Lesson Summary: Models represent neuroscience in important ways, but are not precisely the same as neurons or brains themselves. Students are introduced to models through questions posed by the teacher.

Grade Level 9-12

Lesson Length
Part of class period

Standards Alignment

Next Generation Science Standards

- 4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
- **Framework for K-12 Science Education**: Science & Engineering Practices 2,6,7

Objectives—Students will be able to

- Relate modeling of science concepts to actual representations of what is being modeled.
- Generate a list of other examples of how models are used to represent our understanding of complex cells, subcellular structures, and parts of our world that are difficult to observe first-hand.

Assessment Options

- Discuss students' understanding of models as close representations of actual parts of our world.
- Revisit the apple example when introducing aspects of upcoming neuroscience lessons - i.e. Bead Neurons, Virtual Neurons, etc. - to remind students of models as close representations of actual neurons.

Teacher Notes

The Powerpoint presentation available on the Ways of Knowing lesson page at BrainU.org can be presented from the more abstract form of modeling apples (the word *apple*) to real apples, or vice versa.

Materials (for each table)

- 4 PowerPoint slides of representations of apples:
    1. the word **apple**
    2. a 2D drawing of an apple
    3. a 3D image of an apple
    4. a photograph of apples
- plastic apples
- real apples **Optional:** have one apple for each student so they can taste them.

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Procedures

Engage

1. Start with a PowerPoint slide of the word APPLE and ask students to:
   - Write down what they see.
   - Describe what the word makes them think about. They may also describe characteristics that this word represents.
2. Ask students, “How do you know that this word represents what you’ve described?”
3. Leave them with this thought and move on.

Explore

1. Move to the next slide with the 2D apple drawing. Ask the same questions as above, but this time in a small group discussion (or in pairs). Really focus on *HOW* students know this is an apple. **Hint: There are many different ways of knowing about the same objects in nature and in science.**
2. Lead a class discussion on what the students use as evidence: *HOW* they know this is an apple.
3. Move to the next slide with the 3D apple drawing. Repeat steps 1 and 2 above.
4. Move to the next slide with the photo of apples. Repeat steps 1 and 2 above.
5. Next, hand a plastic apple to each table. Ask each student to handle this *model* of an apple and continue to ask how they know it’s an apple. What does having a model in their hand offer them for evidence that the word, drawings, and photos did not?
6. Finally, hand out an apple to each table (or an apple per child). Ask the students what aspects of the real thing are only present in it AND therefore absent from all other models represented thus far.

   Many will notice the texture, weight, smell. Some may even taste. These are all evidence to reveal what apples have and what is absent from the models of apples.

Explain

1. Explain to students that this process of modeling an apple is similar to modeling difficult concepts or hard-to-observe objects in science, such as neurons, the functional brain, subcellular processes and structures, etc.
2. Ask students to consider other models they have used in science that help them to understand scientific concepts.
3. Help students to see that these models - while very useful in developing understanding - still have limitations (as the apple model does).

Evaluate

Students will generate a list of models used in other disciplines that help them to develop an understanding of difficult concepts. The list should be accompanied by a discussion or a written piece to describe the limitations of the listed models.

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