SCIENTIFIC INVESTIGATION CYCLE

A step-by-step process scientists follow to build knowledge

THE SCIENTIFIC INVESTIGATION CYCLE

1 OBSERVATION

Observe the world around you and notice a problem or pattern.

2 QUESTION

Ask a clear and specific question about your observation.

3 HYPOTHESIS

Form a testable explanation or educated guess.

4 INVESTIGATION

Plan and carry out experiments or collect data to test your hypothesis.

5 EVENDENCE

Analyze the data and look for patterns or results.

6 CONCLUSION

Draw a conclusion. Was your hypothesis supported or not? Communicate your results.

Remember: Science is a cycle. New observations can lead to new questions, and the process begins again!

SCIENTIFIC REASONING PROCESS

Scientists use reasoning to make sense of observations and **explain the natural world.**

1 OBSERVATION

Carefully notice and gather information about a phenomenon.

Example:
The leaves of a plant turn towards sunlight.

2 EVIDENCE

Collect and organize information or data related to the observation.

Example:
Record the direction of leaves at different times of the day.

3 REASONING

Use logical thinking, prior knowledge and patterns in evidence to make sense of it.

Example:
Leaves turn towards sunlight to get more light for photosynthesis.

4 EXPLANATION

Form a clear explanation based on evidence and reasoning. It can be tested and improved.

Example:
Leaves turn towards sunlight because plants need light to make food.

KEY POINTS

- Scientific reasoning turns observations into understanding.
- It is based on **evidence**, not on guesswork.
- Good explanations can be **tested, questioned** and **improved**.

REMEMBER: Good scientists observe carefully, collect evidence, think logically and explain clearly. **That is the power of scientific reasoning!**

SCIENTIFIC MODELS

Models are **simplified representations** of real-world systems.
They help scientists understand, **explain** and predict **natural phenomena.**

1 REAL-WORLD SYSTEM

Scientists observe a phenomenon or system in the real world.

2 CREATE A MODEL

A model is developed to represent the system. It may be a diagram, formula, graph, or physical model.

3 MAKE PREDICTIONS

Use the model to make predictions about how the system behaves in different situations.

4 TEST THE MODEL

Test the predictions by doing experiments or collecting new data from observations.

5 EVALUATE THE MODEL

Compare results with predictions.
Does the model explain the observations accurately?

6 REFINE THE MODEL

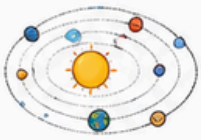
Improve the model based on new evidence. Repeat the cycle to make the model better.

THE MODELING PROCESS

A cycle of learning and improving

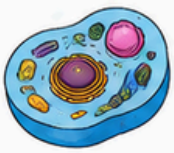
EXAMPLES OF MODELS

Solar System Model



Helps us understand planetary motion.

Cell Model



Helps us study parts of a cell.

Weather Model

Helps predict weather changes.

KEY POINTS

- Models are not perfect. They are **useful tools.**
- New evidence may change or **improve** a model.
- Better models lead to better **understanding** and predictions.

TYPES OF MODELS

- **Physical Models** (e.g., globe, atom model)
- **Mathematical Models** (e.g., equations, formulas)
- **Computer Models** (e.g., simulations)
- **Conceptual Models** (e.g., diagrams, flowcharts)

Remember: Models help us understand the world, make predictions and solve problems.
Science advances when models are tested and improved!

PREDICTION → EVIDENCE → CONCLUSION

The Path to Scientific Understanding

Scientists use a cycle of thinking, testing and learning to understand the world.

1 PREDICTION

A prediction is an educated guess about what will happen.

What we do:

- Observe the situation
- Use prior knowledge
- Ask a question
- Predict the outcome

Key Question

What do you think will happen?

Example:

If a plant gets more sunlight, then it will grow taller.

2 EVIDENCE

Evidence is the information we collect to test our prediction.

What we do:

- Plan and conduct a test
- Make careful observations
- Measure and record data
- Organize the results

Key Question

What did we observe or find out?

Example:

We grow two similar plants. One gets more sunlight. We measure and record their heights for 2 weeks.

Plant Height (cm)

Day	More Sun	Less Sun
0	5 cm	5 cm
3	8 cm	5.5 cm
7	12 cm	6 cm
10	16 cm	6.5 cm
14	20 cm	7 cm

3 CONCLUSION

A conclusion explains what the evidence means.

What we do:

- Analyze the evidence
- Decide if it supports the prediction
- Draw a conclusion
- Communicate the result

Key Question

What does the evidence tell us?

Example:

The plant with more sunlight grew taller than the plant with less sunlight.

Our prediction was supported by the evidence.

HOW EVIDENCE RELATES TO PREDICTION

EVIDENCE SUPPORTS THE PREDICTION

The results match or are consistent with what was predicted.

Example:
The plant with more sunlight grew taller.

Conclusion:
The prediction is supported.

EVIDENCE DOES NOT SUPPORT THE PREDICTION

The results do not match the prediction.

Example:
If the plant with more sunlight did not grow taller.

Conclusion:
The prediction is not supported.

EVIDENCE GIVES NEW UNDERSTANDING

The results lead to a new question or idea.

Example:
Both plants grew the same.

Conclusion:
We need more thinking and further investigation.

Why is this important?

This cycle helps scientists make sense of the world, solve problems and discover new things.

PREDICTION → EVIDENCE → CONCLUSION

LEARN & REPEAT

THINK → TEST → LEARN → IMPROVE THAT IS THE POWER OF SCIENCE!

SCIENTIFIC NOTATION
LARGE & SMALL NUMBERS

1.23×10^n

Scientific notation is a way to write very large or very small numbers in a short and easy form.

Standard Form: $a \times 10^n$

where $1 \le a < 10$ and n is an integer (... −3, −2, −1, 0, 1, 2, 3 ...)

POSITIVE POWERS OF 10 (Large Numbers)

Move the decimal point to the LEFT.
The number of places moved becomes the power of 10 (positive).

Example 1:

$34{,}600{,}000 = 3.46 \times 10^7$

34,600,000

3.46

Moved 7 places left

Example 2:

$5{,}730 = 5.73 \times 10^3$

5,730

5.73

Moved 3 places left

NEGATIVE POWERS OF 10 (Small Numbers)

Move the decimal point to the RIGHT.
The number of places moved becomes the power of 10 (negative).

Example 1:

$0.00056 = 5.6 \times 10^{-4}$

0.00056

5.6

Moved 4 places right

Example 2:

$0.000000237 = 2.37 \times 10^{-7}$

0.000000237

2.37

Moved 7 places right

POWERS OF 10 NUMBER LINE

10^{-6}	10^{-3}	10^{-2}	10^{-1}	10^0	10^1	10^2	10^3	10^6
0.000001	0.001	0.01	0.1	1	10	100	1,000	1,000,000

Smaller than 1 — $10^0 = 1$ — Larger than 1

RULES TO REMEMBER

1. The number before 10^n must be between 1 (inclusive) and 10 (exclusive).
2. Move decimal LEFT for large numbers (positive power).
3. Move decimal RIGHT for small numbers (negative power).
4. Each place moved = change of 1 in the power.
5. $10^0 = 1$ (any number × 1 = same number)

N increases → number gets larger
N decreases → number gets smaller

CONVERT STANDARD FORM ↔ SCIENTIFIC NOTATION

	Standard Form	Scientific Notation
1.	250,000	2.5×10^5
2.	3,780,000,000	3.78×10^9
3.	0.0456	4.56×10^{-2}
4.	0.000000092	9.2×10^{-8}
5.	−0.0078	-7.8×10^{-3}
6.	602,000	6.02×10^5
7.	0.00031	3.1×10^{-4}

QUICK TIP

Count the zeros!

LEFT (Large) → Positive (+) power

RIGHT (Small) → Negative (−) power

SCIENTIFIC NOTATION IN REAL LIFE

Distance to Sun	Size of an Atom	Mass of Earth	Thickness of Paper	Bacteria Size
149,600,000 km = 1.496×10^8 km	0.0000000001 m = 1×10^{-10} m	5,972,000,000,000,000,000,000,000 kg = 5.972×10^{24} kg	0.0001 m = 1×10^{-4} m	0.000002 m = 2×10^{-6} m

WHY IT IS IMPORTANT

- Makes very big or very small numbers easy to write and read.
- Used in all branches of science and engineering.
- Helps in calculations and comparisons.

Think Big or Small... Write It All!

Scientific Notation makes numbers simple, universal and powerful.

MATHEMATICS IN SCIENCE

Math helps scientists organize data, find patterns, make predictions and draw conclusions.

THE SCIENTIFIC PROCESS USING MATHEMATICS

1 DATA

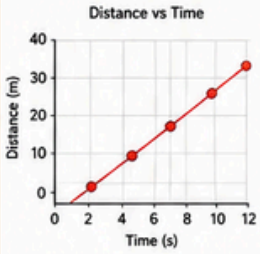
Collect observations or measurements through experiments or surveys.

2 TABLE

Trial	Time (s)	Distance (m)
1	2.0	5.8
2	4.0	11.6
3	6.0	17.5
4	8.0	23.3
5	10.0	29.0

Organize the data in tables to make it easy to read and compare.

3 GRAPH

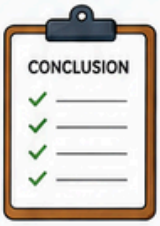


Plot graphs to see trends, patterns and relationships.

4 PATTERN

Look for patterns or relationships in the data.

5 SCIENTIFIC CONCLUSION



Use math-based evidence to draw valid conclusions and make predictions.

EXAMPLE: MOTION OF A CART

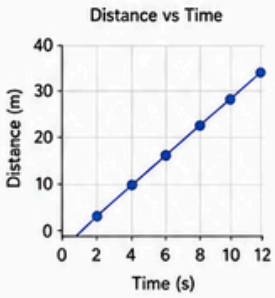
1. DATA

A cart is moved and its distance is measured at different times.

2. TABLE

Time (s)	Distance (m)
0	0.0
2	5.8
4	11.6
6	17.5
8	23.3
10	29.0

3. GRAPH



4. PATTERN

- The graph is a straight line.
- Distance increases by equal amounts in equal time intervals.
- Speed is constant.

Pattern: Distance ∝ Time

5. CONCLUSION

The cart is moving with uniform speed.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Speed} = \frac{29.0\ \text{m}}{10\ \text{s}} = 2.9\ \text{m/s}$$

TYPES OF GRAPHS USED IN SCIENCE

Line Graph — Shows how a quantity changes over time. Example: Distance vs Time

Bar Graph — Compares different categories. Example: Rainfall in different months

Pie Chart — Shows parts of a whole. Example: Composition of air

Scatter Plot — Shows relationship between two variables. Example: Height vs Weight

MATHEMATICS USED IN SCIENCE

- **Arithmetic Operations** (+ , − , × , ÷) — For calculations
- **Averages** (Mean = Sum of values / Number of values) — For central value
- **Ratios & Proportions** — To compare quantities
- **Percentages** — To express parts per hundred
- **Equations & Formulas** — To describe relationships. Example: $v = \frac{d}{t}$, $F = ma$

WHY MATH IS IMPORTANT IN SCIENCE

- Makes data easy to understand.
- Helps in accurate measurements and calculations.
- Reveals patterns and relationships.
- Allows predictions about future events.
- Supports valid conclusions and decisions.

> Mathematics is the language in which God has written the universe.
> – Galileo Galilei

QUICK TIPS

- Always record data carefully.
- Use tables to organize data.
- Choose the right type of graph.
- Look for patterns, not just numbers.
- Use math to support your conclusions.

GOOD SCIENCE USES GOOD MATHEMATICS!

Measure • Organize • Analyze • Conclude

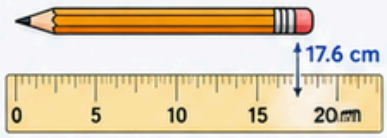
MEASUREMENT & ESTIMATION

Measurement gives the **exact** value using instruments.
Estimation gives an **approximate** value using judgment and experience.

MEASUREMENT (Exact)

Finding the exact value of a quantity using proper instruments and standard units.

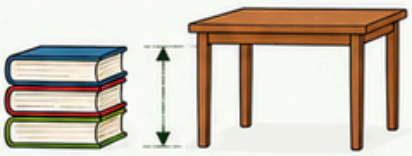
EXAMPLE:
The length of a pencil measured with a ruler is 17.6 cm.



ESTIMATION (Approximate)

Finding a value without using instruments, based on experience, reasoning or comparison.

EXAMPLE:
The height of the table is estimated to be about 3 books high.



STEPS FOR ESTIMATION

1. Understand what needs to be estimated.
2. Think of a suitable unit (cm, m, kg, L, etc.).
3. Compare with familiar objects or experiences.
4. Make a reasonable guess and round it off.

STEPS FOR MEASUREMENT

1. Choose the correct instrument.
2. Place the object or object properly.
3. Take the reading carefully.
4. Note the reading with correct unit and significant figures.

COMMON MEASURING INSTRUMENTS

Ruler	Measuring Tape	Measuring Cylinder	Balance	Stopwatch
				
Measures length of small objects.	Measures length of large objects or distances.	Measures volume of liquids.	Measures mass of objects.	Measures time or intervals.

EXAMPLES: MEASUREMENT vs ESTIMATION

Quantity	Estimation (Approximate)	Measurement (Exact)
Length of a notebook	About 20 cm	21.3 cm
Mass of a water bottle	About 500 g	487 g
Height of a classroom door	About 2 m	2.05 m
Volume of water in a glass	About 200 mL	210 mL
Time to run 100 m	About 20 seconds	18.42 seconds
Mass of a bag of rice	About 10 kg	9.82 kg

TIPS FOR GOOD ESTIMATION

- Use familiar objects as reference.
- Practice regularly to improve your sense of size, volume, mass and time.
- Always state the unit with your estimate.
- Estimation should be reasonable, not too high or too low.
- Use estimation first, then verify with measurement.

Remember: Estimation helps us make quick decisions and plan better.
Measurement helps us be precise, accurate and reliable in science!

SI UNITS & MEASUREMENT

The International System of Units (SI) is the standard system used worldwide for scientific measurements.

SI BASE UNITS

SI system is based on 7 base quantities. Each has a base unit.

Base Quantity	Quantity Symbol	SI Unit	Unit Symbol	What it Measures	Example
Length	l	metre	m	Distance between two points	Length of a table = 1.2 m
Mass	m	kilogram	kg	Amount of matter in an object	Mass of a book = 0.5 kg
Time	t	second	s	Duration of events or intervals	Time for a race = 15 s
Electric Current	I	ampere	A	Flow of electric charge	Current in a circuit = 2 A
Thermodynamic Temperature	T	kelvin	K	Measure of hotness or coldness	Room temperature = 298 K
Amount of Substance	n	mole	mol	Amount of particles (atoms, molecules, ions)	Amount of water = 1 mol
Luminous Intensity	I_v	candela	cd	Measure of the power of light in a given direction	Intensity of a LED light = 20 cd

WHY SI UNITS?

- They are uniform and accepted worldwide.
- They make communication in science easy.
- They are based on natural constants.
- They ensure accuracy and consistency in measurements.

Always use SI units in science for clarity, accuracy and universal understanding.

RULES OF MEASUREMENT

- Use the correct instrument for measurement.
- Measure carefully and avoid parallax error.
- Record value with correct unit. (m)
- Report all digits known plus one estimated digit. (12.3)
- Keep instruments clean and properly calibrated.

COMMON PREFIXES USED IN SI UNITS

Prefix	Symbol	Multiplier	Example
kilo	k	10^3	1 km = 1000 m
hecto	h	10^2	1 hm = 100 m
deca	da	10^1	1 dam = 10 m
(base unit)	–	10^0	1 m = 1 m
deci	d	10^{-1}	1 dm = 0.1 m
centi	c	10^{-2}	1 cm = 0.01 m
milli	m	10^{-3}	1 mm = 0.001 m
micro	μ	10^{-6}	1 μm = 10^{-6} m
nano	n	10^{-9}	1 nm = 10^{-9} m

ACCURATE MEASUREMENT IS THE FIRST STEP OF EVERY SCIENTIFIC DISCOVERY!