

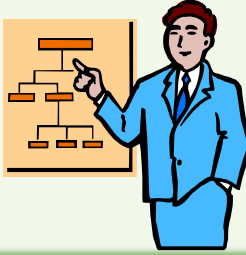
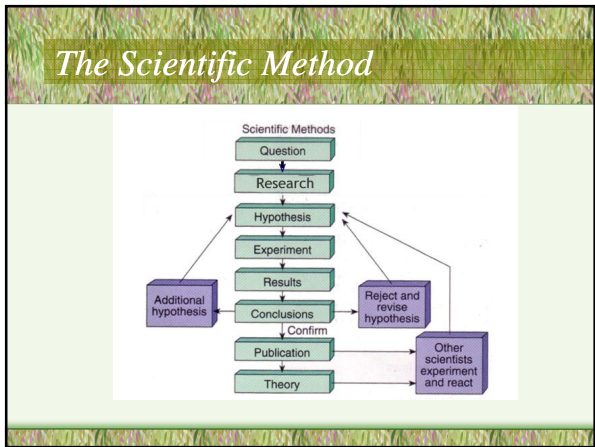
Scientific Methods in Biology

Science Process Skills

- **Measuring:** comparing unknown values to known values
- **Inferring:** forming a conclusion based on facts, not a direct observation
- **Modeling:** using a copy or imitation of the object to help understand or explain something
- **Classifying:** grouping things based on similarities
- **Predicting:** stating in advance how and why something will happen
- **Researching:** gathering information about an idea
- **Communicating:** sharing information with others

The Scientific Method:

- Common steps that scientists use to gather information to solve problems.
- problem solving model.
 - Problem/Question
 - Research
 - Hypothesis
 - Experiment
 - Observation
 - Analyze
 - Conclusion

Inductive Reasoning:

- The most often used method of reasoning in science to develop a hypothesis.
- Reasoning from a particular set of facts to a general rule.
- ie: know a bright colored coral snake is poisonous, assume all bright colored snakes are poisonous.

Deductive Reasoning:

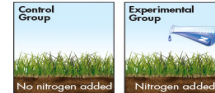
- Suggesting that something may be true about a specific case based on a general rule.
- If...then statements
- Helps develop hypothesis and design experiment to test them.
- ie: know a bright colored coral snake is poisonous, see frogs with same banding pattern you conclude that the frog is poisonous and should be avoided.

Controlled Experiment:

- Only one condition is changed at a time.
- Has 2 experimental groups:
 - Control Group: group under all normal conditions; test group in which all conditions remain unchanged.
 - Control- standard in which all conditions are kept the same; part of an experiment where all conditions are kept constant.
 - Quantities that a scientist wants to remain constant
 - Experimental Group: the group where all conditions are kept the same except for the single condition being tested.

Designing Controlled Experiments

- A controlled experiment keeps track of various factors that can change, or variables.
- Examples of variables include temperature, light, time, and availability of nutrients.
- A hypothesis should be tested by an experiment in which only one variable is changed. All other variables should be kept unchanged, or controlled.

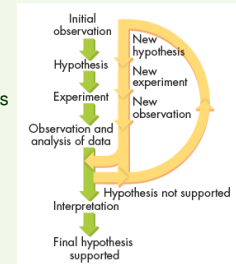


Controlling Variables

- It is important to control variables
 - if several variables are changed in the experiment, researchers can't easily tell which variable is responsible for any results they observe.
- The variable that is deliberately changed is called the **independent variable**
 - Aka the manipulated variable
- The variable that is observed and that changes in response to the independent variable is called the **dependent variable**
 - aka the responding variable

Drawing Conclusions

- New data may indicate that the researchers have the right general idea but are wrong about a few particulars.
- In that case, the original hypothesis is reevaluated and revised; new predictions are made, and new experiments are designed.
- Hypotheses may have to be revised and experiments redone several times before a final hypothesis is supported and conclusions can be drawn.



Sources of Error

- Researchers must be careful to avoid errors in data collection and analysis. Tools used to measure the size and weight of marsh grasses, for example, have limited accuracy.
- Data analysis and sample size must be chosen carefully. The larger the sample size, the more reliably researchers can analyze variation and evaluate differences between experimental and control groups.
- What other sources of error can you think of?

When Experiments Are Not Possible

- Sometimes, ethics prevents certain types of experiments—especially on human subjects.
 - ie: medical researchers who suspect that a chemical causes cancer would search for volunteers who have already been exposed to the chemical and compare them to people who have not been exposed to the chemical.
 - The researchers still try to control as many variables as possible, and might exclude volunteers who have serious health problems or known genetic conditions.
- Medical researchers always try to study large groups of subjects so that individual genetic differences do not produce misleading results.

When Experiments Are Not Possible

- It is not always possible to test a hypothesis with an experiment.
 - researchers devise hypotheses that can be tested by observations.
 - ie: Animal behavior researchers might want to learn how animal groups interact in the wild by making field observations that disturb the animals as little as possible. Researchers analyze data from these observations and devise hypotheses that can be tested in different ways.

Designing an Experiment:

- Experimental design depends on:
 - What other experimenters have done.
 - What information the scientist wants to gain.
- **Dependent Variable:** A condition(s) that results from the change; the item observed and measured when a change or independent variable is present.
- **Independent Variable:** The condition in a controlled experiment that is changed.

Data:

- **Experimental Results:** Data obtained from experiments.
- **Numerical Data (Quantitative Observations):**
 - measurements of time, temp., length, mass, volume, etc.
 - Counts: numbers
- **Verbal Data (Qualitative Observations):**
 - words to describe observations made during and experiment

Reporting Data:

- Scientific journals
- Others testing to verify results
- Theories and Laws



Theory:

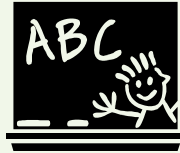
- a statement of an idea or principle that has been tested by many scientists over a period of time
- an explanation of a natural phenomenon that is supported by a large body of scientific evidence obtained from many different experiments and observations
- A theory results from continual verification and refinement of a hypothesis.

Laws:

- Facts of Nature
- Theories that have passed many tests
- ie: the Law of Gravity

Kinds of Research:

- Quantitative:
 - controlled experiments which result in numerical data.
- Qualitative/Descriptive:
 - observational data
 - written descriptions



Can Science Answer ALL Questions?

- NO
- Not judgements
 - Good vs. Evil
- If it is not testable (with the scientific method,) it is not science.
 - Black cat crosses your path you will have bad luck...what is luck, how long wait for it, how distinguish from random bad luck?