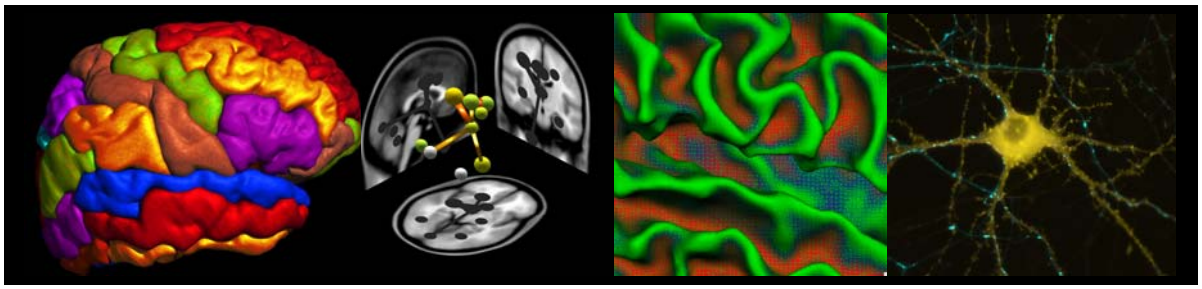


The Role of Models in Science

Activity: "***What is a model?***" is a terrific question for a whole class **brainstorm**. As long as the students have had some exposure to science, they will have various ideas about what a model is and be able to provide examples. However, even advanced students probably will lack a full appreciation of ***how many different types of models there are*** and ***how many unique meanings the word model has in science and in daily life***.

Try brainstorming as many different types of models as students can come up with and then having students work in small groups to sort the models according to type and purpose. Students will probably come up with a mixture of concrete examples (see Example Brainstorm 1) and classifications (see Example Brainstorm 2), which is completely fine because sorting things out is part of the learning process (and the big ideas are more important than the vocabulary). This activity will give students the opportunity to think critically about what models are, what they are used for, their advantages and disadvantages, etc.

Developing a checklist is a good way for students to begin categorizing the different kinds of models.

Model	**Simplification or attempt to account for all factors?**	**Used for explanatory purposes, research purposes, both, neither?**	**Based on mathematics or not?**	**Other characteristics?**

Important concepts:

Purpose. Models have many different functions. Students will mainly be accustomed to models being used to explain difficult concepts and to make concepts more tangible. Scientists use models for explanatory purposes too, but they often use models (e.g. mathematical and computer models) to make and test predictions.

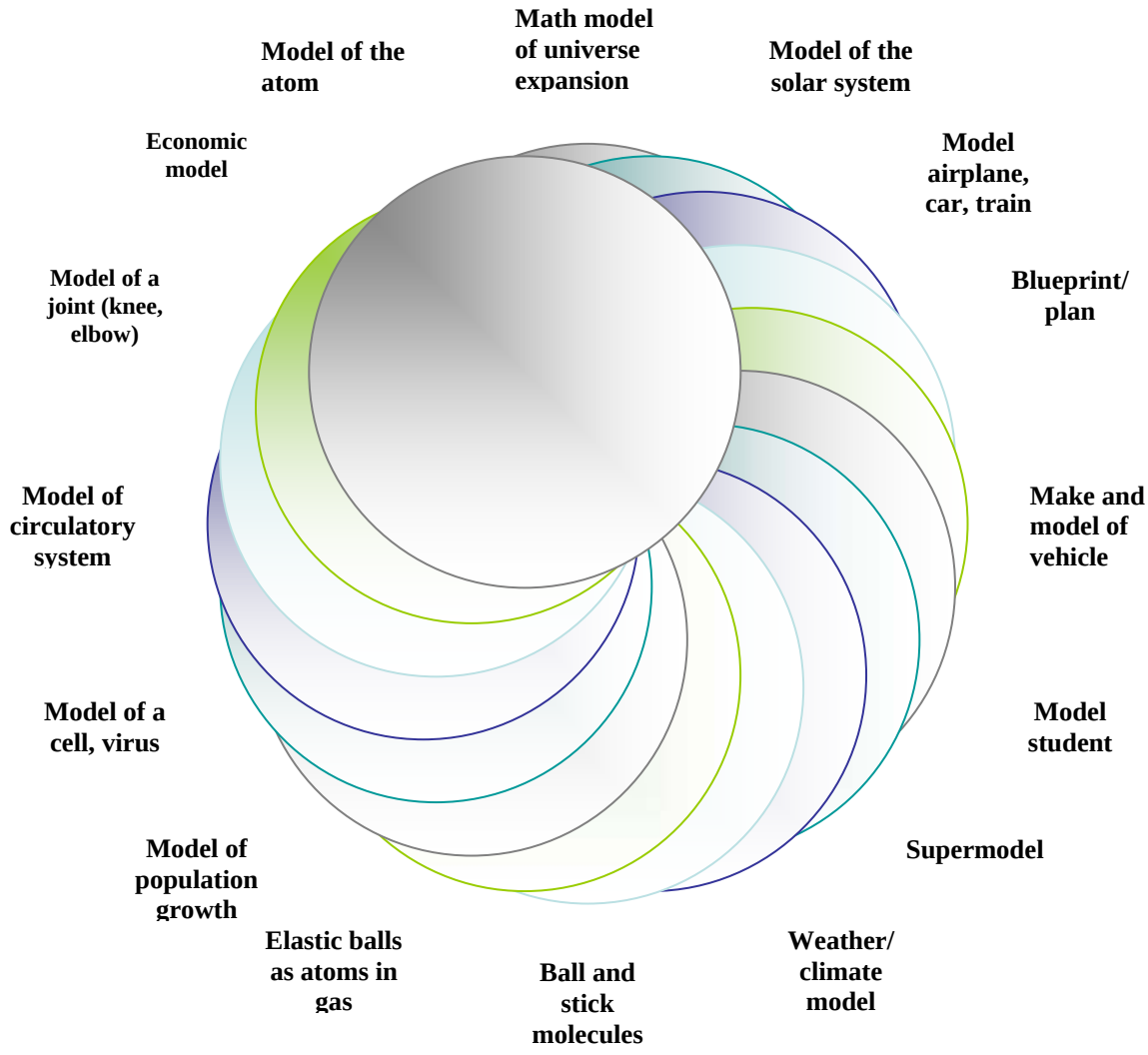
Level of abstraction. Some models are scaled-up (physical model of a virus particle) or scaled-down (model of the solar system) representations of reality. Other models are much more abstract. They may consist of a series of equations or many lines of computer code. The goal of the computer code may not be to create a simulation, but rather to evaluate a possibility (e.g. how big would a star need to be to give rise to a black hole.)

Alternative models. It is quite common for there to be different models to explain the same phenomenon. For example, there are physical models that show where protein synthesis occurs within a cell. There are also computer simulations of processes within a cell (such as the synthesis of protein) and there are mathematical models (such as to calculate the rate of protein synthesis under certain conditions). Sometimes older, "less accurate" models still figure into scientists' thinking (e.g. different models of the atom) when they are more practical for making sense of a particular phenomenon. Of course, scientists take the caveats of the model into consideration.

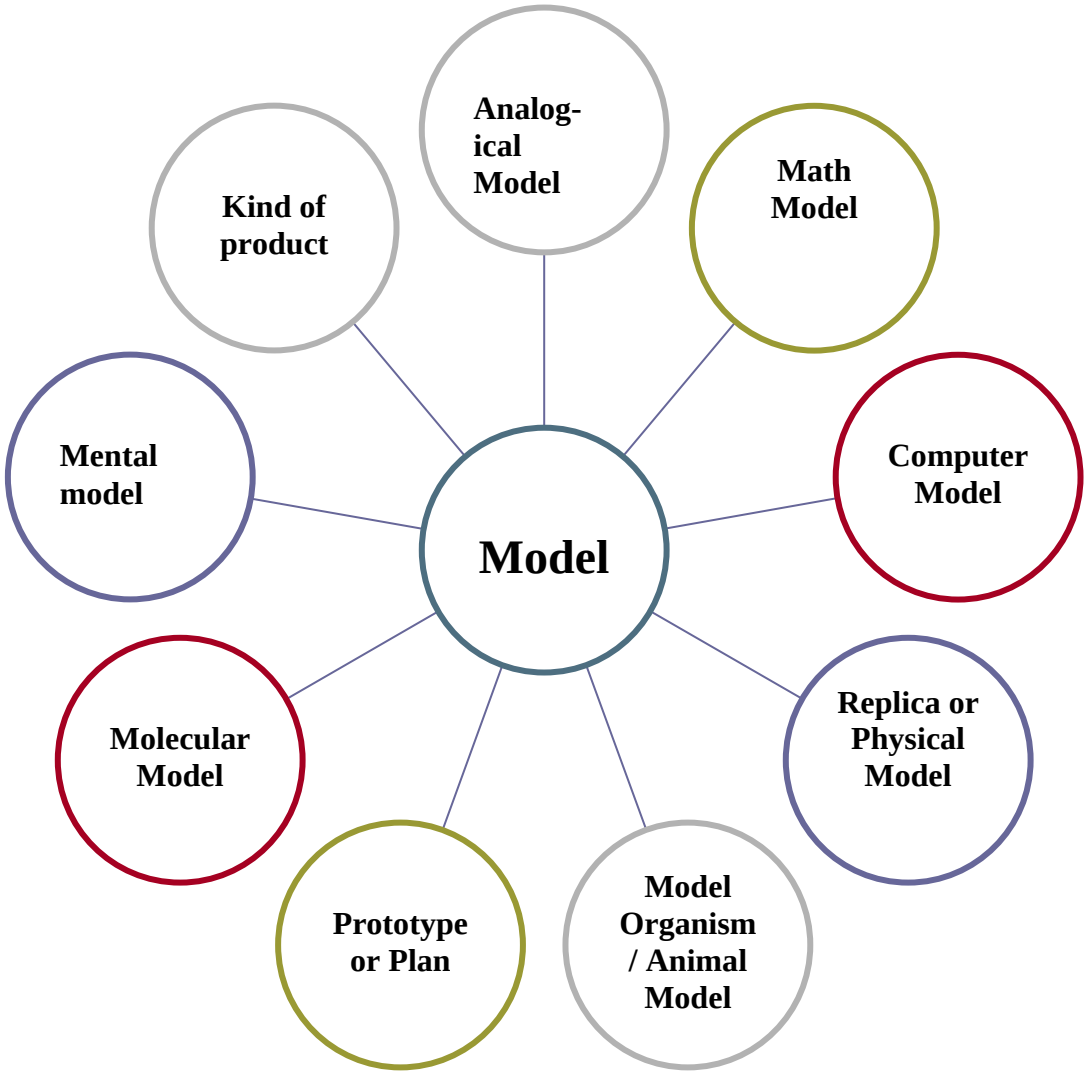
Caveats of Models. Although models can be powerful, they can also misleading. This is especially a problem for analogical models, for example gas atoms as bouncing balls or electricity as flowing water. Even when models are meant to represent reality they can be deceiving. For instance if a computer model is successful at predicting the behavior of a system, this might appear to suggest that the computer program is representing reality. However, the computer model could be reaching the same endpoint via a very different path than in the real situation it is supposed to be representing.

Models and scientific progress. Models can only be as accurate as the current state of scientific knowledge about the phenomenon they describe. Like anything in science, models come under scrutiny and change over time. The most familiar example of a historical progression of models is probably the models of the atom (e.g. Thomson, Rutherford, Bohr, Schrödinger). Sometimes old models are "cast aside," but some older models retain explanatory power and are still useful. For example, the Bohr model of the atom is handy for calculating how much energy will be released or absorbed when an electron moves between orbitals, even though scientists do not think the Bohr model accurately represents the atom. Of course, older models are also useful for pedagogical purposes because their study reveals how scientists draw conclusions from evidence and how new evidence can lead to revolutions in science.

Example Brainstorms:
1) Concrete examples



2) Classifications:



Some Additional Links and Resources

Models, theories, hypotheses, laws and the scientific method
NASA
http://genesismission.jpl.nasa.gov/educate/scimodule/Cosmogony/CosmogonyPDF/AppendixB.pdf

Introductory chapter on scientific inquiry
Arizona Collaborative for Excellence in the Preparation of Teachers (ACEPT)
http://acept.asu.edu/courses/phs110/si/chapter1/main.html

Overview of scientific modeling and types of scientific models
Mid-continent Research for Education and Learning
http://www.mcrel.org/epo/resources/sci_modeling.asp

Reasoning in science (for younger students)
Biology4Kids.com
http://www.biology4kids.com/files/studies_scimethod.html

Comparison of different types of models
Wikipedia
http://en.wikipedia.org/wiki/Model

More on model organisms
Wikipedia
http://en.wikipedia.org/wiki/Model_organisms

Opportunities for students to build their own models for climate-related phenomena (most suitable for middle school)
Australian Bureau of Meteorology
http://www.bom.gov.au/lam/Students_Teachers/learnact.htm#hpe

Scientific investigations in biology for high school and middle school students
University of Pennsylvania
http://serendip.brynmawr.edu/sci_edu/waldron/