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Name: _____ Class: _____ Date: _____

SECONDARY 1 · SCIENCE · THE SCIENTIFIC ENDEAVOUR

The Scientific Endeavour

Theory and worked examples

What is science about?

Science is a way of finding out about the natural world. It is not only done in a laboratory: a cook watching how dough rises, a farmer noticing which crops grow best and a child wondering why a rainbow forms are all asking scientific questions. Science is a human endeavour, which means people from every civilisation have added to it over the centuries. For example, the Chinese invented the magnetic compass and paper, Arab scholars such as Ibn al-Haytham studied how light and vision work, and Indian mathematicians developed the number zero.

KEY IDEA

Scientific knowledge is built from systematic evidence and careful reasoning. Evidence can be quantitative (numbers) or qualitative (descriptions).

- Evidence can be gathered with our senses (sight, hearing, smell, touch). Never taste chemicals in the laboratory.
- Instruments extend our senses: a thermometer measures hotness more exactly than touch, and a microscope lets us see things too small for the eye.

WORDS TO KNOW

evidence	information gathered from observations and measurements that is used to support an idea
quantitative	evidence given as numbers or measurements, with units, e.g. 25 cm or 3.4 s
qualitative	evidence described in words without numbers, e.g. colour, smell, texture, shape

	Quantitative evidence	Qualitative evidence
Form	numbers with units	words and descriptions
Example	The water temperature rose from 28 °C to 64 °C.	The water became hot and the glass fogged up.
Gathered by	instruments (ruler, balance, stopwatch)	senses (sight, smell, touch) or instruments

WORKED EXAMPLE

A pupil heats a piece of wax in a beaker. She records: (1) The wax melted after 95 s. (2) The wax changed from a white solid to a clear liquid. (3) The wax has a waxy smell. Which of her records are quantitative?

1. Quantitative evidence is given as a number with a unit, usually from a measuring instrument.
2. Record (1) has a number and a unit (95 s), so it is quantitative.
3. Records (2) and (3) describe colour, state and smell in words, so they are qualitative.

Only record (1) is quantitative because it gives a measurement (95 s). Records (2) and (3) are qualitative.

TRY THIS

Is 'the rod felt rough' qualitative or quantitative?

Answer: Qualitative (a description of texture, with no number).

Scientific inquiry: the steps of an investigation

Scientific knowledge comes from cycles of observation, experiment and analysis, and also from human imagination and creativity. Scientists use scientific inquiry skills to find answers: posing questions, planning and carrying out investigations, evaluating results and communicating their findings. The steps are usually followed in the order below, and the cycle may start again with a new question. The same evidence can sometimes be explained in more than one way, so scientists discuss and test different interpretations. When new evidence is found, an explanation may change, so scientific knowledge is always open to change.

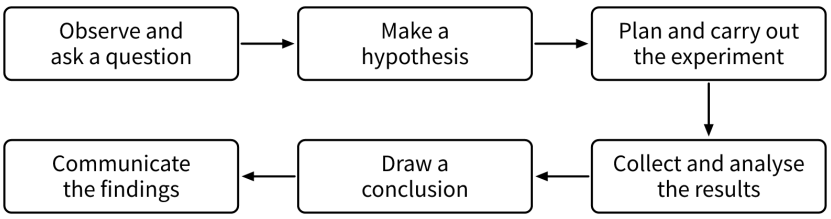
KEY IDEA

A good investigation starts with a question, tests a hypothesis fairly, and ends with a conclusion based on the evidence. Scientific knowledge is not fixed: it can change when new evidence is found.

- Planning includes choosing the apparatus, what to change, what to measure and what to keep the same, and thinking about safety.
- Evaluating means checking whether the method was fair and the results were reliable, and suggesting improvements.
- Communicating means sharing findings clearly, for example with a table, a graph and a written conclusion.
- A conclusion must always be supported by the evidence. An experiment is a test carried out to collect evidence under controlled conditions; analysis means studying the evidence to find the pattern it shows.

WORDS TO KNOW

investigation	a planned way of finding out the answer to a scientific question
hypothesis	a testable prediction about how one thing affects another, which can be supported or rejected by evidence



TRY THIS

Why can scientific explanations change over time?

Answer: New evidence may be found that does not fit the old explanation, so scientists improve or replace it.

Variables and the fair test

A variable is anything that can change in an investigation. In a fair test, only one variable is changed on purpose. The other variables are kept the same, so that any change in the results can only be caused by the variable that was changed.

KEY IDEA

Change one (independent), measure one (dependent), keep the rest the same (controlled).

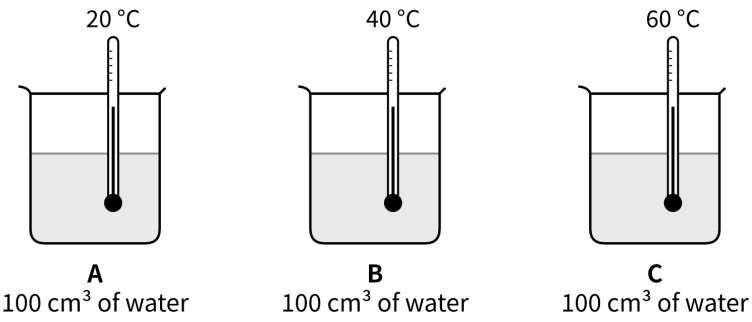
WORDS TO KNOW

independent variable	the variable that you change on purpose
dependent variable	the variable that you measure; it depends on the independent variable
controlled variable	a variable that you keep the same (constant) so that the test is fair
fair test	a test in which only the independent variable is changed

Variable	What it is	Example: how the temperature of water affects the time a sugar cube takes to dissolve
Independent	what you change	temperature of the water
Dependent	what you measure	time taken for the sugar cube to dissolve
Controlled (constant)	what you keep the same	volume of water, size of the sugar cube, stirring

WORKED EXAMPLE

Hamid wants to find out how the temperature of the water affects how fast a sugar cube dissolves. He uses three beakers of water, A, B and C, as shown, and adds one sugar cube to each. State the independent variable, the dependent variable and two variables he must keep the same. Then state a suitable hypothesis.



1. Independent variable: the one Hamid changes on purpose. The beakers differ only in the temperature of the water.
2. Dependent variable: the one he measures to see the effect, which is the time taken for the sugar cube to dissolve.
3. Controlled variables: things that could also change the dissolving time, such as the volume of water, the size of the sugar cube and how much the water is stirred.
4. Hypothesis: a testable prediction that links the independent and dependent variables.

Independent variable: the temperature of the water. Dependent variable: the time taken for the sugar cube to dissolve. Controlled variables (any two): volume of water, size (mass) of the sugar cube, stirring. Hypothesis: the higher the temperature of the water, the shorter the time taken for the sugar cube to dissolve.

TRY THIS

In an investigation on how the height of a ramp affects the time a toy car takes to roll down it, which variable is the dependent variable?

Answer: The time taken for the toy car to roll down the ramp (the height of the ramp is the independent variable).

Hypotheses, control set-ups and conclusions

A hypothesis is a testable prediction. It names the independent and dependent variables and says how they are linked. It is made before the experiment, so it must not quote results. A control set-up is a set-up in which the independent variable is not changed or applied (for example a plant given no fertiliser). It is used for comparison, to show that the effect really is caused by the independent variable. A conclusion is written after the experiment. It states what the results show and whether the hypothesis is supported or not supported.

KEY IDEA

A hypothesis is a prediction made before the test. A conclusion is a statement based on the results, made after the test.

Type of statement	Example (fertiliser and bean plants)	Right for a hypothesis?
Aim or question	To find out how fertiliser affects the height of bean plants.	No. It is an aim, not a prediction.
Weak hypothesis	Fertiliser is good for plants.	No. It does not name the variables or say how they are linked.
Good hypothesis	The more fertiliser given, the taller the bean plants grow.	Yes. It is testable and links the two variables.
Conclusion	Plants given 4 g of fertiliser grew 18 cm, taller than those given 0 g (9 cm). The hypothesis is supported.	No. It uses results, so it comes after the experiment.

WORKED EXAMPLE

Wei Lin grows bean seeds to find out if fertiliser makes them grow taller. The table shows how she set up the two pots. State two things that make her test unfair, and say what the pot with no fertiliser is called.

	Pot X	Pot Y
Fertiliser	none	5 g
Volume of water each day	40 cm^3	80 cm^3
Position	sunny window	dark cupboard
Type of soil	same	same
Type of seed	bean	bean

1. In a fair test, only the independent variable (fertiliser) should differ between the pots.
2. Compare each row: the volume of water and the position also differ, so these variables were not controlled.

CHAPTER 1

Practice Questions

Part 2: The Scientific Endeavour



In the practice questions

23 questions, 61 marks. For each multiple-choice question, write the letter of the correct option (A, B, C or D) in the brackets. Write your other answers on the lines given. The answers are on page 293.

- Section A: Multiple-Choice Questions: 15 questions, 15 marks
- Section B: Structured Questions: 6 questions, 29 marks
- Section C: Free-Response Questions: 2 questions, 17 marks

Name: _____ Class: _____ Date: _____

SECONDARY 1 · SCIENCE · THE SCIENTIFIC ENDEAVOUR

The Scientific Endeavour

INSTRUCTIONS

- 23 questions, 61 marks in total.
- Answer all questions in the spaces provided.
- For MCQs, write the letter (A, B, C or D) in the brackets.
- Write your other answers on the lines given, in full sentences.

Section A: Multiple-Choice Questions

1 Which of these observations is qualitative evidence? ( ) [1]

(A) The leaf is 6.2 cm long.
(B) The solution turned pale green.
(C) The beaker has a mass of 48 g.
(D) The water boiled after 4 min.

2 Jia Hui writes four steps of a scientific investigation.
P: Make a hypothesis.
Q: Draw a conclusion.
R: Observe something and ask a question.
S: Plan and carry out the experiment.
In which order should the steps be carried out? ( ) [1]

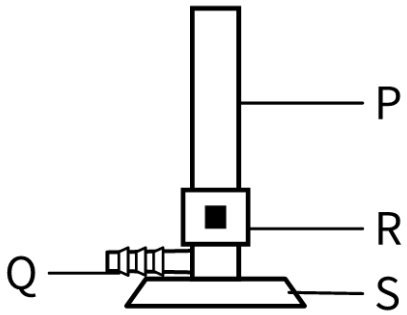
(A) P, R, S, Q (B) R, S, P, Q (C) S, R, P, Q (D) R, P, S, Q

3 A bottle in the laboratory carries the hazard symbol shown. Which precaution is the most important when using it? ( ) [1]



(A) Keep it away from naked flames.
(B) Keep it away from magnets.
(C) Store it on a sunny window ledge.
(D) Shake it well before use.

4 The diagram shows a Bunsen burner. Which part is turned to open or close the air hole? ( ) [1]



Ⓐ P Ⓑ Q Ⓒ R Ⓓ S

5 Which of these lengths is equal to 1.5 m? ( ) [1]

Ⓐ 15 mm Ⓑ 150 cm Ⓒ 1500 cm Ⓓ 0.015 km

6 Which of these are SI base units?

1 kilogram
2 gram
3 second
4 minute

( ) [1]

Ⓐ 1 and 3 only Ⓑ 2 and 3 only Ⓒ 2 and 4 only Ⓓ 1, 3 and 4 only

7 Mei Ling investigates how the mass of salt added to 200 cm^3 of water affects the boiling point of the water. What is the dependent variable? ( ) [1]

Ⓐ the mass of salt added
Ⓑ the volume of water
Ⓒ the type of beaker used
Ⓓ the boiling point of the water

8 Ravi investigates how the surface area of a paper parachute affects the time it takes to fall to the ground. Which statement is a hypothesis? ( ) [1]

Ⓐ To find out how the surface area of a parachute affects the time it takes to fall.
Ⓑ Paper parachutes are fun to make and test.
Ⓒ The larger the surface area of the parachute, the longer the time it takes to fall.
Ⓓ The parachute with the largest surface area took 3.2 s to fall.

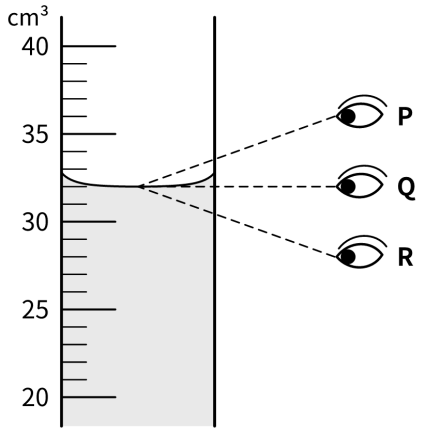
9 Dr Tan's results did not support her hypothesis. She reported the results exactly as she measured them and changed her explanation to fit the new evidence. Which scientific attitudes did she show? ( ) [1]

(A) integrity and open-mindedness
(B) creativity only
(C) perseverance only
(D) creativity and perseverance

10 Which of these are safe ways to heat a liquid in a test tube?
1 Point the mouth of the test tube away from everyone.
2 Fill the test tube almost to the top.
3 Hold the test tube with a test-tube holder.
4 Hold the test tube upright, not at a slant. ( ) [1]

(A) 1 and 2 only (B) 1 and 3 only (C) 2 and 4 only (D) 1, 3 and 4 only

11 The diagram shows part of a measuring cylinder containing water, and three eye positions P, Q and R. Which eye position should be used, and what is the volume of the water? ( ) [1]



(A) P; 32 cm³ (B) R; 31 cm³ (C) Q; 33 cm³ (D) Q; 32 cm³

12 An electronic balance reads −0.2 g when nothing is on its pan. With a beaker on the pan, it reads 64.5 g. What is the actual mass of the beaker? ( ) [1]

(A) 64.3 g (B) 64.5 g (C) 64.7 g (D) 66.5 g

13 A thermometer always reads 1 °C higher than the true temperature. Which statement about this error is correct? ( ) [1]

(A) It is a systematic error, and repeating the readings does not remove it.
(B) It is a random error, and repeating the readings removes it.
(C) It is a systematic error, and taking an average removes it.
(D) It is a random error, caused by a slow reaction time.