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| **Standards**  **HS-LS2 Ecosystems: Interactions, Energy, and Dynamics**  **HS-ESS2 Earth’s Systems**  **HS-ESS3 Weather and Climate** | | |
| **Performance Expectations**  The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The materials/lessons/activities outlined in this article are just one step toward reaching the performance expectations listed below.  **HS-LS2-3.** Construct and revise an explanation based on evidence for the cycling of matter and flow of energy.  **HS-ESS2-4.** Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate.  **HS-LS2-5.** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.  **HS-LS2-6.** Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.  **HS-ESS3-5.** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current or regional climate change and associated future impacts to Earth Systems.   |  |  | | --- | --- | |  |  | | | |
| **Dimension** | **Name and *NGSS* code/citation** | **Specific connections to classroom activity** |
| **Science and Engineering Practices** | **Developing and Using Models**   * Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (HS-LS2-5) * Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate. (HS-ESS2-4)   **Analyzing and Interpreting Data**   * Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. (HS-ESS3-5)   **Constructing Explanations and Designing Solutions**   * Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. (HS-LS2-3) | Students iteratively develop visual models with written explanations to explain their understandings of carbon cycling and its connection with global climate change.  Students engage with data analysis on global carbon dioxide and methane concentrations and their connections with global climate change using standardized data from NOAA and NASA, archived on the project website.  Students explore and explain the processes of photosynthesis, cellular respiration, and the carbon cycle and their connections with atmospheric, terrestrial, and aquatic carbon sinks.  Students apply what they have learned through developing explanatory models to create a predictive model for climate change impact on a species of their choice. |
| **Disciplinary Core Ideas** | **LS2.B: Cycles of Matter and Energy**   * Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5) * Photosynthesis and cellular respiration provide most of the energy for life processes (HS-LS2-3)   **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 as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystem sin terms of resources and habitat availability. (HS-LS2-6)   **ESS2.D: Weather and Climate**   * The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space. (HS-ESS2-4)   **ESS3.D: Global Climate Change**   * Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) | Through a field trip to a tallgrass prairie, students interact with researchers, collect data, and explore how climate change might affect a local ecosystem.  Students explore the competitive dynamics between woody and herbaceous plants on a prairie (with an emphasis on access to water) and predict impacts of changing climate (which likely lead to changes in precipitation patterns) on competition between woody and herbaceous plants.  Students explore trophic levels, energy, and matter cycling within a local prairie ecosystem and predict changes over time due to climate change.  Using a photosynthesis/cellular respiration lab adapted from Drouin et al. 2006, students explore and explain the process of photosynthesis and its connections to cellular respiration and the carbon cycle, as well as how water acts as a sink for carbon dioxide. |
| **Crosscutting Concepts** | **Cause and Effect**   * Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. (HS-ESS3-5)   **Systems and System Models**   * Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (HS-LS2-5) * Models can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)   **Energy and Matter**   * Energy drives the cycling of matter within and between systems. (HS-LS2-3)   **Stability and Change**   * Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. (HS-LS2-6) * Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6) | Through a field trip to a tallgrass prairie, students interact with researchers, collect data, and explore how climate change might affect a local ecosystem.  Students explore the competitive dynamics between woody and herbaceous plants on a prairie (with an emphasis on access to water) and predict impacts of changing climate (which likely lead to changes in precipitation patterns) on competition between woody and herbaceous plants.  Students explore trophic levels, energy, and matter cycling within a local prairie ecosystem and predict changes over time due to climate change.  Students engage with data analysis on global carbon dioxide and methane concentrations and their connections with global climate change using standardized data from NOAA and NASA, archived on the project website.  Students iteratively develop visual models with written explanations to explain their understandings of carbon cycling and its connection with global climate change. |

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| **Connections to Nature of Science**  Science knowledge is based on empirical evidence. (HS-ESS3-5) | Students engage with data analysis on global carbon dioxide and methane concentrations and their connections with global climate change using standardized data from NOAA and NASA, archived on the project website. The controversy surrounding the media’s confirmation bias and coverage of climate change is discussed early in the unit, and students engage in a media literacy activity to evaluate the validity of data and look for potential bias. |

**Connecting to the *Common Core State Standards* (NGAC and CCSSO 2010)**

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| *ELA/Literacy*  **RST.11-12.1.** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-5)  **RST.11-12.2.** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS3-5)  **SL.11-12.5.** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-4) | During their analysis and presentation of carbon accumulation data, carbon cycle models, and summative predictive model for climate change impacts, students analyze and communicate using a variety of media, draw evidence from rigorous sources, use appropriate citations, and use mathematical reasoning and models.  The evaluation of data sources for validity and potential bias is featured with the Know Your Sources activity. |