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Overview

This *Delta Science Module* introduces students to six famous scientists and some of the contributions they have made to human civilization.

The scope of *Famous Scientists* is expansive. It reaches beyond classroom exploration with objects, concepts, and principles to put a human face on science. Not only do the activities engage students in several science disciplines appropriate to middle school investigation—physical science and technology, environmental science and astronomy, life science and ecosystems—they also present scientific milestones and turning points in the context of times, places, and cultures. In other words, the module is interdisciplinary both within the sciences *and* within the overall grade 6–8 curriculum.

The biographies of the six science pioneers establish links between science and society, and between the past and present. In doing so, the historical and contemporary examples help students develop an understanding of the nature and history of science. They reveal the advance of scientific knowledge as a human endeavor, undertaken by men and women of courage, imagination, perseverance, and insight. Many overcame extraordinary obstacles to pursue their inquiries and achieve their goals. These case studies of scientists at work demonstrate both the historical resistance to scientific innovation and the great contributions that one individual can make.

The science/society connection also enhances student appreciation of the role of technology in society: What questions can science reasonably address? Just as important, the activities strengthen students' scientific understanding of personal and global health, and the hazards that threaten both.

Activities 1 and 2 introduce students to the ancient Greek mathematician Archimedes, the "father of experimental science." In Activity 1, they learn about Archimedes' principle, also called the law of buoyancy. They discover that the buoyant force on an object immersed in water is equal to the weight of the water displaced by the object. Then they compare the buoyant force with the weight of the object to discover why some objects sink while others float.

Archimedes did not invent the lever, but he was the first to explain how it worked. In Activity 2, students use a ruler and some washers to manipulate the load and effort of a lever and achieve a state of equilibrium. From their observations they should be able to communicate the law of levers and infer how levers can make lifting heavy things easier.

Activities 3 and 4 introduce students to the Italian physicist and astronomer Galileo Galilei. In Activity 3, students repeat Galileo's experiments with objects in motion. By dropping plastic, glass, and metal spheres from a height, they discover that all objects fall at the same rate (assuming no air resistance).

In Activity 4, students build a telescope similar to the one used by Galileo. First students review how lenses focus light, and distinguish between concave and convex lenses. Next, they build their own refracting telescopes from cardboard cylinders and convex lenses, calculate the magnification, and make observations with the telescope.

In Activities 5 and 6, students are introduced to American inventor Thomas Edison. In Activity 5, students reproduce one of the projects that made Edison famous: the incandescent light bulb. Students build their own light bulb and describe how it works. Students then experiment with different types of filaments in an attempt to make their bulbs glow longer and brighter.

In Activity 6, students discover how sound waves can be "written down" and played back again on a phonograph—one of Edison's greatest inventions. Students review the concept of sound waves, and demonstrate how sound waves can cause objects to vibrate. Students come to understand how a vibrating object can make a visible "record" of sound waves. Finally, students build a simple stylus and a hand-operated turntable and use them to "play back" sounds recorded on a vinyl record.

In Activities 7 and 8, students are introduced to the great African-American explorer and codiscoverer of the North Pole, Matthew Henson. In Activity 7, students identify the Arctic Ocean on a map or globe and discuss polar conditions. Then they measure the insulating properties of a variety of materials to determine which best controls heat loss in cold weather.

In Activity 8, students discover that the rigors of Arctic exploration put tremendous nutritional demands on the human body. First they discuss the role of food as the body's energy source. Then they keep a food journal to determine their average caloric intake and calculate the number of calories they need to maintain body weight. Finally, they compare their dietary needs to those of the Arctic explorers.

Activities 9 and 10 introduce students to the great environmentalist Rachel Carson. Activity 9 is based on Carson's 1955 best-seller *The Edge of the Sea.* In this activity, students identify the intertidal zone and discuss the living conditions there. Then they examine the skeletal remains of some of the animals that live along the shore and research how these animals are uniquely adapted to their environment.

Activity 10 is based on Carson's most important book, *Silent Spring* (1962). In this activity, students discover several alternatives to chemical insect control. They use sticky traps, rubbing alcohol, soap spray, and natural predators (ladybugs) to rid their pea plants of aphids. From this, students come to realize that there are safer ways to control insects than through the use of potentially harmful chemicals.

Finally, in Activities 11 and 12, students are introduced to cosmologist Stephen Hawking and his work with black holes. In Activity 11, students model the gravitational pull of a black hole on objects that cross its event horizon. They discover that the more massive the black hole, the greater its gravitational pull and the farther away objects are affected.

In Activity 12, students take a theoretical journey to a black hole. Using a balloon stretched over a jar, they observe the tidal forces that affect objects as they fall into a black hole. This simple but effective demonstration illustrates the tremendous force and acceleration associated with a black hole vortex.

Materials List

Qty		Description
1	c	alcohol wipe
8		balls, glass, 1"
8		balls, plastic, 1"
4		balls, solid foam, 1"
1		ball, sponge
9		balls, steel, 1"
8		balls, steel, 1.5"
1		balloons, p/9
4		batteries, AA, 1.5-volt
8		†batteries, 6-volt
1		beads, glass, p/100
1		biographies of scientists, set/6
1	c	candles, p/36
1		clay, modeling, stick
8	c	cups, paper
16	c	cups, foam
3		fabrics, assorted
1	c	feathers, ½ oz
8		film canisters, with caps
4		flashlights
1		fur, synthetic
9		jars, with lids
8		lenses, large
8		lenses, small
16		magnifiers
1	c	matches, book
1		nail
8		needles, sewing machine
1		nylon stocking
1	c	petroleum jelly
40		pins, straight
1		poster, moon
8		records, vinyl, 33 rpm
1	c	rubber bands, p/50
1		shells, Rocky Shore, set/6
1		shells, Sandy/Muddy Shore, set/6
1		spray bottle
8		spring scales
1	c	steel wool pad
1	c	string, kite
1	c	tagboard, yellow
1	c	tape, masking
9		thermometers
1	c	toothpicks, p/15
8		trays, shallow
8		tubes, cardboard, set/2
8		tubes, glass

Qty		Description
8		washers, p/100
1		wire, copper, 25'
1		wire, Nichrome, #30
1		wire, Nichrome, #32
1		wire stripper
1		teacher's guide

Living Materials Order

4	c	pea plants with 50 aphids
1	c	ladybugs, p/10

Teacher-supplied items

–	access to reference materials
1	aluminum foil
–	assorted bulletin board materials
–	assorted colored pencils or crayons
4	bottles, 1-L
8	boxes, cardboard, medium-size
1	bucket
8	compasses (drawing tools)
1	detergent, liquid
1	*The Edge of the Sea* (optional)
1	flashlight or desk lamp
1	globe
1	glue, bottle
1	hammer
1	knife, paring
1	light bulb, clear, burned out
1	light bulb, clear, new
8	markers, black, felt-tip (fine)
4	paper, construction, black
19	paper, white
–	paper towels
32	pencils, with erasers
–	pictures of different coastlines
–	pitcher
–	rocks, for habitat displays
32	rulers, standard and metric
32	safety goggles
32	scissors
1	*Silent Spring* (optional)
1	spoon, measuring, tsp.
1	sugar, salt, or flour, cup
1	tape, transparent
–	towels or remnants (optional)
8	T-shirts, light-colored, old
–	water, tap

c = consumable item † = in separate box

Activity 2

The Law of Levers

Objectives

Levers had been used for thousands of years before Archimedes finally explained how they worked. In this activity, students learn about the law of levers and discover how levers can make the hard work of lifting heavy things much easier.

The students

- review the parts of a lever
- manipulate the load and effort of a lever to achieve a state of equilibrium
- communicate the law of levers
- infer how levers can make lifting heavy things easier

Schedule

About 50 minutes

Vocabulary

effort
effort arm
fulcrum
the law of levers
lever
load
load arm
state of equilibrium

Materials

For each student

1	Activity Sheet 2
1	*ruler, standard

For each team of two

2	*pencils
50	washers

For the class

1	*paper, white
1 roll	tape, masking

*provided by the teacher

Preparation

1. Make a copy of Activity Sheet 2 for each student.
2. Each student will need a solid wooden ruler (standard, not metric). Each team of two will need fifty washers, two pencils, and a piece of tape.
3. Cut the piece of paper into eight rectangles (about 2 x 2¾") so that students can make a simple sleeve to hold a stack of washers. Each team needs one small piece of paper and two 2-inch pieces of tape.

Background Information

A *lever* consists of a straight bar that rests on and pivots around a support. Applying force to one part of a lever produces a useful action at another part of the lever.

All levers have four parts: 1) a rigid bar, called the *arm;* 2) the *fulcrum,* or support around which the arm pivots; 3) the *load,* which is the object to be moved; and 4) the *effort,* or force that is applied to move the load. In addition, the part of the arm between the fulcrum and load is called the *load arm.* The part of the arm between the fulcrum and the effort is called the *effort arm.* (See Figure 2-1.)

In a first-class lever like the one in Figure 2-1, the fulcrum is located between the effort and the load. Such a lever can be used as a balance. When a balance is level, it is said to be in a *state of equilibrium.* This simply means that the load on one side of the fulcrum equals the effort applied to the other side of the fulcrum.

When the fulcrum is centered (as it is in a seesaw, for example), you need only apply effort equal to the weight of the load in order to support the load. However, moving the fulcrum closer to the load (or the load closer to the fulcrum) reduces the amount of effort you need to lift the load. This makes first-class levers useful for lifting very heavy objects. By manipulating the size of the load and the location of the fulcrum, Archimedes came up with the law of levers:

Load x Load Arm = Effort x Effort Arm

The law of levers can be used to figure out in advance just how much effort you need to apply, and where to apply it, in order to lift a load. Archimedes theorized that, given the right size lever—perhaps thousands of miles long—and a place to stand, he could single-handedly lift an object the size of Earth.

In this activity, students build a first-class lever and use it as a balance. By manipulating the elements of the lever—the size of the load and effort and the length of the load and effort arms—they will come to understand the law of levers and how levers can make lifting heavy objects much easier.

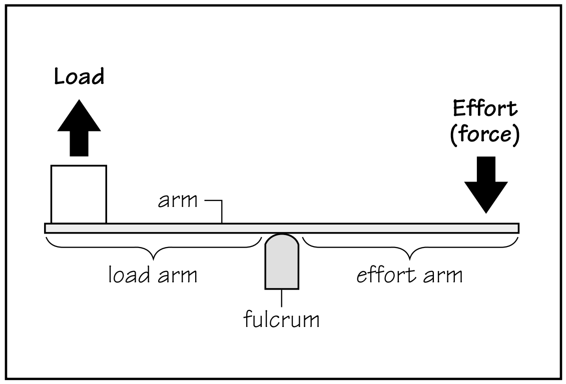


Figure 2-1. The parts of a lever.

Name ________________ Activity Sheet 2

The Law of Levers

1. Experiment with the washers and ruler to fill in the blanks in the chart below.

Load (number of washers)	**Length of Load Arm** (distance from fulcrum, in inches)	**Is Balanced By** (equals)	**Effort** (number of washers)	**Length of Effort Arm** (distance from fulcrum, in inches)
1	5	=	1	5
5	1	=	1	5
2	4	=	4	2
4	2	=	2	4
6	1	=	2	3
6	2	=	3	4
8	3	=	6	4
3	4	=	6	2
6	5	=	10	3
9	2	=	6	3

2. What do you think Archimedes meant when he said, "Give me a lever long enough and a place to stand, and I will move the Earth"?

In theory, using a lever thousands of miles long and standing in outer space, you could move an object as massive as a planet.

Teaching Suggestions

Additional Information

1

Distribute a ruler to each student. Challenge students to balance the ruler on the end of one finger.

Tell students that they are using the ruler as a lever. A *lever* consists of a straight bar that rests on and pivots around a support, called a *fulcrum.* Write the terms on the board. Ask, **What is the fulcrum in this lever?**

a finger

Now ask, **Where must you position your finger under this lever in order to keep the lever balanced?**

in the exact center; under the 6-inch mark

Tell students that when a lever is in balance, it is said to be in a *state of equilibrium.* Write the term on the board.

2

Divide the class into teams of two. Distribute fifty washers and 2 pieces of tape to each team. Each team will also need two pencils.

Tell students to tape two pencils side by side onto their desk and to place one ruler across the pencils, so that the pencils line up at about the 6-inch mark. Tell students to adjust the position of the ruler so that it balances. (See Figure 2-2.)

You can also conduct this experiment with just one pencil, but using two pencils makes the ruler more stable and easier to balance.

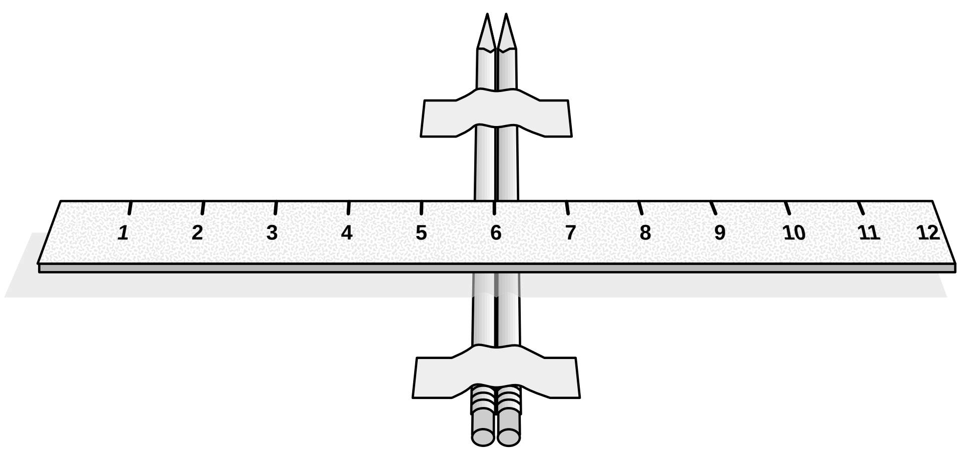


Figure 2-2. Making a lever from a ruler and two pencils.

3

Tell students to place one washer next to (just *before*) the 1-inch mark on the ruler and observe what happens to that end of the lever.

It drops and touches the desk.

Write the term *load* on the board. Tell students that the washer is considered the load. In order to balance the lever again, this load must be lifted. The load, then, is the weight or object to be lifted by the lever.

Ask, **How can you lift this washer load and get the ruler to balance again?**

Students should suggest adding a washer to the opposite end of the lever.

Tell students to place one washer at the opposite end, next to (just *after*) the 11-inch mark and watch what happens to the ruler.

It should balance again. However, due to differences in the thickness of the washers or slight defects in the ruler, students may need to make minor adjustments to get the ruler perfectly level again.

Write the term *effort* on the board. Tell students that the washer at the 11-inch mark is the effort. The effort is the force applied in order to lift the load.

Have students repeat this step two more times: with three, then six washers. When they have finished, ask, **What did you do each time to get the lever to balance again?**

Students needed the same number of washers at each end to balance the lever.

4

Next, tell students to measure the distance from each stack of washers to the fulcrum (in this case, the 6-inch mark on the ruler). Ask, **What do you notice about the distance of each stack from the fulcrum?**

Students should observe that the stacks are equal distances (each is 5 inches) from the fulcrum.

Write the terms *load arm* and *effort arm* on the board. Tell students that the part of the lever from the fulcrum to the load is called the load arm. The part of the lever from the fulcrum to the effort is called the effort arm. The load arm and the effort arm are the same length right now.

5

Now ask, **What would happen to the lever if the load were moved closer to the fulcrum?**

The load arm would become shorter. Students will probably also guess correctly that the lever will no longer be balanced.

Tell students to move the load (the stack of six washers at the 1-inch mark) to the 3-inch mark on the ruler and observe what happens.

The effort end drops.

Ask, **How many washers will you need to add to the load to balance the lever again?** Give students an opportunity to try it and see.

Answer: Students add four, for a total load of ten washers.

Ask students, **How much effort does it take to lift the ten-washer load when it is at the 3-inch mark?**

Students may be surprised to discover that it takes an effort of only six washers to lift a ten-washer load.

Have students measure the length of the load arm and effort arm and compare them.

Students should see that the load arm is only 3 inches long while the effort arm is 5 inches long. The load arm is shorter than the effort arm.

6

Tell students to move the ten-washer load to the 4-inch mark. Challenge students to find out how many washers of effort it takes to lift the load now.

Answer: Students should remove two washers from the effort stack, for a total of four.

Tell students to measure and compare the load and effort arms. (See Figure 2-3.)

The load arm is now 2 inches, while the effort arm is 5 inches. Again, the load arm is considerably shorter than the effort arm.

Ask students to think about what they have just observed. Ask, **What can you conclude about the position of the fulcrum and the amount of effort it takes to lift a load?**

Students should begin to see that the closer the load is to the fulcrum, the less effort it takes to lift the load.

7

Distribute a copy of Activity Sheet 2 to each student. Have students experiment with their rulers and washers to fill in the blanks in this chart. The first one has been done for them.

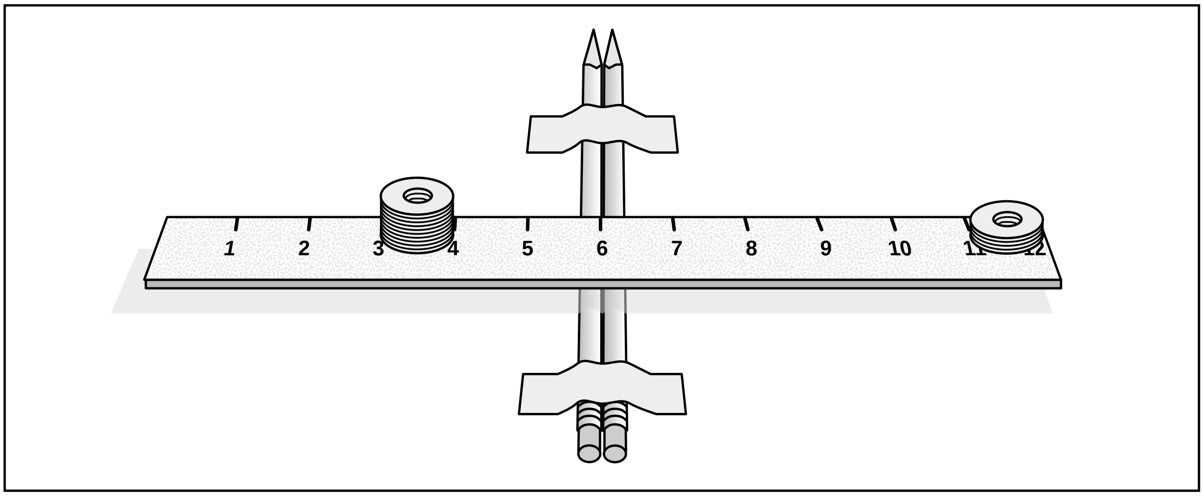


Figure 2-3. Moving the load closer to the fulcrum reduces the length of the load arm as well as the effort needed to lift the load.

8

When students have finished, ask them if they see a pattern in their data. Then write the following equation on the board:

Load x Load Arm = Effort x Effort Arm

Tell students that this is the law of levers, which Archimedes was first to describe. Write the term *law of levers* above the equation.

9

Challenge students to put the law of levers to work. Challenge them to lift a load of forty-five washers with an effort of just five washers. The load should be taped to the 1-inch mark on the ruler, and the effort will be applied to the 11-inch mark. Ask, **What must you do in order to lift a forty-five-washer load with a five-washer effort?**

Show students how to make a sleeve or wrapper to secure the load. Stack the washers, wrap a small piece of paper around them, and seal the seam and bottom with tape.

Answer: Move the fulcrum to the 2-inch mark (45 x 1 = 5 x 9).

Finally, ask, **How do levers help us move heavy things?**

by reducing the amount of effort needed to move the load

Tell students to complete the activity sheet. Review their responses as a class.

Reinforcement

R

Have students balance the ruler on their fingers again. Then have them tape a washer to one end of the ruler and try to balance the ruler. Where did they place their fingers in order to balance the ruler? What did this do to the length of the load and effort arms? Have them repeat the exercise with different numbers of washers at both ends of the ruler.

Cleanup

C

Collect the rulers and pencils, and return the washers to the kit. Discard the paper sleeves.

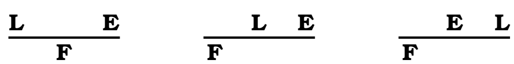
Science at Home

Point out that many household tools and utensils are levers; for example, scissors, wrenches, pliers, can openers, tweezers, tongs, hinged doors, and shovels are all levers. Challenge students to find at least three levers at home and compile a class list of their results. Vote on the most unusual lever. If possible, students should measure the load arm and the effort arm of a lever used to do work around the house. Why, in general, would we expect the effort arm to be longer than the load arm?

Connections

Science Challenge

Remind students that the lever they used in Activity 2 was a first-class lever, in which the fulcrum is between the load and the effort. Point out that there are two other types of levers: second-class, in which the load is between the fulcrum and the effort, and third-class, in which the effort is between the fulcrum and the load. Use the diagrams shown below and a fulcrum and lever to illustrate the three types of lever. As you explain each type, identify one or two examples. Then challenge students to offer additional examples.



First-Class	Second-Class	Third-Class
hand cart, crowbar, shovel	wheelbarrow, bottle opener, hinged door	hammer, fishing rod, baseball bat

Give teams of students a fulcrum, a lever, and a taped stack of washers for a load. Encourage students to discover as much as they can about the three classes of lever by experimenting with this equipment. After students have had sufficient time to investigate the possibilities, let them tell what they discovered.

Science Extension

Discuss with students the use of a jack to lift a car in order to change a tire. Encourage students who have used a jack or seen one used to explain its operation. Which part of the jack acted as the arm? the effort? Was the fulcrum closer to the car or to the person jacking it up? Why? (The handle that was used to pump the jack was the arm, and the pumping motion was the effort. The fulcrum was closer to the car so that less effort would be needed to lift it.)

Science and Health

Point out to students that the human body contains examples of levers. Have students do the following activity to discover one lever in the human body. Stretch out one arm on a desk and hold an object, such as a ball, in your hand. Resting your elbow on the desk, pull your forearm up to your shoulder. Then return your arm to the desk. How does your arm work like a lever? (The forearm is the arm, the elbow joint is the fulcrum, the object held is the load, and the muscles in the forearm and upper arm exert the effort to raise the load.) Encourage students to try to identify examples of other levers. If possible, obtain a model of a human skeleton so that students can observe such levers directly.

Science and Social Studies

Suggest that students research the use of catapults (a third-class lever), which were an important seige weapon of the ancient world. Giant catapults such as that developed by Archimedes could hurl stones weighing almost 200 pounds (90 kg) up to 200 yards (183 m).

Encourage interested students to research Archimedes' other inventions and discoveries. In addition to the water-lifting auger and ship-lifting device comprised of levers and pulleys, Archimedes developed a war device referred to as "claws," which shook enemy ships. Primarily a mathematician, Archimedes was famed for his theorems for calculating the volume of spheres and other geometrical shapes.