

Definition of Science:

Science: intellectual activity surrounding the study of structure and behaviour of the world through **observation and experiment**.

Biology: The study/science of how life works

Scientific Inquiry: Ways which scientists study the natural world and explain concepts based on **evidence**

Two approaches:

- Description-based → sensory based
 - Need to see and describe how nature works
 - Ex. You cannot protect what you don't know, therefore description is very important
- Hypothesis-based → non-sensory based
 - Need a framework to explain concepts

The Scientific Method:

There are two parts of the scientific method:

- Inductive reasoning (linked to a descriptive-based approach)
 - ◆ Making general observation based on lots of specific observations
 - ◆ **Particular** → **general (or a statement)**
 - ◆ Describe something, then might be tempted to make a generalization
 - ◆ Ex. You see that there was a clear blue sky in the morning → can predict that it's going to be a nice day
 - From data, you make a generalization
 - Ex. You see 400 students entering a classroom → predicts that there's going to be a class
 - ◆ Ex. **Observing an orange (trying an orange):** The orange is sweet
General statement of oranges: All oranges are sweet
 - ◆ PROBLEM: induction may provide you with wrong information
 - Ex. maybe there isn't a lecture → could be a movie instead
- Deductive reasoning
 - ◆ Stating a hypothesis and drawing conclusions (after experimentation or observation) from this hypothesis
 - ◆ Really evidence based
 - ◆ **General** → **particular**
 - ◆ Ex. Someone guesses that people have a lecture in that classroom → becomes a hypothesis → comes to class to see if there's a prof, course number, to see if he's right
 - He made a guess and experimented to see if he was right
 - ◆ Requires more work

- ◆ Provides us with evidence to make us closer to the truth

The Scientific Process:

- ★ All scientific inquiry starts with one or multiple observation
 - Ex. The case of the dead fish of Gatineau
 - Fish were seen dead in the river
 - Could be from a toxic spill, anoxia, etc.
- ★ Scientific hypotheses *must be verifiable, refutable and reproducible*
 - Ex. Observation: flashlight doesn't light
 - Question: Why doesn't the flashlight work?
 - Hypothesis 1: Dead batteries
 - Hypothesis 2: Burnt-out light bulb
- ★ From a hypothesis, you can **make a prediction (a way to test the hypothesis)**
 - They must be testable and give a clear result
 - If... then... statements
 - Tool used to attempt on proving your hypothesis
 - Ex. Predictions
 - Prediction 1: replacing batteries might fix the problem
 - Prediction 2: replacing bulb will fix the problem
- ★ Hypothesis can be falsified or not
 - Tests and Results
 - Test of prediction 1: Replace batteries
 - Test of prediction 2: Replace bulb
 - Result 1: Flashlight doesn't work → falsified hypothesis
 - Result 2: Flashlight works → does not falsify hypothesis
- ★ We can never prove that a hypothesis is the scientific truth → things might change
 - If a hypothesis has survived multiple attempts of falsification attempts, then it becomes a **THEORY**
- ★ Ex. After the whole process of the scientific process of the fish issue:
 - Cause of death: gas bubble disease caused by the outflow of a hydro-electric dam on the river
 - Supersaturation of N and O

Back to the Fish Situation:

- There was a toxic spill
- Possible explanation
 - Lack of oxygen didn't make sense
 - They say bubbles in air in the fish
 - Diagnosis on what they observed → gas bubble disease → super saturation of gas
 - Hypothesis that has been suggested
 - Therefore, the hypothesis after a lot of testing → prediction was made with the outflow of gas

- Not 100% sure, but it was highly probable that the gas bubble disease was the reason why the fish all died

Another Example of the Scientific Process

Observation: This orange I tasted was sweet

Hypothesis: All oranges are sweet

Prediction: If I tasted all kinds of oranges, then they will always be sweet

Tests: I taste all kinds of oranges

Result: Goes to Madagascar and tasted a very sour orange, therefore NOT ALL ORANGES ARE SWEET (hypothesis is falsified)

When your hypothesis is falsified, it gives you the opportunity to build and new one

Scientific Process → Contract Between Science and Knowledge

- Skepticism (doubtfulness)
 - We ask honest questions on facts and hypothesis (tangible/real things) and we always re-test what has been found
 - There's no truth in science
 - Never stop testing ideas
 - Honest questions that can be answered in real things to provide a logical answer
- Realism
 - Cannot have preconceived ideas of the result you will obtain
 - Put aside all ideologies and concepts before attacking a scientific problem
 - Need to be entirely objective (not influenced by personal feelings or opinions in considering and representing facts).
 - Need to be evidenced based (ex. No religious beliefs can get in the way)
 - Assess data from the real world
- Rationality
 - Steps to arrive to a conclusion
 - **Parsimony:** Life can be complicated, therefore you need to keep it simple (unless there's already evidence about the more complicated hypothesis)
 - Ex. You're faced in front of a fence and you hear galloping
 - Most parsimonious answer might be that there's a horse
 - Poorly parsimonious answer → there's a zebra → gets complicated because now you have to further analyze if there's a zoo
 - Crop Circle Enigma (also relates to parsimony)
 - Signal for flying saucers
 - E.T life → no evidence of it → not parsimonious
 - Assumptions of E.T life
 - Discovered that a human did it at night
 - Scientists prefer the most simple hypothesis

- Methodological materialism
 - All that is experimentally accessible in the real world is material or has a material origin
 - Cannot use E.T. materials
 - Cannot be outside the realm of science

Mimicry (Skepticism Example)

- Ex. Monarch butterfly
 - Always feeds on milkweed
 - They are toxic to many birds → birds leave them alone because they're toxic → they cannot digest them
- Viceroy
 - Pattern of wings is very similar to the monarch → scientists believe that this was an example of Batesian mimicry
 - Batesian Mimicry: Species that are non-toxic that evolve into the colour that is very similar to a toxic species → protection against predation
 - Through evolution, they believed that viceroys mimicked monarchs since they are toxic to birds
 - Someone wanted to test this out/redo the analysis → they were skeptical
 - They fed birds the bodies of viceroys without revealing their wings to the birds
 - It has been tested that they are toxic
 - Then they revealed that it was a different type of mimicry → **Mullerian Mimicry**
 - Mullerian Mimicry: Individuals that are toxic will evolve into the same colouration as another species to simply provide their potential predator to a stronger advertisement of their toxicity
 - **IN CONCLUSION, retesting the hypothesis allowed scientist to modify certain concepts**

Case Study

- Colouration where the same species of mouse can change colours based on their environment
 - Ex. of inductive reasoning → made a few observations and then a generalization
- Piscivorous fish are fish that eat other fish
 - Investigation on the fish communities in Ottawa
 - Lakes that didn't have small fish had piscivorous fish
 - WE DON'T NEED TO MEMORIZE THE DETAILS, NAMES, NUMBERS, ETC. → JUST THE CONCEPTS

In conclusion

In this chapter, we have established the definition of science and explain the scientific method/process with several examples.

important: a valid scientific process needs to respect the clauses of the contract between the acquisition of knowledge and science.

–Breaking one of the clauses invalidates the contract because the acquisition of knowledge is not associated with an objective search for the scientific truth (which we can never say we have obtained).