Announcements

- The first homework is available on ICON. It is due one minute before midnight on Tuesday, August 30.
- Labs start this week. All lab sections will be in room 665 VAN.
- Kaaret has office hours Tuesday 1–3 pm, Wednesday 10-11 am, or by appointment. Please stop by...

Today’s lecture

- Scientific method
- Hypotheses, models, theories...
- Occam' razor
- Examples
- Diet coke and menthos

To understand the universe, scientists use the "**Scientific Method**"

- **Observe** - Observe something. Write down the observations and make sure that other people can repeat them on their own.
- **Hypothesize/Model** - Make a statement about how that something happens. The statement has to be in the form of an explanation that can be used in other contexts. The statement must help to make predictions about other observations.
- **Test and Criticize** - Observe similar things to see if the statement is correct or needs to be modified.
- **Repeat** - until you get it right.

Hypothesis/Model

- One or more ideas to explain an observation or set of observations.
- Must be useful in making predictions about other observations
- Must be testable
- Must be falsifiable.

Other words are “Theory” (e.g. Einstein’s Theory of Gravity) and “Law” (e.g. Newton’s Law’s of Motion).

Which is not a valid scientific hypotheses?

A. Any two objects dropped from the same height above the surface of the moon will hit the lunar surface at the same time.
B. Our universe is surrounded by another, larger universe, with which we can have absolutely no contact or interaction.
C. All horses are brown.
D. Unicorns exist.

Science, religion, and pseudo-science

- **Scientific theories** are *experimentally verifiable (or falsifiable)* and *predictive*. They address **how** questions (e.g. How do stars form? How is a lunar eclipse caused? How did the Universe evolve?)
- **Religious and ethical statements** are (generally) not verifiable. They address **why** questions (e.g. Why does the Universe exist? Why is life worth living?). These are not intrinsically less worthwhile than scientific inquiries, they are simply addressing different questions. Religion and science come into conflict when religion supplies answers for questions that can now be addressed by science, i.e. evolution of humans, age of the Universe.
- **Pseudo-science theories** pretend to be scientific but are either not falsifiable (e.g. séances,) or supporters or use anecdotal evidence to support claims (e.g. astrology, 'creation' science).

Skepticism and Truth

- Role of skepticism. An essential part of the scientific method. Scientists always question the basis for an scientific assertion. This is often considered ‘impolite’ behavior in social settings, but is ***not*** impolite in scientific discussion.

- **‘What is truth?’** - Scientific theories are ***not*** statements of ***truth***. They are the best available explanation for observed facts, but are subject to revision or falsification.

- Scientists must be able to admit that they are wrong. (This is also good for non-scientists ;).

Occam's Razor

- What if two or more competing hypotheses both pass some initial tests - how do you choose between them?

- If the hypotheses generate different predictions it will be a simple matter to pick the best one - as long as it is feasible to carry out the experimental tests. What if the competing hypotheses don't give distinguishable, feasible predictions? Enter "Occam's Razor".

- William of Occam was a medieval scholar and logician, and, in modern form, the principle that has come to be known as Occam's Razor says:

  If two hypotheses can't be distinguished experimentally, choose the simpler one.

What is a scientific model?

A. An approximation of a real system that omits all but the most essential variables of the system.
B. A scientific model is a representation of an object or system. An example of a scientific model would be a diagram of a cell or a map ... even a model rocket!
C. A really good looking scientist.
D. None of the above.

Hypothesis/Model

- **Must be useful in making predictions about other observations and be testable/falsifiable.**

- Does not consider the full complexity of the system or object being examined – only “essential variables”.
- Often uses math, but can be anything that allows one to make predictions.

- In deciding if a hypothesis or model is legitimate think about predictions, falsifiable, and essential variables.

Hypothesis/Model

- Is our scale model of the solar system a scientific model?

  A = Yes, B = No

Hypothesis/Model

- Can one make predictions using our scale model of the solar system?

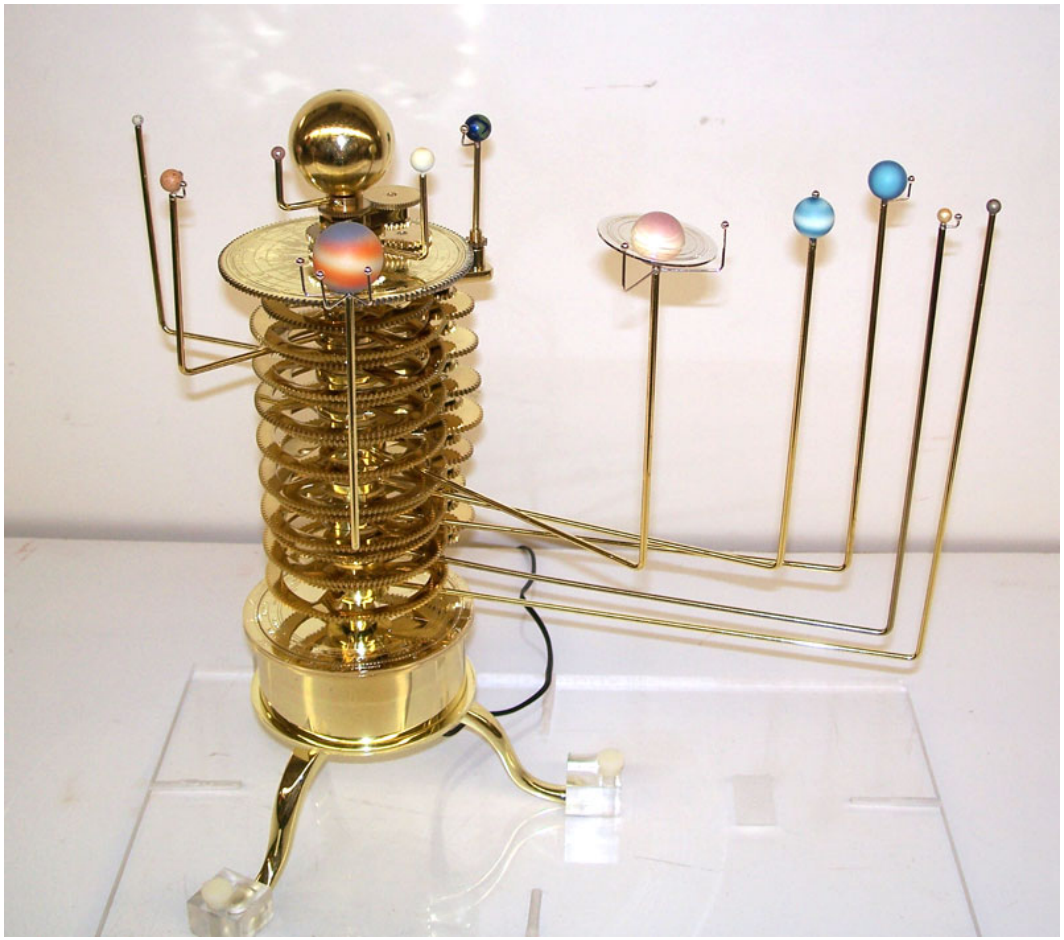
- Is the scale model of the solar system falsifiable?

  A = Yes, B = No

- What “essential variables” does it describe?

Hypothesis/Model

- Is this a scientific model? A = Yes, B = No



Earth, Moon, Sun 8A10.10

Hypothesis/Model

- Is the following statement a scientific hypothesis?

Left-handed people can stand on one foot longer than right-handed people.

A = Yes, B = No

- Does it make predictions? It falsifiable?
- What “essential variables” does it describe?

Hypothesis/Model

- Is the following equation a scientific hypothesis?

$$\boldsymbol{F = ma}$$

A = Yes, B = No

- Does it make predictions? It falsifiable?
- What “essential variables” does it describe?

Diet Coke and Mentos

- What is the first hypothesis that Jamie makes (and tests) about the Diet Coke and Mentos phenomenon?

  A) Smaller bottles make higher cascades.

  B) CO_2 gas is essential.

  C) It doesn't work with regular Coke.

  D) It ruins the taste of the Coke.

Diet Coke and Mentos

- Is Jamie's first hypothesis a valid scientific hypothesis?

  A) Yes

  B) No

Diet Coke and Mentos

- What is the second hypothesis about the Diet Coke and Mentos phenomenon?

  A) CO_2 gas is the only important component of soda.

  B) Soda water will make as high a cascade as diet Coke.

  C) It only works for men with facial hair.

Diet Coke and Mentos

- Adam uses an important technique often used in science to narrow down the range of chemicals important in making the cascade. What is it?

  A)

  B)

  C) Falisification

  D) Humor

Diet Coke and Mentos

- Are there any flaws in the "proof" that nucleation on the Mentos surface is important?
- What would be a better test?

Diet Coke and Mentos

- Are Jamie and Adam having fun?

  A) Yes

  B) No

Diet Coke and Mentos

- Do you think scientists have fun while using the scientific method?

  A) Yes

  B) No