

# PHENOMENON MODEL

*Students observe a phenomenon and create a diagram to describe it. Then they think about and label seen and unseen forces that may affect the phenomenon, and use this model to make possible explanations for how the phenomenon works.*

The world is filled with phenomena and mechanisms that we take for granted and often do not understand. What are the mechanisms behind the patterns of ripples on the surface of a pond during the rain? Why is a heated pot of water loudest before it is at a full boil? How does a refrigerator work? We can come up with some ideas about how these things happen, but making a model is a deeper approach, one that externalizes our thinking and shows us what we do not yet understand. Modeling a complex phenomenon calls on our background knowledge of science concepts from, for example, physics, ecology, or biology, and sends us to additional sources of information to deepen our understanding. Modeling can change the way we think and how we approach problems, but it is not always an intuitive skill. This activity offers an approach to modeling that students can apply in future journal entries and in other disciplines. Students will also observe a phenomenon in detail and begin to understand it, setting them up for future learning experiences and deepening their knowledge of key science concepts.

Modeling like this makes our ideas visible. It doesn't matter whether our explanation is right or wrong. We model to clarify our thinking. Once the ideas are down on paper, we can more easily see connections, gaps in our thinking, and strengths and weaknesses of our ideas.

## NATURAL PHENOMENA

This activity can be done with any interesting phenomenon that can be observed by the whole class. Look for things that make you wonder "How does that work?" or "What causes that?" The more authentically mysterious a phenomenon, the more that students will be drawn to explore it. Look around you for the phenomena that are occurring constantly outside the field of your attention. You may also be able to find aspects of a familiar phenomenon that are new to you, such as the yellowing of leaves in the fall, or steam rising from a wooden fence on a cold day. In this description, we use a mackerel sky (clouds formed in narrow parallel rows) as a phenomenon. These instructions would change slightly for a different phenomenon. Note that the demonstration is about a double rainbow, not the clouds the students will be observing. This is intentional, because it allows you to discuss recording observations without telling the students what they should notice about the particular phenomenon.

If students come to you with a question about something they have found and you can bring the whole class out to see it, take their suggestion and run with it. You can also choose a phenomenon based on the science subject areas that you and your class are working with.

## PROCEDURE SUMMARY

1. Observe the phenomenon, writing observations and creating a diagram to show what you can see.
2. (Later) Make possible explanations for how the phenomenon might work, using words, pictures, and numbers to show your thinking.

### Time

Introduction: 10 minutes

Activity: 35–60 minutes

Discussion: 10 minutes



### Materials

- Journals and pencils
- Colored pencils (at least two per student)



### Teaching Notes

This activity is meant for fifth grade and up.



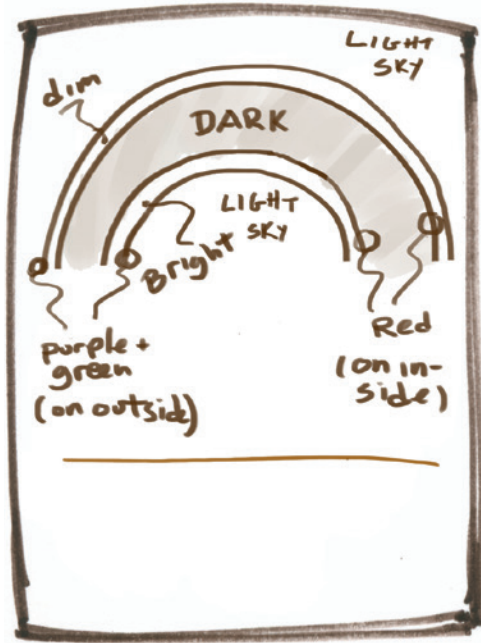
Models are important tools in scientific inquiry. When we think of a model, we often envision gluing together a plastic plane or making a cell out of marshmallows and macaroni in school. Scientific models (such as those referred to in the NGSS) do more than represent an enlarged or miniaturized object; they are tools to explain the behavior of a phenomenon. By this definition, a labeled drawing on its own is a description, not a model. By adding the interaction of seen elements and unseen forces and making possible explanations for how they produce the observed phenomenon, students move from diagramming to modeling.

This activity can be used as an introduction to modeling. Students do not need to solve or figure out the mysterious phenomenon. Be clear about this at the beginning, telling students to instead focus on generating many possible explanations and opening up ideas.

3. Include seen and unseen forces, using labeled arrows to show how you think they might affect the phenomenon.
4. Revise your model after you share ideas with your classmates.

## DEMONSTRATION 1

When the whiteboard icon appears in the procedure description: Draw a line one-third from the bottom of the page. Above this line, demonstrate how a student might take notes about a double rainbow. Do not erase this drawing once it is done; you will add to it later.




## PROCEDURE STEP-BY-STEP

1. Describe how students might record observations of a phenomenon, and demonstrate on a whiteboard how the notes might look.



- a. "Have you ever seen a double rainbow? Let's say we wanted to make detailed observation of this phenomenon and record it in our journals. We might observe that the colors are in the opposite order in the rainbows. The lower rainbow has red at the top, and the upper one has red at the bottom. The lower rainbow is brighter than the upper."
  - b. "We might also notice that the sky between the two rainbows is darker than the sky outside the rainbows. When you record observations about a phenomenon, your goal is to record every detail you notice. The best way to do this is with words, pictures, and numbers."
2. Tell students to record observations of your chosen phenomenon using words and pictures.
    - a. "Those are amazing cloud formations [stream currents, ice patterns, etc.]. Let's take seven minutes to record as much information as we can about them."

- b. "Start by drawing a light line across your paper, one-third of the way from the bottom." 
- c. "Use words and pictures or diagrams to describe everything you can notice about the clouds. Use the top two-thirds of the page. Do not worry about spelling or making pretty pictures; just try to make your notes clear and easy to understand."

3. After students have had some time to record observations in words and pictures, encourage them to try to incorporate numbers as observations. For example:
  - a. "If you can, use numbers to deepen your observation. Is there is a repeating shape or formation? If so, how many do you see? Are they the same size or different sizes? Is the distance they are away from each other consistent? What are some estimations you can come up with of distances between parts of the interesting formations?"
  - b. (If you are far away from the phenomenon) "We can't get real measurements because the clouds are so far away, but can you think of a way to more accurately estimate their size or spacing from down here? For instance, how does cloud width compare to the spaces between them?"
4. After 10 minutes have passed, call for the group's attention. Encourage students to ask questions about the phenomenon and why it appears as it does.
  - a. "What questions do these observations stimulate?"
  - b. "Can you ask questions about how or why the clouds [currents, shapes, etc.] appear as they do?" (Examples: "What makes the clouds form rows?" "Why are some of the rows broken into puffy balls while some are continuous?" "Why are the rows smaller in that part of the sky?")
5. Call for the group's attention, ask them to share their observations, and generalize these to some concise statements about the phenomenon. Keep the conversation focused on observations, not explanations.
  - a. "Let's see if we can turn this large set of observations into a concise set of statements describing this phenomenon."
  - b. Elicit observations from the group, encouraging students to add on to or modify what has been described. (For example: "Who can get us started?... Great, can anyone add to or modify that?... What else can we say about what is happening here? What else did we notice?")
6. Give students a moment to write a summary of what the group has observed in their journals.
  - a. "In your journal, write your own summary of what is happening here."
  - b. "Be careful to only write observations. This is what we can directly see, not our explanations of what we can see."

7. Give students a moment to ask questions and record questions about the phenomenon with a partner, then share them with the group.
  - a. "What were some of your most interesting questions you came up with earlier?"
  - b. "Take a moment to share your questions with a partner, then see whether you can come up with any more questions and write them in your journal."
  - c. "Let's hear some questions. What are we wondering about?"
8. Model how a student might create a visual explanation for a phenomenon they observed by first proposing possible explanations.

- a. "Let's go back to that demonstration of observing a rainbow. We could develop several questions, but let's say we are most interested in what causes the dark band between the rainbows. Here is where creative thinking comes in. What are some possible explanations for this band? Think creatively; you do not have to be right." (Students respond.)
- b. "At this point we are not worried about whether an explanation is right or wrong. Instead, we generate possible ideas."

## DEMONSTRATION 2

Direct students to use a different color of colored pencil and the lower third of the page to create a model of a possible explanation for the phenomenon. They can use arrows to show forces at work or stages of a process. They should consider how to show both seen and unseen forces. The explanation does not have to be right.



9. Demonstrate how a student might create a visual explanation for a phenomenon they observed by picking one possible explanation and making a model diagram of it.
  - a. "You can then choose an explanation that is interesting and make a model of the idea to help you think about it. The explanation does not have to be right. In the case of the double rainbow, let's say we chose the explanation that there is scattered 'white light' beyond the violet end of the rainbow and some kind of scattered darkness or 'dark light' beyond the red end of the rainbow." (Study demonstration 2 for an idea of how to draw this.)
  - b. "Getting the idea on paper helps you think about it more clearly. After you lay out an idea like this, you can more easily see holes in your thinking or places you could modify the idea."
  - c. "In this case, we might see that the idea of 'dark light' was problematic and discard this explanation in favor of another idea. If the model helps you think about an idea, it is a success whether the idea is right or wrong."
10. Divide students into groups and set them up to generate several plausible explanations for the mechanism behind the phenomenon they observed (e.g., cloud formations), focusing on sharing ideas without worrying about being wrong.
  - a. "Organize yourselves in groups of four and choose a record keeper for your group."
  - b. "With your group, take five minutes to come up with ideas about what could cause the clouds to make these shapes."
  - c. "Come up with several plausible explanations. Your explanation does not have to be right; we are just playing around."
  - d. "Be creative, and make sure you get everyone's ideas. The record keeper will write the explanations down using language of uncertainty, such as 'Perhaps...'; 'Could it be...'; 'I wonder whether...'; and 'Maybe...'"
11. After a few minutes, share and discuss possible explanations with the entire group, emphasizing that the explanations do not need to be right, just plausible.
  - a. "Time is up. As a group, choose the two explanations you find the most interesting. The record keeper will report these out in a moment. We are not interested in right or wrong, just in listening to the possible explanations."
12. Facilitate the process of sharing explanations. After all groups share, discuss and explore the thinking behind some of the explanations without evaluating whether they are right or wrong, using follow-up questions such as "Say more about that" or "What makes you think that?"





How might these rock features have formed? Could you draw a series of diagrams to lay out one explanation? What features would your explanation account for? You do not have to be right. Be wrong boldly. Interesting is better than safe.

**13. Explain how to make a model of the phenomenon in a journal: Make a simple diagram of what can be seen, then show an explanation for the causes of the observed features, labeling seen and unseen forces, using arrows to show interactions, and using text to explain what is happening.**

- a. "Choose one of these explanations and create a model diagram that explains how it works. Don't worry about being right; just focus on explaining your thinking clearly."
- b. "Use your notes to help you draw a simple, clear, labelled diagram that explains the phenomenon."
- c. "Think about the unseen forces that interact with what you can see to create the patterns. Make the diagram of your explanation with a different color of pencil. Add arrows to show forces or movement, lines to show connections, and text to explain what is happening. You can draw steps in a process or a single diagram. You may use the empty space at the bottom of the page."

**14. Tell students that they can have fun with the process, coming up with interesting ways to represent their thinking on the page.**

- a. "This can be a fun and creative process. See whether you can find interesting ways of representing your thinking, explaining the process, and showing interactions between seen and unseen forces."
- b. "Are there any questions? You have ten minutes."

**15. After students have had time to model their explanations, regather the group and let them to share any new insights, questions, or explanations they came up with, or instances where making the model brought up things they realized they didn't understand.**

*Note:* If students have new ideas or want to add to explanations the group discussed earlier, this process could go on for a little while. Stay with it as long as students are interested. This is a huge opportunity for students to struggle with ideas, construct new understandings, and learn.

- a. "When we move from making a verbal explanation to making a model, it often brings up more questions or reveals to us places where our explanation might not be as good as we thought."

- b. "What did we learn through making our models? What questions do we have? What do we think we understand, and what don't we understand?"
- c. "What do you want to know more about in order to better understand this phenomenon? What questions do you have?"

**16. Review and share student work by placing journals on tables and giving students time to circulate and see how their classmates showed their thinking and explained the phenomenon.**

- a. "Circulate around the room and take a look at the ways other people described this phenomenon. Look for creative strategies and solutions that you could use if you were to do a similar project again."

- b. "Also look for places someone else might have been more accurate or might have better explained what is happening here."

**17. Give students a little more time to modify their diagram based on feedback or ideas they saw in other students' work.**

- a. "Take four minutes to add any other details or elements to your diagram that would make it more clear or that would better show your understanding of the phenomenon. It's OK to use ideas you saw in someone else's journal."

**18. (Optional) (Upon return from the field) Direct students to sources of information that could offer more evidence to explain the phenomenon.**

## DISCUSSION

Lead a discussion using the general discussion questions and questions from one of the Crosscutting Concept categories. Interperse pair talk with group discussion.

### General Discussion

- a. "Today you created a model to explain cloud formations [stream currents, ice patterns, etc.]. What was the process you used to create your model?"
- b. "How did developing and using a model help you learn?"
- c. "What are other situations or phenomena that modeling could help you learn about?"
- d. "What were some approaches your classmates used for showing their thinking in their model on the page?"



"So it started as a baby." The diagram depicts a sapling being struck by wind and bending away from the force.

This is an illustration of the same tree, now older, permanently bent by the wind. Curled lines indicate the strongest wind.

Circles on the leeward side of the tree show clusters of *Trentepohlia* algae "popping" up on protected surfaces.

- e. "We used different colors of pencil for our observations and our explanations. Why do you think we make such a clear distinction between them?"
- f. "What is the value of making a model if you aren't sure your explanation is correct?"

### Patterns

- a. "Describe the patterns you observed."
- b. "There is often a mechanism or a force that creates patterns we see. What are some possible explanations of how these patterns were formed?"
- c. "What does this pattern remind you of? Can you think of other things or phenomena that create a pattern that is similar to what we observed? Consider things on a larger or smaller scale."
- d. "What forces might be behind these similar patterns?"

### Scale, Proportion, and Quantity

- a. (Follow-up to Patterns question 4) "Forces act differently on large and small objects. How might scale and size change the way forces interact and create patterns in phenomena?"

## Systems and System Models

- a. "You can think of the clouds [stream currents, ice patterns, etc.] and the forces that combine to make them as a system of interconnected parts that produce behavior, in this case the patterns we observed. What are some of the parts of this system?"
- b. "What system behavior did we observe?"
- c. "How do the parts interact? What are the inputs to the system and the outputs of the system?"
- d. "Where would you draw the boundaries of this system?"

## Energy and Matter

- a. "How might energy flow into this system?"
- b. "How might sunlight energy affect this system?"
- c. "Can you think of ways that these patterns might be related to cycles in nature? How?"
- d. "How does matter change form in this system?"

## Stability and Change

- a. "How long did these patterns last?"
- b. "When the pattern changed, what came next?"
- c. "What forces might make these patterns more stable? What would disrupt them?"

## FOLLOW-UP ACTIVITIES

### Conducting Additional Research

When students finish this activity, they may have more questions than answers. Many of the phenomena you will encounter will be outside the realm of what students can understand or figure out on their own. Brainstorm resources beyond Google with students that might help them begin to better understand the phenomenon. This might include books, internet resources, or local scientists in the discipline of study of the effect you were observing. The results of the research may or may not support the students' explanations. Either is interesting and useful.

Help students process their current questions about the phenomenon and brainstorm next steps about how to continue to build understanding. Offer instruction and new information that they can integrate into their models, then offer time for modification of explanations. This can be a process that drives an entire unit of study. The chapter *Teaching Science and Inquiry: A Deeper Dive* offers some approaches for extended investigations.

### Studying Models

Models are powerful tools that scientists use to explore, test, and explain the world. They range in complexity and are used in all scientific fields. Search the internet for examples of scientific models. Ask students: "What is the purpose of this model? How is it intended to be used? Who is intended to use it? What are its limitations? Are there any ideas that you could use to help you model or think about other systems?"

