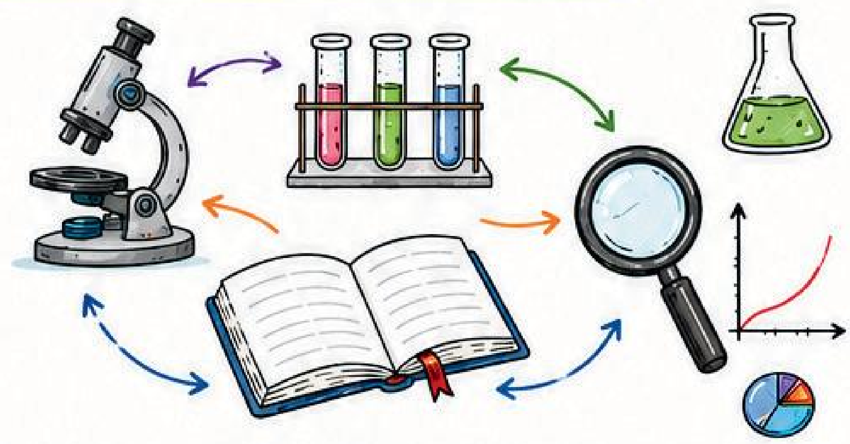
SCIENCE IN THE SECONDARY STAGE

Definition

Science is a systematic way of understanding the natural world through observation, measurement, experimentation, reasoning, and evidence.

Observation → Measurement → Experimentation → Reasoning → Evidence



Key Idea

In middle school, science focused on:

- ✓ Curiosity
- ✓ Asking questions
- ✓ Simple experiments
- ✓ Observation

Middle School Science ↓ Secondary Science ↓ Deeper Understanding ↓ Scientific Thinking

In secondary school, science goes deeper into:

- ✓ Scientific exploration
- ✓ Measurements
- ✓ Mathematical relationships
- ✓ Models
- ✓ Predictions
- ✓ Scientific reasoning
- ✓ Evidence-based conclusions

Important Points

Science is not only about:

✗ What we know

Science is also about:

✓ How we know it

This includes:

HOW WE KNOW: Observations, Measurements, Experiments, Models, Evidence, Testing ideas

Scientific Ideas

Scientific ideas:

- ✓ Can be revised
- ✓ Can be tested
- ✓ Can be improved
- ✓ Can be discarded if evidence disagrees

Idea → Testing → Evidence → Improved Idea / Rejected Idea

Symbols in the Textbook

Magnifying Glass

Represents:

- Careful observation
- Looking for patterns
- Attention to detail

Compass

Represents:

- Direction in exploration
- Choosing correct models
- Asking proper questions
- Understanding limitations

→ Questions → Models → Exploration → Understanding

Teacher's Note

Science is not random exploration. It is a careful and purposeful attempt to understand the world.

Observation → Evidence → Conclusion

MCQs

Q1 Science mainly helps us:

A. Memorise facts
B. Understand nature through evidence ✓
C. Learn only equations
D. Perform magic

Q2 The magnifying glass in the textbook represents:

A. Direction
B. Curiosity only
C. Careful observation ✓
D. Technology

Q3 Scientific ideas are:

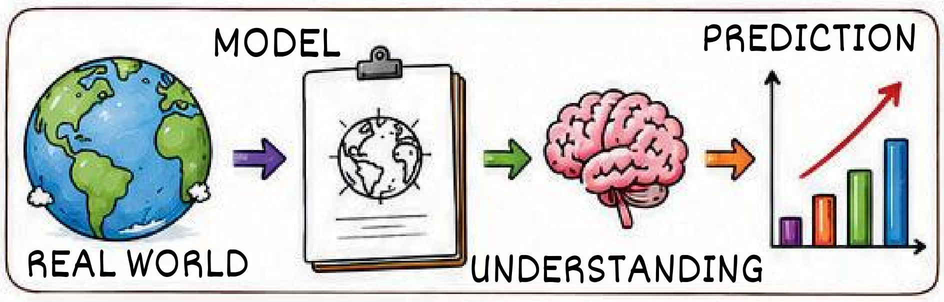
A. Always permanent
B. Never questioned
C. Open to revision ✓
D. Based on beliefs

Idea → Revision

SCIENTIFIC MODELS

Definition

A scientific model is a simplified representation of a real system that focuses only on the important features needed to answer a particular question.



Why Models Are Needed

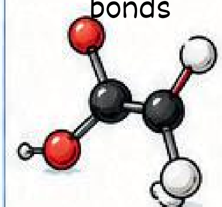
- The natural world is extremely complex.
- Studying every detail is impossible.
- Therefore scientists use models.

Complex Reality → Too Many Details → Simplification → Scientific Model → Easy Understanding

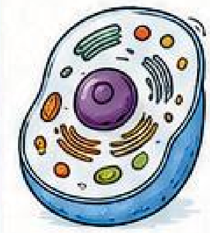
Examples of Models

Physics
A moving car may be represented as: A single point

Chemistry
Atoms and molecules may be represented as: Spheres and bonds



Biology
Cells may be represented as: Simplified diagrams

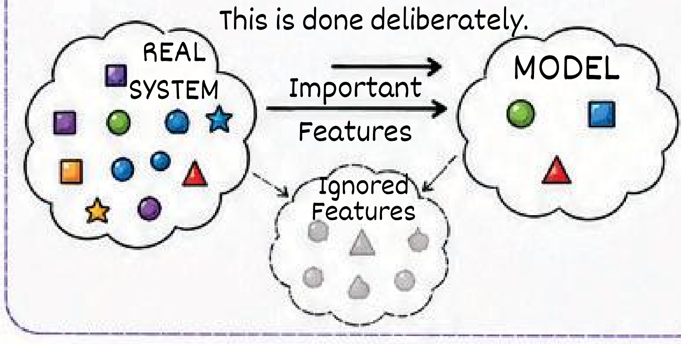


Earth Science
Earth may be represented as: A smooth sphere with layers

Assumptions in Models

Scientists often:
- Make assumptions
- Ignore unnecessary details

This is done deliberately.



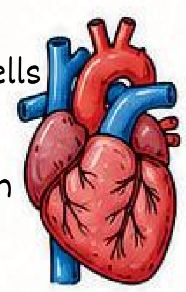
Examples of Assumptions

Falling Object
Ignored:
✗ Air resistance

Considered:
✓ Gravity

Heart Function
Ignored:
✗ Individual cells

Considered:
✓ Whole organ function

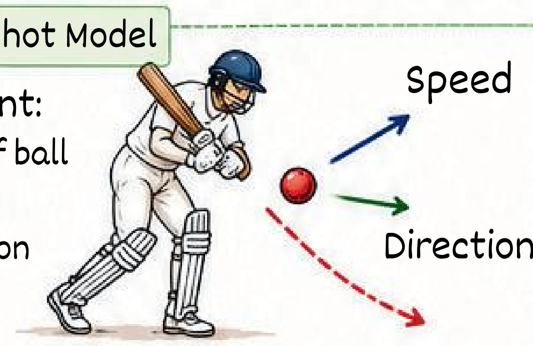


Characteristics of Good Models

A good model should:
- Be simple
- Focus on important details
- Help answer a question
- Allow predictions

Cricket Shot Model

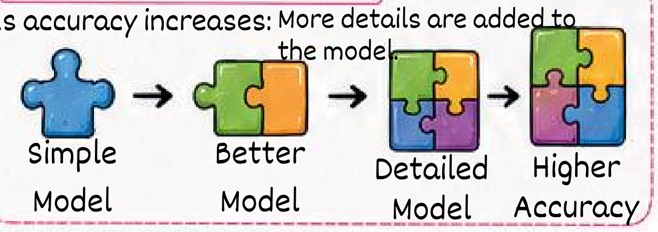
Important:
- ✓ Mass of ball
- ✓ Speed
- ✓ Direction



Ignored:
- ✗ Colour of ball
- ✗ Brand of bat
- ✗ Grass on field

Important Concept

As accuracy increases: More details are added to the model.



Meet a Scientist – Meghnad Saha

Contribution: Explained how star colour depends on temperature.

His simplification:
He treated stars as hot gases and focused on:
✓ Temperature ✓ Ion formation
✓ Pressure while ignoring many complex details.

MCQs

Q1 A scientific model is:
A. Exact copy of reality
✓ B. Simplified representation
C. Scientific law
D. Theory

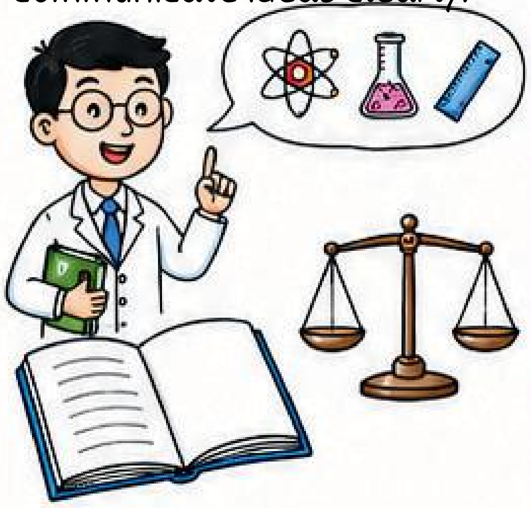
Q2 When studying a falling object, scientists often ignore:
A. Gravity
B. Mass
C. Air resistance ✓
D. Height

Q3 Meghnad Saha explained:
A. Photosynthesis
B. Star colour and temperature ✓
C. Evolution
D. Electricity

LANGUAGE OF SCIENCE

Definition

Science uses precise terms, symbols, and units to communicate ideas clearly.



Why Precision is Important

Scientific communication must be:

- Clear
- Universal
- Unambiguous

Scientific Communication → Clear → Universal → Unambiguous

Scientific Terms

Many common words have special meanings in science.

Examples:

Everyday Word	Scientific Meaning
Force	Push or pull
Work	Energy transfer
Cell	Basic unit of life
Reaction	Chemical change

Scientific Symbols

Quantity	Symbol
Mass	m
Velocity	v
Force	F
Electric Current	I

Standard Units

Every quantity has a defined unit.

Examples:

Quantity	SI Units
Length	metre (m)
Mass	kilogram (kg)
Time	second (s)

Importance of SI Units

SI units:

- Prevent confusion
- Allow global communication
- Improve accuracy

SI Units → No Confusion → Global Communication → Accuracy

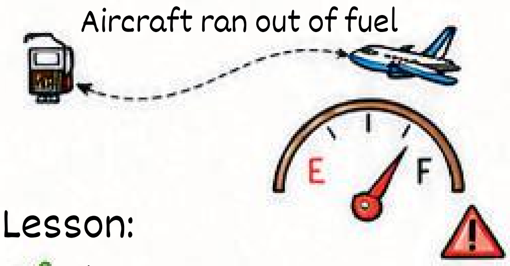
Airplane Fuel Incident

A fuel calculation error occurred because:

❌ Pounds (lb) were confused with kilograms (kg)

RESULT:

Aircraft ran out of fuel



lb ↔ kg Confusion → Fuel Error → Aircraft Problem → Use SI Units

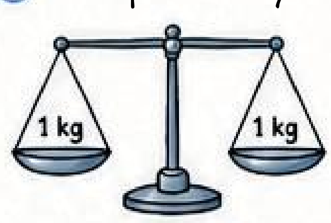
Lesson:

✅ Always use standard units.

Why Kilogram is Used Everywhere

Because measurements need:

- Fairness
- Uniformity
- Comparability



Threads of Curiosity

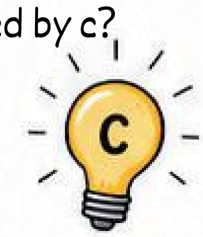
Why is speed of light denoted by c?

Comes from Latin word:

Celeritas

Meaning:

"Speed"



Speed of Light

$c = 299{,}792{,}458$ m/s

Q1 Symbol of electric current is:

A. V
B. F
C. I ✓
D. M

Q2 SI unit of mass is:

A. Gram
B. Kilogram ✓
C. Pound
D. Ton

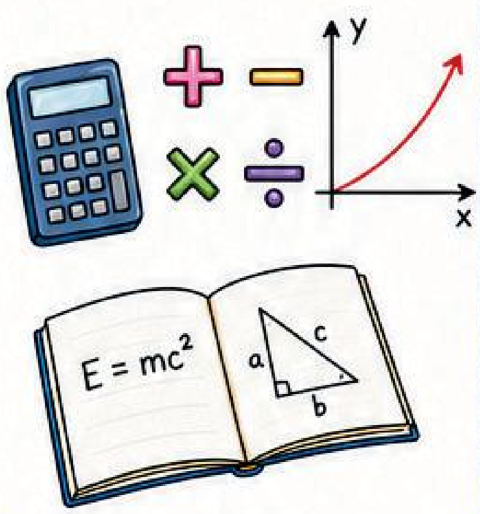
Q3 The symbol c comes from:

A. Current
B. Celsius
C. Celeritas ✓
D. Circle

MATHEMATICS AS THE LANGUAGE OF SCIENCE

Definition

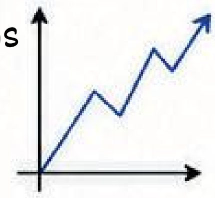
Mathematics is a language used in science to express relationships between quantities clearly.



Important Points

Mathematics helps us:

- Describe patterns
- Make predictions
- Test ideas
- Express laws



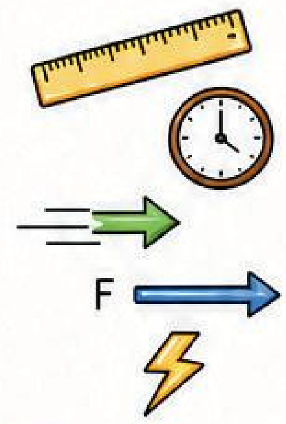
$y = mx + c$

Mathematics → Describe Patterns → Make Predictions → Test Ideas → Express Laws

Scientific Quantities

Examples:

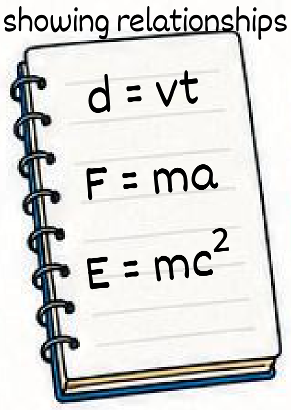
- Distance
- Time
- Velocity
- Force
- Energy



Scientific Quantities → Distance, Time, Velocity, Force, Energy

Equations

An equation is a compact statement showing relationships among quantities.



Quantity A → Equation → Quantity B

Important Principle

Do not memorise equations blindly.

Instead:

- Understand the situation
- Identify relevant quantities
- Apply relationships

Situation → Identify Quantities → Apply Relationships → Solution

Teacher's Note

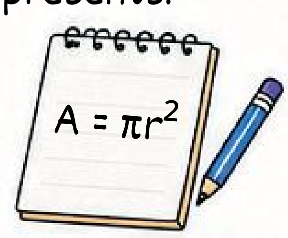
Understanding is more important than memorisation.

Q1 Mathematics in science helps:

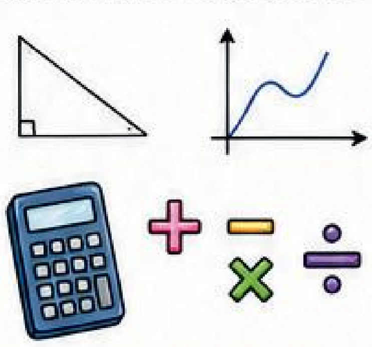
A. Confuse ideas
B. Express relationships clearly ✓
C. Avoid reasoning
D. Replace experiments

Q2 An equation primarily represents:

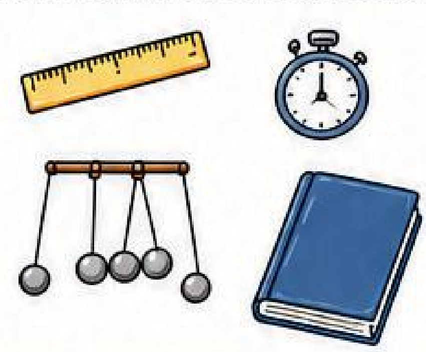
A. A drawing
B. A relationship ✓
C. A law only
D. A theory only



QUICK REVISION MAP



Quantities → Mathematics in Science → Equations → Relationships → Predictions → Quantities

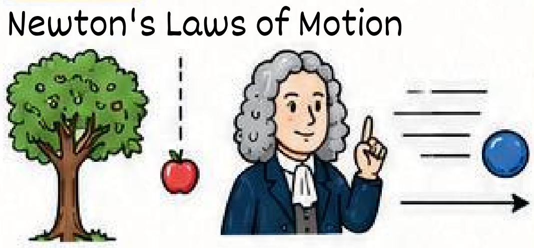


LAWS, THEORIES AND PRINCIPLES

Scientific Law

Definition
A law describes a regular pattern observed in nature.

Example
Newton's Laws of Motion

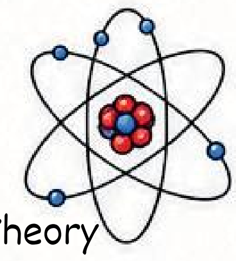


Observation
↓
Repeated Pattern
↓
Scientific Law

Scientific Theory

Definition
A theory explains why patterns occur.

It is based on:
- Testing
- Experiments
- Evidence



Example Atomic Theory

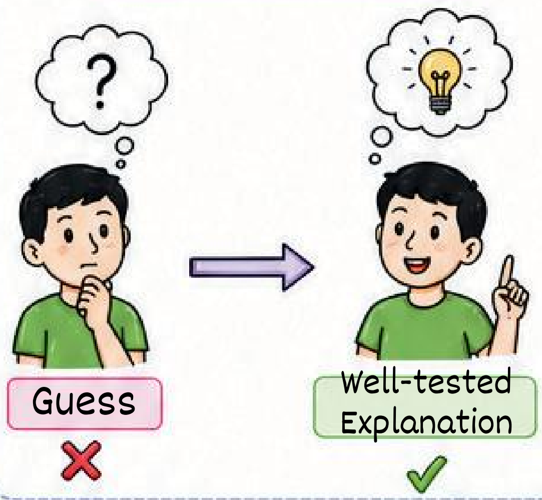
Evidence
↓
Experiments
↓
Testing
↓
Theory

Important Note

A scientific theory is NOT:

✗ A guess

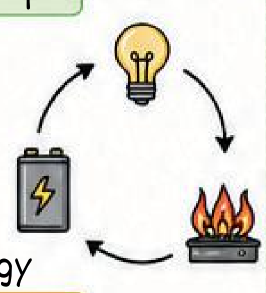
✓ Well-tested explanation



Scientific Principle

Definition
A broad idea used to understand situations.

Example
Principle of Conservation of Energy



Energy
↓
Changes Form
↓
Not Destroyed

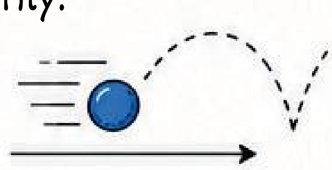
Difference

Law	Theory	Principle
Describes what happens	Explains why it happens	General guiding idea

LAW ⟷ THEORY ⟷ PRINCIPLE

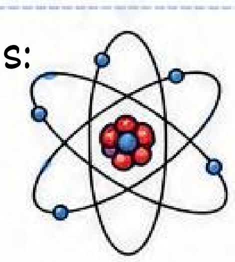
Q1 A scientific law mainly:

A. Explains
B. Predicts only
C. Describes patterns ✓
D. Guesses



Q2 Atomic theory explains:

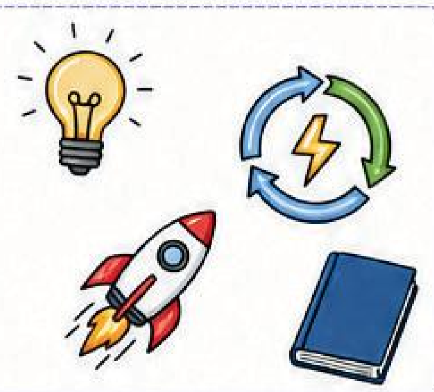
A. Why molecules form ✓
B. Weather
C. Gravity
D. Magnetism



QUICK REVISION MAP

Scientific Knowledge

Law	Theory	Principle
↓	↓	↓
What	Why	Guiding Idea



SCIENTIFIC PREDICTIONS

Definition

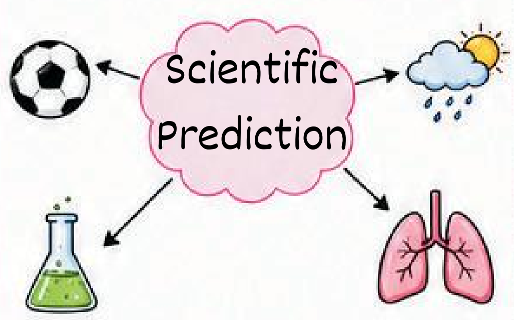
Scientific prediction is a reasoned expectation based on evidence, laws, theories, and models.

Evidence → Laws → Theories → Models → Prediction

Examples

Scientists predict:

- Motion of football
- Weather
- Chemical products
- Breathing changes



Characteristics

Predictions are:

- Evidence-based
- Testable
- Logical
- Measurable

Evidence → Logic → Testing → Measurement

When Predictions Fail

Scientists:

- Recheck observations
- Recheck measurements
- Recheck assumptions

Prediction Fails → Observations → Measurements → Assumptions → Improved Prediction

Weather Forecasts

Sometimes fail because weather depends on:

- Temperature
- Humidity
- Pressure
- Wind

Tiny changes can create very different outcomes.

Temperature → Pressure → Humidity → Wind → Forecast

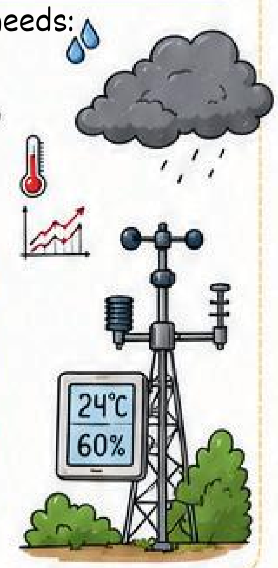
Example 1.2

Dark clouds alone are not enough.

Scientific prediction needs:

- Humidity data
- Wind data
- Temperature data
- Previous patterns

Dark Clouds → Not Enough → Need Data → Prediction

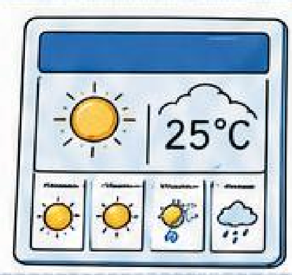


Q1 Scientific predictions are based on:

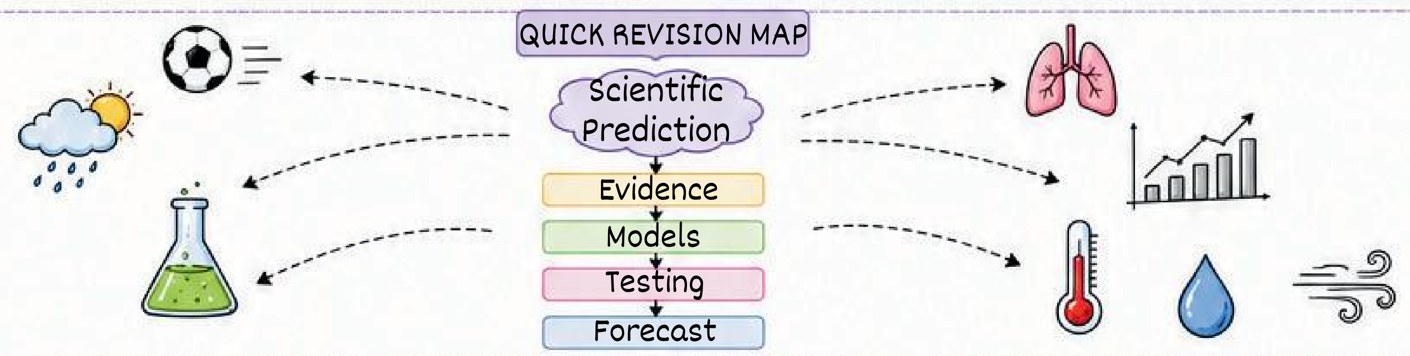
A. Luck
B. Guesswork
C. Evidence ✓
D. Belief

Q2 Weather forecasts use:

A. Magic
B. Models and measurements ✓
C. Stories
D. Assumptions only



QUICK REVISION MAP



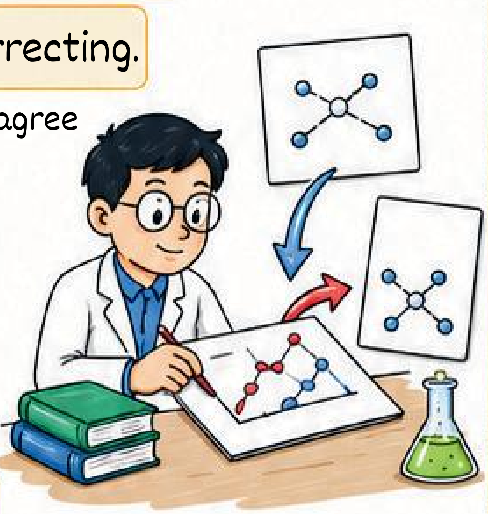
SELF-CORRECTING NATURE OF SCIENCE

Important Concept

Science is self-correcting.

When observations disagree scientists:

- Change theories
- Improve models
- Collect more evidence



Observation → Disagreement → New Evidence → Improved Science

Key Feature

- No scientific theory is final.
- Every idea can be questioned.

Theory → Question → Testing → Improvement

Example

Eclipse Food Myth

Claim:
❌ "Food becomes harmful during eclipse."

Scientific Analysis Shows

- No physical change
- No chemical change
- No biological mechanism

Food During Eclipse → Physical Test → Chemical Test → Biological Test → No Change Found

Conclusion

Myth ❌ → Evidence ✓

Claim → Evidence Check → Unsupported

Q1 Science changes ideas based on:

A. Beliefs
B.Opinios
C. Evidence ✓
D. Tradition

QUICK REVISION MAP

Science → Observation → Evidence → Testing → Correction → Better Understanding

ESTIMATION IN SCIENCE

Definition

Estimation is finding an approximate answer that is close enough for practical use.

Importance

Estimation helps:

- ✓ Detect mistakes
- ✓ Build intuition
- ✓ Save time
- ✓ Check reasonableness

ESTIMATION

Example

- Rice needed for a family.
- Exact value unnecessary.
- Approximation gives useful understanding.

Exact Count ✗ → Approximate Amount ✓

Air Breathed Per Day

- Breaths per minute ≈ 12–15
- Breaths per day ≈ 20,000
- Volume per breath ≈ 0.5 L

12–15 breaths/min
↓
≈ 20,000 breaths/day
↓
0.5 L per breath
↓
Therefore:
Air per day ≈ 10,000 litres

Important Formula Used

Minutes per day

$= 24 \times 60$

$= 1440$

MCQs

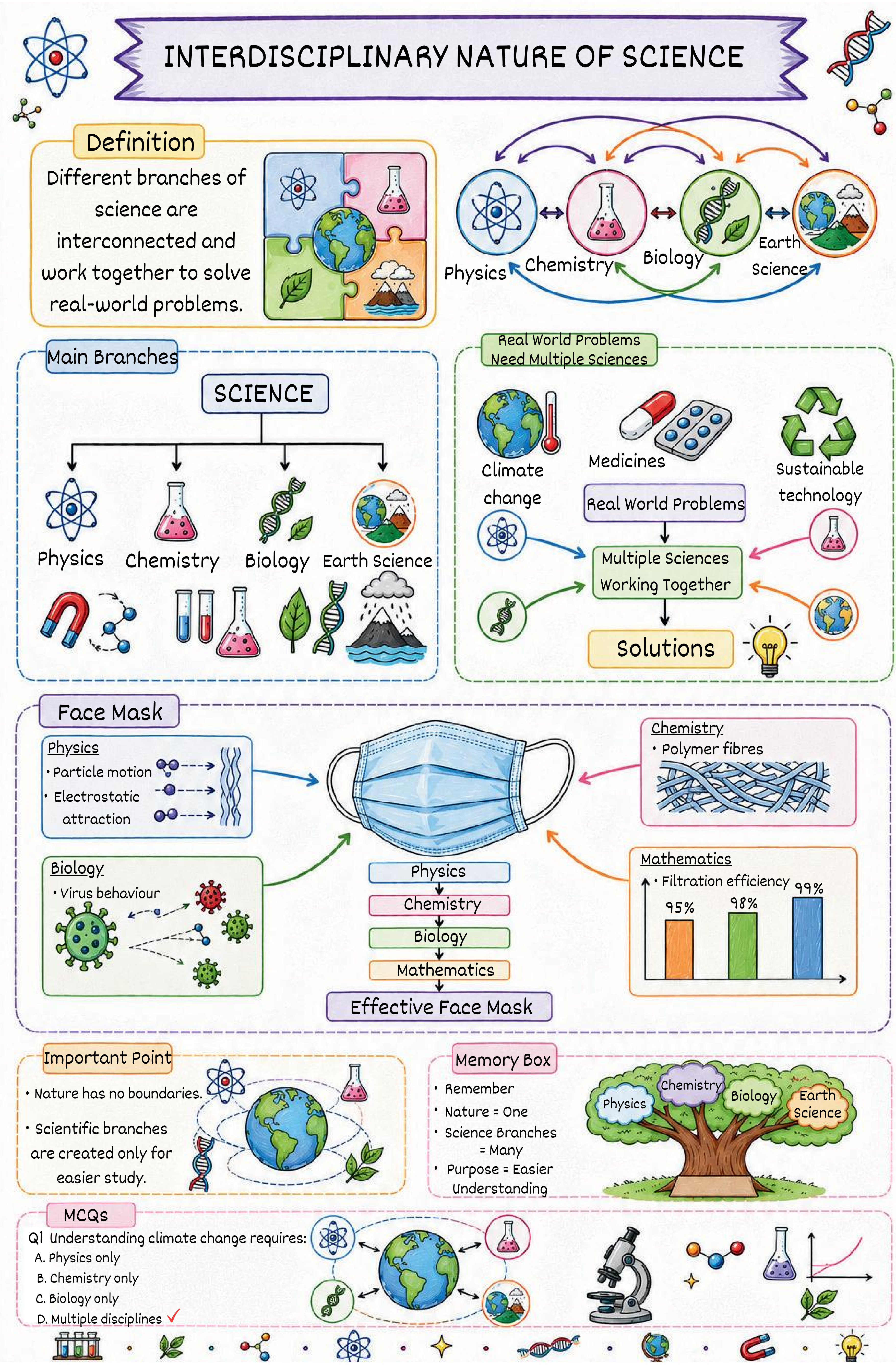
Q1 Estimation provides:

A. Exact answer
✓ B. Approximate answer
C. Wrong answer
D. Guess only

Q2 Approximate air breathed daily is:

A. 100 L
B. 1000 L
C. 10,000 L ✓
D. 1,000,000 L

1 2 3


INTERDISCIPLINARY NATURE OF SCIENCE
Definition
Different branches of science are interconnected and work together to solve real-world problems.
Physics
Chemistry
Biology
Earth Science
Main Branches
SCIENCE
Physics
Chemistry
Biology
Earth Science
Real World Problems Need Multiple Sciences
Climate change
Medicines
Sustainable technology
Real World Problems
Multiple Sciences Working Together
Solutions
Face Mask
Physics
• Particle motion
• Electrostatic attraction
Chemistry
• Polymer fibres
Biology
• Virus behaviour
Physics
Chemistry
Biology
Mathematics
Effective Face Mask
Mathematics
• Filtration efficiency
95%
98%
99%
Important Point
• Nature has no boundaries.
• Scientific branches are created only for easier study.
Memory Box
• Remember
• Nature = One
• Science Branches = Many
• Purpose = Easier Understanding
Physics
Chemistry
Biology
Earth Science
MCQs
Q1 Understanding climate change requires:
A. Physics only
B. Chemistry only
C. Biology only
D. Multiple disciplines ✓

COMPETENCY-BASED / HIGHER ORDER QUESTIONS WITH SOLUTIONS

Q1. Why is a model necessary in science?

Solution:

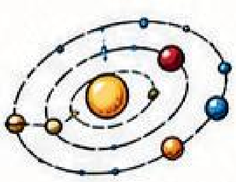
Real systems are complex. Models simplify reality by focusing on important details, making analysis and prediction easier.

Examples

- Earth – Simplified Globe Model
- Solar System Orbit Diagram
- Weather Forecast Model

Real World
↓
Complex System
↓
Model
↓
Easy Analysis
↓
Prediction






Q2. A student predicts rain because clouds are dark. Why is this not fully scientific?

Solution:

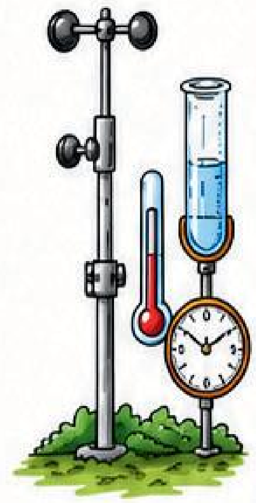
The prediction lacks measurable evidence.

Scientific prediction should include:

- Humidity
- Wind speed
- Pressure
- Past weather data

Flow

Prediction
↓
❌ Incomplete Evidence
↓
Humidity + Wind Speed + Pressure + Weather Data
↓
Scientific Prediction



Q3. Differentiate between a law and a theory.

LAW

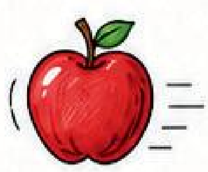
Describes what happens.

Example:

Newton's Law describes motion.

Flow:

Description
↓
LAW



THEORY

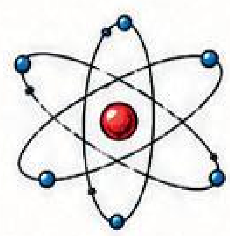
Explains why it happens.

Example:

Atomic Theory explains matter.

Flow:

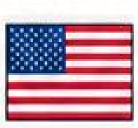
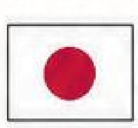
Explanation
↓
THEORY



Q4. Why are SI units important?

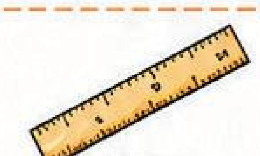
They ensure uniform measurements worldwide and prevent calculation errors.

- India
- USA
- Japan
- Germany


Flow:

Same SI Units
↓
Accurate Communication
↓
No Calculation Errors

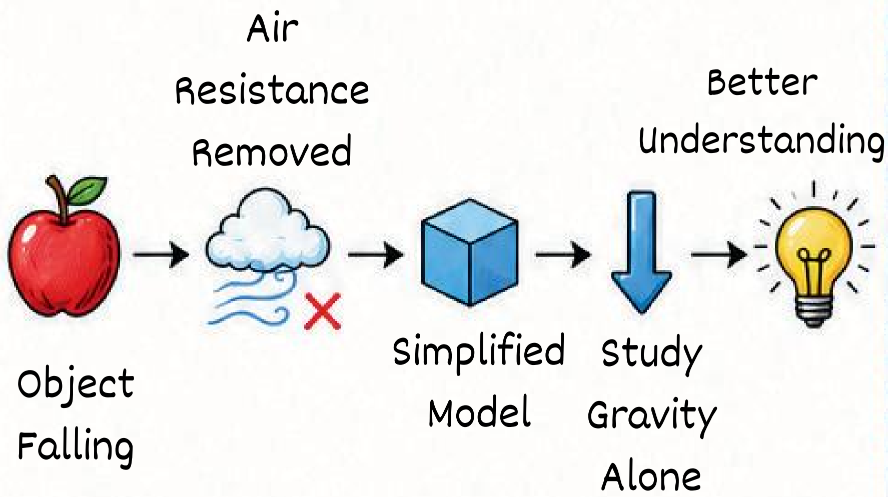



COMPETENCY-BASED / HIGHER ORDER QUESTIONS WITH SOLUTIONS

Q5. A scientist ignores air resistance while studying free fall. Why?

Solution: To simplify the model and understand the primary effect of gravity.

Flow

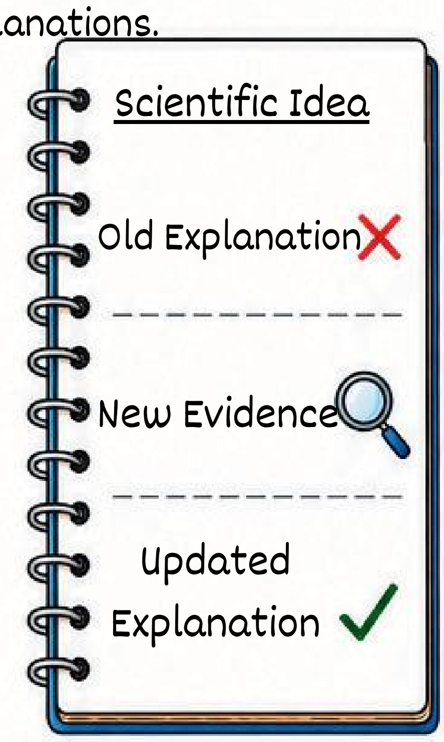


Q6. Why is science considered self-correcting?

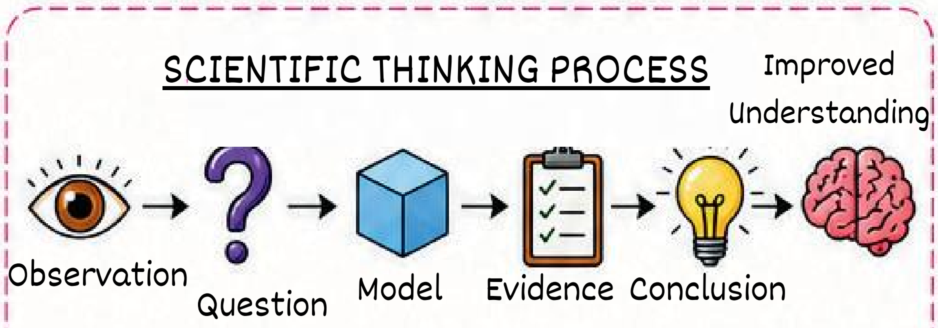
Solution:

Scientific ideas change when new evidence contradicts previous explanations.

Old Idea → New Evidence → Testing → Revision → Improved Scientific Idea



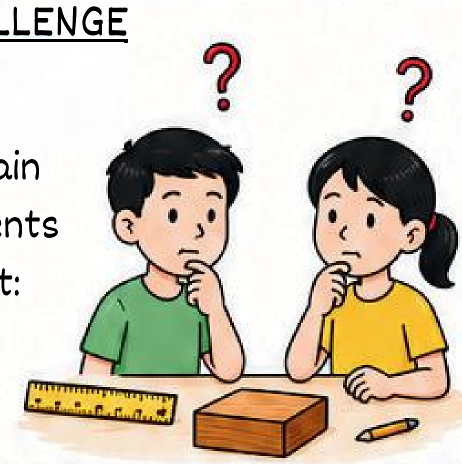
SCIENTIFIC THINKING PROCESS



COMPETENCY CHALLENGE

Think Like a Scientist

If two students obtain different measurements for the same object: What could be the reasons?

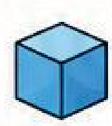


REMEMBER

✓ Laws describe.

✓ Theories explain.

✓ Models simplify reality.



✓ Evidence strengthens prediction.

✓ SI units standardize measurements.

Q7. Estimate the number of breaths taken in a day if breathing rate is 15 breaths/minute.

Solution

Breaths/day

= 15 × 60 × 24

= 21,600 breaths

15 breaths/min → 60 min/hour → 24 hours/day → 21,600 breaths/day

Answer = 21,600 breaths/day

Q8. One breath contains 0.5 L air. If a person takes 20,000 breaths/day, estimate air intake.

Solution

Air intake = 20,000 × 0.5

= 10,000 L

20,000 Breaths × 0.5 L Air → 10,000 L Air Intake

Answer = 10,000 litres/day

COMPETENCY-BASED / HIGHER ORDER QUESTIONS WITH SOLUTIONS

Q9. Why do weather forecasts become less reliable for distant dates?

Solution

Tiny differences in atmospheric conditions grow over time, increasing uncertainty.

Flow

Small Change → Atmosphere Changes → More Variations → Higher Uncertainty → Less Reliable Forecast

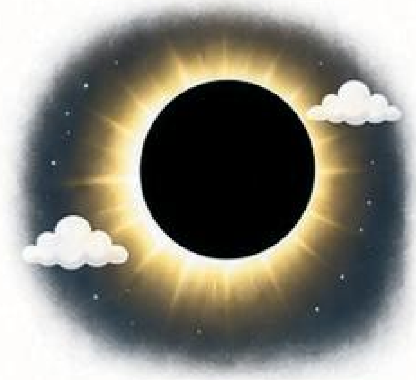
Time → Uncertainty Increases

Q10. Explain why eating food during an eclipse is not scientifically harmful.

Solution

An eclipse only creates a shadow. No physical, chemical, or biological mechanism makes food harmful.

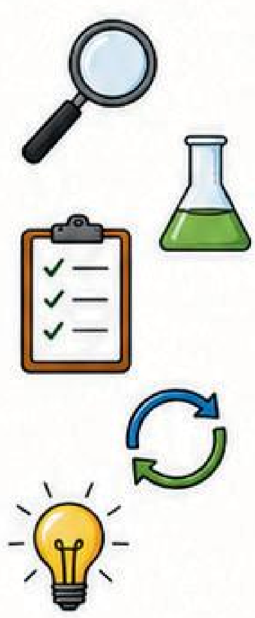
Eclipse → Shadow Formation → No Chemical Change → No Biological Change → Food Remains Safe



CRITICAL THINKING BOX

How Science Improves Knowledge

Observation → Evidence → Testing → Revision → Better Understanding



QUICK RECALL

- ✓ Science is self-correcting
- ✓ Evidence improves explanations
- ✓ Estimation gives practical answers
- ✓ Weather prediction has uncertainty
- ✓ Scientific claims require mechanisms

THINK LIKE A SCIENTIST

Question

Why might two weather models give different predictions for the same day?