowers, which will lead it to the pond, which will lead it to the turtle on the other side of the pond.” | **Look Fors:**   * Student describes a contestant challenge that includes only one accurate type of organism interaction (ie. commensalism, competition, predation, parasitism, etc). * The interactions are accurately described but they utilize the same type of interaction. For example. “The grass is eaten by the insect, which is then eaten by the egret. Both are examples of predation.” | **Look-Fors**   * Student describes a contestant challenge that includes at least two types of organism interactions (ie. commensalism, competition, predation, parasitism, etc). * These interactions are partially described. For example. “The bee pollinates the plant. The plant is then eaten by the cow.” The type of interaction is missing. | **Look Fors:**   * Student describes a contestant challenge that includes at least two types of organism interactions (ie. commensalism, competition, predation, parasitism, etc). * These interactions are accurately described in detail. For example. “The bee pollinates the plant, which is an example of commensalism. The plant is then eaten by the cow, which is an example of predation.” |

**Rubric 6**: Student predicts how removing a resource might affect populations of organisms and explains why by making connections between sub-systems in the larger arena ecosystem.

* Dimensions Assessed: DCI – LS2.A: Interdependent Relationships in Ecosystems, CCC – Systems and System Models

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student predicts how removing a resource might affect **irrelevant** populations of organisms. | Student predicts how removing a resource might affect **one relevant** population of organisms and explains why **without** making connections between sub-systems in the larger arena ecosystem. | Student predicts how removing a resource might affect **multiple** relevant populations of organisms and explains why **without** making connections between sub-systems in the larger arena ecosystem. | Student predicts how removing a resource might affect **multiple** relevant populations of organisms and explains why **by** making connections between sub-systems in the larger arena ecosystem. |
| **Look Fors:**   * Student identifies the removal of one major resource in their arena – for example, coal. * Student attempts to describe an effect on a population of organisms, but the organism is irrelevant. For example, “If coal is removed from the arena, then more plants will die, causing more animals to die.” | **Look Fors:**   * Student identifies the removal of one major resource in their arena – for example, grass. * Student then gives an example of a relevant population that will be affected. However, because only one example is given, no chain of events or interactions of sub-systems is apparent. For example, “When grass is removed, the rabbits have nothing to eat, so their population decreases.” | **Look Fors:**   * Student identifies the removal of one major resource in their arena – for example, sagebrush. * Student then gives examples of multiple relevant populations that will be affected. However, the examples do not show interactions of sub-systems as part of a larger ecosystem. For example, “When sagebrush is removed, the deer have nothing to eat, so they can decrease in population. The cows also eat sagebrush, so they can decrease in population.” | **Look Fors:**   * Student identifies the removal of one major resource in their arena – for example, sagebrush. * Student then gives examples of multiple relevant populations that will be affected. The examples show a chain of events that showcases the interactions of sub-systems as part of a larger ecosystem. For example, “When sagebrush is removed, the deer have nothing to eat, so they can decrease in population. This makes more sunlight and water resources available for cheatgrass to grow and increase in population. Since elk eat cheatgrass, their population increases.” |

**Rubric 7**: Student cites data that provides evidence of a cause-and-effect relationship between resource availability and populations of organisms.

* Dimensions Assessed: SEP – Analyzing and Interpreting Data, DCI – LS2.A: Interdependent Relationships in Ecosystems, CCC – Cause and Effect

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student describes an **inaccurate** cause-and-effect relationship between resource availability and populations of organisms. | Student cites **no** data to provide evidence of an **accurate** cause-and-effect relationship between resource availability and populations of organisms. | Student cites **a relevant** data point that provides evidence of an **accurate** cause-and-effect relationship between resource availability and populations of organisms. | Student cites **multiple relevant** data points that provide evidence of an **accurate** cause-and-effect relationship between resource availability and populations of organisms. |
| **Look Fors:**   * Within Criteria 6, student may have identified the removal of one important resource in their arena, but no cause-and-effect relationship is explained accurately. For example, “If the main plant dies, more plants would die.” | **Look Fors:**   * Within Criteria 6, student has already identified the removal of one major resource in their arena and described at least one relevant effect. * Student does not cite any data but does explain the cause-and-effect relationship that allowed them to predict those effects. For example, “When one organism is removed, it often frees up resources for another population of organisms to increase.” | **Look Fors:**   * Within Criteria 6, student has already identified the removal of one major resource in their arena and described multiple effects. * Student then cites one data point to provide evidence of the cause-and-effect relationship that allowed them to predict those effects. For example, “In Simulation 2, we see that the removal of one plant frees up resources for another population of plant to increase.” | **Look Fors:**   * Within Criteria 6, student has already identified the removal of one major resource in their arena and described a chain of effects. * Student then cites multiple sources of data to provide evidence of the cause-and-effect relationship that allowed them to predict those effects. For example, “In Simulation 2, we see that the removal of one plant frees up resources for another population of plant to increase. We also see in this simulation that when more food is available for an organism, its population increases, like with the bunny.” |