**Overview**: The following rubrics can be used to assess the individual project: the aquaponics system instruction manual. 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 | * Identify at least one organism that does cellular respiration in your aquaponics system   + Model and describe the process of cellular respiration (using pictures, labels, arrows, and captions) | **Developing and Using Models**   * Develop a model to describe unobservable mechanisms. | **LS1.C: Organization for Matter and Energy Flow in Organisms**   * Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, and to release energy.   **PS3.D: Energy in Chemical Processes and Everyday Life**   * Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials (*secondary*). | **N/A** |
| 2 | * + In your model, make sure to show and explain how matter is conserved in this chemical reaction | **N/A** | **PS1.B: Chemical Reactions**   * Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules and these new substances have different properties than those of the reactants. * The total number of each type of atom is conserved, and thus the mass does not change. | **Energy and Matter**   * Matter is conserved because atoms are conserved in physical and chemical processes. |
| 3 | * Identify at least one organism that does photosynthesis in your aquaponics system   + Model and explain the process of photosynthesis (using pictures, labels, arrows, and captions)   + In your model, make sure to show all forms of energy and matter involved   + Cite evidence from Task 3 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. | **LS1.C: Organization for Matter and Energy Flow in Organisms**   * Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.   **PS3.D: Energy in Chemical Processes and Everyday Life**   * The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (ie. from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen (*secondary*). | **Energy and Matter**   * Within a natural system, the transfer of energy drives the motion and/or cycling of matter. |
| 4 | * Model and describe which processes of the rock cycle might occur in your aquaponics system over time   + Identify the flow of energy that drives the processes you identify | **Developing and Using Models**   * Develop and use a model to describe phenomena. | **ESS2.A: Earth’s Materials and Systems**   * All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms. | **N/A** |
| 5 | * + Explain why some of the rock cycle processes you explored in Task 4 will not occur in your aquaponics system and are not seen in short time periods | **N/A** | **ESS2.A: Earth’s Materials and Systems**   * All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms. | **Stability and Change**   * Explanations of stability and change in natural and designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. |
| 6 | * Identify and explain one physical and one chemical change that will occur in your aquaponics system   + Use data from Task 1 to explain how looking at macroscopic properties of matter can help you determine whether physical or chemical changes are happening at the microscopic level | **Analyzing and Interpreting Data**   * Analyze and interpret data to determine similarities and differences in findings. | **PS1.A: Structure and Properties of Matter**   * Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.   **PS1.B: Chemical Reactions**   * Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules and these new substances have different properties than those of the reactants. | **Patterns**   * Macroscopic patterns are related to the nature of microscopic and atomic-level structure. |
| 7 | * Draw a diagram of the heat-regulation device you designed and explain how it will work in your aquaponics system   + Describe the design process that led you to your final product | **Designing Solutions**   * Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific criteria and constraints. | **PS1.B: Chemical Reactions**   * Some chemical reactions release energy, others store energy. | **Energy and Matter**   * The transfer of energy can be tracked as energy flows through a designed or natural system. |

**Rubric 1**: Student develops a model to describe the process of cellular respiration that occurs within an animal in their aquaponics system, including all matter and energy involved.

* Dimensions Assessed: SEP – Developing and Using Models, DCIs – LS1.C: Organization for Matter and Energy Flow in Organisms and PS3.D: Energy in Chemical Processes and Everyday Life

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student develops an **incomplete** model to describe the process of cellular respiration that occurs within an animal in their aquaponics system.  OR  Student develops **a partial written explanation** to describe the process of cellular respiration that occurs within an animal in their aquaponics system. | Student develops a **partial** model to describe the process of cellular respiration that occurs within an animal in their aquaponics system.  OR  Student develops **a complete written explanation** to describe the process of cellular respiration that occurs within an animal in their aquaponics system, including all matter and energy involved. | Student develops a **complete** model to describe the process of cellular respiration that occurs within an animal in their aquaponics system, including all matter and energy involved. | Student develops a **complete** model to describe **in detail** the process of cellular respiration that occurs within an animal in their aquaponics system, including all matter and energy involved. |
| **Look Fors:**   * Student’s model consists of pictures and labels that show limited components of cellular respiration (ie. only the transformation from food to energy is modeled). Thus any arrows and captions only offer an incomplete explanation of cellular respiration.   OR   * Student writes an explanation that partially describes cellular respiration, but no model is present. | **Look Fors:**   * Student’s model consists of pictures and labels that show some components of cellular respiration (ie. the energy component is missing). Thus any arrows and captions only partially explain cellular respiration.   OR   * Student writes an explanation that completely describes cellular respiration (See Advanced Look-Fors), but no model is present. | **Look Fors:**   * Student’s model consists of pictures and labels that show all components of cellular respiration (ie. animal, oxygen, glucose or food, water, carbon dioxide, and ATP or energy). * The model has arrows that show all interactions, but captions are limited to explain these interactions. For example, arrows show: glucose and oxygen entering the animal, releasing energy and creating carbon dioxide and water as byproducts. | **Look Fors:**   * Student’s model consists of pictures and labels that show all components of cellular respiration (ie. animal, oxygen, glucose or food, water, carbon dioxide, and ATP or energy). * The model has captions and arrows that show and explain all interactions. For example, arrows and captions show: glucose and oxygen enter the animal, bonds are broken and energy is released, and carbon dioxide and water are created as byproducts. |

**Rubric 2**: Student describes that matter is conserved, specifically within the context of the cellular respiration chemical reaction.

* Dimensions Assessed: DCIs – LS1.C: Organization for Matter and Energy Flow in Organisms and PS3.D: Energy in Chemical Processes and Everyday Life, CCC – Energy and Matter

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student uses a model to describe that matter is **not** conserved within the context of the cellular respiration chemical reaction. | Student **explicitly** describes that matter is conserved, **but not** specificallywithin the context of the cellular respiration chemical reaction. | Student **implicitly** describes that matter is conserved, specifically **within the context** of the cellular respiration chemical reaction. | Student **explicitly** describes that matter is conserved, specifically **within the context** of the cellular respiration chemical reaction. |
| **Look Fors:**   * Student inaccurately describes that matter is not conserved in cellular respiration. | **Look Fors:**   * Student explicitly states that matter is conserved in cellular respiration, but does not explain how they know. | **Look Fors:**   * Student uses their model to implicitly show how matter is conserved in cellular respiration. For example, student may show the number of each type of atom in the reactants and products, but does not explicitly compare the two or state that matter is conserved. | **Look Fors:**   * Student uses their model to explicitly show how matter is conserved in cellular respiration. For example, student may show that the number of each type of atom in the reactants and products is equal. Then the student compares the reactants and products and discusses how atoms in the reactants were rearranged into the products, and thus matter is conserved. |

**Rubric 3**: Student describes photosynthesis, explaining how energy drives the cycling of matter and supporting the explanation with evidence from the tasks.

* Dimensions Assessed: SEP – Constructing Explanations, DCIs – LS1.C: Organization for Matter and Energy Flow in Organisms and PS3.D: Energy in Chemical Processes and Everyday Life, CCC – Energy and Matter

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student **partially** describes photosynthesis, but **does not** support the explanation with evidence from the tasks. | Student **partially** describes photosynthesis, supporting the explanation with evidence from the tasks. | Student **completely** describes photosynthesis, **implicitly** explaining how energy drives the cycling of matter and supporting the explanation with evidence from the tasks. | Student **completely** describes photosynthesis, **explicitly** explaining how energy drives the cycling of matter and supporting the explanation with evidence from the tasks. |
| **Look Fors:**   * Student’s explanation of photosynthesis is partial, describing some components and interactions. For example, student discusses how sunlight is used to create glucose in plants. This response omits many components of the photosynthesis reaction. * Student does not support this explanation with evidence from the Task 3 lab. | **Look Fors:**   * Student’s explanation of photosynthesis is partial, describing some components and interactions. For example, student discusses how carbon dioxide and water are used to create glucose and oxygen. In this response, student doesn’t discuss how energy drives the cycling of matter. * Student supports this explanation with evidence from the Task 3 lab. For example, student discusses how in the experiment, there was evidence of photosynthesis because the water turned blue, meaning the plant took in some carbon dioxide to do photosynthesis. | **Look Fors:**   * Student’s explanation of photosynthesis is complete, describing all components and interactions. For example, student discusses how carbon dioxide, water, and sunlight are used to create glucose and oxygen. While implicit, student doesn’t explicitly discuss how the Sun’s energy drives the cycling of matter. * Student supports this explanation with evidence from the Task 3 lab. For example, student discusses how in the experiment, there was evidence of photosynthesis because the water turned blue, meaning the plant took in some carbon dioxide to do photosynthesis. | **Look Fors:**   * Student’s explanation of photosynthesis is complete, describing all components and interactions, including how energy drives the cycling of matter. For example, student discusses how plants combine carbon dioxide and water to create glucose and oxygen. This process is only possible with the presence of sunlight to provide energy to break the bonds. * Student supports this explanation with evidence from the Task 3 lab. For example, student discusses how in the experiment, only the Elodea in the light did photosynthesis. They know this because the water turned blue, meaning the plant took in some carbon dioxide to do photosynthesis. |

**Rubric 4**: Student develops a model to show the cycling of Earth’s materials in the aquaponics system and describes the flow of energy that drives this process.

* Dimensions Assessed: SEP – Developing and Using Models, DCI – ESS2.A Earth’s Materials and Systems

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student develops a **partial** model to show the cycling of Earth’s materials in the aquaponics system with no descriptions. | Student develops a **partial** model to show the cycling of Earth’s materials in the aquaponics system and **partially** describes the flow of energy that drives this process. | Student develops an **accurate** model to show the cycling of Earth’s materials in the aquaponics system and **partially** describes the flow of energy that drives this process. | Student develops an **accurate** model to show the cycling of Earth’s materials in the aquaponics system and **completely** describes the flow of energy that drives this process. |
| **Look Fors:**   * Student model depicts either sedimentation or weathering/erosion, but not both processes. For an aquaponics system, this could mean showing soil erosion or a buildup of sediments over time. No descriptions about flow of energy are present. | **Look Fors:**   * Student model depicts and explains either sedimentation or weathering/erosion, but not both processes. For an aquaponics system, this could mean showing soil weathering/erosion or a buildup of sediments over time. Description partially describes the flow of energy with one or more components. For example, a response like “Wind and rain causes weathering,“ skips the fact that the energy from the sun causes wind and rain, which result in weathering. | **Look Fors:**   * Student model depicts and explains both sedimentation and weathering/erosion. For an aquaponics system, this could mean showing soil weathering/erosion and a buildup of sediments over time. Description partially describes the flow of energy with one or more components. For example, a response like “Energy from the sun causes wind and rain, which result in weathering and erosion“ does not include the process of sedimentation. | **Look Fors:**   * Student model depicts and explains both sedimentation and weathering. For an aquaponics system, this could mean showing soil weathering/erosion and a buildup of sediments over time. Description completely describes the flow of energy for the processes identified. For example, a response like “Energy from the sun causes wind and rain, which result in weathering. This also erodes rock and deposits it other places, and the pressure of gravity eventually leads to sedimentation. “ |

**Rubric 5**: Student explains why some rock cycle processes will not occur in their aquaponics system by examining each process at different time scales.

* Dimensions Assessed: DCI – ESS2.A Earth’s Materials and Systems, CCC – Stability and Change

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student **inaccurately** explains why some rock cycle processes will not occur in their aquaponics system. | Student explains why some rock cycle processes will not occur in their aquaponics system **but does not** examine each process at different time scales. | Student **partially** explains why some rock cycle processes will not occur in their aquaponics system by examining each process at different time scales. | Student **completely** explains why some rock cycle processes will not occur in their aquaponics system by examining each process at different time scales. |
| **Look Fors:**   * Student inaccurately explains that weathering/erosion will not happen in their aquaponics system because there is no wind. | **Look Fors:**   * Student explains that crystallization and/or deformation will not happen in their aquaponics system because there is no geothermal energy input. Student does not specifically reference time scales in their explanation. | **Look Fors:**   * Student explains that crystallization or deformation (instead of both) will not happen in their aquaponics system because there is no geothermal energy input. They also specifically reference time scales by explaining that this process also takes a very long time, so they wouldn’t be visible over our lifetime anyways. | **Look Fors:**   * Student explains that crystallization and deformation will not happen in their aquaponics system because there is no geothermal energy input. They also specifically reference time scales by explaining that these two processes also take a very long time, so they wouldn’t be visible over our lifetime anyways. |

**Rubric 6**: Student identifies a physical and chemical change that occurs in their aquaponics system, supporting identifications with an explanation of how macroscopic patterns allow them to determine the microscopic structure for each change.

* Dimensions Assessed: SEP – Analyzing and Interpreting Data, DCIs – PS1.A Structures and Properties of Matter and PS1.B Chemical Reactions, CCC – Patterns

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| --- | --- | --- | --- |
| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student identifies **at least one accurate** physical and/or chemical change that occurs in their aquaponics system, **with no explanation**. | Student identifies **at least one accurate** physical and/or chemical change that occurs in their aquaponics system, supporting identifications with an explanation of macroscopic patterns **OR** microscopic patterns. | Student **accurately** identifies a physical and chemical change that occurs in their aquaponics system, supporting identifications with an **implicit** explanation of how macroscopic patterns allow them to determine the microscopic structure for each change. | Student **accurately** identifies a physical and chemical change that occurs in their aquaponics system, supporting identifications with an **explicit** explanation of how macroscopic patterns allow them to determine the microscopic structure for each change. |
| **Look Fors:**   * Student accurately identifies at least one physical and chemical change in their aquaponics system. For example, photosynthesis is a chemical change and evaporating water is a physical change. * No supporting explanation is provided. | **Look Fors:**   * Student accurately identifies at least one physical and chemical change in their aquaponics system. For example, photosynthesis is a chemical change and evaporating water is a physical change. * Student supports the identifications with macroscopic OR microscopic patterns, but not both. For example, the properties of reactants and products are different for photosynthesis and the same for evaporating water. This means photosynthesis is a chemical change and evaporating water is a physical change. | **Look-Fors**   * Student accurately identifies a physical and chemical change in their aquaponics system. For example, photosynthesis is a chemical change and evaporating water is a physical change. * Student supports the identifications with macroscopic and microscopic patterns, but does not explicitly connect the two. For example, the properties of reactants and products are different for photosynthesis and the same for evaporating water. The reactants and products for photosynthesis are also different, but the same for evaporating. This means photosynthesis is a chemical change and evaporating water is a physical change. | **Look Fors:**   * Student accurately identifies a physical and chemical change in their aquaponics system. For example, photosynthesis is a chemical change and evaporating water is a physical change. * Student supports the identifications with macroscopic and microscopic patterns, explicitly connecting the two. For example, the properties of reactants and products are different for photosynthesis, which shows us that the molecules are different and that it is a chemical change. Meanwhile, the properties of reactants and products are the same for evaporating water, which shows us the molecules are the same and that it is a physical change. |

**Rubric 7**: Student shows and explains how their design uses a chemical reaction to release heat and describes their design process.

* Dimensions Assessed: SEP –Designing Solutions, DCI – PS1.B Chemical Reactions, CCC – Energy and Matter

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student **partially** shows and explains how their design uses a chemical reaction to release heat and **partially** describes their design process.  OR  Student **accurately** shows and explains how their design uses a chemical reaction to release heat and **does not** describe their design process. | Student **accurately** shows and explains how their design uses a chemical reaction to release heat and **partially** describes their design process. | Student **accurately** shows and explains how their design uses a chemical reaction to release heat and **mostly** describes their design process. | Student **accurately** shows and explains how their design uses a chemical reaction to release heat and **completely** describes their design process. |
| **Look Fors:**   * Student’s diagram partially shows a device that uses a chemical reaction to release heat. Labels and/or captions to describe how the device works may be missing information; for example, the specific chemical reaction that releases heat. Student describes their design process, but it is very limited.   OR   * Student’s diagram accurately shows a device that uses a chemical reaction to release heat. Labels and/or captions describe how the device works, including the chemical reaction that releases heat. No description of design process is present. | **Look Fors:**   * Student’s diagram accurately shows a device that uses a chemical reaction to release heat. Labels and/or captions describe how the device works, including the chemical reaction that releases heat. * Student describes their design process, but it is very limited. For example, student only discusses testing their device and making modifications. | **Look Fors:**   * Student’s diagram accurately shows a device that uses a chemical reaction to release heat. Labels and/or captions describe how the device works, including the chemical reaction that releases heat. * Student describes their design process, including most of the following: identifying criteria/constraints, developing models, testing, modifying with others’ ideas, and final testing. For example, they leave out identifying criteria/constraints. | **Look Fors:**   * Student’s diagram accurately shows a device that uses a chemical reaction to release heat. Labels and/or captions describe how the device works, including the chemical reaction that releases heat. * Student describes their design process, including all of the following: identifying criteria/constraints, developing models, testing, modifying with others’ ideas, and final testing. |

**Additional Notes:**

* The first and last bullet points of the Individual Project Criteria for Success does not have rubrics as they are merely meant for students to tie together pieces of their project.
* Two additional rubrics are provided in Task 5 to assess the Engineering and Design Performance Expectations (MS-ETS1-3 and MS-ETS1-4); these PEs are not assessed explicitly in this Culminating Project.