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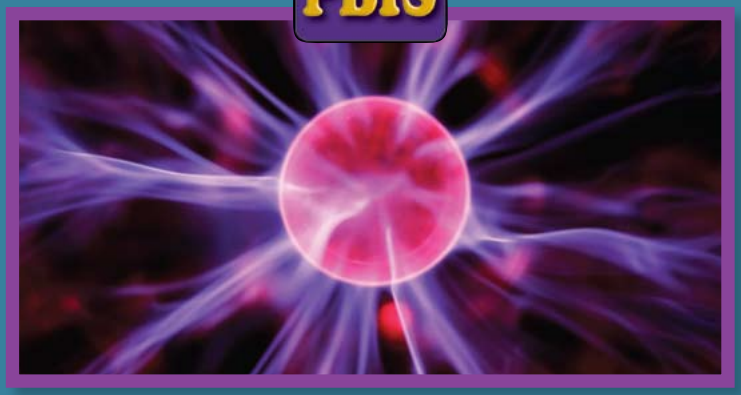
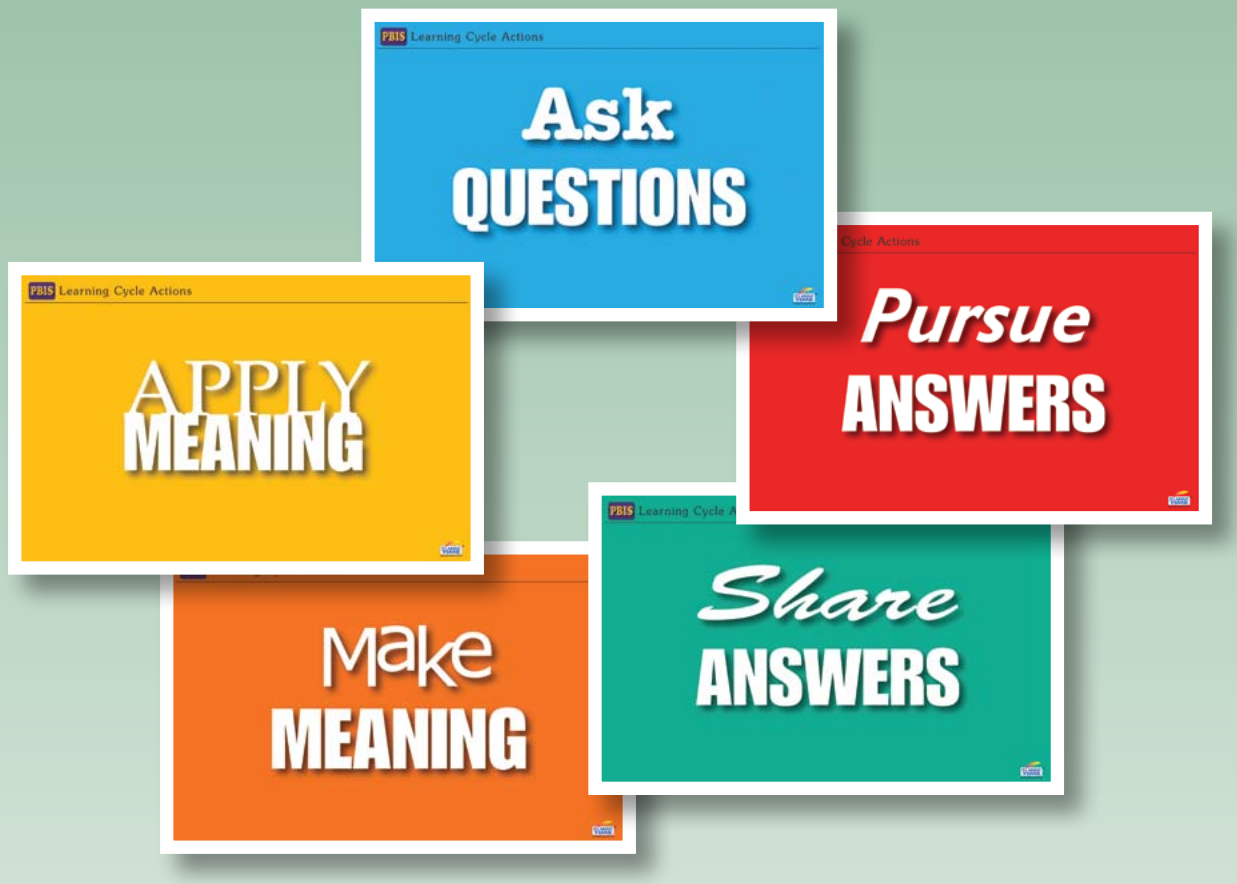


# ENERGY

*As a student scientist, you will...*



# What's the Big Challenge?

## *Design a Rube Goldberg machine to turn off a light.*

The word energy is used every day in many different ways. You have probably heard people say, *"I don't have the energy to clean my room," "Turn off the lights to save energy," "The energy from these batteries will make the flashlight light up,"* or *"People must conserve energy."* To what, exactly, are they referring? Every day you observe many different kinds of energy, and you probably do not even think about it. A few common examples are shown on the opposite page.

Look carefully at the picture. Do you think the soccer players have enough energy to play harder? Where does their energy come from? How can you know if the oven has enough energy to finish baking the cupcakes? Where does the oven's energy come from? Candles on a birthday cake produce both heat and light. Are heat and light energy? Where does this energy come from, and where does it go?

In this Unit, you will learn how to identify the presence of energy, and many different types of energy, and the ways energy is **transformed** from one type into another type of energy. Energy transformations are key to how work gets done. And that is the important word—*work.* You will be encountering this word many times in this Unit. Work and energy are closely related to one another.

**transform:** to convert from one form into another form.

Look at the *Big Challenge* in this science Unit: *Design a Rube Goldberg machine to turn off a light.* This project will be a lot of fun. You will give your imagination the freedom to be creative. You will not be able to design this machine right away. First, you will need to learn what energy is, what kinds of energy are in your world, and how one type of energy can be transformed into another type.

*Welcome to* Energy.
*Enjoy your journey as a student scientist.*

# Think About the *Big Challenge*

## *Design a Rube Goldberg machine to turn off a light.*

Usually, when you turn off a light switch, you place a finger on the switch and use muscles to push down the switch. Your muscles use *energy* to do the *work* of pushing down a switch. You may not know exactly what the words energy and work mean. For now, if you think about energy as the ability to cause change and work as applying energy to objects, you will be able to get started understanding energy and achieving the challenge. By the end of this Unit, you will be able to give scientific definitions for these two words.

You will be learning more about energy and work as you address the *Big Challenge.* The *Big Challenge* in this Unit is to design a complex, multi-step machine that does the simple job of turning off a light. Designing this machine will allow you to use your imagination and creativity. If people think about how your machine will actually work, they may find it amusing or even laugh out loud. However, the task of designing the machine is serious. Your machine will use several types of energy to do the job of turning off a light. It will *transform* one kind of energy into another kind at each and every step.

*Children playing on this merry-go-round provide the energy to power a water pump.*

To prepare for addressing this challenge, you will first think about what you already know about energy. You cannot always see energy, but you can see the effects of energy transformations. Any time you observe a change in an object, you know that energy is being transformed.

A good example is a battery. A battery has stored energy, but you cannot see the energy in a battery. A "dead" battery looks exactly like a battery that is fully energized. Only by observing a change—a flashlight coming on, a toy car moving across the floor, or a car's engine starting up—can you know that the battery had stored energy, and that some of the energy has been used to perform a task.

Your machine may use energy in unusual and funny ways. But around the world, people are designing and building machines that use energy in unusual ways to do serious work. One company in the Netherlands, *Enviu,* has designed a dance floor that uses dancers' energy to help power the amplifiers and disco lights. They use the term "sustainable dancing" to describe the conversion of fun into energy savings. Another example is using the energy of children at a playground to power a water pump. As the children use their energy to turn a merry-go-round, water is pumped up from a well for people in the village to use. In both examples, the energy that is normally lost in having fun is put to good use.

There are many types of energy. A machine often changes the available energy into a different form needed to perform a task. The merry-go-round water pump you read about transforms a child's energy into energy that can be used to pump water. In a flashlight, a battery's energy is transformed into the energy released by a light bulb. In a toy car, the energy in a battery is transformed into energy that makes the car start to move.

To succeed with this Unit's challenge, you will need to know

- how to identify and describe the effects of different types of energy,
- what affects how much energy an object has,
- how to store energy,
- how energy moves from one place to another,
- how to transform one type of energy into another type of energy, and
- how to control energy so it can do work.

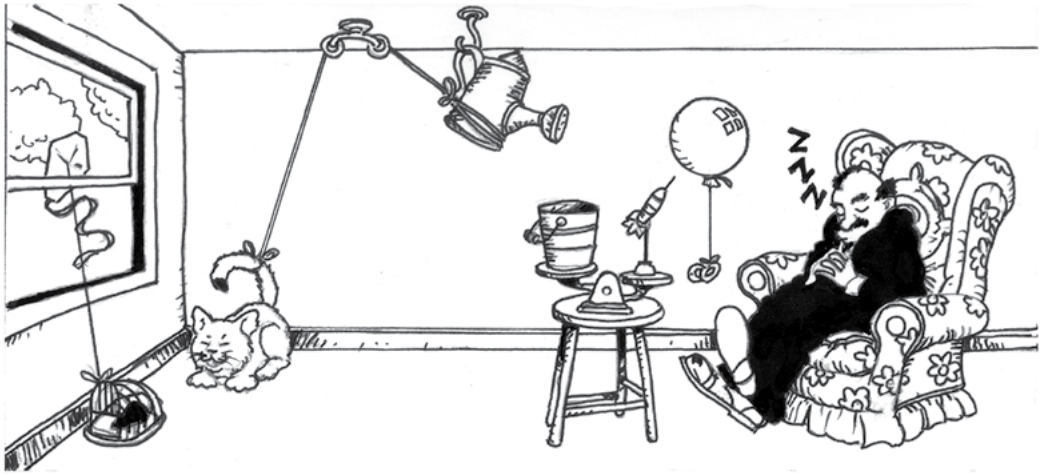
## Get Started

Meet Rube Goldberg. Rube Goldberg was a cartoonist who enjoyed drawing amusingly complex machines. Each machine included a series of complicated steps that combined together to achieve a simple task. In your challenge, the simple task is to turn off a light switch. Rube Goldberg's designs were only drawings and did not really carry out tasks. But they were imaginative and fun, and they amused millions of people. In the United States, machines like this are often called "Rube Goldberg machines."

## Rube Goldberg (1883–1970)

Rube Goldberg was an engineer, cartoonist, sculptor, and author. He is best known for his humorous drawings of overly complex machines. For example, the cartoon pictured is a Goldberg-like alarm clock cartoon. Even though the machine is not practical, you can see that Goldberg had good engineering skills. His devices showed many types of energy transformations in a series of linked steps.

The comical inventions of Rube Goldberg have inspired contests that motivate and challenge people to come up with their own complex solutions to simple tasks. When people design Rube Goldberg machines, the more steps it takes to complete a task, the better the invention!

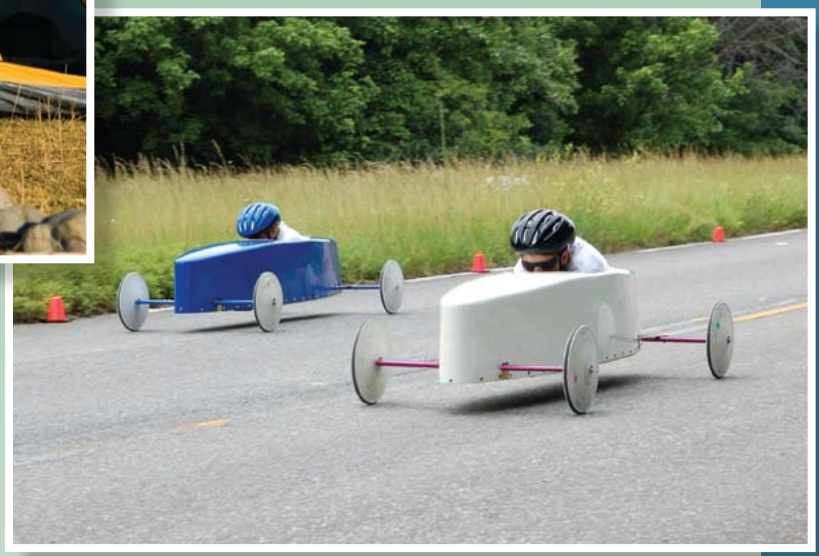



*A Rube Goldberg-like alarm clock cartoon.*

**Rube Goldberg knew a lot about energy and how one type of energy can be transformed into another. To design your machine, you will also have to understand energy and energy transformations. You will begin by thinking about how energy makes things operate in your world. You will use those**

**examples to help you think about energy and work. You will record your ideas on an *Energy Types* page. For now, you may not be able to fill in every column. As you learn more, you will be able to complete the columns. You will add to this page throughout the Unit.**

*Energy from a campfire can keep you warm and roast your marshmallows. The campfire supplies heat energy.*



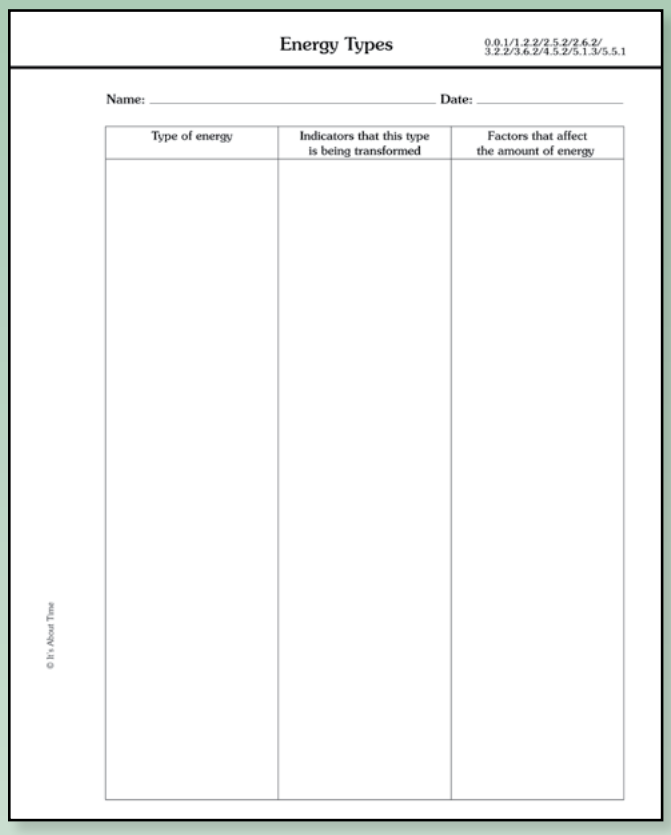
*A soapbox racing car at the top of a hill will remain motionless if its brakes are on. But when its brakes are released, the car will roll down the hill. You might wonder where that energy was when the cart was motionless.*

*You may not think of mousetraps as having energy—until you see them being set off.*

# Conference

With your group, identify when and where you see examples of energy transformations in your everyday life. Remember that you can know if energy is transformed when you observe something change.

Begin by listing 10 examples of energy transformations you are familiar with on your *Energy Types* page. Then answer these questions about your examples:



Energy Types

0.0.1/1.2.2/2.5.2/2.6.2/3.2.2/3.6.2/4.5.2/5.1.3/5.5.1

Name: _____ Date: _____

| Type of energy | Indicators that this type is being transformed | Factors that affect the amount of energy |
|---|---|---|
| | | |



- What types of energy transformations occur in your examples?
- How does one type of energy transform into another type in your examples?
- How does the amount of energy transformed differ among your examples?
- How is energy used to do work in each of your examples?

When you have completed your list and answered the questions above, answer the following questions with your group. Be prepared to share your examples and answers with the class.

1. What do you think energy is?
2. What do you think work is?
3. What questions do you have about energy?

# Communicate

Share your group's examples and answers to the questions with the class.

# Observe

## Energy in Action

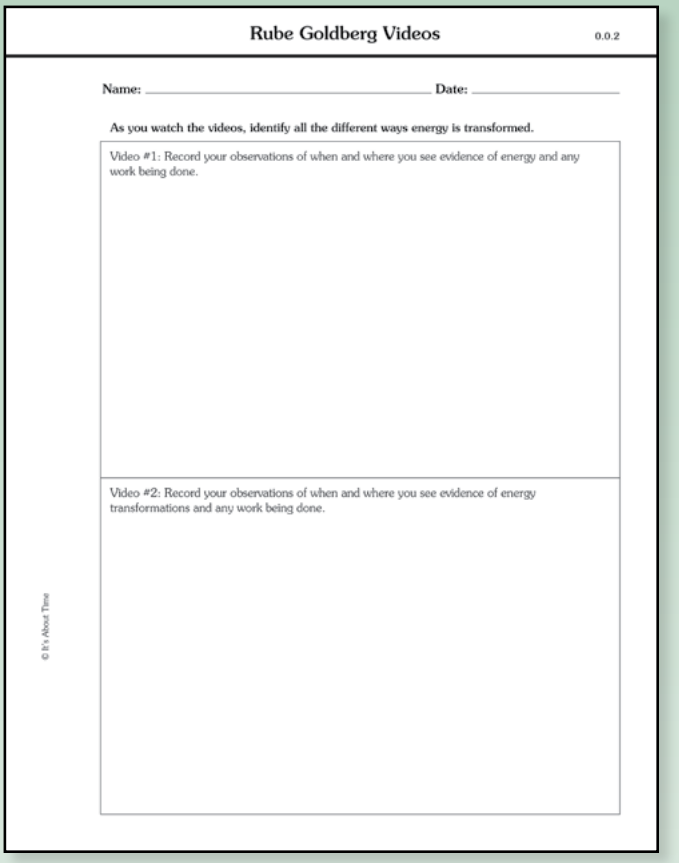
You have identified what you know about energy so far. Now you can enjoy and learn from videos of some examples of Rube Goldberg machines. You will watch two videos. As you watch them, you will identify the different ways energy is transformed. View the videos, keeping in mind what you have already discussed about energy. Record on your *Rube Goldberg Videos* page your observations of when and where you see evidence of energy and any work being done. You may want to view the videos more than once. If there is something you would like to look at again, ask if a video can be replayed for you. Remember that energy has been transformed when you observe something change.

# Reflect

1. Select your favorite step in one machine and give a reason why you found that step interesting. Describe how you think an energy transformation was involved in making that part of the machine operate properly.

2. Describe the machine's step that comes right after the step you selected in Question 1. How do you think the energy was transferred from one step to the next?

3. Based on what you discussed with your group and observed in the videos, how would you change your answers to the questions, *What is energy?* and *What is work?*



Rube Goldberg Videos 0.0.2

Name: _____ Date: _____

As you watch the videos, identify all the different ways energy is transformed.

Video #1: Record your observations of when and where you see evidence of energy and any work being done.

Video #2: Record your observations of when and where you see evidence of energy transformations and any work being done.


*The Breakfast Server*


*The Trash-to-Stereo Server*


*The Can Picker*


*The Orange Squeezer*

# Explore

Your challenge for this Unit is to design your own machine that will turn off a light. To help you understand your goal and how you might accomplish it, each group will look at a different example of a Rube Goldberg machine designed by a professional cartoonist. These energy-transformation cartoons, shown on the previous pages, use many of the same concepts that you saw illustrated in the videos. Each machine performs what should be an easy task with a complicated series of steps. Your group will be assigned one of these four cartoons:

- *The Breakfast Server*
- *The Trash-to-Stereo Server*
- *The Can Picker*
- *The Orange Squeezer*

Each step in these machines has been labeled with a letter so that you can follow the actions taken by the machine. You will examine your machine and look for the change that occurs in each step. Then you will try to identify the type of energy transformation that is causing that change.

# Procedure

1. Examine the machine your group was assigned. What is the purpose of the machine?

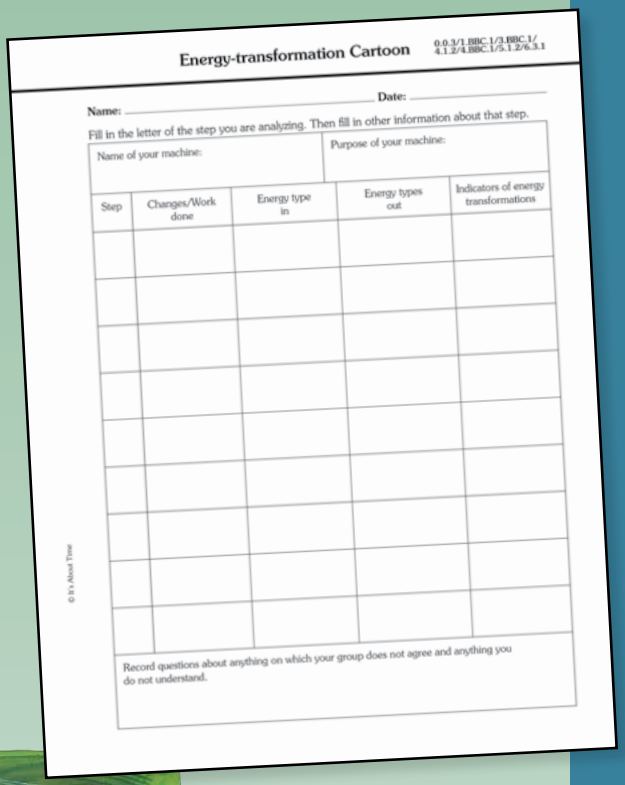
2. Identify what you can about how the machine carries out its task. Follow these instructions.
   a) List the changes that occur at each step in your machine on your *Energy-transformation Cartoon* page. For example, does an object go downhill from a higher point to a lower point? Does a fire start? Use as many *Energy-tranformation Cartoon* pages as you need.
   b) Identify what type of energy transformation occurs at each step. What type of energy is transformed into what other type?
   c) Wherever you can, identify how energy changes from one type to another within a step or between steps.

3. You may have questions about how energy is involved in a change. Record questions about anything on which your group does not agree and anything you do not understand.

# Communicate

## Share Your Ideas

Share with the class what the machine in your sketch does. Be sure to include the purpose of your machine, the changes that happen during the operation of the machine, and anything you could identify about the energy used to make those things happen. Discuss any questions you may have about your machine and the other groups' machines.



Energy-transformation Cartoon

0.0.3/1.BBC.1/3.BBC.1/4.1.2/4.BBC.1/5.1.2/6.3.1

Name: _____ Date: _____

Fill in the letter of the step you are analyzing. Then fill in other information about that step.

| Name of your machine: | | | Purpose of your machine: | |
|---|---|---|---|---|
| Step | Changes/Work done | Energy type in | Energy types out | Indicators of energy transformations |
| | | | | |
| | | | | |
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Record questions about anything on which your group does not agree and anything you do not understand.

© It's About Time

# Your Challenge

Your challenge is to design a machine to turn off a light. Your machine will include at least five steps and use at least three types of energy. You will design your machine and describe how and why each part of it operates properly. You will also describe the ways energy is transformed from one form to another.

You will not build your design. You will only draw it on paper. However, you must be able to convince your classmates that it would operate properly if built. That means each step must be believable, and the sequence of steps must be logical. Remember the cartoons and videos you have seen so far. Some of the steps in those machines seemed outrageous. But the steps combined in a way that completed a task.

Your machine should use materials commonly found in a home, a supermarket, or a hardware store. Even though you are not going to be building the machine, it should be designed to be safe enough to operate with a parent or teacher around to help. For example, it can use fire, but it should not use explosives.

# Identify Criteria and Constraints

**criteria (singular: criterion):** conditions that must be satisfied to successfully achieve a challenge.

**constraints:** factors that limit how you can solve a problem.

Before you start, make sure you understand the **criteria** and **constraints** of your challenge. Criteria are conditions that must be satisfied to achieve the challenge. One criterion is that your machine must have at least five steps. Another criterion is that, in at least three of its steps, energy must be transformed from one form to another.

Constraints are factors that limit how to solve a problem. You will not build the machine, only design it and sketch it. However, one constraint is that each step must be logical and believable. Your classmates need to believe that it would operate properly if built. Another constraint is that the design must use easy-to-find materials. Another constraint is safety. Your design must be safe enough to operate with adult supervision.

Record the criteria and constraints in a table like the one shown below, so you can refer to them as you move through the Unit.

| Design a Rube Goldberg machine to turn off a light | |
|---|---|
| **Criteria** | **Constraints** |
| | |
| | |

## Create a *Project Board*

It is useful to keep track of your progress when you are designing something. It is also useful to keep track of what you already know and what you still need to learn as you move through a challenge. Throughout this Unit, you will be using a *Project Board* to do this. During classroom discussions, the ideas from the class will be recorded on a class *Project Board.* At the same time, you will keep a record of what has been discussed on your own *Project Board* page.

Remember that a *Project Board* has space for answering five guiding questions:

- What do we think we know?
- What do we need to investigate?
- What are we learning?
- What is our evidence?
- What does it mean for the challenge or question?

To get started on this *Project Board,* you need to record the *Big Challenge* at the top of the *Project Board: Design a Rube Goldberg machine to turn off a light.*

| Design a Rube Goldberg machine to turn off a light | | | | |
|---|---|---|---|---|
| **What do we think we know?** | **What do we need to investigate?** | **What are we learning?** | **What is our evidence?** | **What does it mean for the challenge or question?** |
| | | | | |

## *What do we think we know?*

In this column of the *Project Board* you will record what you think you know about energy, energy transformations, and work, and about completing the challenge. You have read about and discussed many ideas about energy in this introduction. You have also discussed many examples of Rube Goldberg machines. Record those ideas and thoughts in this column.

## *What do we need to investigate?*

In this column, you will record what you need to know more about to complete the challenge. This column is designed to help you keep track of ideas that are debatable or unknown and need to be investigated. For example, you may disagree with members of your group about what energy is. This is something that needs to be investigated. You identified questions when you were watching the videos and examining the cartoon drawings of machines. Record those questions in this column.

Later in this Unit, you will return to the *Project Board.* For now, you and your classmates will fill in the first two columns.