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| **Standards HS-PS3-1 Energy** **HS-LS1-7 From Molecules to Organisms: Structures and Processes** |
| **Performance Expectation(s)***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 activities outlined in this article are just one step toward reaching the performance expectations listed below.***HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are unknown.****HS-LS-7. Use a model to illustrate the cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.**  |
| **Dimension** | **Name and *NGSS* code/citation** | **Specific Connections to Classroom Activity** |
| **Science and Engineering Practices** | **Using Mathematics and Computational Thinking*** Create a computational model or simulation of a phenomenon, designed device, process, or system.

**Developing and Using Models*** Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7)
 | Students use video analysis tools to collect distance and time data for calculation of potential and kinetic energies of different systems.Students develop a model for similarities and differences of energies between non-living and living systems in motion and at rest. |
| **Disciplinary Core Ideas** | **PS3.B: Conservation of energy and Energy Transfer** * Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1).
* Mathematical expressions, which quantify how the stored energy in a system depends on its configuration and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)

**HS-LS1-7: Organization for Matter and Energy Flow in Organisms** * As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
* As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
 | Student groups discuss and analyze total energy transfer from potential to kinetic energy of a ball that loses energy with each bounce and then apply the same approach to the motion of a kangaroo that maintains a consistent bounce.Students complete a pre-lab quiz, perform experiments with video capture/analysis of a ball, write a lab report and complete a post-lab quiz, which assess concept/application of a rubber ball versus a kangaroo in motion. Students develop a physical understanding of a body in motion from the physical ball and then apply this prior knowledge to a more complex system of a red kangaroo, whose energy from chemical systems and cellular respiration is converted into maintaining energy required for a continuous hopping motion (ie – metabolism or potential chemical energy of food that converts into kinetic energy of motor function of muscles that cause the kangaroo to hop). |
| **Crosscutting Concept(s)** | **Systems and System Models*** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)

**Energy and Matter** * Energy cannot be created or destroyed – it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS1-7)
 | Students perform extension research projects on an animal video of their choice.(ex. rabbits hopping, cats leaping, mantis shrimp forelimb striking, and birds flying.) |
| **Connections to Nature of Science (when appropriate):*** Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4)
 | Post-activity discussions and research extensions allow students to explicitly reflect on the nature of science, especially initial models that are meant to be revised as data analyses and interpretations continue. |
| **Common Core State Standards Connections (when appropriate):***ELA/Literacy* **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)**MP.2** Reason abstractly and quantitatively. (HS-ESS3-1)**MP.4** Model with mathematics. (HS-ESS2-4) | In an extension research presentation, students communicate using digital media, support their analysis with evidence and appropriate citations, and use mathematical reasoning and models for the motion analysis of an animal of their choosing. |