HS Science Lesson Plan

# of Students: 30 **Age/Grade Level:** 9 - 10
Content Area: Integrated Science (Regular and Honors)

Putting the *Green* Into Goldberg

Essential Questions:
How do the inputs and outputs in a system affect its functioning?
How do energy and matter flow in living systems?
How can an engineered physical system (with designed inputs that can be manipulated) inform/model how energy moves through natural systems?

Building towards the following Performance Expectations:

HS-PS3-3 Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

(**note:** students are building toward the knowledge and skills that would allow them to demonstrate the PEs and targeted elements of each of the dimensions, which are end of 12^{th} grade goals.)

Lesson Level 3 -Dimensional Learning		
Science and Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Constructing Explanations and Designing Solutions • Design, evaluate and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. Engaging in Argument from Evidence • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student -generated evidence. Models: • Develop and Use a model based on evidence to illustrate the relationships between systems or between components of a system.	PS3.A Definitions of Energy: • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light and thermal energy 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 and out of the system. • The availability of energy limits what can occur in any system. LS. 2B Cycles of Matter and Energy Transfer in Ecosystems • Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.	Energy and Matter Flows, Cycles and Conservations • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of and within that system. Systems and System Models: • Models (Physical, mathematical, computer) can be used to simulate systems and interactions-including energy, matter, and information flows- within and between systems at different scales

Teaching and Learning Context:

This lesson is a transfer task following a learning progression, focusing on student thinking about energy flow through systems. In this lesson, students will transfer 3D understanding of LS2.B Cycles of Matter and Energy Transfer in Ecosystems (from previous classroom experiences) and connect to their understanding of PS3.B Conservation of Energy and Energy and Energy Transfer. Students will use their understanding of the crosscutting concepts of Energy and Matter and System and System Models to organize thinking around these core ideas from different disciplines during the lesson while constructing explanations and engaging in arguments from evidence. The end-goal of this 3D learning in future lessons will be an understanding of the efficiency of a system, in both a life science and physical science context. Students will use this understanding to "Green a Goldberg" to make their original system more efficient. Following this lesson, students will continue to deepen their understanding of systems and energy and matter flows as they increase their proficiency in the practice of argument as they "Green" another system: a life science system.

Students will use the crosscutting concepts of energy and system and system models to connecting knowledge from the various disciplines (life science and physical science) to support the building of a coherent and scientifically-based view of the world

Student Engagement

- Student choice in determining both the life science and physical science designs/systems serves to engage all students in the learning by providing them with a mechanism to relate the goals of the classroom to their own personal contexts.
- Students are encouraged to express their ideas in a variety of ways: speaking, drawing, model building, and writing. Students have multiple opportunities to explain their ideas. The goal of the lesson is to create a learning experience which students can engage with in ways that are comfortable and appropriate to their learning styles, while giving all students equal access to the discourse and meaning-making that happens.
- Students are in heterogeneous groupings and group roles encourage equitable participation with accompanying peer modeling.
- The use of sentence stems supports individual reflection and metacognition of the knowledge and skills associated with the crosscutting concepts and practice, as well as guides for thinking shared in small group discussion to serve as peer modeling in heterogeneous groups.
- Focusing communication on evidence and reasoning, as opposed to the 'right answer', creates opportunity for all students to share their thinking in a way that is valued and contributes productively to constructing a common understanding.
- This lesson is intended to emphasize conceptual understandings, not science vocabulary. Students' science language evolves as conceptual understanding develops, which gives all students the opportunity to engage and grow their thinking and use of language without being penalized or left out of the conversation because they don't have a full grasp of the vocabulary.

Lesson Plan

Rube Goldberg Explanations
Student groups create video explanations of their Rube Goldberg devices that can be shared to authentic audiences for systematic evaluation of solutions.

Science Talk
Students use Life Science individual designs to consider the most efficient source of energy for a human, and the ecosystem within which this organism would be found. This scaffolds students to begin using their recent experiences with energy transfers in a physical science system (the rube) to frame/prime student thinking to be interdisciplinary. The explicit connection is energy flows through systems, which sets students up to explicitly engage in interdisciplinary comparisons in the next portion of the learning experience. Students use sentence stems, questions, and different crosscutting concepts to help organize and share their thinking. Some examples of questions provided to the student could include:

- What would you need to know support the claim that energy is being conserved in the living world?
- What would you need to know to support that energy is being conserved in the physical world?

Engaging in Argumentation: explicitly asking students to engage in the common energy relationships in discipline-disparate systems
In small groups (3-4 students) students are asked to compare the conservation of energy and energy transfers through systems in the living and physical world, using evidence from both the Rube Goldberg they designed as well as the life science system under study. Students are explicitly told that they should cite evidence from the systems under study and respectfully question and respond to their peers. This prompt is intentionally specific in terms of a conceptual goal, and intentionally general in specific features of an “answer”, giving students the opportunities to make their own unique connections to the material through different lenses. The nature of the task also shifts the emphasis from an “answer” to a thinking process.

Students make their thinking visible to the larger group, which allows them to develop a common understanding of their experiences with the common features of energy transfer in the physical and life science system they are working with. This large group conversation also allows students to create a need for the class to further investigate efficiency, and its role in both physical and life science systems.

Next Steps in following lessons:
***Green* the Goldberg Task (Design a Rube Goldberg with efficiency in mind)**
Student groups design a *Green* Goldberg that has at least 3 steps with the ultimate measure of success being that it accomplishes the end task in the most efficient way possible. This device must use everyday items and be a device someone can realistically build.
As you design, prepare to share your evidence and reasoning to support your claim that your Rube is more efficient.

Reflection:
I can support the claim that my device is efficient by______________________

Respond to one of the following:

- What have you learned?
- How have you learned to apply previous understanding in a new way?

What connections have you made between the living and the nonliving world that you did not come in with today?