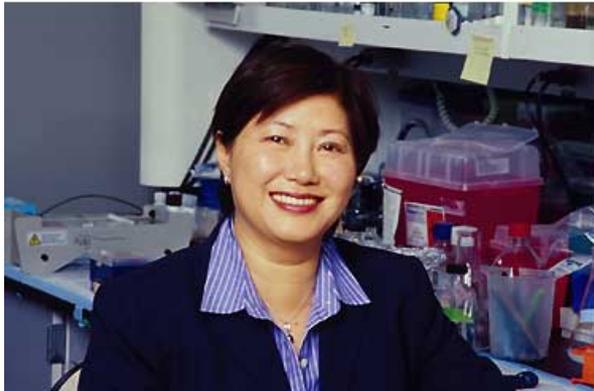


What is Science?



What is Science?



Science is a process of questioning.

Science as Inquiry



- **Biology = the Study of Life**

(From the Greek *bios=life* and *logos=the study of*)

- **At the heart of science is INQUIRY**



- ◆ Inquiry is a process of investigation, with thoughtful questions leading to a search for answers.



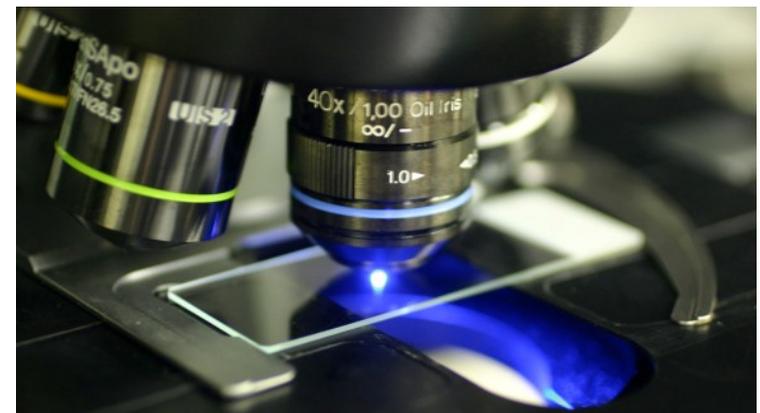
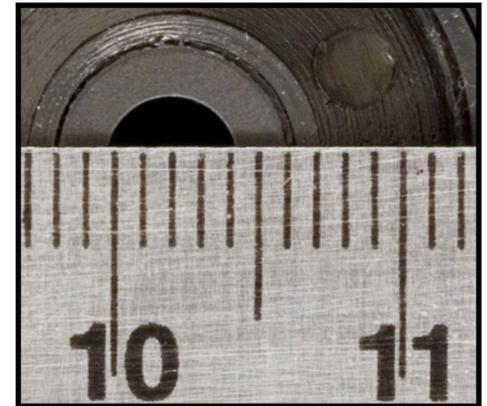
Observations & Data

- **Observations** = The use of the senses to gather and record information about structures or processes.

- **Data** = Recorded Observations

- **Scientific instruments**

vastly **increase** the range of possible **observations**



Observations & Data

- **Quantitative Data** = Observations recorded as measurements.
 - ◆ In science, such measurements are often recorded using the Metric System.
 - **Numerical:** Depicts measurements like counts, frequencies, rates, percentages etc
 - **All numerical measurements must always be reported alongside the proper units!**
- **Qualitative Data** = Data in the form of descriptions instead of measurements.
 - ◆ **Descriptive:** Describes characteristics like texture, color, hue, behaviors etc.
- **All data most useful when:**
 - ◆ Clearly organized,
 - ◆ consistently recorded,
 - ◆ and reliable.

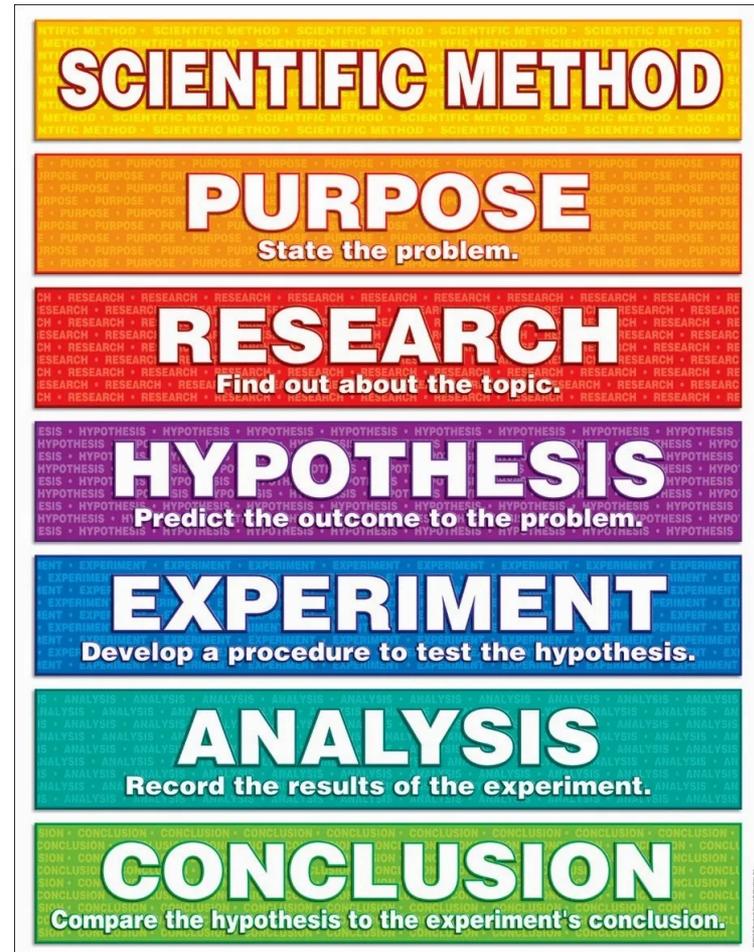


Science involves questioning in order to **describe** or **explain**.

- **Scientific Method**: A process of critical thinking that uses observations and experiments to investigate testable predictions about the physical universe.

- **Two type main types of scientific inquiry:**

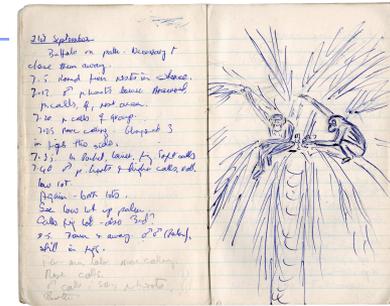
1. **Discovery Science**
(Descriptive Science)
2. **Hypothesis-Based Science**
(Experimental Research)



DISCOVERY SCIENCE / OBSERVATIONAL RESEARCH

Discovery Science

- ◆ Accurately describes natural structures & processes.
- ◆ Based on recorded observations
- ◆ Data collected is analyzed
 - In these studies, Investigators observe subjects and measure variables of interest without assigning treatments to the subjects.
 - The researcher does NOT manipulate any variable in order to observe its effect on other variables
 - ◆ No experiment is conducted
 - Ex: Jane Goodall's studies on Chimpanzees



Discovery Science

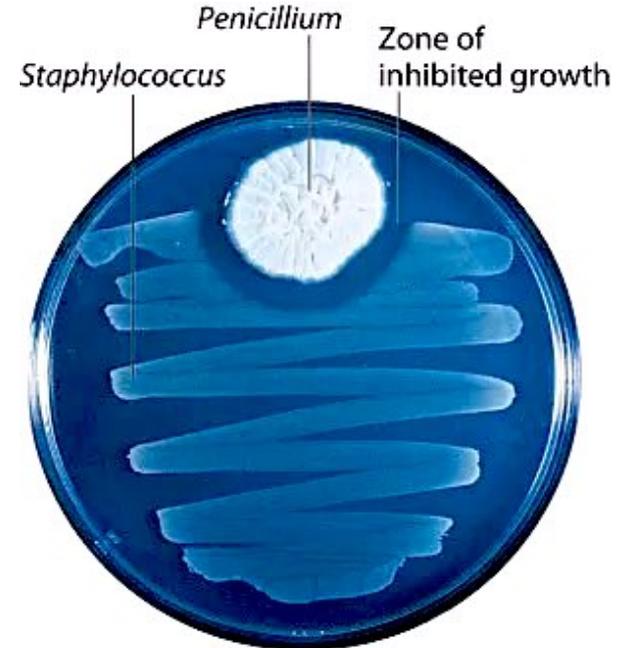
- Sometimes discoveries happen by accident.

- ◆ In 1928, Alexander Flemings discovered that mold had accidentally contaminated his culture of bacteria (*S. Aureus*)

- ◆ No bacteria were growing around the mold.

- ◆ Fleming concluded that the mould was secreting a substance that was killing the bacteria.

- ◆ Without meaning too, Fleming discovered this antibacterial substance that was being produced by the fungus to kill the bacteria, later named penicillin.



- ◆ **Penicillin - the first antibiotic discovered - revolutionized medicine.**

Inferences in Science

Inference = A logical conclusion based on observations

- Inferences must **not** stretch too far beyond the data.
- Scientific inferences must be based on **logical principles of reasoning**.
- Inferences derived must **match with observed evidence**.
 - Often, a person makes an inference by relating observations to their prior knowledge.
 - For instance, you infer someone is at the door when you hear the doorbell ring because you know the same thing has happened before.
 - For instance, Fleming inferred that the fungus might be secreting a substance that was deadly to the bacteria in his petri dish
 - Inferences help convert general questions into more specific questions that can be explored in depth.
 - Flemings observations of bacteria dying near the fungus in the petri dish lead to him asking "What substance produced by this particular mold kills bacteria?"

Observations vs. Inferences in Science

OBSERVATION VS INFERENCE

OBSERVATION

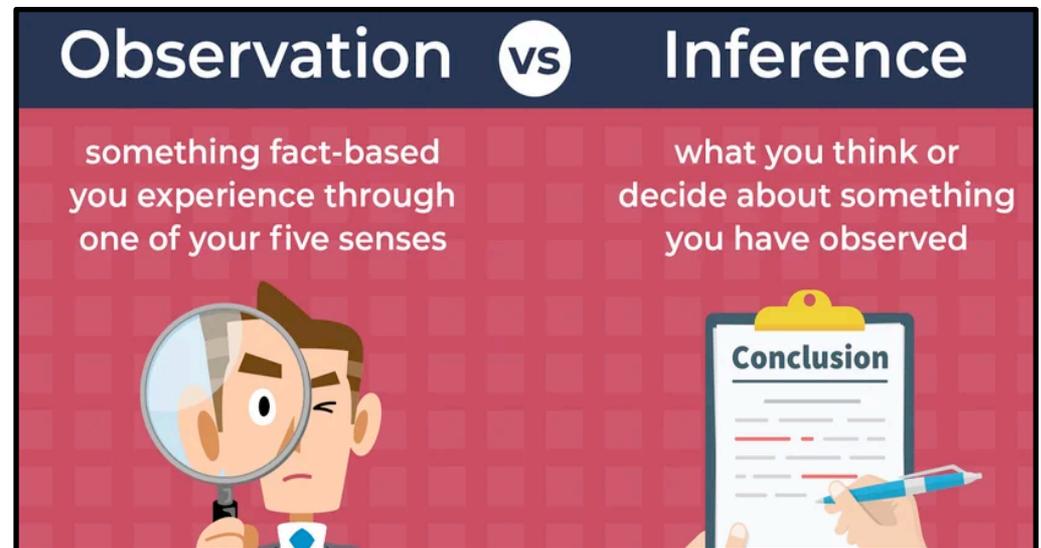
Observation refers to an act of taking note of a phenomenon that is occurring around you. This can be done by simply using your senses (touch, sight, hearing, etc.) or even complex scientific instruments. Valuable data is obtained from this approach, providing a foundation for any scientific inquiry.

INFERENCE

Inference occurs after observation, where the observed data is utilized to form a logical conclusion. Whereas observation requires data gathering, inference requires reasoning, critique, and analysis skills to interpret and explain observations that have been made. Valid inference relies on higher-order cognitive skills.

Inferences in Science

- It is important not to confuse inferences with the observations on which they are based.
 - Hearing the doorbell ring is an observation.
 - Inferring that someone is at the door, though reasonable, has less certainty.
 - **Maybe an electrical short circuit is causing the bell to ring**
- Scientists are skeptical of inferences that "stretch" far beyond the data.
 - **For Ex: Inferring solely from Fleming's observation that some molds can produce antibiotics capable of curing bacterial diseases in humans.**
 - It took much more research before this conclusion was accepted by science.



Inferences in Science

- Examine the picnic table below.
 - What can you infer from the place settings and other objects you observe on the table?
 - Can you infer anything from what is present or absent?
 - Can you make reasonable inferences about the weather and time of day when this photograph was taken?

Observation: Two meals are sitting on a table. The table and food is outdoors. It's daylight.

Inference: Two people are having lunch together.

Inferences have less certainty than observations.

- ➔ It could be that 4 people are sharing the food in two plates.
- ➔ It would a stretch to infer that the people got kidnapped before they could eat lunch.



Generalizations in Discovery Science

Generalization = A general conclusion reached by scientists after they putting together the data from many specific observations.

In the 1800's, scientists noticed in both plants and animals tiny units called cells.

But it was the accumulation of many observations that gave them the confidence to make the generalization that...

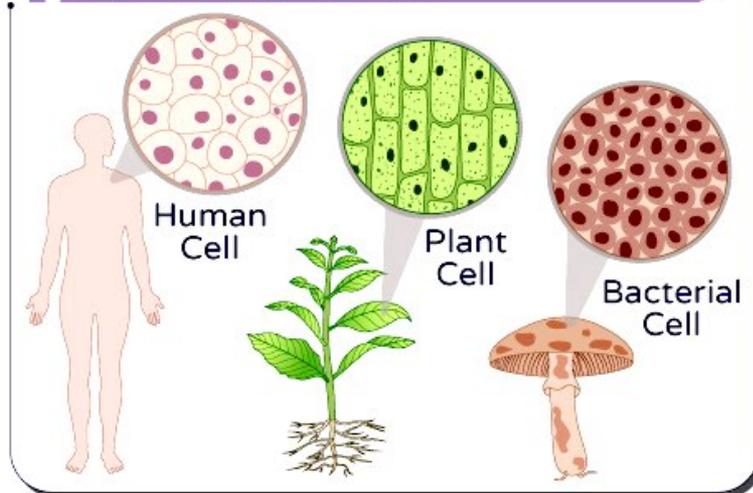
“all living things are made of of cell”



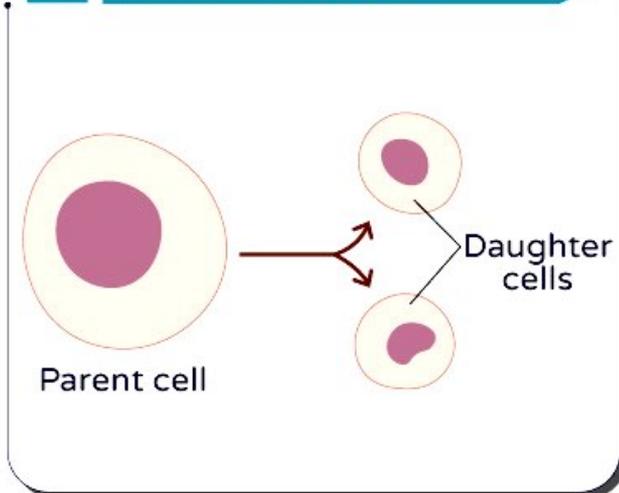
This generalization became part of what is known as the **Cell Theory**, one of the most important products of discovery science in the nineteenth century.

Modern Cell Theory

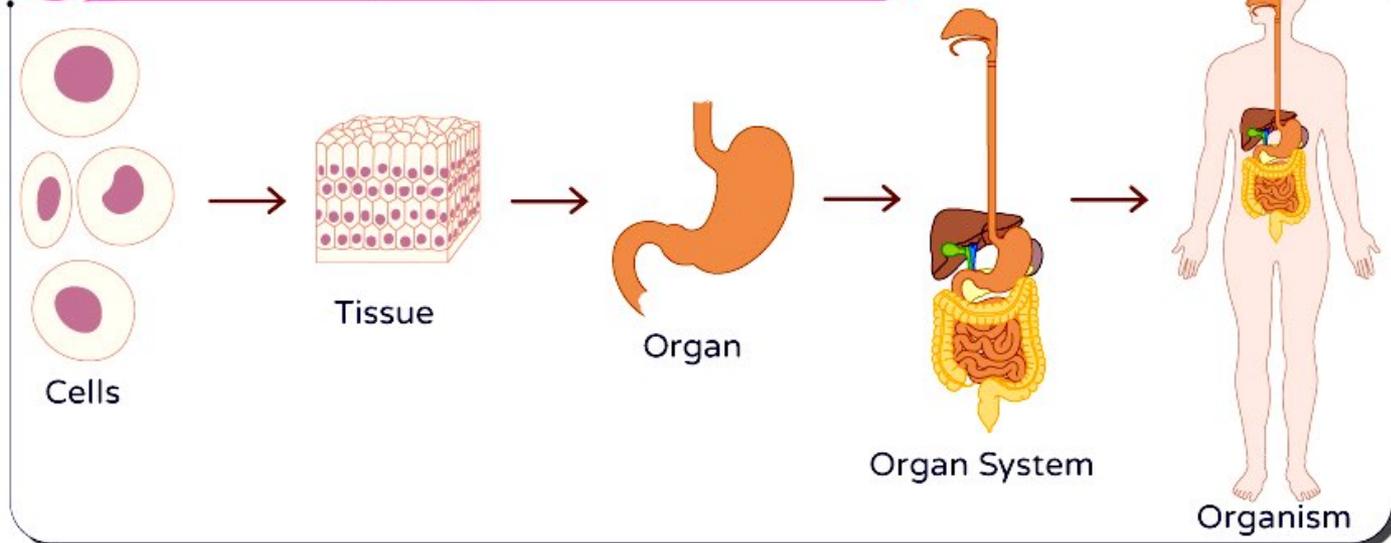
1 All organisms are composed of one or more cells



2 All cells arise from pre-existing cells



3 The cell is the structural and functional unit of all living things



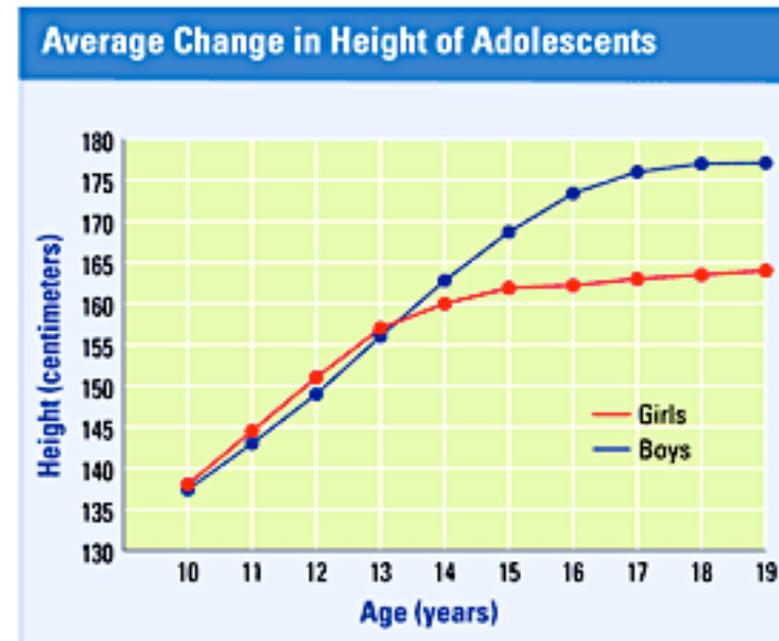
Generalizations in Discovery Science

Though the cell theory derives from a generalization made from qualitative data (the cell-based organization of tissues), **generalizations can be made from quantitative data as well.**

- **This usually requires combining measurements from a very large sample or multiple samples**
 - ➔ **To look for general patterns in measurements, it often helps to put the data in a graph.**

Ex: This graph compares the changes in heights of teenage boys and girls over time. Each point on the graph is an average measurement for many thousand boys or girls. The graph makes it easier to spot the reason for the **generalization that girls, on average, stop growing at a younger age than boys.**

Of course, there are individual exceptions. But the generalization still holds across this very large sample of teens.



Generalizations & Inferences in Science

- Observations, data collection and analysis, inferences, and generalizations all advance our understanding of the natural world.
 - These processes of Discovery Science are often just the beginning of a scientific inquiry.
 - For ex: Trees do not grow above a certain altitude in several mountain ranges. Observations of this “tree line” phenomenon in many mountain ranges in Western North America may lead you to a generalization: **At a particular latitude, trees don't generally grow above a certain altitude.** Next, you might infer that **environmental conditions at high altitude are unfavorable to tree growth.**
 - But which environmental factors influence tree growth most? Low temperatures? "Thin" atmosphere? Strong winds? Lack of soil? A combination of factors?
 - The answer would provides us with an EXPLANATION



Generalizations & Inferences in Science

- Discovering something interesting inspires curious minds to seek an **explanation**.
 - It is one thing to describe and measure the growth of a plant toward light (discovery science).
 - But what **causes** this phenomenon?
 - How can scientists explain the plant's ability to detect and respond to the direction of light?
 - Questions related to causes of phenomenon are at the center of **hypothesis-based science** (*experimental science*)
 - Through experimental science, different **explanations** for **cause and effect relationships** between variables are tested.

