

# Introduction to Biology



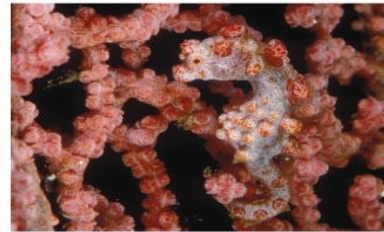
Biology is likely to remain the biggest part of science through the twenty-first century.

- Freeman Dyson

- Biology is the scientific study of life
- For something to be considered living, each of these characteristics must be present:



(a) Order.



(b) Evolutionary adaptation.



(c) Response to the environment.



(d) Regulation.



(e) Energy processing.



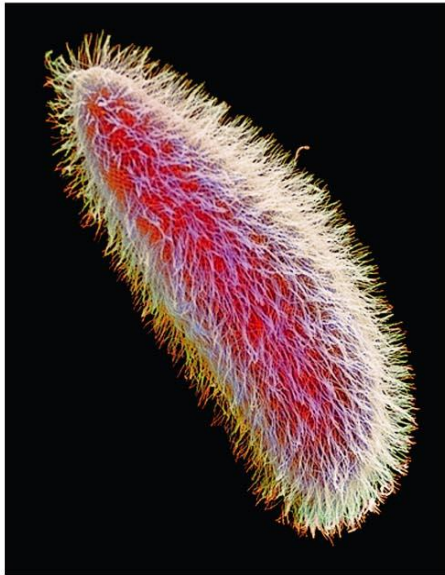
(g) Reproduction.



(f) Growth and development.

# Characteristics of Life

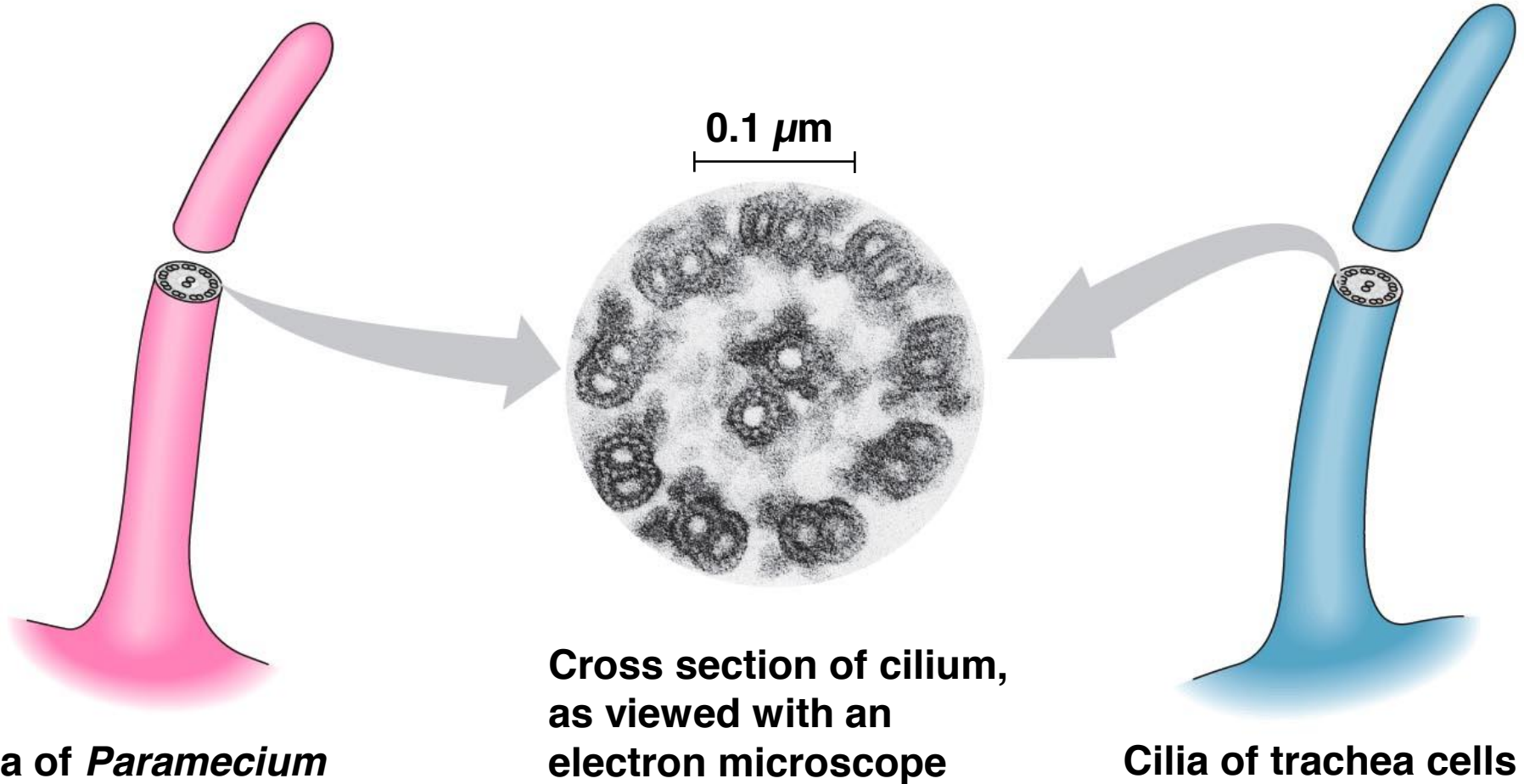
- **Order:** High amount of organization in an organism's internal and external parts.
  - Example: Special cells called cilia



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**Cilia of *Paramecium***

**Cilia of cells in a human trachea**



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**The internal structure of cilia, whether from *Paramecium* or a human trachea, have a nearly identical internal order.**



# Characteristics of Life

- **Adaptation:** Organisms will evolve specific traits to aid in their survival.
  - What adaptations are found in a bat?



# Characteristics of Life

- **Response:** An organism will respond to a stimulus (change in the external environment).
  - Example: Venus flytrap



# Characteristics of Life

- **Regulation:** An organism maintains constant internal conditions in spite of the outside changes. This balance is called **homeostasis**.
  - Example: Chickens panting in high temperatures





# Characteristics of Life

- **Reproduction:** Able to independently pass along genes to offspring.
  - Example: King snake hatching.

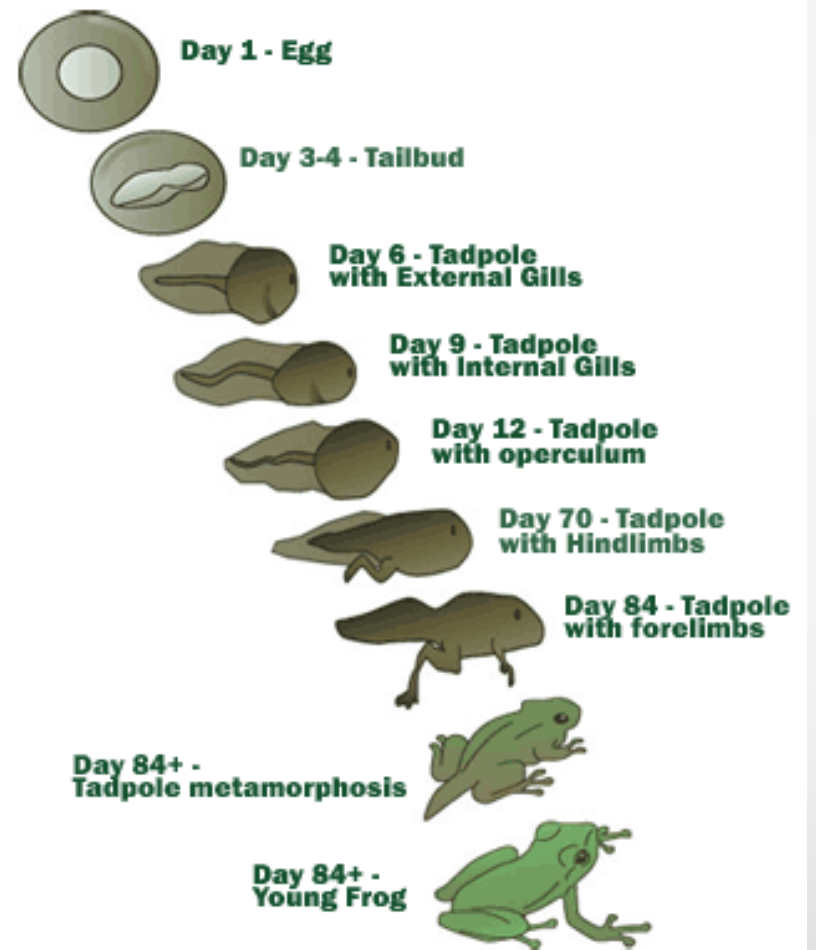




# Characteristics of Life

- **Growth and Development:** Inherited genes from the parents control how an organism grows.

Example: All frogs pass through the same stages of life as they mature to adulthood.



# Characteristics of Life

- **Energy Processing:** An organism will obtain energy from the environment to do work.
  - Example: Giraffe eating leaves.



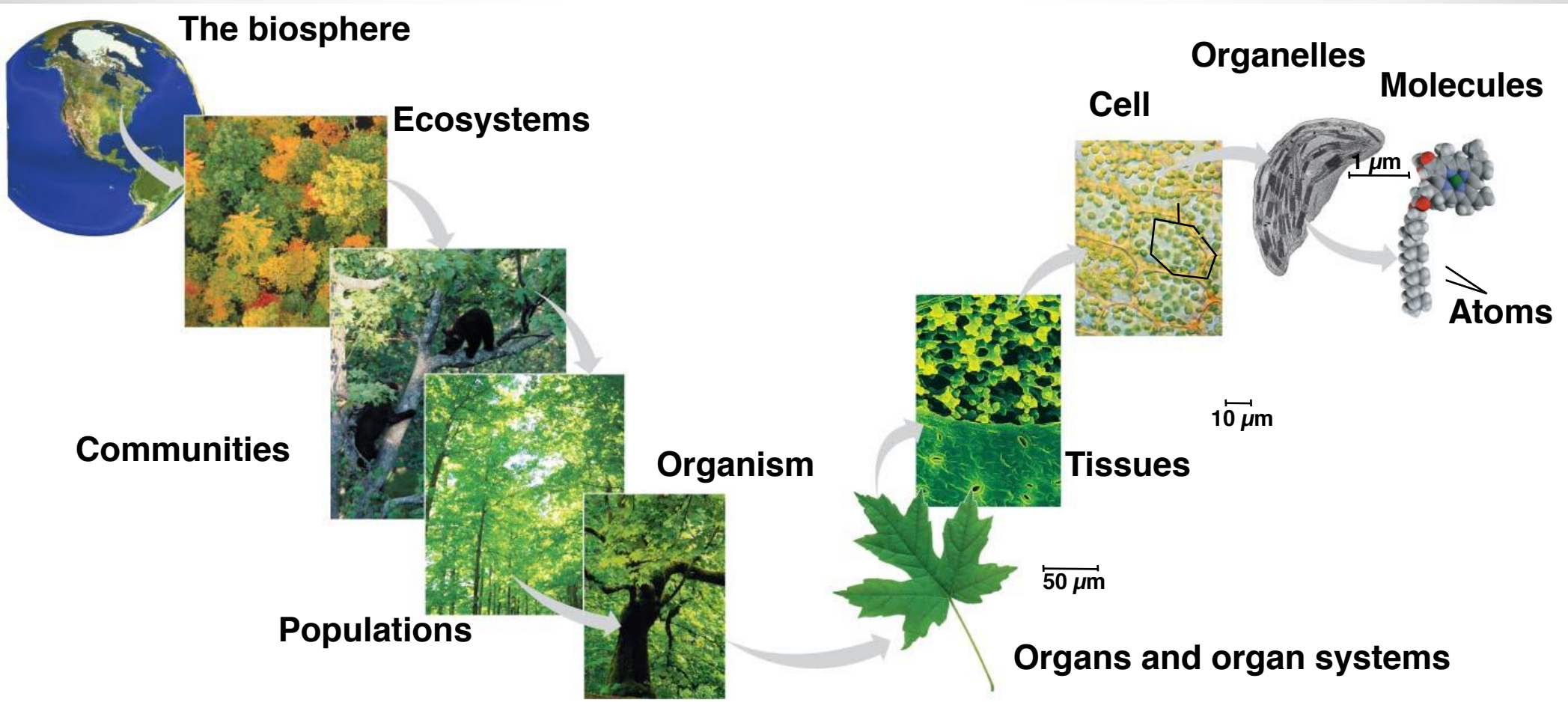
# A Hierarchy of Biological Organization

- Biological organization is based on a hierarchy of structural levels.
- Working from largest to smallest:
  1. Biosphere: all environments on Earth
  2. Ecosystem: all living and nonliving things in a particular area
  3. Community: all organisms in an ecosystem
  4. Population: all individuals of a species in a particular area
  5. Organism: an individual living thing



# A Hierarchy of Biological Organization (continued)

6. Organ and organ systems: specialized body parts made up of tissues
7. Tissue: a group of similar cells
8. Cell: life's fundamental unit of structure and function
9. Organelle: a structural component of a cell
10. Molecule: a chemical structure consisting of atoms



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**Example:** Earth → Deciduous Forest → Living Things in Forest → All Maple Trees → Individual Maple Tree → Leaves → Leaf Surface → Leaf Cell → Chloroplast → Chlorophyll → Phosphorous

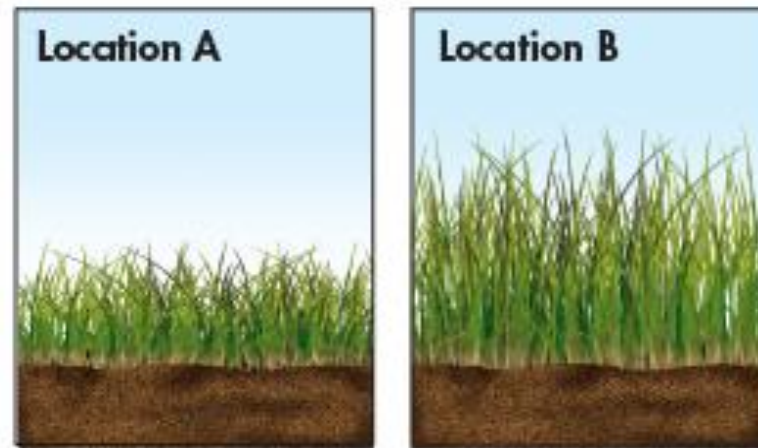
# Scientific Methodology

- What procedures are at the core of scientific methodology?
- Scientific methodology involves:
  - observing and asking questions,
  - forming hypotheses
  - conducting controlled experiments,
  - collecting and analyzing data
  - drawing conclusions.



# Observing and Asking Questions

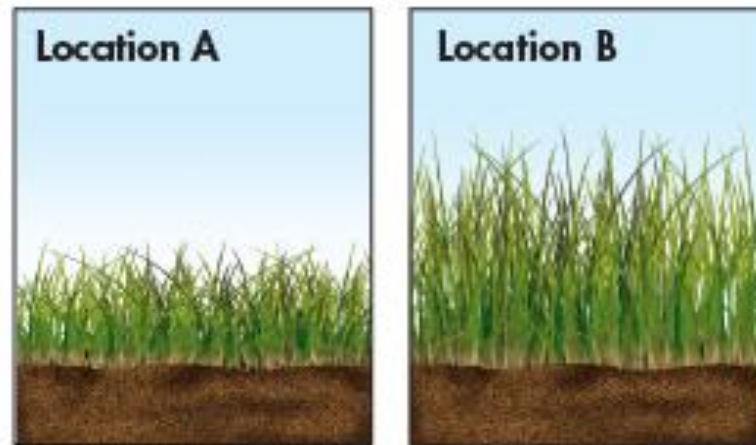
- Scientific investigations begin with **observation**, the act of noticing and describing events or processes in a careful, orderly way.
- What observation would be made from the example below?



- This observation leads to a question: Why do the marsh grasses grow taller in Location B?

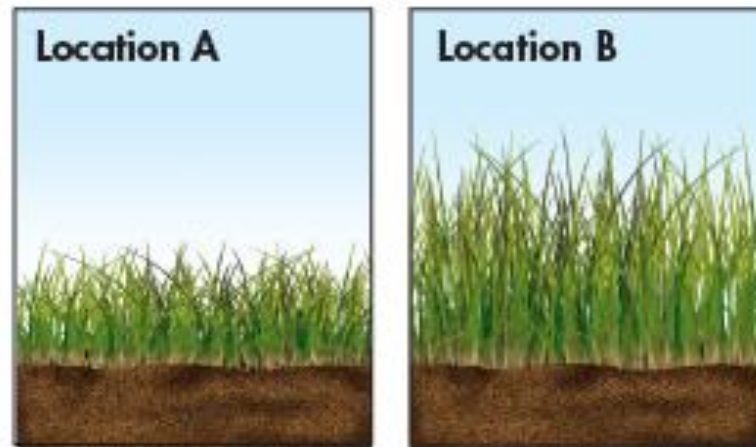
# Forming a Hypothesis

- After posing questions, scientists make a **hypothesis**, or a scientific explanation for a set of observations that can be tested in ways that support or reject it.
  - A hypothesis is NOT a guess. It is a prediction based on what you already know.



# Forming a Hypothesis

- For example, everyone knows that plants need nutrients to grow (plant food).
- Based on their knowledge of salt marshes, they hypothesized that marsh grass growth is limited by available nitrogen.





# Experimental Design

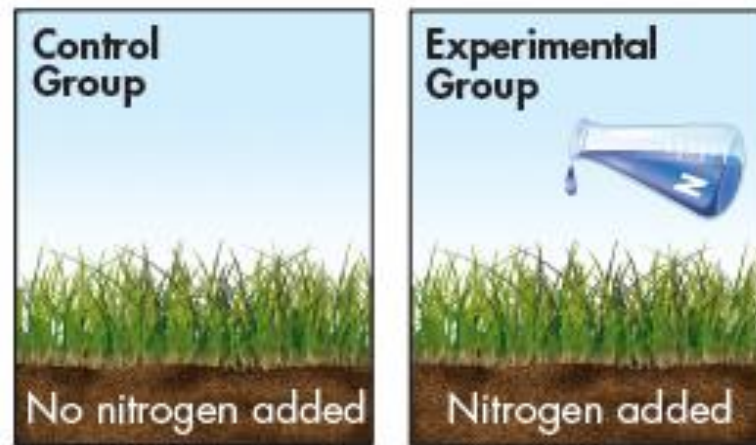
- Testing a scientific hypothesis often involves designing an experiment that keeps track of various factors that can change, or **variables**.
  - Examples of variables include temperature, light, time, and nutrients.
- Whenever possible, a hypothesis should be tested by an experiment in which only one variable is changed.
- All other variables should be kept unchanged, or controlled. This type of experiment is called a **controlled experiment**.

# Experimental Design

- It is important to control as many variables as possible to make sure you know what is causing the change.
  - The variable that is deliberately changed is called the **independent variable** (also called the manipulated variable).
    - Example: The plant nutrient nitrogen
  - The variable that is observed and that changes in response to the independent variable is called the **dependent variable**.
    - Example: The plant's growth
- Typically, an experiment is divided into control and experimental groups.
  - A **experimental group** is exposed to the independent variable.
  - A **control group** is exposed to the exact same conditions as the experimental group except for one independent variable.

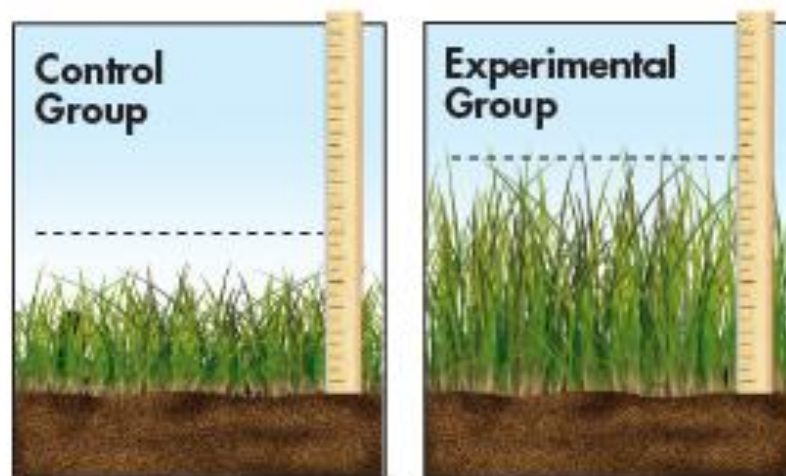
# Experimental Design

- For example, the researchers selected similar plots of marsh grass. All plots had similar plant density, soil type, and amount of rainfall. The plots were divided into control and experimental groups.
- The researchers added nitrogen fertilizer (the independent variable) to the experimental plots. and nothing to the control plots.



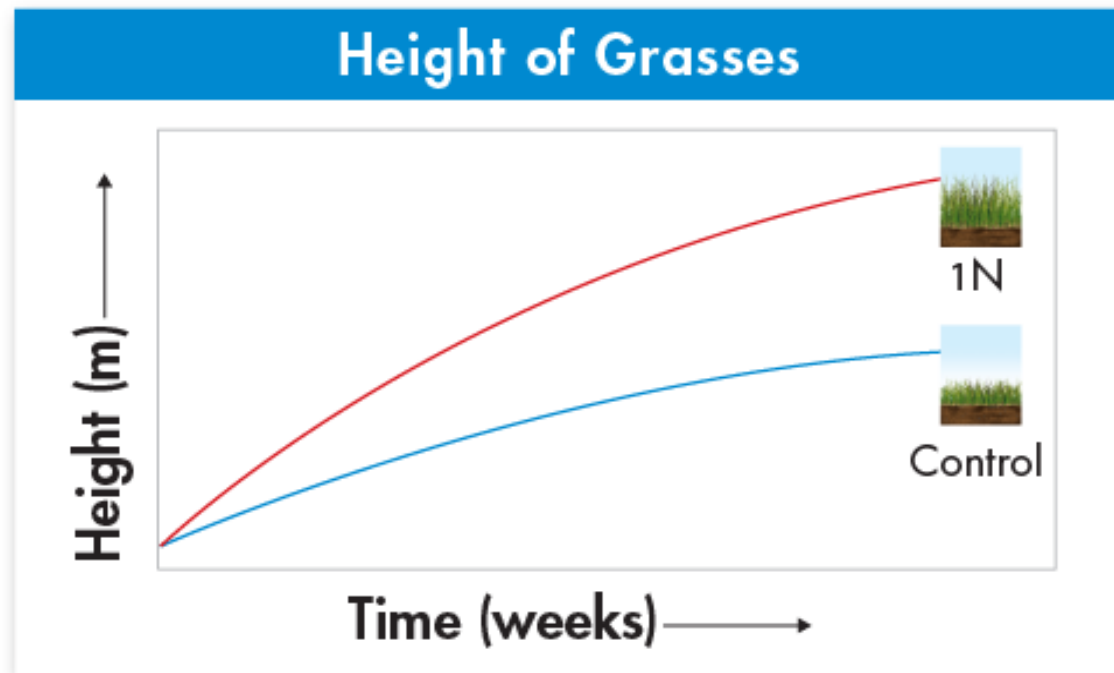
# Collecting and Analyzing Data

- Data could be any numbers obtained by counting or measuring.
  - This type of data is called **quantitative data**.
  - In the marsh grass experiment, it could include the number of plants per plot, plant sizes, and growth rates.



# Drawing Conclusions

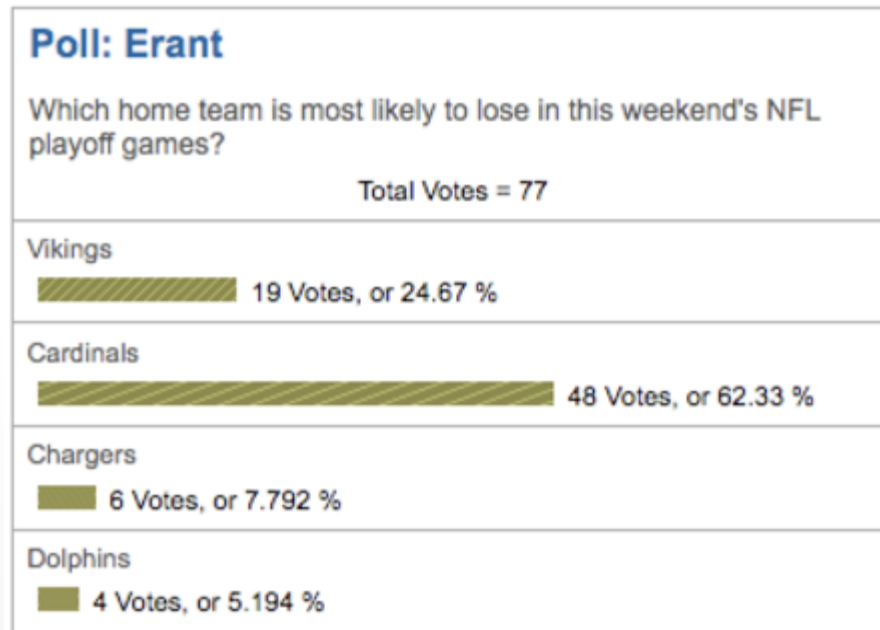
- A **conclusion** states whether the hypothesis is supported or not by the experimental data.





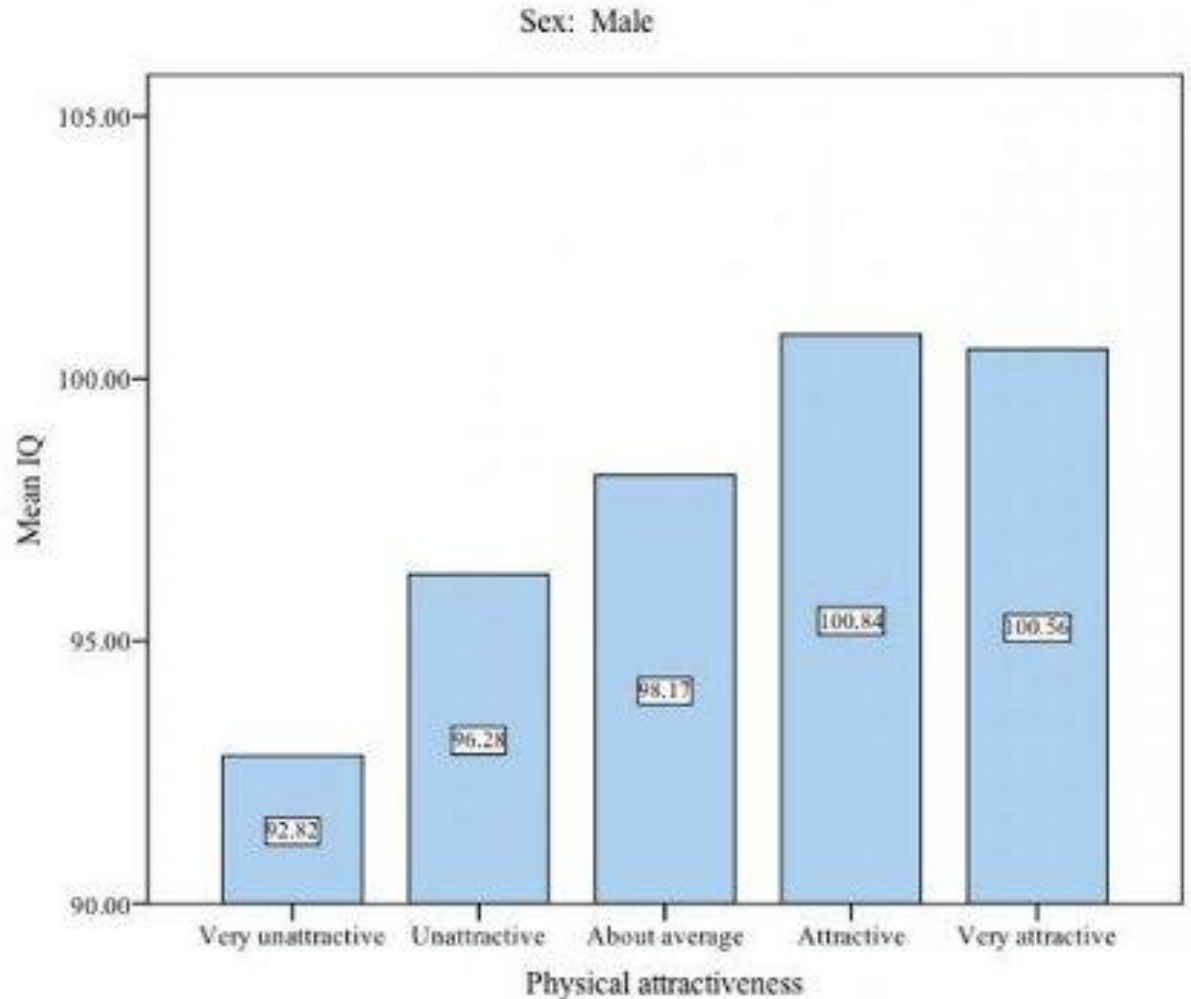
# Sources of Error

- There are many possible ways that error can affect an experiment.
- The most likely cause of error is **sample size**.
- The larger the sample size, the more reliable the data, and the less error is present.
  - This applies to both experiments and polls.



# Sample Size

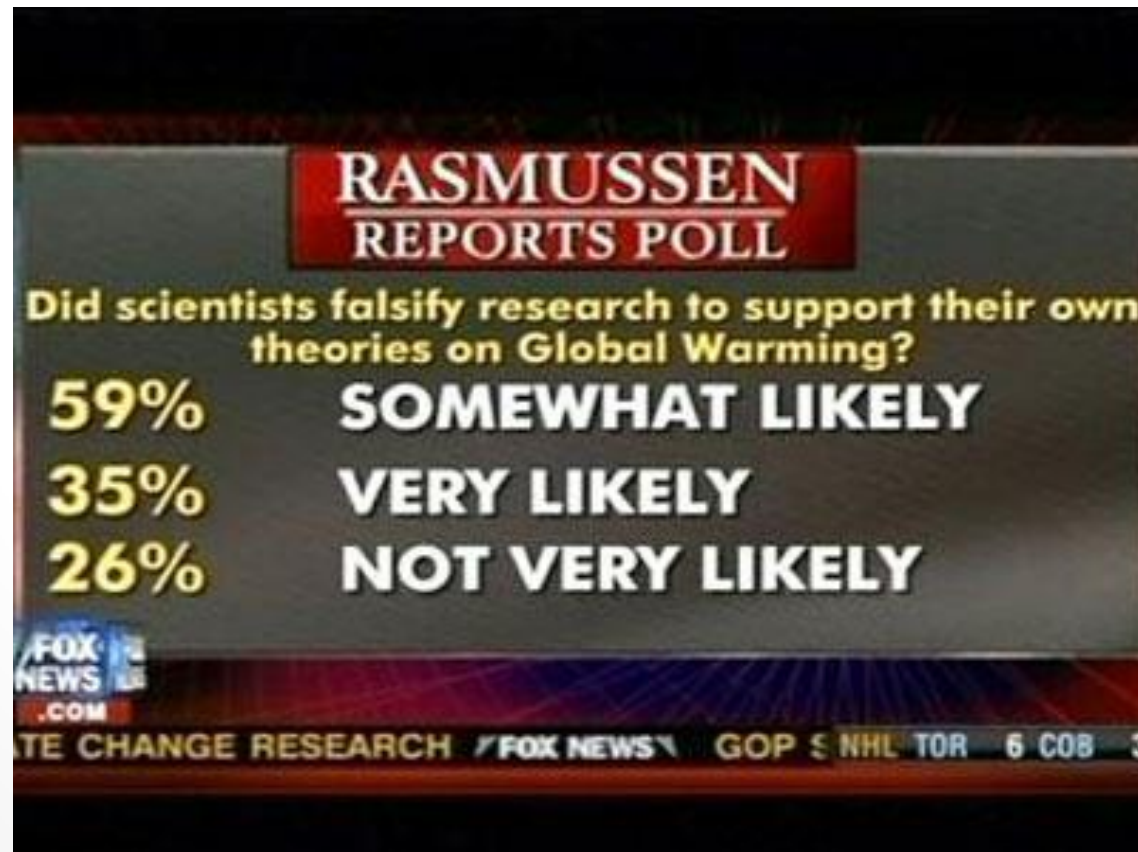
- This is an experiment from *Psychology Today* where hundreds of women were asked to rate the attractiveness of a selected pool of men.
- The average IQ score of men in each level of attractiveness was then calculated.

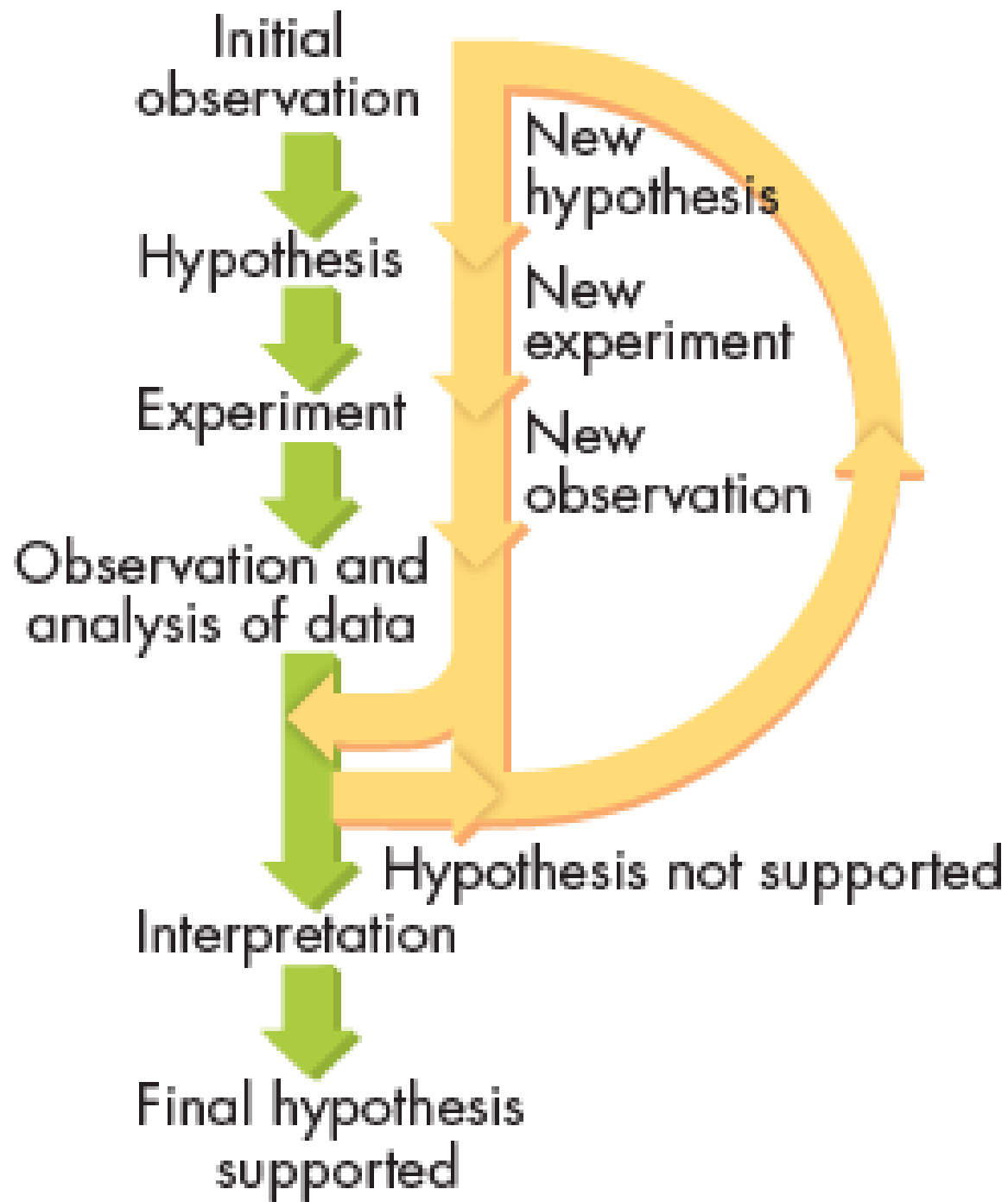


Source: Psychology Today

# Math Errors

- Errors in mathematical calculations is also a major source of experimental error.





# Other Sources of Error

- Error can also arise when doing a controlled experiment if not all variables are known or properly accounted for.
- This is the advantage of field or natural experiments, which are conducted directly in the environment.



# Other Types of Data

- Not all data involves numerical measurements, some data requires descriptions and observations.
- This is qualitative data.



# A Case Study in Scientific Inquiry: Mimicry

- In **mimicry**, a harmless species resembles a harmful species
- An example of mimicry is a stinging honeybee and a nonstinging mimic, a flower fly

**Flower fly  
(nonstinging)**



**Honeybee (stinging)**

- This case study examines king snakes' mimicry of poisonous coral snakes
- The hypothesis states that mimics benefit when predators mistake them for harmful species
- The mimicry hypothesis predicts that predators in non-coral snake areas will attack king snakes more frequently than will predators that live where coral snakes are present



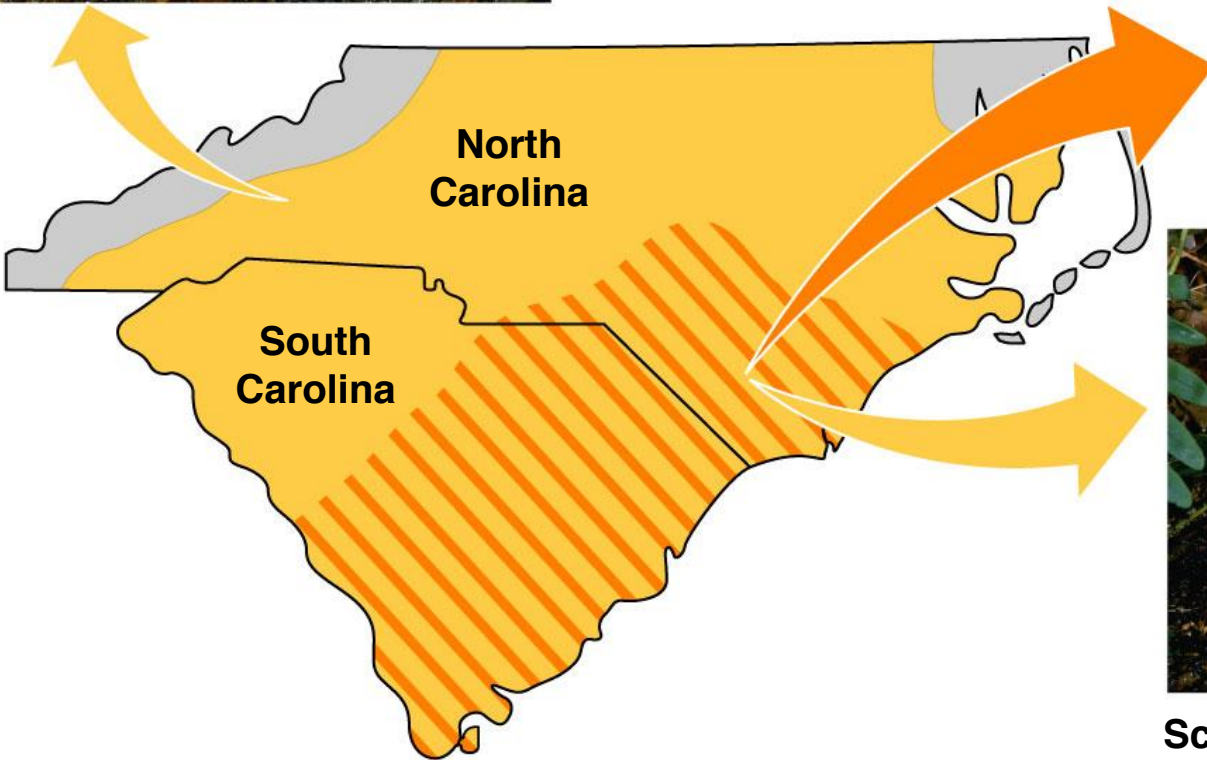
# Scarlet king snake



## Key

 Range of scarlet king snake

 Range of eastern coral snake



**Eastern coral snake**



**Scarlet king snake**

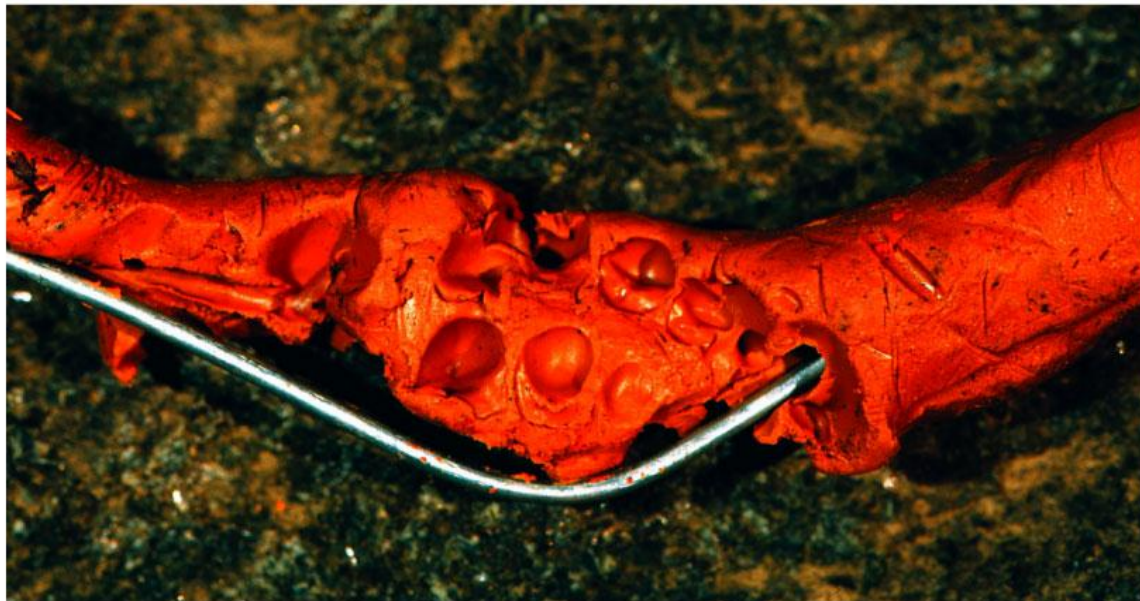


# Field Experiments with Artificial Snakes

- To test this mimicry hypothesis, researchers made hundreds of artificial snakes:
  - An experimental group resembling king snakes
  - A control group resembling plain brown snakes
- Equal numbers of both types were placed at field sites, including areas without coral snakes
- After four weeks, the scientists retrieved the artificial snakes and counted bite or claw marks
- The data fit the predictions of the mimicry hypothesis

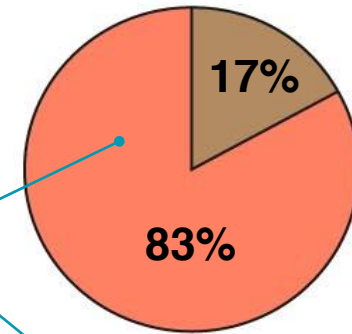


**(a) Artificial king snake**





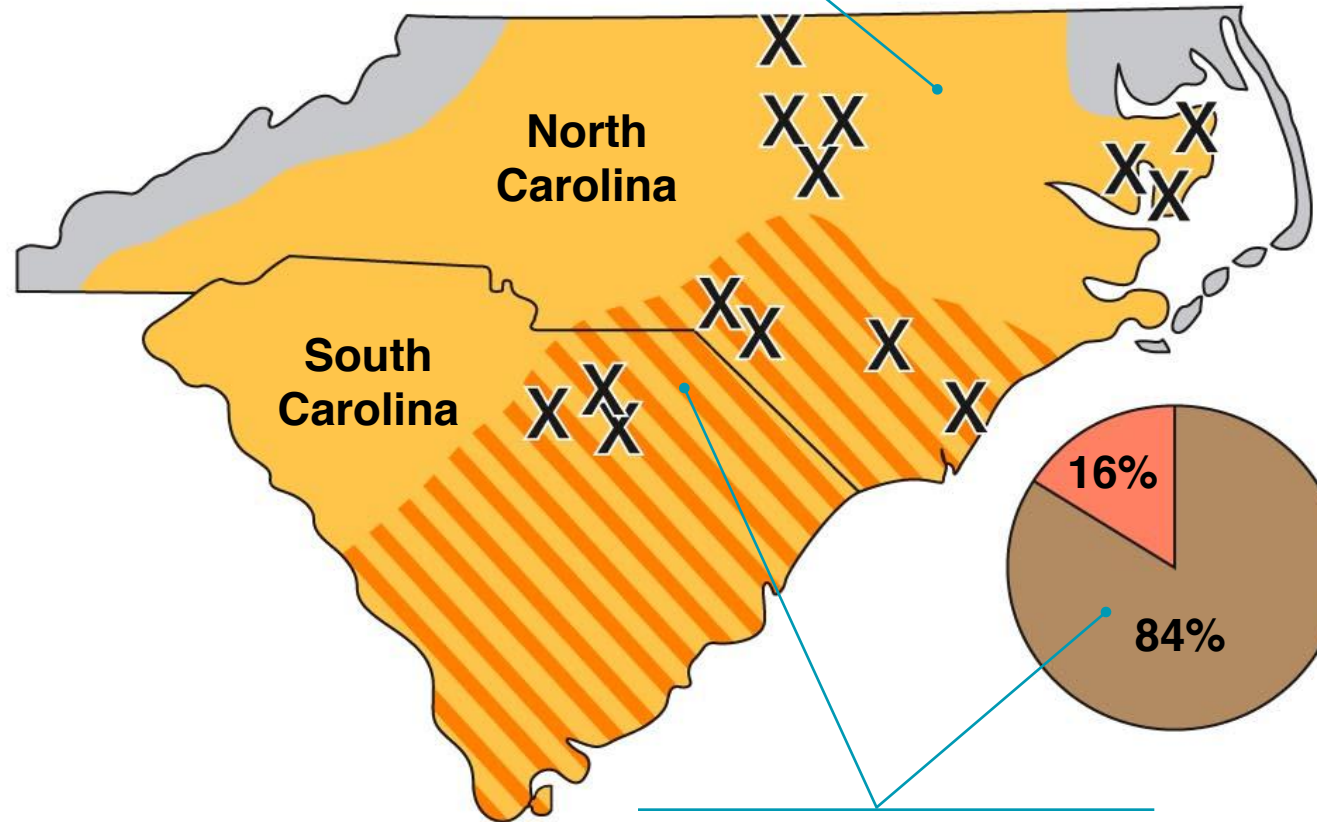
**(b) Artificial brown snake that has been attacked**

In areas where coral snakes were absent, most attacks were on artificial king snakes.

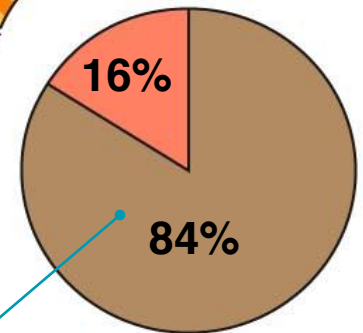


**Key**

-  % of attacks on artificial king snakes
-  % of attacks on brown artificial snakes
-  Field site with artificial snakes



In areas where coral snakes were present, most attacks were on brown artificial snakes.



# Peer Review

- All experimental data and conclusions must be published and reviewed to be considered valid.
  - Check for mistakes.
  - Check for bias.
  - The way that science is applied in society can be affected by **bias**, which is a particular preference or point of view that is personal, rather than scientific.
  - Experiments as well as how results are interpreted can be affected by bias.

# Theories in Science

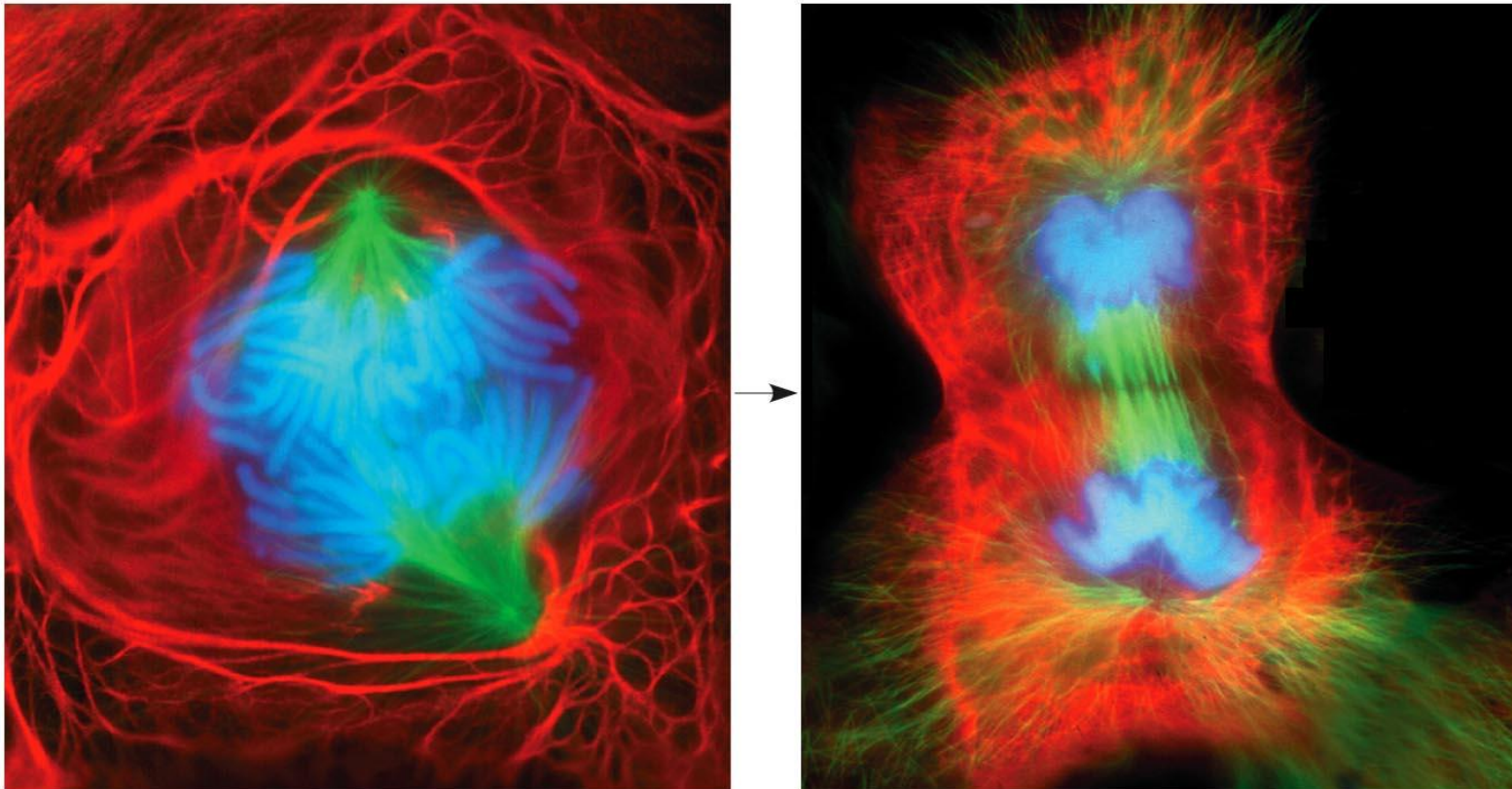
- Over time, multiple hypothesis and experiments that are connected may be summarized as a **scientific theory**.
- A scientific theory is:
  - Very broad (not specific)
  - Supported by a lot of data and evidence
- Examples:
  - Evolution
  - Ice Ages
  - Cells



# Major Fields of Biology

## Cell Biology

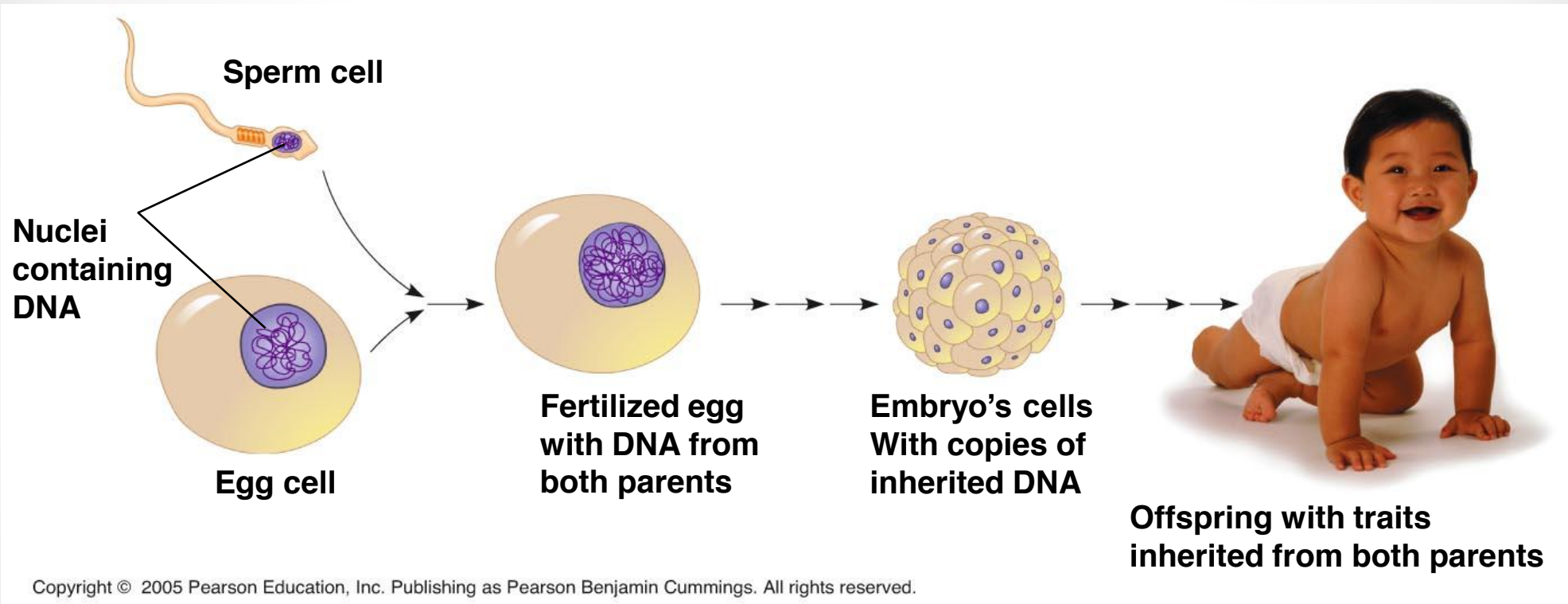
- The cell is the lowest level of organization that can perform *all* activities of life



# Major Fields of Biology

## **Heredity and Genetics**

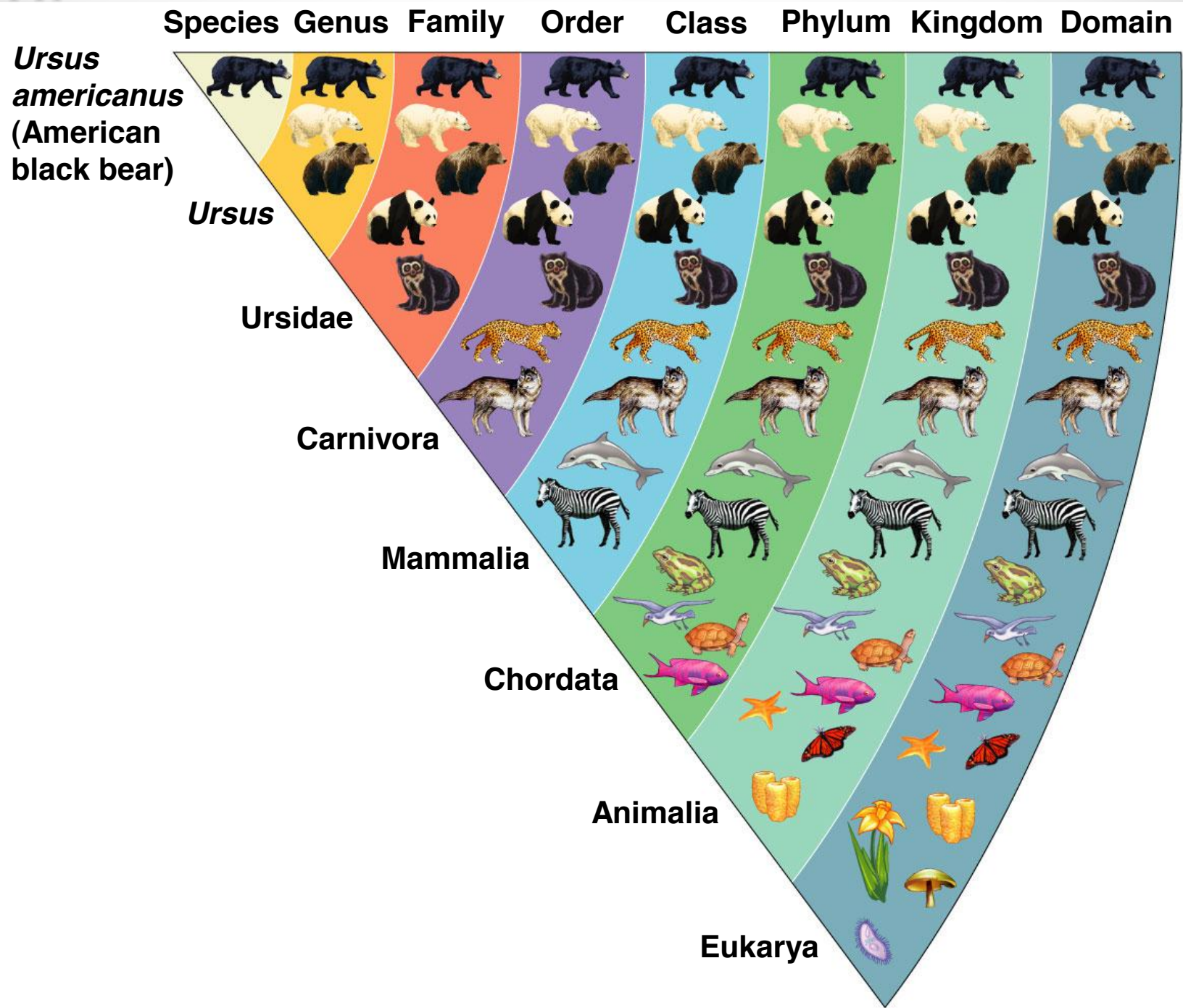
- Cells contain DNA, the heritable information that directs the cell's activities
- DNA is the substance of genes
- Genes are the units of inheritance that transmit information from parents to offspring



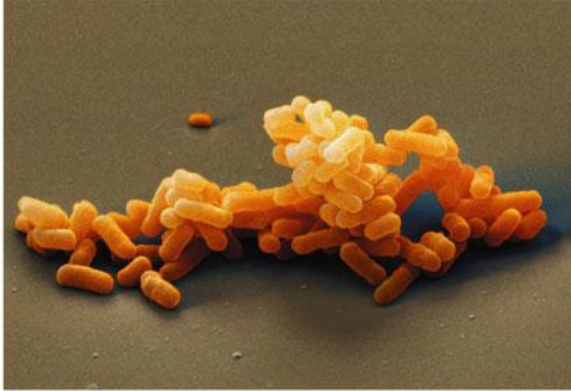
# Major Fields of Biology

## Taxonomy

- The branch of biology that names and classifies species into a hierarchical order
- Kingdoms and domains are the broadest units of classification

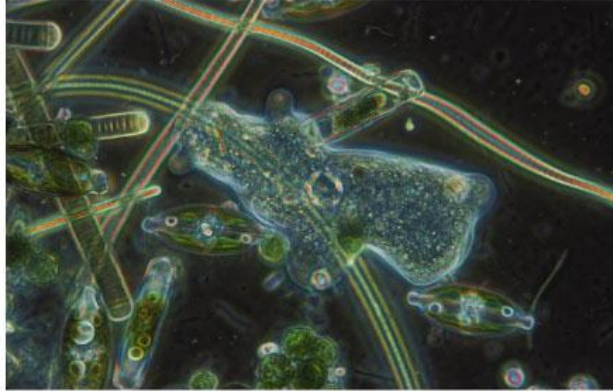






**Bacteria**

4  $\mu\text{m}$

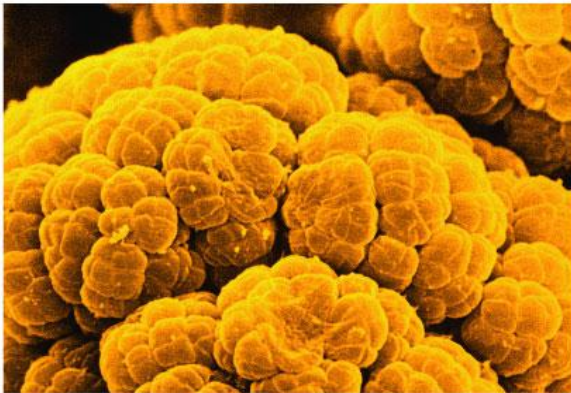


**Protists**

100  $\mu\text{m}$



**Kingdom Plantae**



**Archaea**

0.5  $\mu\text{m}$



**Kingdom Fungi**



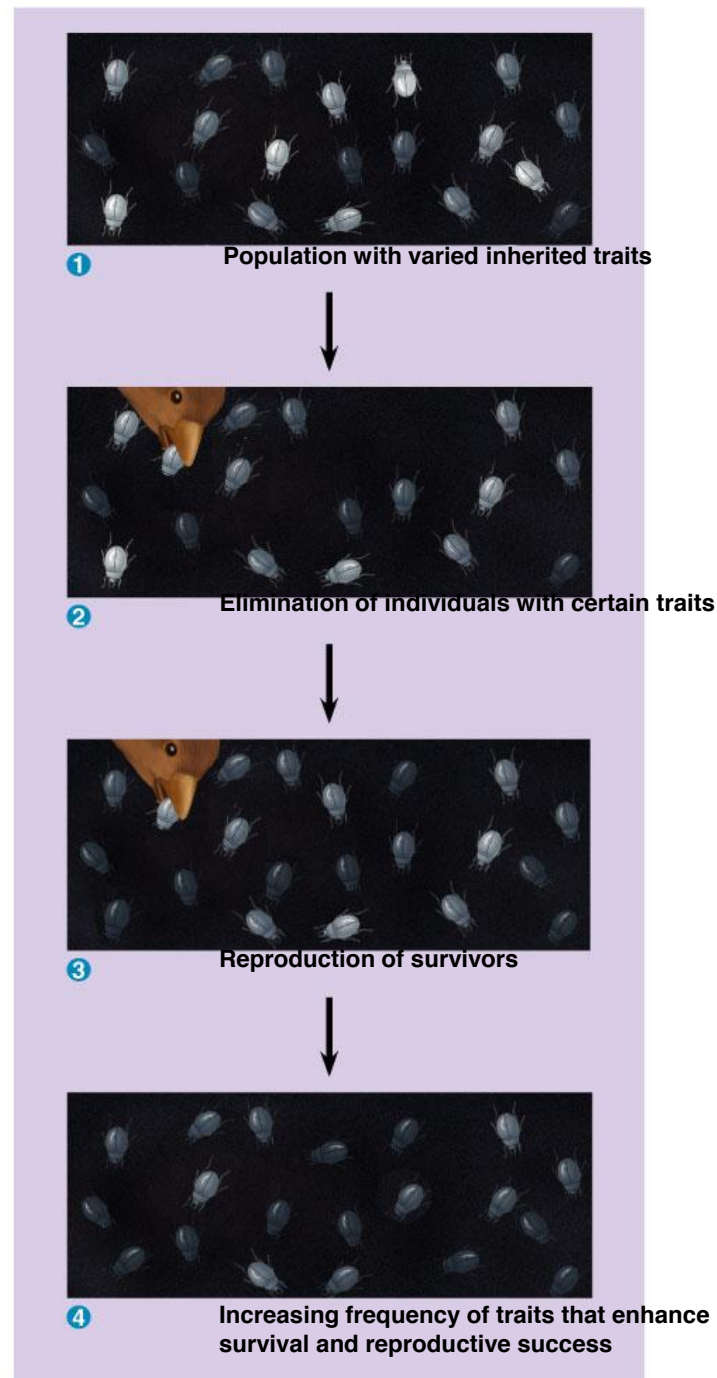
**Kingdom Animalia**

# Major Fields of Biology

## Evolution

- All species that exist today came from the same common ancestors.
- The species with the best adaptations survive the best.

- An example of natural selection is the effect of birds preying on a population of differently colored beetles.



# Major Fields of Biology

## Zoology

- The study of different species of animals, their behavior, habitat, and how they are adapted to their environment.

## Botany

- The study of different species of plants, how they reproduce and grow, and what habitats they are found in.

