Preparing Scientists

Leave the beaten track behind occasionally and dive into the woods. Every time you do, you will be certain to find something you have never seen before.

Alexander Graham Bell

Types of Science:

1. **Hypothesis Testing**
   - A formal process by which a decision is made. In science, using the scientific method and experimentation to draw conclusions.
2. **Natural History**
   - Describe where organisms live and how they interact with each other. Organismal biology. Often more descriptive than experimental.
3. **Taxonomy**
   - Identification and description of species. Classification of organisms.
4. **Monitoring**
   - Process of detecting change in the environment.

Humans use many ways to understand the natural world

- **Religion** = an organized system of faith and worship
- **Aesthetics** = philosophy of the nature of beauty
- **Ethics** = Study of values of a person or group. It covers the concepts of right and wrong, good and evil, and responsibility

Leap of Faith

Science

- Differs from others because science mandates a process

- Science considers only what is observable by the senses or by instruments that extend the ability of our senses

Phenomenon

- The observable event is the foundation of science
- We refer to this observable event as a **phenomenon**

- In addition to an event being observable (phenomenon) the event must be **reproducible** to be reliable.

Religion, Aesthetics, Ethics or Science?

- This flower is beautiful
- Stealing is wrong
- This drug will cure Type II diabetes
- My wife loves me
- This pesticide kills ants
- John saw a UFO at the dunes last week
- Little green men live on the moon
- There is a God

- Just because you cannot observe and prove things scientifically does not mean they are wrong or somehow weaker than scientific questions.

- Religion, aesthetics, ethics and science, by themselves, cannot answer all questions. Making sense of life requires portions of all four philosophies. They all play a part in explaining and giving meaning to the world.

- We should not fall into the trap of saying because we cannot prove God's existence that he does not exist. Nor should we say that just because many people fervently testify of god that he does exist.

- Faith is important in life. Religion, aesthetics and ethics will not be the focus of this course. I do encourage your study of these topics though as your life will be richer for it. In this course, we will focus on the many things that do not require faith and in those instances we look to science to help us understand.

Scientific Method

1. Observe
2. Do Research
3. Form a Hypothesis
4. Test the Hypothesis
5. Collect Data
6. Analyze Data
7. Draw Conclusions
8. Publish methods, results and conclusions for peer review

1. Observe

- You observe something (phenomena) and want to explain what you observe but cannot
- May or may not be known by someone else
- May or may not be a new phenomena

2. Do Research

- You do research about the idea to see if someone else has observed and described the same thing.
  - You go to the internet
  - You go to the library
  - You ask people who might know
  - You watch and observe phenomena

3. Form a Hypothesis

- After research, you use these gathered facts and some creative thinking to come up with a possible explanation.

- This is called **inductive reasoning** --- using specific observations and the process of logic to come up with a **hypothesis**.

- A hypothesis is really just a guess with a little more thought put into it.
- "Educated Guess". The educated is based on the research. It is not just a guess.

3. Form a Hypothesis – Cont.

- A hypothesis is testable.
- Must be phrased in such a way as to be tested
- Another way of saying this is that the hypothesis can be proved false.
- An important component of a hypothesis that makes it different than guessing.
- This is also what sets science apart from other methods of explaining the world.
- Science only considers hypotheses that can be tested. Hypotheses are tested.

4. Test the Hypothesis

- You do not prove your hypothesis you **falsify** it.
- This is a peculiar quirk of science.
- Science never proves anything.
- It only has the power to disprove something. Science is the search for evidence that proves our concepts wrong.
- Dissent is the activity of science, fueled by free inquiry and independence of thought

5. Collect Data

- Science often relies on quantitative data. This type of data is more easily reproducible and testable. However, science can also be conceptual or qualitative.
- Method must be repeatable by others

6. Analyze Data

- After the data is collected it is analyzed
- Uncertainty is an inherent feature of science, arising from the limitation that we can only focus on a small subset of nature, resulting in an incomplete perspective
- Statistical tests are often used to describe data that has great amounts of variation. This will be discussed later

7. Draw Conclusions

- **Great care should be made in making a conclusion.**
- **Science carries responsibility**

- **In addition, you should be aware that others will try to prove you are incorrect. You need both a thick skin and a humble attitude**

8. Publish methods, results and conclusions for peer review

- Peer review is an important part of science
- It can eliminate bias, allow for others to reproduce the experiment and determine if they get the same results, and keeps the process transparent

- All efforts should be made to disprove any conclusion that is made. Sounds harsh but that is how science should work. Any conclusion that is not disproven is only valid until it is disproven

Types of Publications

- Research Paper
- Review Paper
- Conference Presentation
- Technical Notes
- Agency Report
- Grant or mandated reports
- Popular Magazines