THE SCIENTIFIC METHOD

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LEARNING OBJECTIVES

After this lesson, students should be able to:

- Define the scientific method.
- Explain the importance of the scientific method.
- Describe each step of the scientific method.

LEARNING OBJECTIVES

After this lesson, students should be able to:

- Differentiate scientific law from scientific theory.
- Explain the role of observation, experimentation, and evidence.
- Apply the scientific method to real-life situations.

WE ALL USE A SCIENTIFIC PROCESS

Every day we make decisions such as:

What should I wear?

What should I eat?

Why won't my phone charge?

Why did my plant wilt?

Which route is the fastest to school?

These situations require:

- Observation
- Thinking
- Testing possible solutions
- Making conclusions

THE SCIENTIFIC METHOD

The Scientific Method is the application of a logical process of reasoning to arrive at a certain law or principle that is consistent with experimental results.

THE SCIENTIFIC METHOD

It relies on

Observation

Experimentation

Critical thinking

Data analysis

Evidence

WHY IS THE SCIENTIFIC METHOD IMPORTANT?

It helps scientists

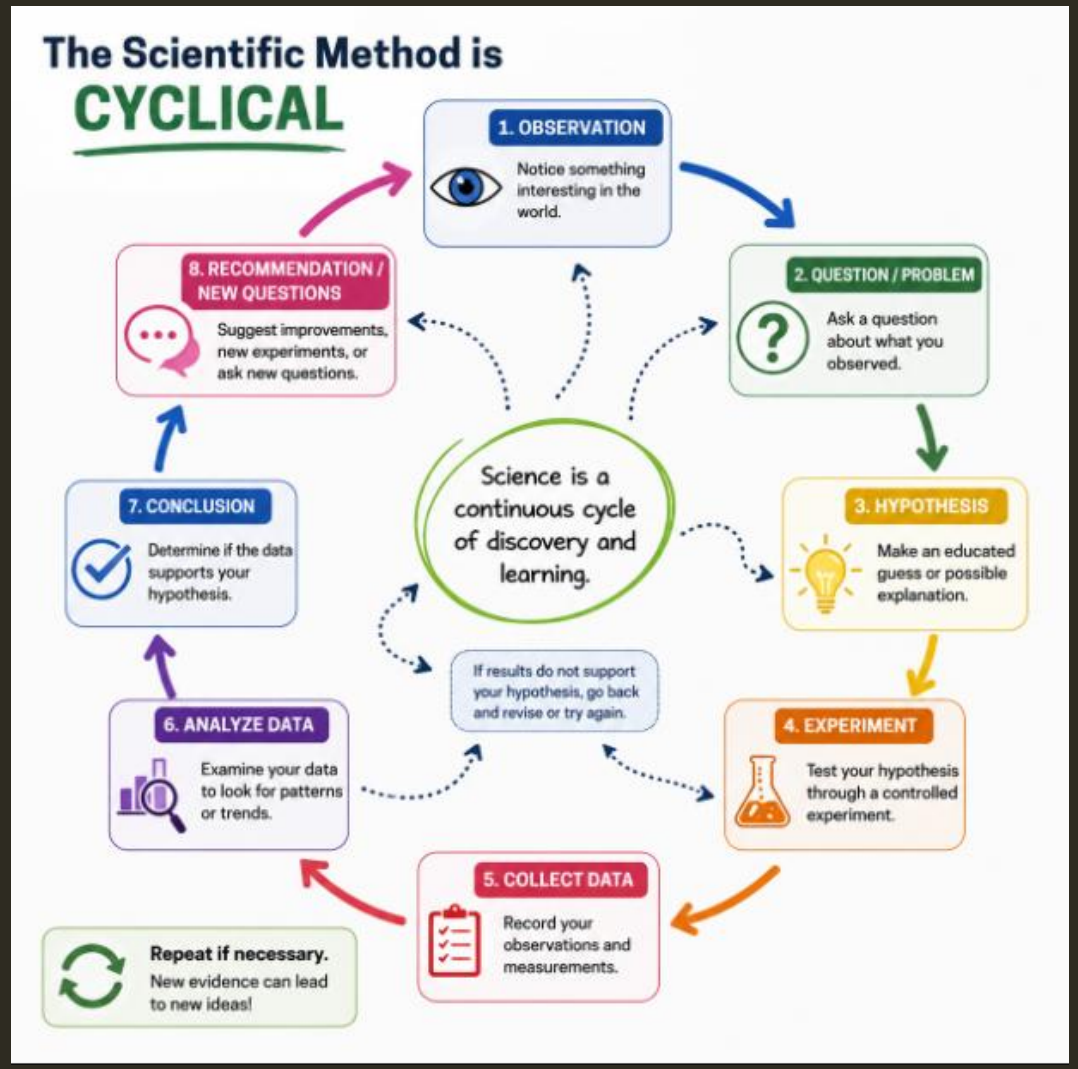
- Discover new knowledge
- Solve problems objectively
- Reduce bias
- Produce reliable results
- Develop medicines
- Improve technology
- Understand natural phenomena

CHARACTERISTICS OF THE SCIENTIFIC METHOD

A good scientific investigation is:

- Logical
- Objective
- Systematic
- Evidence-based
- Repeatable
- Testable
- Open to revision

THE SCIENTIFIC METHOD CYCLE



Step 1: Observation

Observations may be

- **Qualitative**

Descriptive

Example:
"The solution became blue."

- **Quantitative**

Numerical

Example:
"The temperature increased from 25°C to 45°C."

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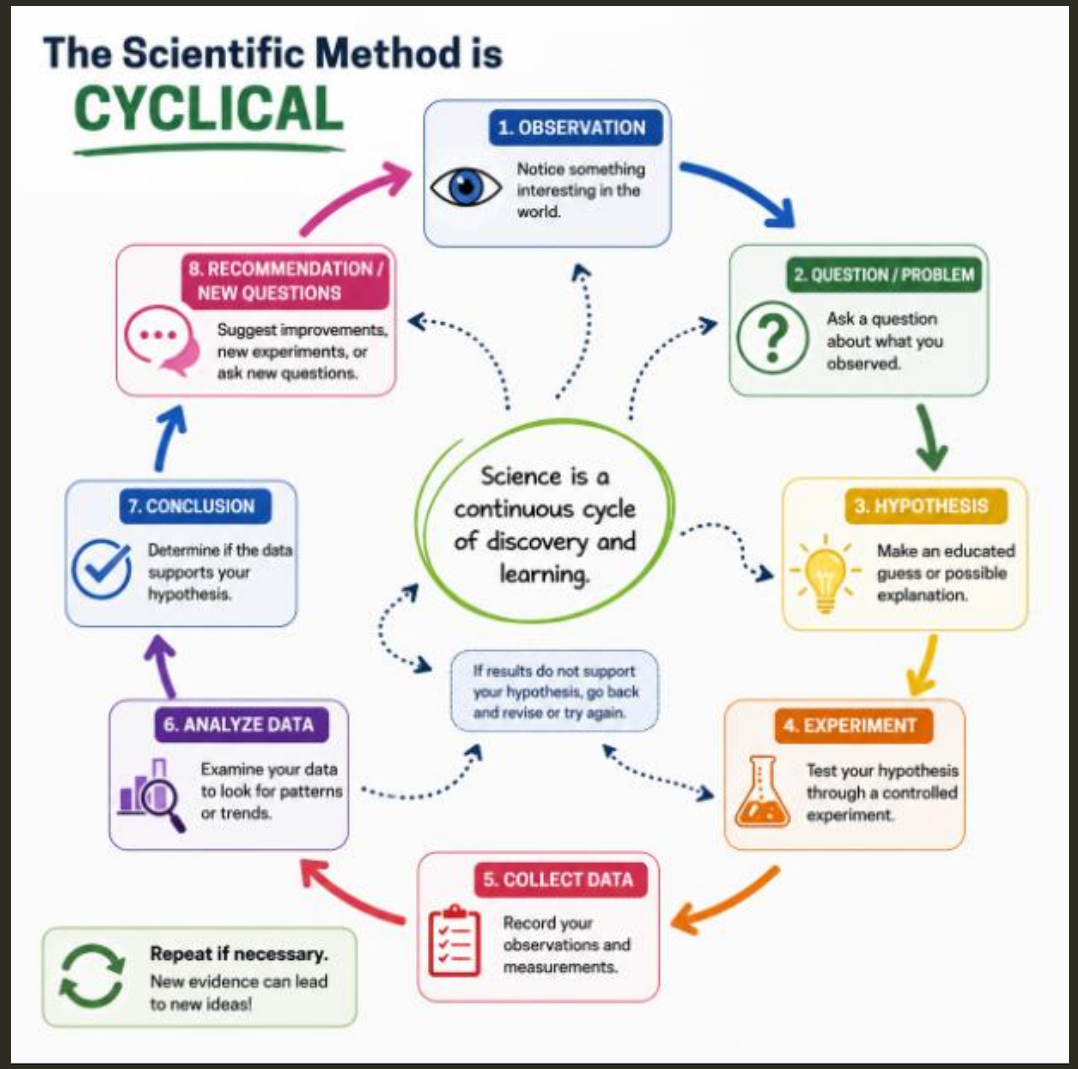

Step 1: Observation

Observation involves using

- Sight
- Hearing
- Touch
- Smell
- Instruments

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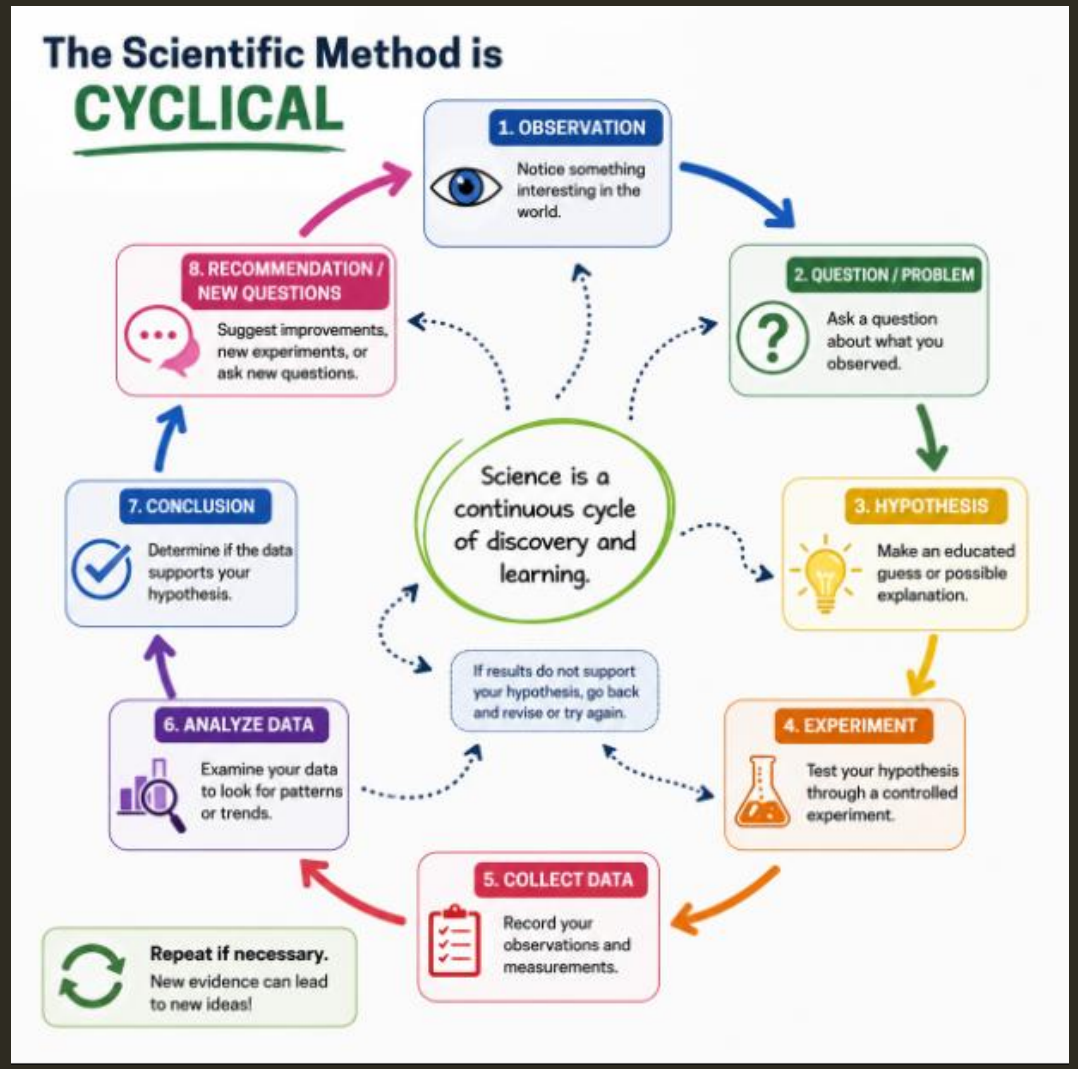

Step 2: State the Problem

Everything begins with a question.

Examples:

Why do apples turn brown?

Which fertilizer promotes plant growth?

Does temperature affect the rate of reaction?

Which soap removes bacteria most effectively?

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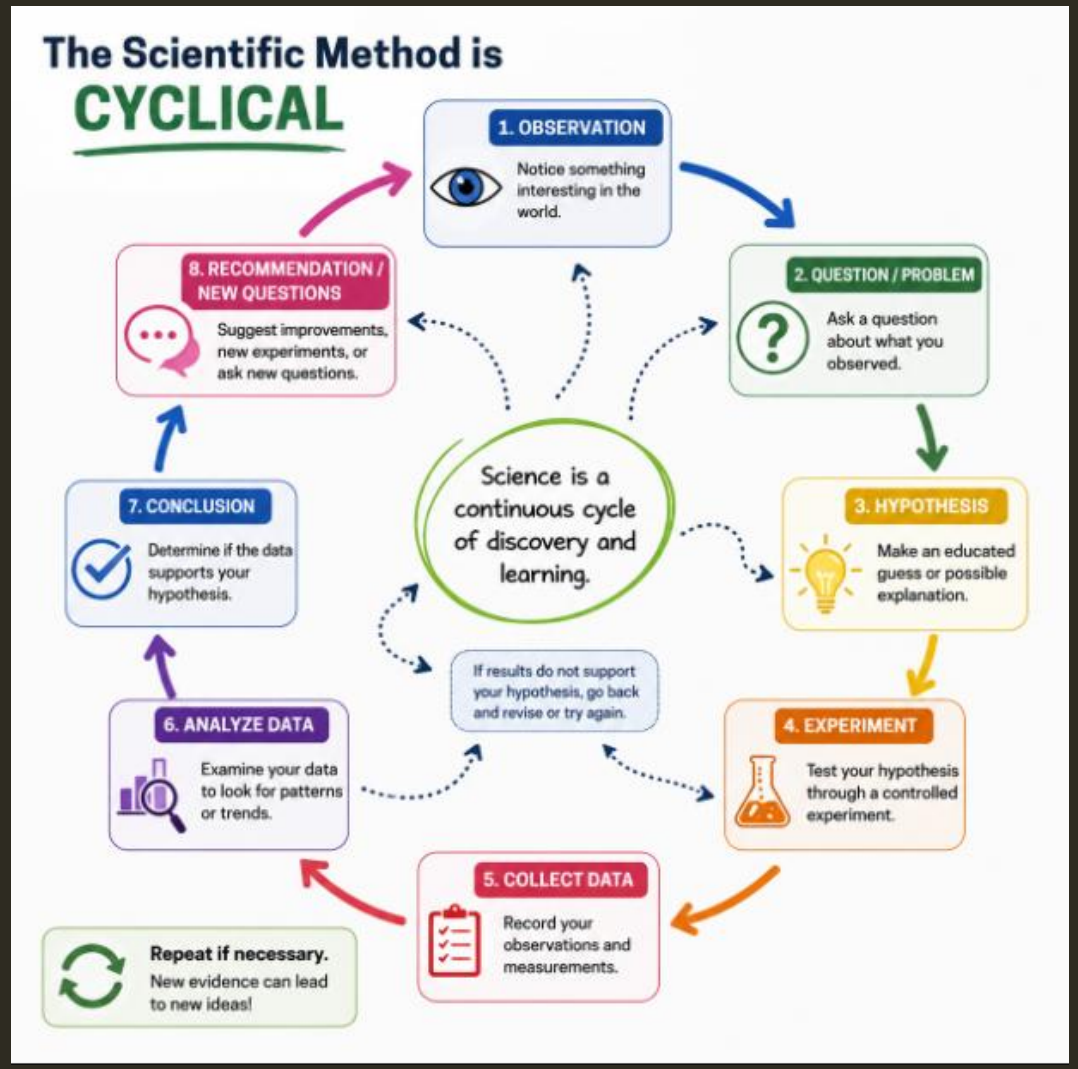

Step 2: State the Problem

A good scientific question should be

- Clear
- Specific
- Testable

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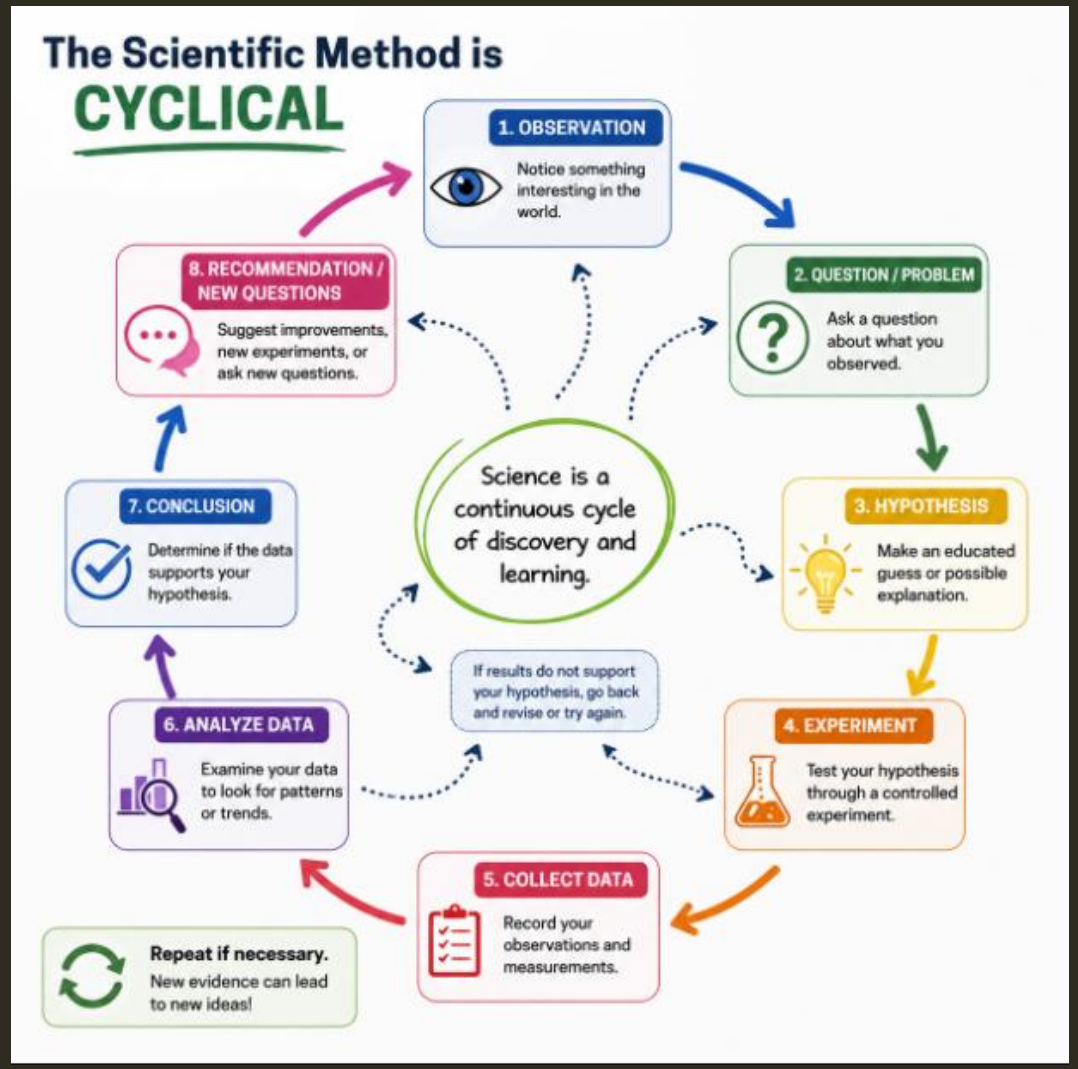

Step 3: Formulate a Hypothesis

A **hypothesis** is

A tentative explanation or prediction that can be tested.

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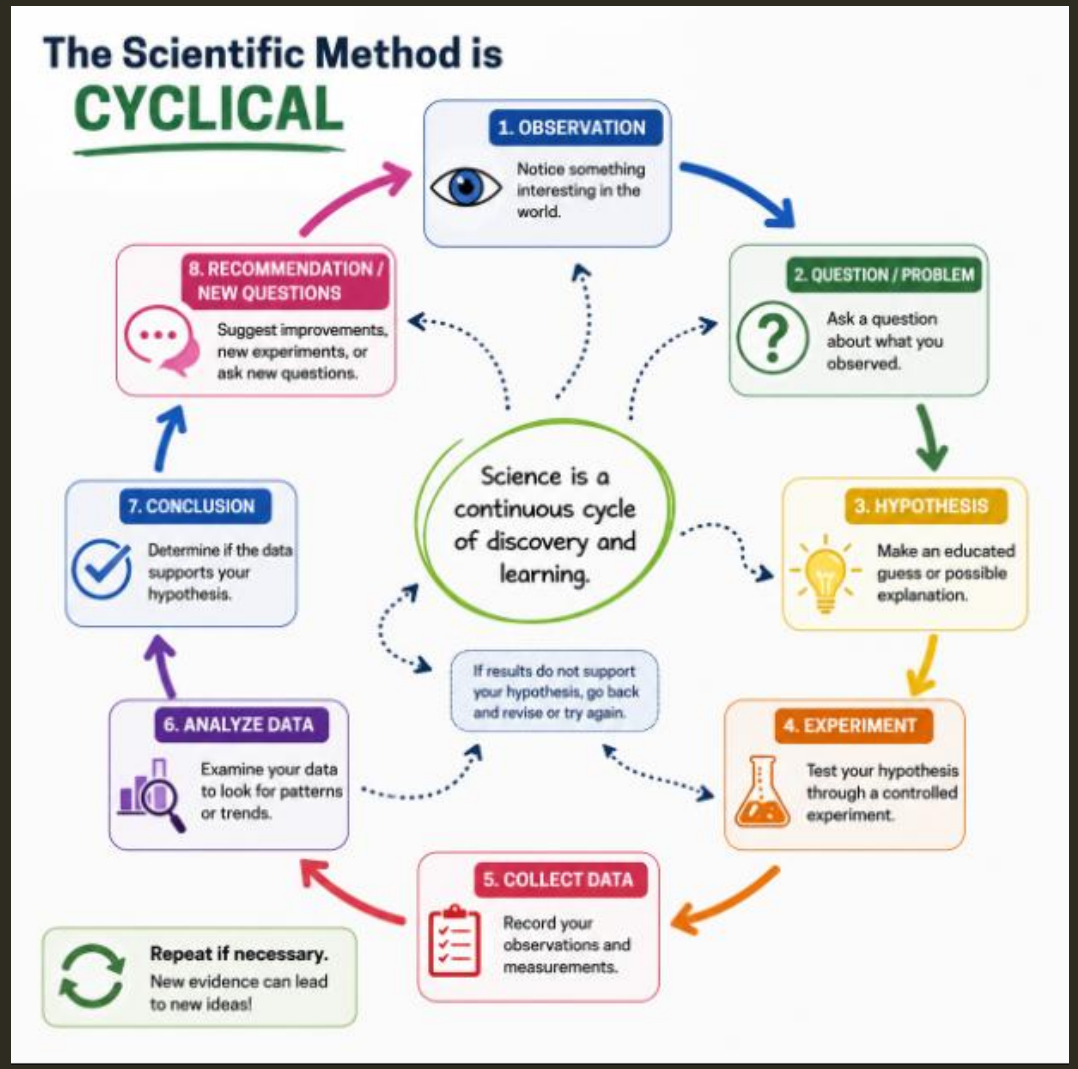

Step 3: Formulate a Hypothesis

Good hypotheses are

- Testable
- Logical
- Based on observations
- Falsifiable

Example

"If fertilizer contains nitrogen, then plants will grow taller."

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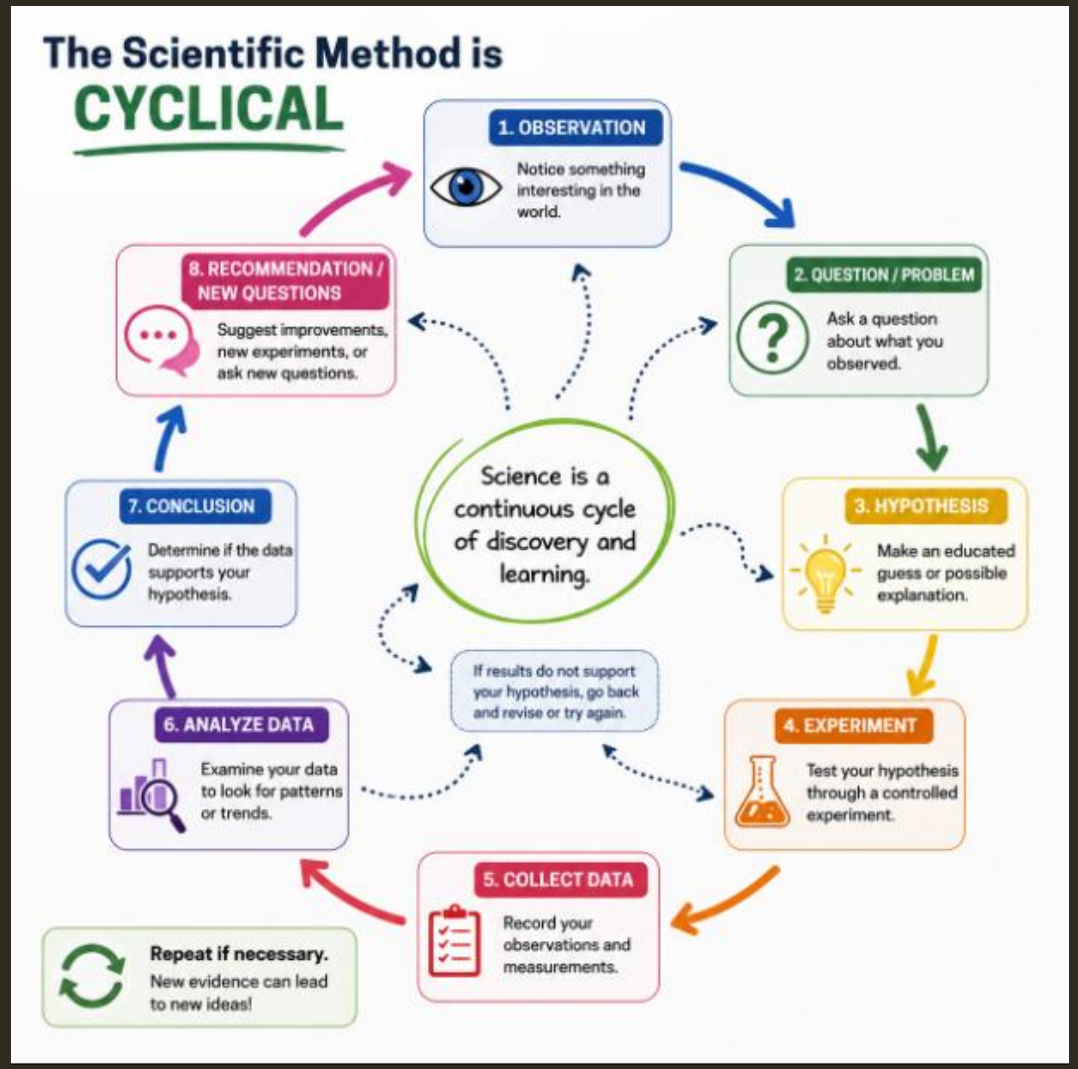

Variables in an Experiment

- **Independent Variable**

The factor changed by the researcher.

- **Dependent Variable**

The factor measured.

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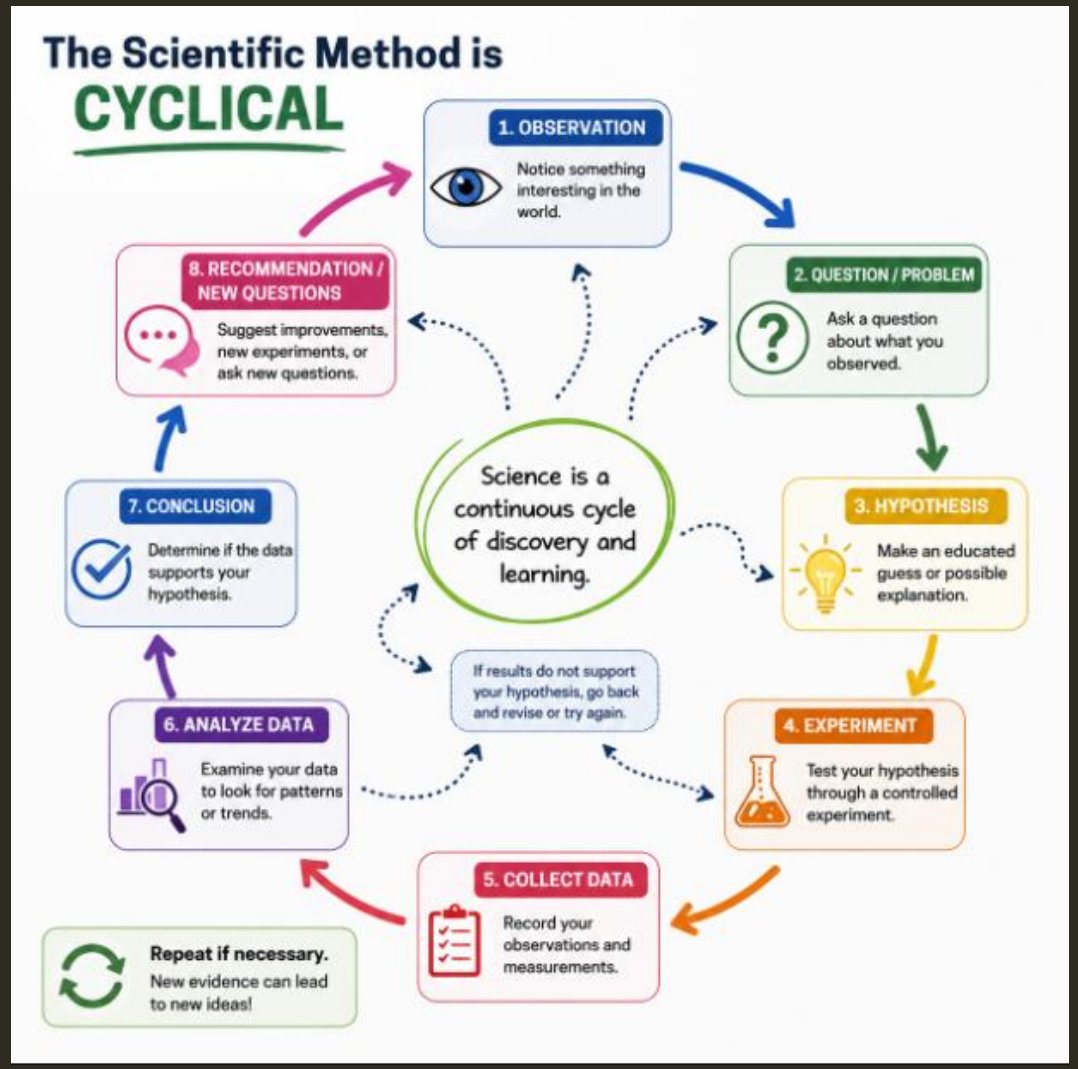

Variables in an Experiment

- **Controlled Variables**

Factors kept constant.

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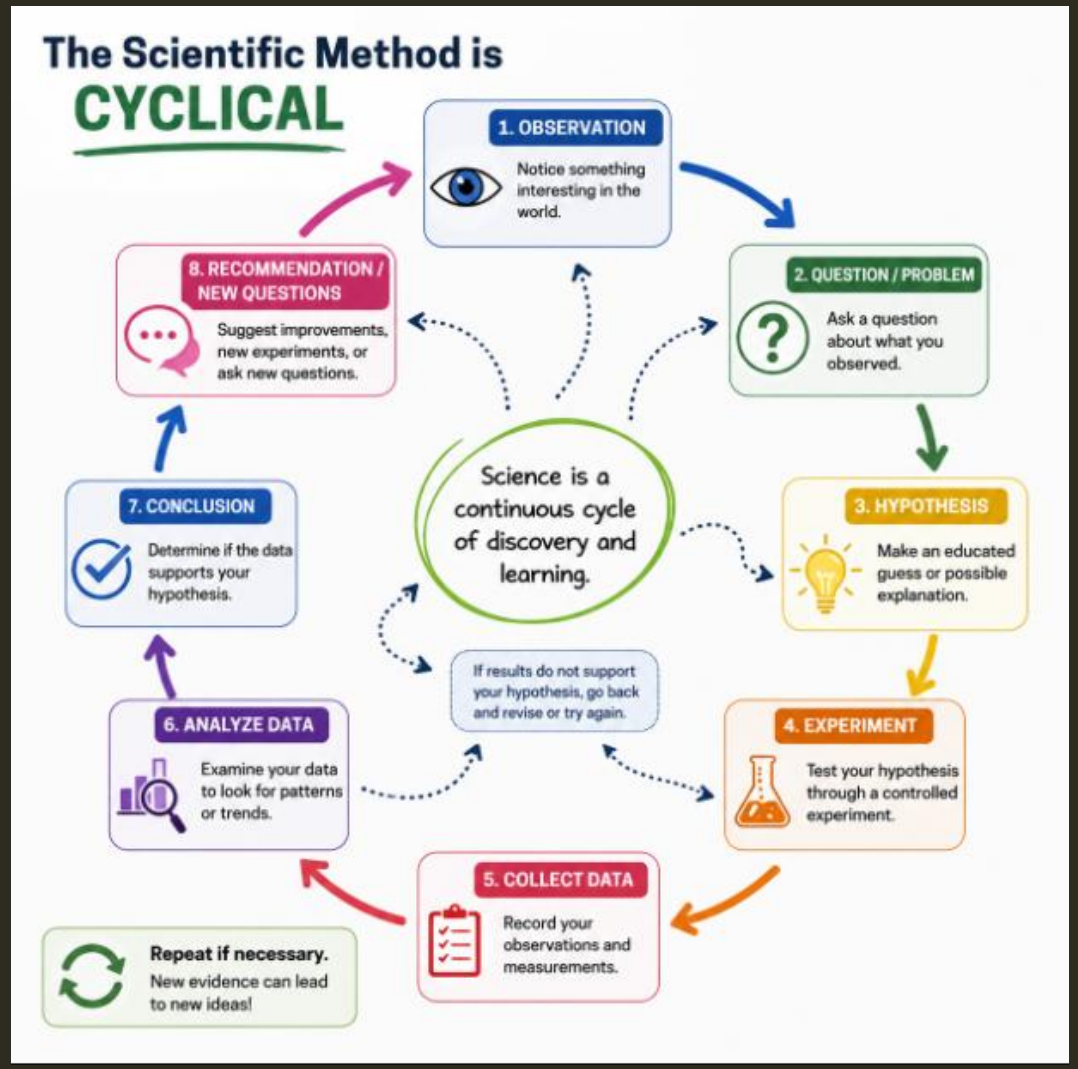

Example

- Plant Experiment
- Independent:
  Amount of fertilizer
- Dependent:
  Plant height
- Controlled:
  Water, sunlight, soil, plant species

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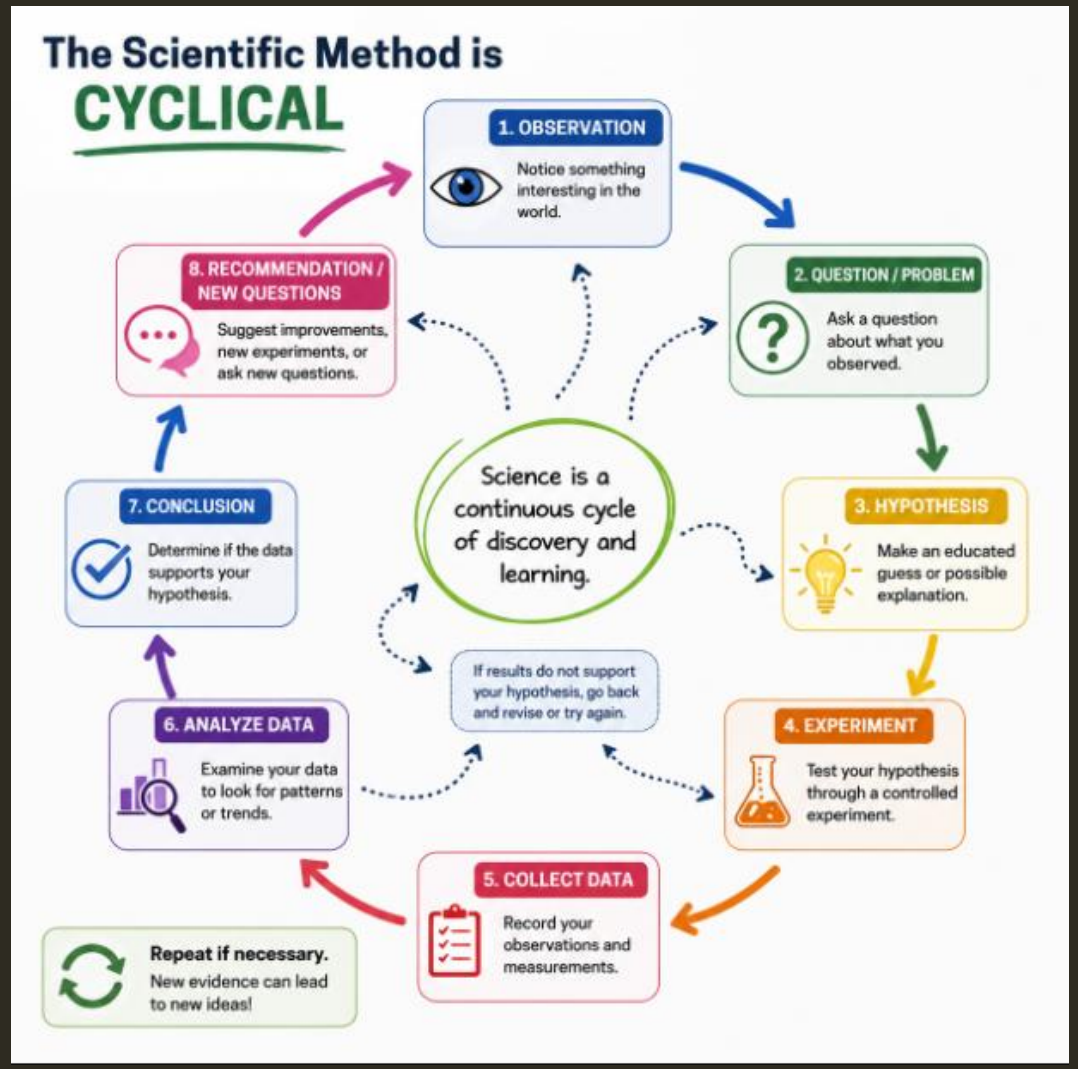

Controlled Experiments

A controlled experiment compares

Experimental Group vs.

Control Group

- Purpose

To determine whether one factor causes a specific effect.

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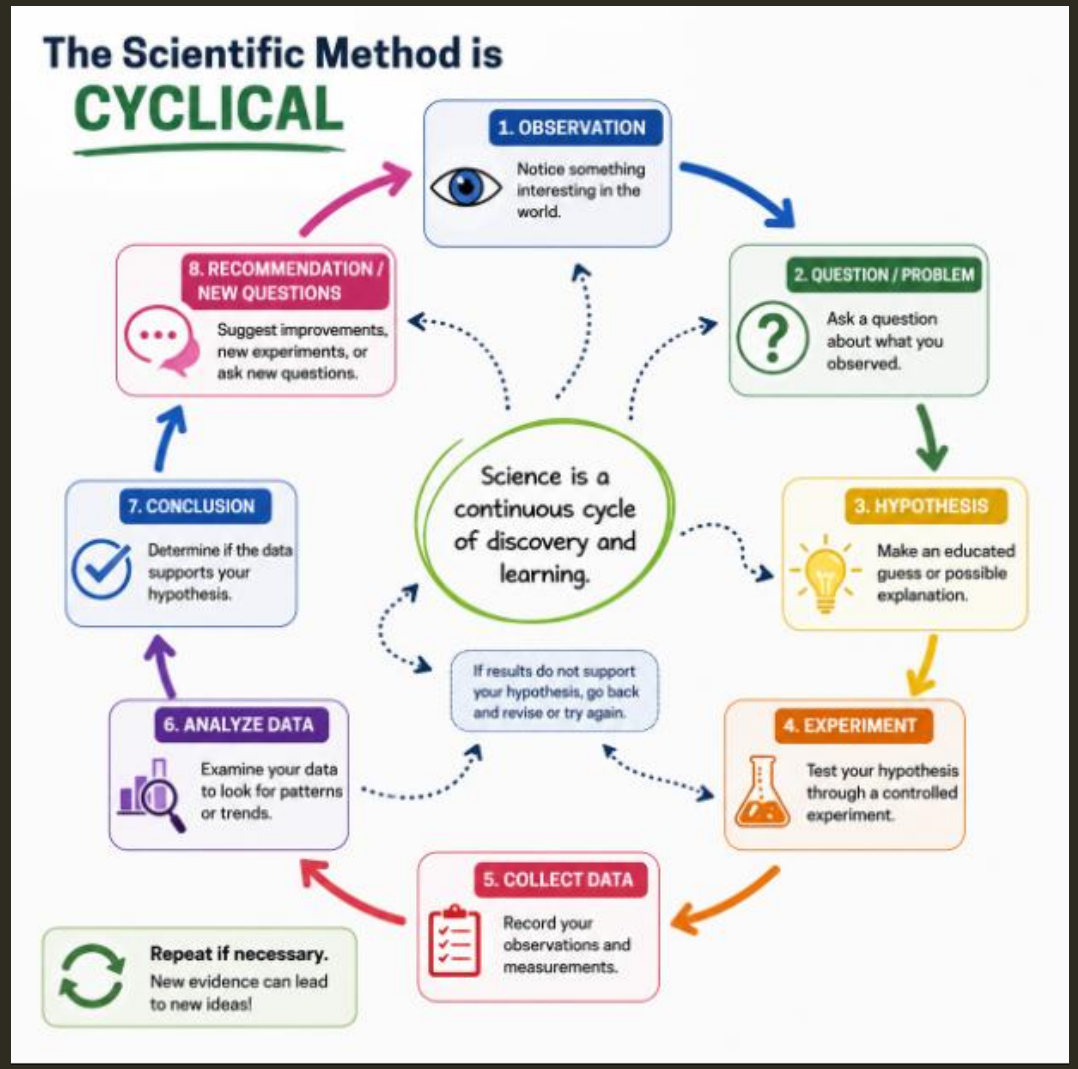

Controlled Experiments

Example

Testing fertilizer

- Control: No fertilizer
- Experimental: With fertilizer

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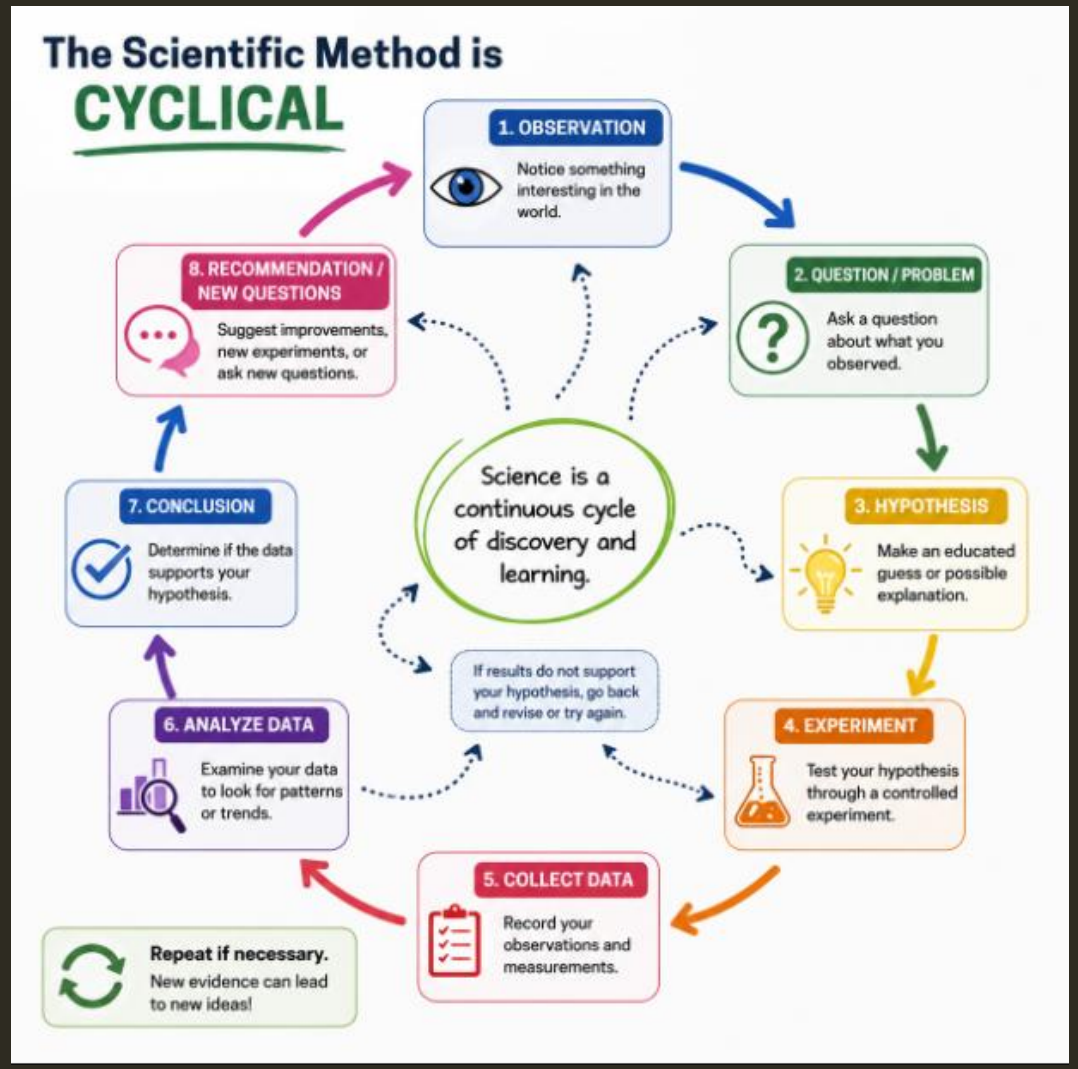

Step 4: Experimentation

Experiments should be

- Fair
- Repeatable
- Accurate
- Safe
- Carefully planned

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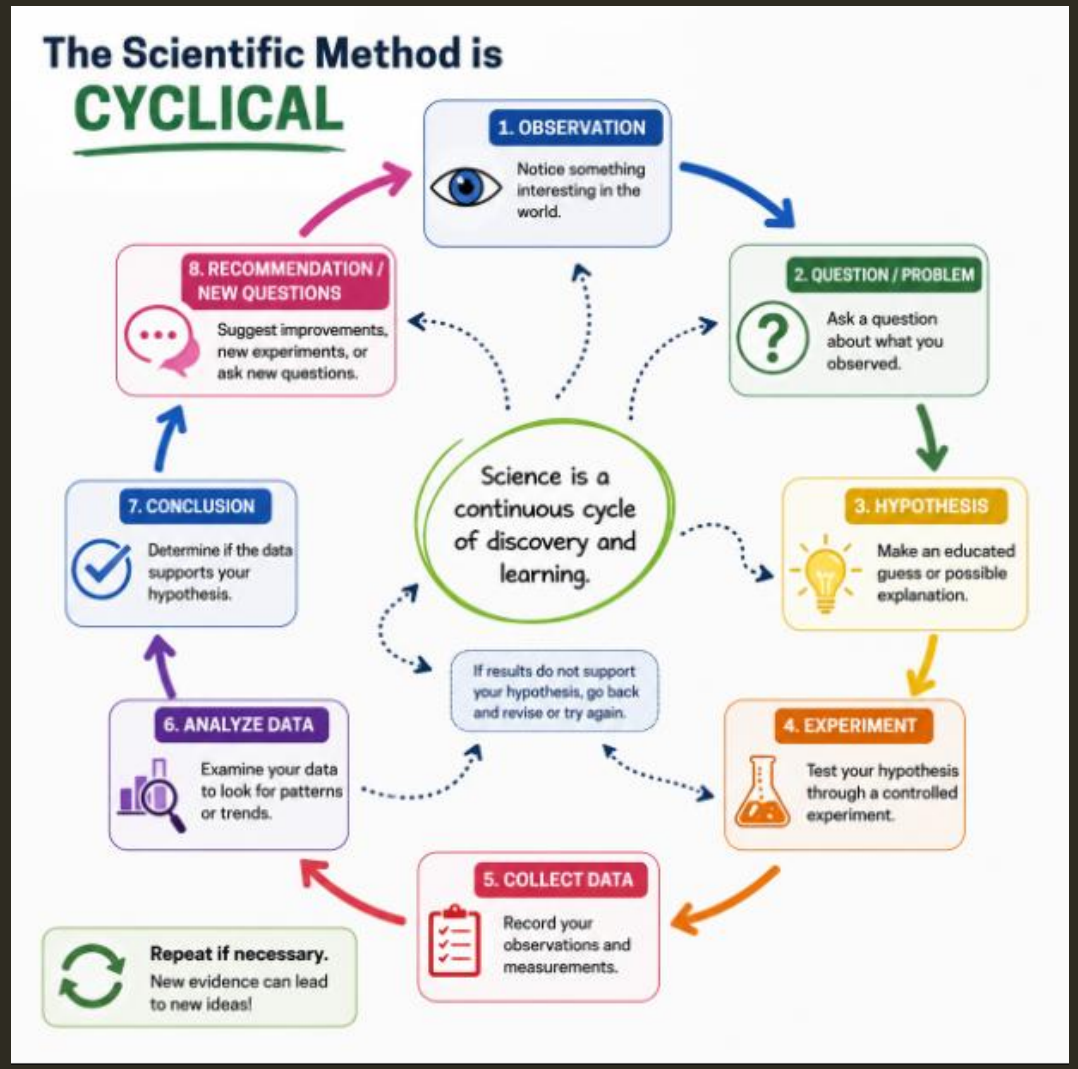
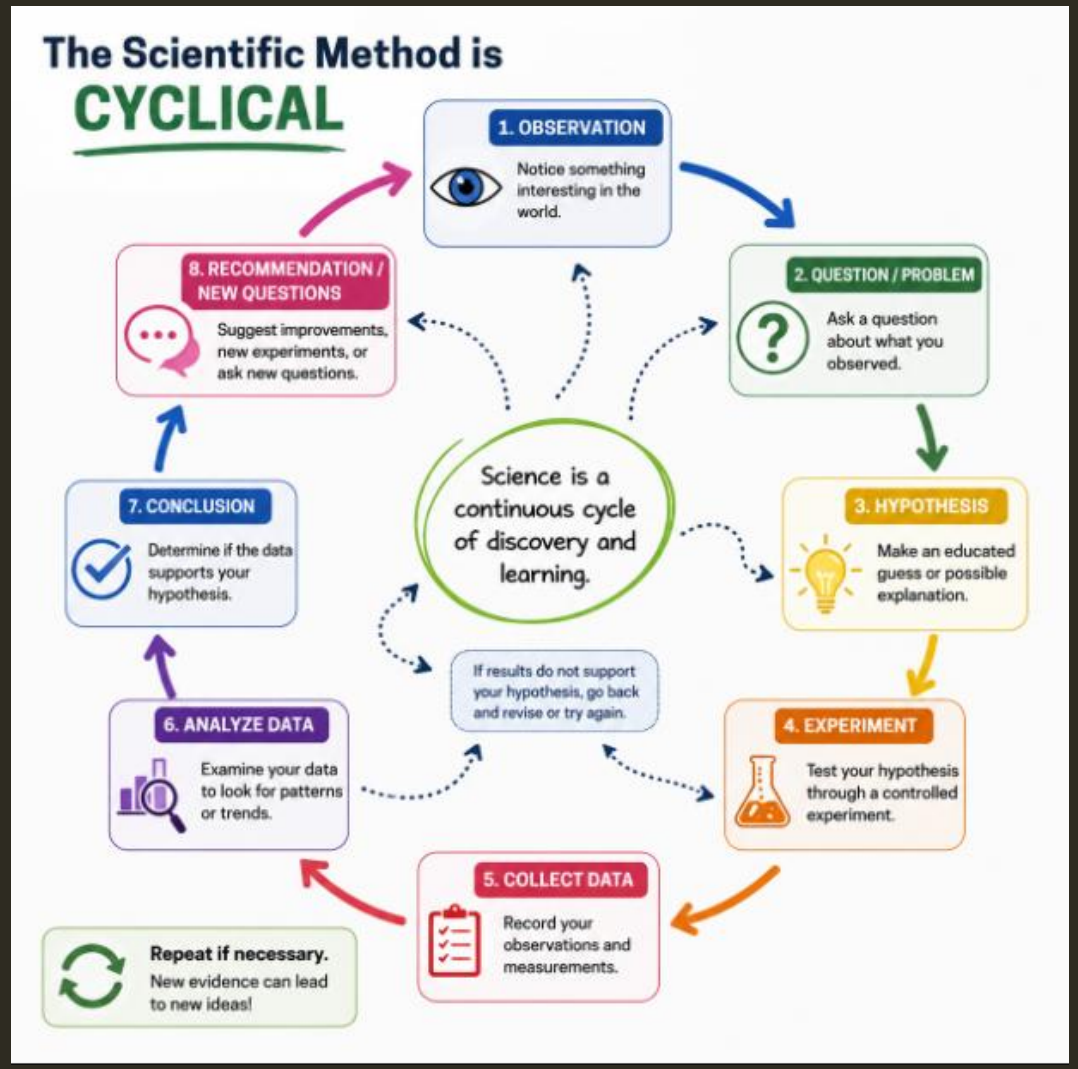


Step 4: Experimentation

Scientists record

- Measurements
- Observations
- Unexpected events

THE SCIENTIFIC METHOD CYCLE



Step 5: Collect and Record Data

Scientists gather

- **Quantitative Data**
  - Mass
  - Volume
  - Temperature
  - Time

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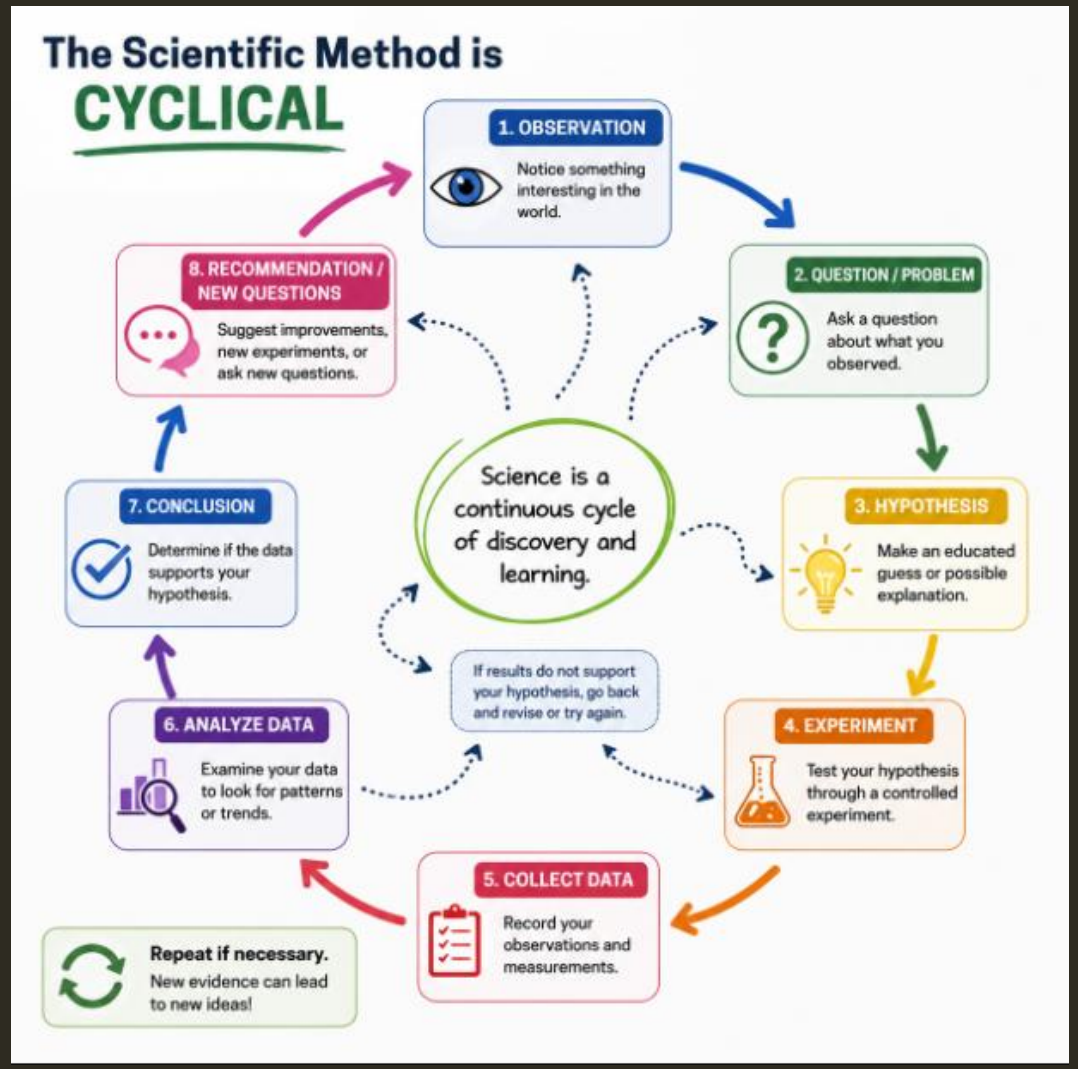

Step 5: Collect and Record Data

Scientists gather

- **Qualitative Data**
  - Color
  - Odor
  - Texture
  - Appearance

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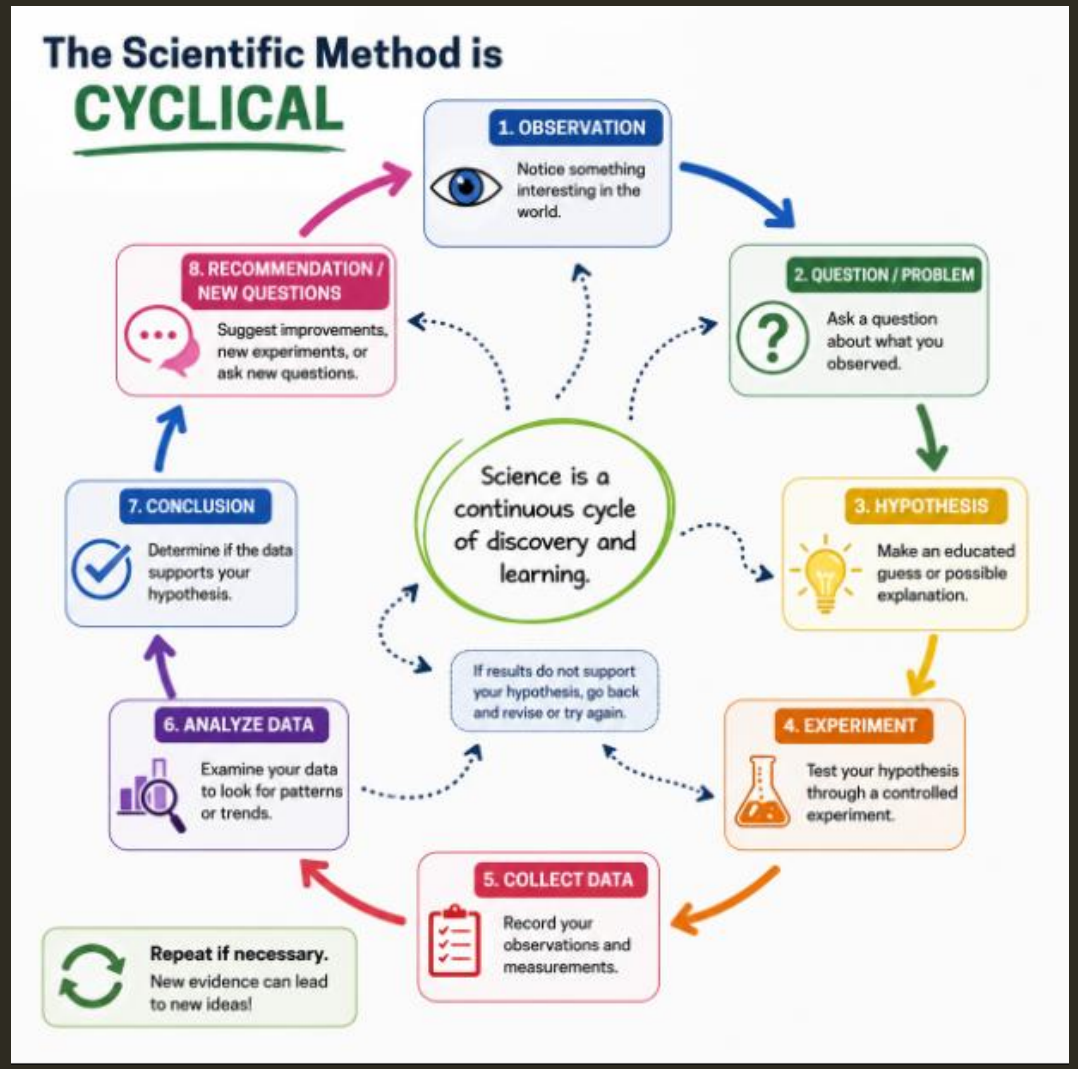
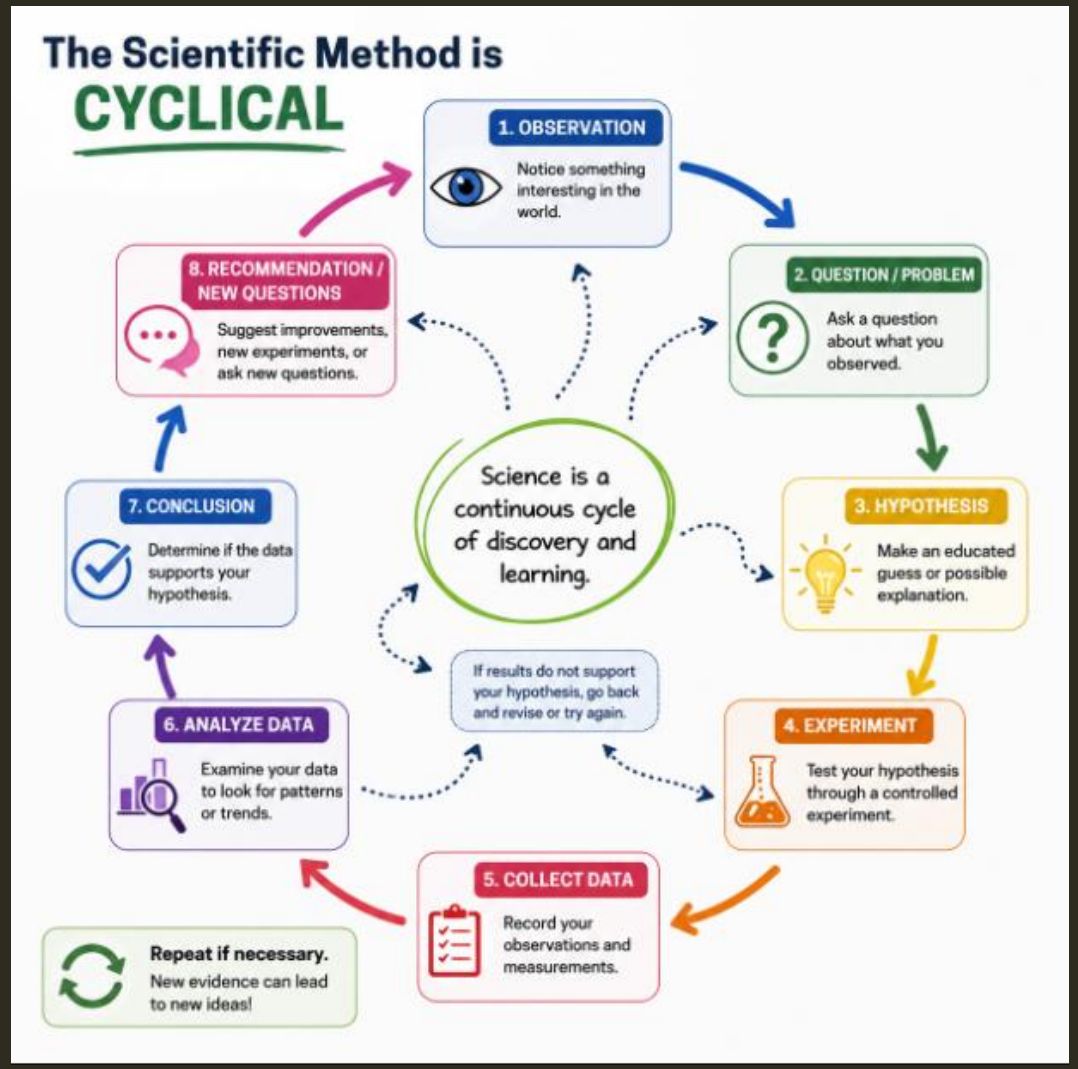


Step 5: Collect and Record Data

Scientists gather data should be

- Organized
- Accurate
- Honest

THE SCIENTIFIC METHOD CYCLE



Step 6: Analyze the Data

Scientists analyze data using

- Tables
- Graphs
- Statistics
- Calculations
- Trends

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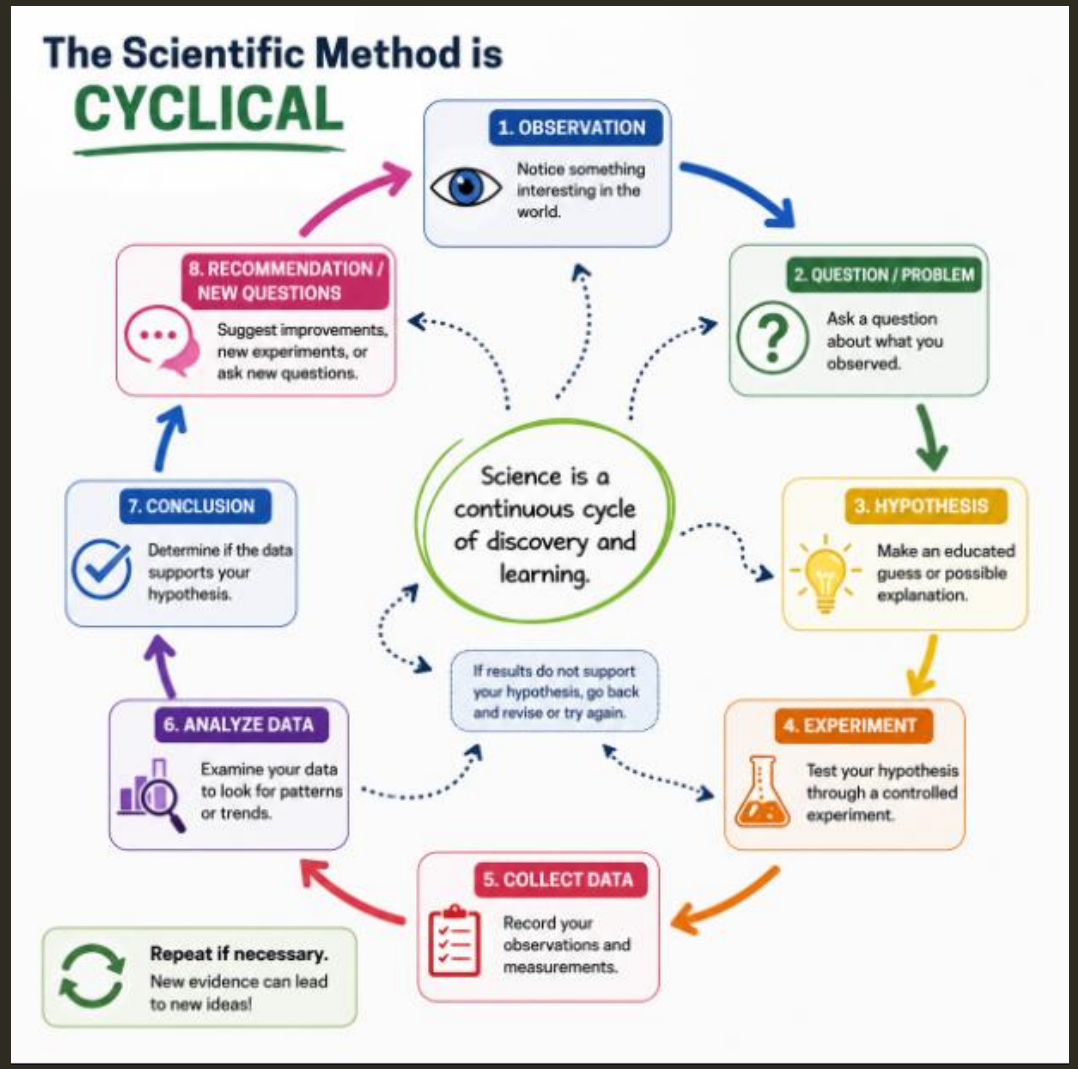

Step 6: Analyze the Data

Questions include

- Did the experiment support the hypothesis?
- Were there errors?
- Are the results reliable?

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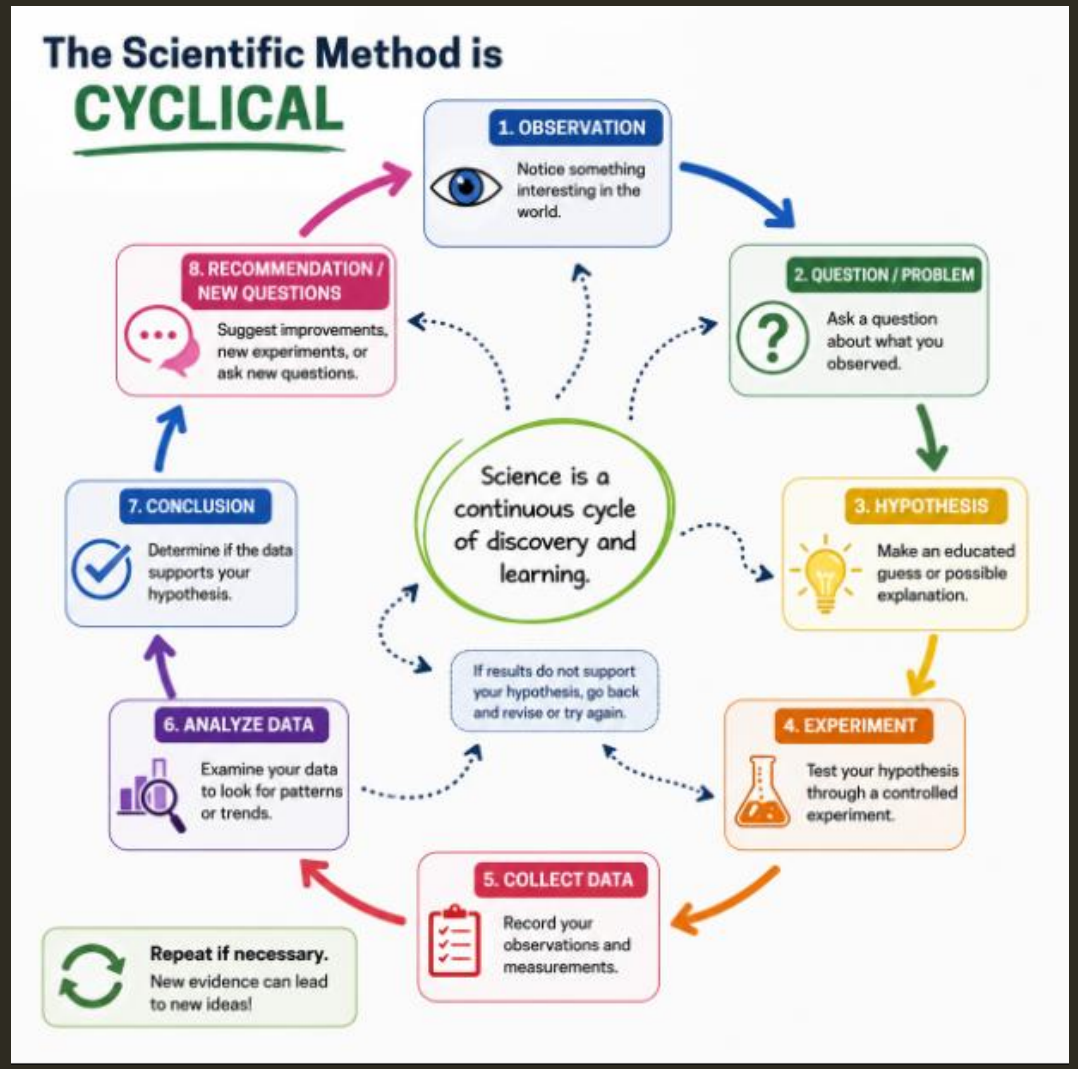

Step 7: Draw Conclusions

A conclusion should answer

- Was the hypothesis supported?
- What evidence supports your answer?
- What did you learn?

Remember

- A hypothesis is **supported**, not proven.

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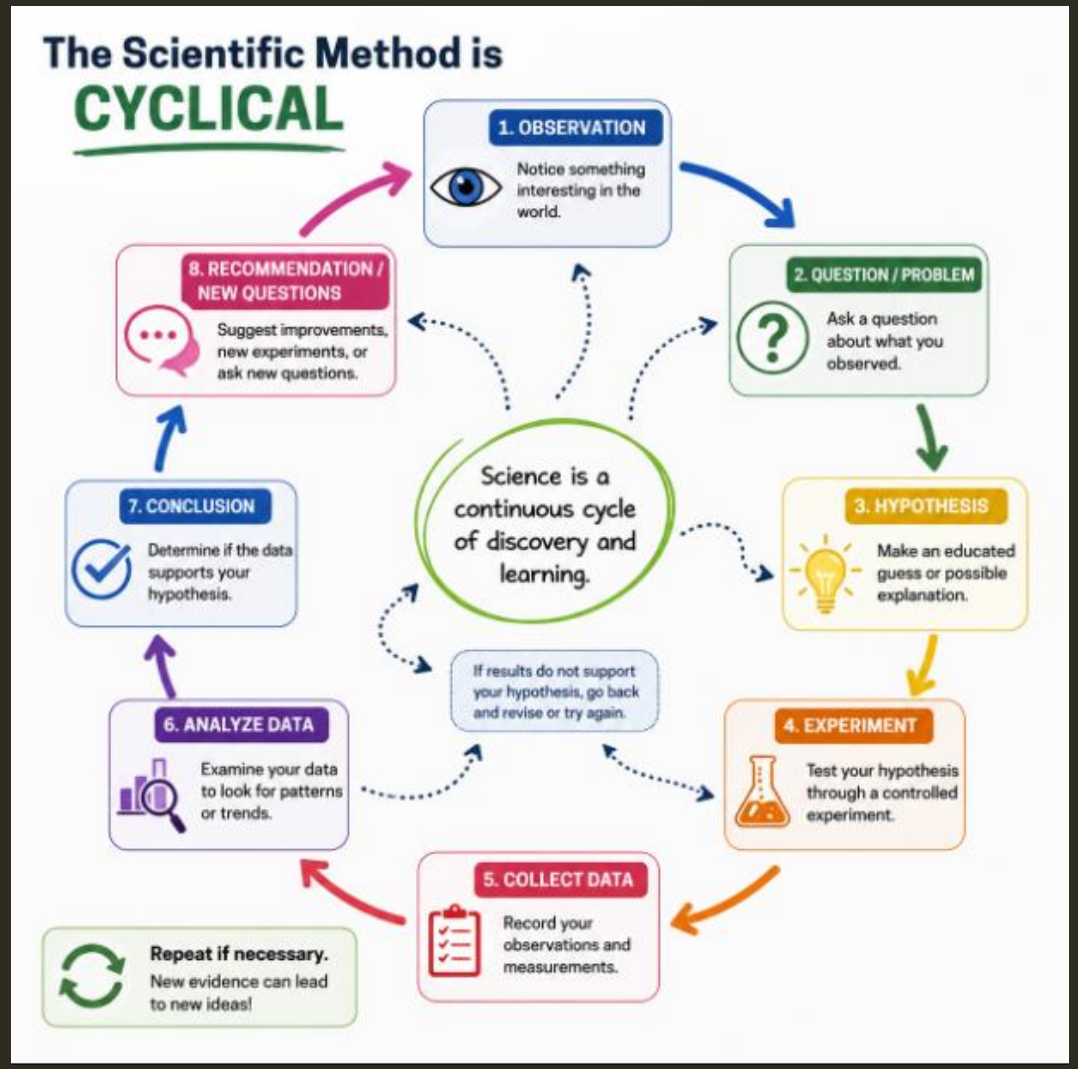


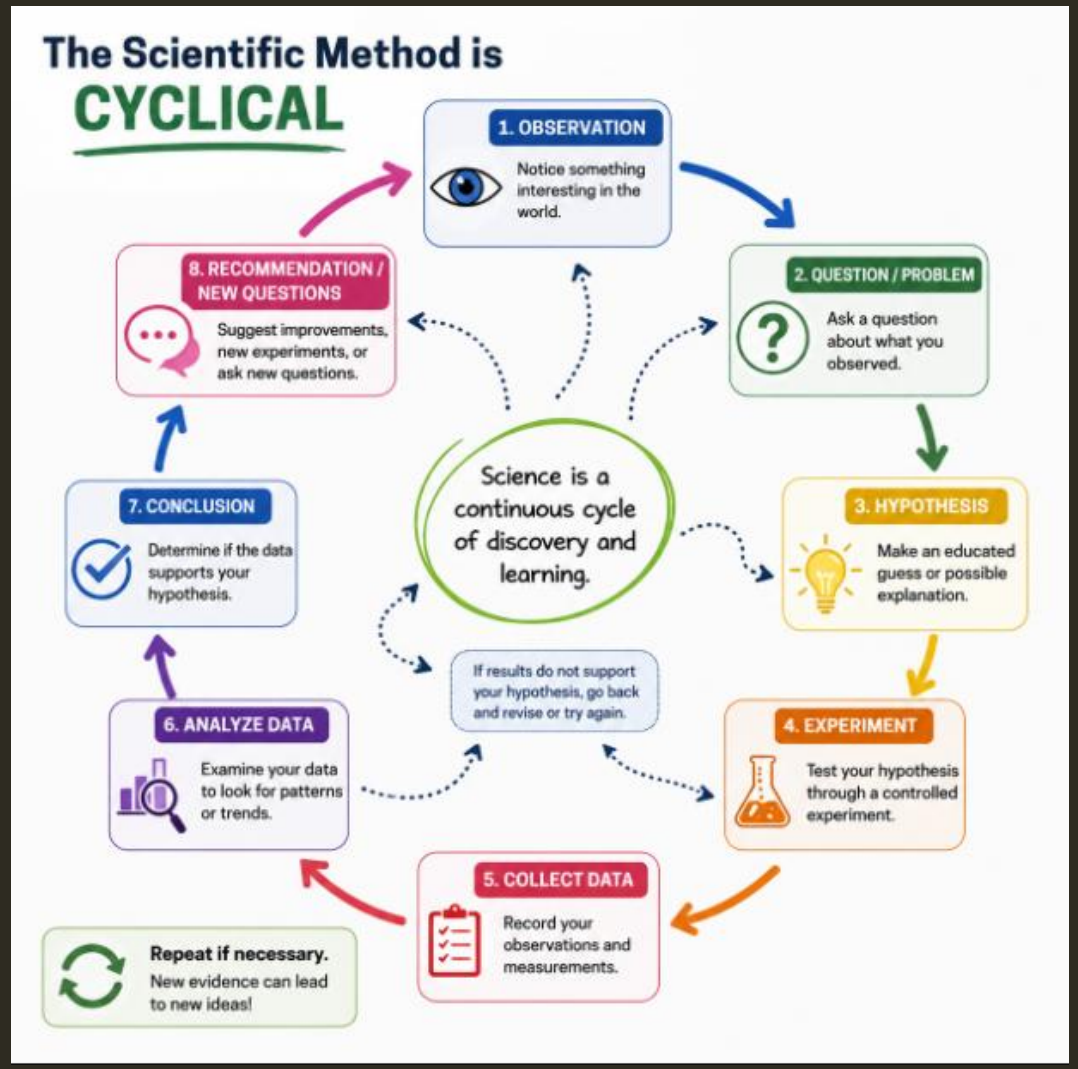
Step 8: Recommendations

Scientists often recommend

- More experiments
- Improved procedures
- Larger sample sizes
- Different conditions
- New research questions

Science is continuous.

THE SCIENTIFIC METHOD CYCLE



The Scientific Method is Cyclical

If results disagree with the hypothesis

Scientists

- Revise the hypothesis
- Design another experiment
- Collect more evidence

Failure is part of science.

CASE STUDY: ALEXANDER FLEMING AND PENICILLIN

1928

Alexander Fleming observed

- Mold contaminated bacterial cultures.
- Bacteria near the mold died.

<u>Hypothesis</u>

The mold produced a substance that killed bacteria.

<u>Result</u>

The substance became known as **Penicillin**.

SCIENTIFIC LAW VS SCIENTIFIC THEORY

Scientific Law	Scientific Theory
Describes what happens	Explains why it happens
Based on repeated observations	Based on extensive evidence
Usually mathematical	Comprehensive explanation
Can be revised	Can also be revised

PHLOGISTON THEORY VS MODERN COMBUSTION THEORY

The phlogiston theory states that all materials that burn contain a substance called phlogiston. When these materials burn, they give off phlogiston, the material can no longer burn and the flame dies.

This theory seemed to explain why a candle burns in open air and why it burns only a short time when placed inside a closed container.

PHLOGISTON THEORY VS MODERN COMBUSTION THEORY

But in 1778, French chemist Antoine Lavoisier discovered that when sulfur and phosphorus were burned, they gained weight. This statement was contrary to the phlogiston theory which suggested that burning materials would lose weight since they gave off phlogiston.

Lavoisier successfully demonstrated that a burning material uses up oxygen from the air rather than giving off something to it. Lavoisier's work became the basis of a new theory that burning involved a chemical combination of a material with oxygen. His theory replaced the phlogiston theory.

SCIENTIFIC LAWS

Scientific laws

- Summarize repeated observations
- Describe natural behavior
- Are concise
- Often expressed mathematically

Examples

- Boyle's Law
- Charles' Law
- Law of Conservation of Mass

SCIENTIFIC THEORIES

Scientific theories

- Explain observations
- Are supported by many experiments
- Predict future observations
- Can be modified

Examples

- Atomic Theory
- Kinetic Molecular Theory
- Collision Theory
- Evolutionary Theory

SUMMARY

The Scientific Method

✓ Starts with observations

✓ Begins with a question

✓ Develops a hypothesis

✓ Tests through experimentation

✓ Collects and analyzes data

✓ Draws conclusions

✓ Leads to new questions

SUMMARY

Science is not about proving ideas—it is about continuously improving our understanding of the natural world through evidence.