# Earthquake Lightbox

| *Program Type:* Demo | *Audience Type:* Grades 3 to adult |
|---|---|

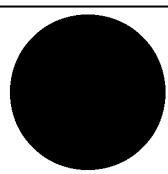
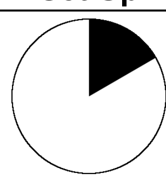
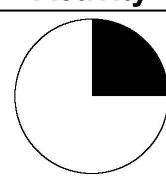
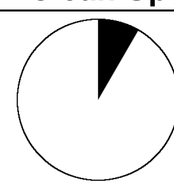
**Description:** In this activity, visitors explore light as an analog to understand earthquake magnitude and intensity. In this demo, the absolute brightness of the light corresponds to earthquake magnitude. The *perceived* brightness of the light corresponds to shaking intensity. By manipulating small lights inside of a lightbox, learners gain an appreciation for how intensity can vary with magnitude, depth, and distance from the epicenter.

## LEARNING OBJECTIVES

*For Next Generation Science Standards alignment, see end of outline.*

After this demo, visitors will understand:
- Magnitude is the amount of energy released during an earthquake
- Intensity is the amount of shaking felt at a particular location
- Intensity depends largely on the earthquake's magnitude, depth, and one's location relative to the epicenter

## TIME REQUIRED

| Advance Prep | Set Up | Activity | Clean Up |
|---|---|---|---|
|  |  |  |  |
| 60 minutes | 10 minutes | 15+ minutes | 5 minutes |

## SITE REQUIREMENTS

- Table space to set up lightbox
- Space around the table for audience to clearly see the demo on the table

## SUPPLIES

| **Supplies** | **Amount** | **Notes** |
|---|---|---|
| Lightbox | 1 | See instructions for assembly, below |
| Cardboard box (at least 10”x10”x12”) | | |
| Felt (approx 6”x6”) | | |
| Utility knife | | |
| Tape and/or glue | | |
| Printed map (8.5x11”) | | See appendix |
| Small, battery operated lights of various strength | 2-4 | Various flashlights, “puck” lights, electric candles, etc. |
| Explanatory signs (optional) | | See appendix |
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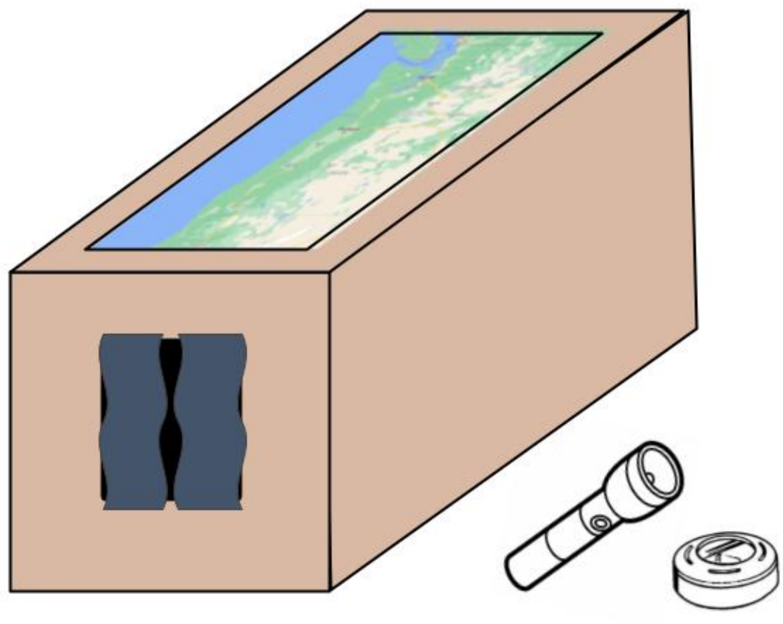
## ADVANCE PREP

Prepare the lightbox as follows:

1. Using tape or glue, secure the ends of the box so that they remain in a closed position.
2. Optional: paint the box a solid color and/or cover in butcher paper.
3. Choose one side of the box to be the top. Using a utility knife, carefully cut out a 7.5”x10” rectangular opening. Place the printed map over the opening and secure around the edges with glue or tape. (If you plan to use the model repeatedly, you can laminate the map first).
4. On the front end of the box, cut another hole, this one just large enough to comfortably reach a hand inside. About 6”x6” should be good.

5. Using the felt, make two small curtains for the hole, so that when you reach a hand inside the box, less external light gets in.

Your final result should look something like this:



When you put a small light (i.e., an “earthquake”) inside the box, it will illuminate the map from below, indicating where “shaking” is felt. Experiment with the model and get a feel for how using different lights and/or placing the lights at different positions within the box changes the effect.

## SET UP

- Place lightbox, lights (turned on), and signage on table

## ACTIVITY

10 minutes

*Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.*

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

How do you measure *how big* an earthquake is?

*Responses may vary, and may include qualitative as well as quantitative factors.*

There are a lot of different ways to talk about the size of an earthquake. Two measures that scientists often use are ***magnitude*** and ***intensity***.

When an earthquake occurs, it releases energy. Because I can't hold an earthquake in the palm of my hand, we're going to use something else that releases energy to *represent* an earthquake--a light. These two lights [hold up small and large lights] represent two earthquakes. Which one releases more energy?

*The big light.*

The big one releases more energy. It's more powerful. If it was an earthquake, we'd say it had a higher *magnitude.* [Indicate sign, if using]. Magnitude is essentially the amount of energy that an earthquake releases. Often, when we hear about an earthquake on the news, this is what we hear about: "It was a Magnitude 6, or a Magnitude 7," or so on. Magnitude is measured on the Moment Magnitude scale, which goes from 1-10. The most powerful earthquake ever recorded was a 9.5.

I have also this box, which represents a chunk of earth's crust. The top, where the map is, represents the surface of the earth.

Now, let's see what happens when we put the smaller light--the smaller magnitude "earthquake"--inside the box. What do you notice?

*Answers will vary, but will likely include an observation about how the surface "lights up."*

In this model, the parts of the map that are lit up are the areas where people feel shaking. *Intensity* is a measure of *how much* shaking. [Indicate sign, if using]. Notice that, right above the light, shaking intensity is pretty high, but farther out from the center, shaking intensity is lower. The same is true of earthquakes. In general, the closer you are to the center of an earthquake (the epicenter), the more shaking you will feel.

From here, there are multiple options for exploration, based on the age, skill level, and interests of the learner. Some things to try, in order of complexity:

- Swap out the lights. Notice that, in general, higher magnitude earthquakes (i.e., higher powered lights) produce greater shaking intensity, spread out over a wider area.
- Identify points of interest on the map (cities, bodies of water, etc.). Experiment with moving the light north, south, east and west underneath the surface of the earth. Notice how shaking intensity varies; people in one city may experience intense shaking, while people 100 miles away experience mild shaking.
- **Experiment with changing the depth of the earthquake (i.e. moving the light vertically up and down inside the box).** Notice how deeper earthquakes tend to produce lower intensity shaking at the surface, spread across a wide geographic area. Shallow earthquakes tend to produce higher intensity shaking at the surface, concentrated in a smaller geographic area.
- Invite learners to consider whether, and under what circumstances, a magnitude 5 earthquake could cause more damage than a magnitude 6 earthquake, and to model those conditions using the lightbox. (A relatively low magnitude quake can cause significant damage if it occurs near a large population center and/or at shallow depth; a higher magnitude earthquake can be relatively harmless if it occurs far from populated areas and/or very deep in the earth).
- Using a geologic map for reference, draw plate boundaries and/or faults on the map. Note that earthquakes are most likely to occur along these boundaries.
- Invite learners to consider the limitations of the model. What *isn't* represented here?
    - For one, this model doesn't capture differences in soil or rock type, which significantly affect the intensity of shaking felt in different locations.
    - Also, this model doesn't emphasize the exponential nature of the magnitude scale, which increases by a factor of 32 for each degree magnitude. If a magnitude 5 is represented by a tiny electric candle (about 10 lumens), then a magnitude 6 would be represented by a powerful flashlight (about 300 lumens) and a magnitude 7 would have to be represented by an industrial flood light (about 10,000 lumens). Our model is far too small to accommodate this exponential scale

## GLOSSARY

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|---|---|
| Magnitude | A measure of earthquake size that correlates to the amount of energy released. Most scientists today use the Moment Magnitude (Mw) scale, where each value (1-10) represents a 32-fold increase in energy. To calculate Mw, seismologists take into account the size of the ruptured area, how far it moved, and the rigidity of the rocks that ruptured. |
| Intensity | A measure of the amount of shaking at a given location. Most scientists today use the Mercalli Intensity Scale, which ranges from I (not felt) to X (extreme). |
| Epicenter | The location at the surface of the earth, directly above the hypocenter. |
| Hypocenter | The location within the earth where an earthquake starts. |

## NEXT GENERATION SCIENCE STANDARDS

| | **Practices** |
|---|---|
| ✓ | Asking questions and defining problems |
| ✓ | Developing and using models |
| | Planning and carrying out investigations |
| | Analyzing and interpreting data |
| | Using mathematics and computational thinking |
| | Constructing explanations and designing solutions |
| | Engaging in argument from evidence |
| | Obtaining, evaluating, and communicating information |

| | **Crosscutting Concepts** |
|---|---|
| | Patterns |
| ✓ | Cause and effect |
| ✓ | Scale, proportion, and quantity |
| ✓ | Systems and system models |
| ✓ | Energy and matter |
| | Structure and function |
| | Stability and change |

| | Disciplinary Core Idea | 3 | 4 | 5 | MS | HS |
|---|---|---|---|---|---|---|
| Physical Science | | | | | | |
| PS1 | Matter and Its Interaction | n/a | n/a | | | |
| PS2 | Motion and Stability: Forces and Interactions | | n/a | | | |
| PS3 | Energy | n/a | ✓ | ✓ | ✓ | ✓ |
| PS4 | Waves and Their Applications in Technologies for Information Transfer | n/a | | n/a | | |
| Life Science | | | | | | |
| LS1 | From molecules to organisms: Structures and processes | | | | | |
| LS2 | Ecosystems: Interactions, Energy, and Dynamics | | n/a | | | |
| LS3 | Heredity: Inheritance and Variation of Traits | | n/a | n/a | | |
| LS4 | Biological Evolution: Unity and Diversity | | n/a | n/a | | |
| Earth & Space Science | | | | | | |
| ESS1 | Earth's Place in the Universe | n/a | | | | |
| ESS2 | Earth's Systems | ✓ | ✓ | ✓ | ✓ | ✓ |
| ESS3 | Earth and Human Activity | | | | | |
| Engineering, Technology, and Applications of Science | | | | | | |
| ETS1 | Engineering Design | | | | | |