Model Reading

What is a scientific model?

Over the last few days you observed what happened when you added certain amounts of water to the "buckets" on your lab benches. You kept records of your data and looked for specific patterns in that data. You have also constructed explanations for your observations. This process — making observations, identifying patterns in data, and developing and testing explanations for those patterns — is quite similar to what scientists do as they develop explanations for natural phenomena. Such *explanations* are called *scientific models*.

Scientists use drawings, graphs, equations, three dimensional structures, or words to communicate their *models* (which are *ideas* and *not* physical objects) to others. For example, you drew diagrams of the inside mechanisms in the bucket in order to help communicate to your classmates how your model could account for your data. The diagrams were a teaching tool, but the models were the actual ideas of how a particular mechanism operated and accounted for the patterns you observed. Similarly, a scientist might use a 3-dimensional ball and stick representation to help her communicate her ideas about molecular structure to her peers.

You may have already heard about many models in your middle school science classes. For example, Galileo developed a model to explain the patterns in the movements of objects in the sky, including the rising and setting of both the sun and moon. Currently scientists are developing models to explain the phenomenon of uncontrolled cell division (or lack of "apoptosis," programmed cell death) associated with cancer. There are countless other important models already accepted by scientists and as many others that are currently being developed. This year you will have a chance to be scientists yourselves: you will be developing and using models to explain a number of biological phenomena.

How do you decide whether a model is "right"?

A community of scientists may have more than one model to explain a given phenomenon. You have experienced this with the buckets: not everyone in your class proposed an identical model, right? When you shared your initial models with other groups, you heard about models involving sponges, cup dumps, tube loops, two containers, etc. Given all these different models, how did you decide which one(s) you liked best? Which one(s) were the most "believable" to you?

As you probably noticed so far with the black boxes, models are judged based on a number of factors:

1. Can the model *explain all the observations* (or, as you may have experienced, explain some, but not all)?

2. Can the model be used to *predict* the behavior of the system if it is manipulated in a specific way? For example, based on your model, what would happen if you added 500 mLs of water? Did your prediction occur when you did the experiment? Being able to correctly predict experimental outcomes is a powerful way of testing some kinds of models.

3. Is the model *consistent with other ideas* we have about how the world works? Any models involving a small person hidden in the box, catching and pouring out water are automatically rejected on the basis of their absurdity: it is not realistic or plausible for such a person to exist shut up in a box — no matter how completely such an explanation might be able to account for your data!

Getting back to the question, "which model is right?", we have two important points to make: first, scientists don't ask whether an answer is "right". *They ask whether a model is "acceptable"*. And acceptability is based on a model's ability to do the three things outlined above: *explain, predict, and be consistent with other knowledge*. Second, more than one model may be an acceptable explanation for the same phenomenon. *It is not always possible to exclude all but one model* — and also not always desirable. For example, physicists think about light as being wavelike or particle-like and each model of light's behavior is used to think about and account for phenomena differently.

Do models ever change?

Absolutely!!! Your models for what is happening to produce the data patterns you saw may have changed from one day to the next. The modified models were more acceptable to you because they were able to explain more data, were better able to be used to predict experimental outcomes, or were more consistent with other ideas.

Historically, many scientific models have changed a great deal in light of new data and new ideas. For example, at one time scientists thought that human sperm contained a tiny, pre-formed person (a "homunculus") and that the human egg was mainly a source of food for the developing organism. When more advanced microscopes made closer observations of sperm and egg possible, this model was discarded. The current model — in which both egg and sperm contribute DNA to the future organism — is better able to explain the fact that organisms inherit characteristics of both parents as well as observations of cellular mitosis.

What is the point of this reading?

If you have skipped the rest of the reading and are trying to cheat by reading only this paragraph, STOP IT. Go back and read. If you already read the previous paragraphs, here's the summary:

- Models are ideas that scientists use to explain patterns they observe in the world.
- Models are judged to be acceptable (or not) based on how well they can explain and predict data and how consistent they are with what is already known about the world.
- Models are constantly being used to ask more questions about the world and when new data are gathered, models are revised or discarded altogether. Scientific knowledge is not static, but is always changing.

Homework Questions

1. In YOUR OWN WORDS write a sentence or two describing what a scientific model is.

2. What are some important things a scientist looks for when she is judging the acceptability of a model? (Describe AT LEAST THREE.)

3. Give an example of a once-accepted model that was replaced by a revised model. Describe SPECIFICALLY why the model was replaced and why the new model is considered to be better than the old one (you may use an example from the article, from the modeling activity you did in class, or from another area of science).