Crosscutting Concept: Systems and System Models

The purpose of this video is to give students experience with the crosscutting concept of Systems and System Models. It is a resource to work directly with one of the Crosscutting Concepts identified in the Next Generation Science Standards (NGSS). Reflecting on a novel, authentic example of this crosscutting concept applied to scientific research will prepare students to apply this lens to other science experiences.

The video can be accessed at https://www.youtube.com/watch?v=dGEzVEsLgBA

Expected Outcomes: After working with this video, students should be ready to begin using the "lens" of systems and system models to make sense of their scientific experiences.

Guide:

1. Before watching the video, gather students' initial ideas about systems and why we model them. What are some examples of systems in nature? How do we define a system? How do we decide on the parts of a system? Why would we use a model to study a natural system that is very complicated?

2. Explain that we will watch a video about a scientist who wants to learn more about the health of the human system. Explain that you will watch the video all the way through, and then watch again to focus on specific parts.

3. Watch the video all the way through.

4. Lead a brief discussion to clarify the purpose of Kenny's research: He is interested in how food/nutrition affects healthspan (how long people stay healthy). He gives different types of fruit flies different types of food to see how it affects their health. He has observed that different types of fruit fly have different healthspan, even when they eat the exact same type of food. This suggests that our DNA might influence how our bodies react to different types of nutrients.

5. Watch the video again. This time, ask students to take notes on the system, its parts (inputs and outputs), and the model being used. You can do this as a class by having students raise their hands when they hear the words "system" "input" "output" and "model".

6. Debrief the video by making a class diagram of the system and system model under investigation. The diagram should look similar to the image at 0:46 in the video

What input is the scientist studying? (diet; nutrients)
What output is the scientist studying? (health)
How does the scientist add a complexity to his simple system? (looking at genetic information in addition to diet; looking at different types of diet)
Why can it be helpful to use a model instead of studying humans directly? (flies live shorter than humans; we can study flies in a lab and control their environment and food more easily; they are smaller and less expensive to feed)
Why can the fruit fly be a good model of humans? (it shares a lot of genetic information with humans; it needs to eat similar nutrients to humans; it can move like humans)
What might be the limits of this model? Can it tell us everything about how diet affects human health? (humans and flies are not the same and don't share all genetic information; humans don't live in a lab and how they respond to diet might be be affected by other inputs, such as exercise or environmental factors)

7. Broaden the discussion to other systems and system models students under investigation in the classroom. How can it be helpful to think about what we are studying as a system? What are the parts of our system and how could we make a model of it?

Background Information on Systems and System Models

Science is all about understanding the world around us, but the world is complex! **Identifying and isolating systems** is one way to simplify things and make answers to our questions more accessible. By identifying a system with clear inputs and outputs, we **can develop a model of that system and start making predictions** about what will happen to the outputs when we change the inputs. Once we have a good understanding of our inputs and outputs, we can **start adding complexities** to the model to make it more similar to the real world and give it more power to explain our observations.

The purpose of working with systems and system models can be to

- Design and carry out experiments that are difficult in the real world
    - e.g. using digital climate models instead the actual climate system to answer climate questions; using model organisms in a lab environment rather than humans to study biological questions
- Isolate independent variables to explore their role in a system, rather than try to make sense of multiple variables/inputs at once, as in a natural system

It is important for scientists to be clear about the limits of their models. A model that doesn't include all the inputs of the natural world can't possibly explain everything we observe. Models are simplifications that give insights into the natural systems around us. Models often evolve as we develop greater understanding of the systems they represent.

Follow up: Give students an opportunity to reflect on their classroom investigations and phenomena using the lens of systems and system models. For example, if studying photosynthesis, have students identify the parts of the system. What are the inputs in photosynthesis? What are the outputs? How is growing a plant in the classroom a model for how plants grow in the wild? What complexities are missing and what are the limits of understanding plant growth in a controlled environment?