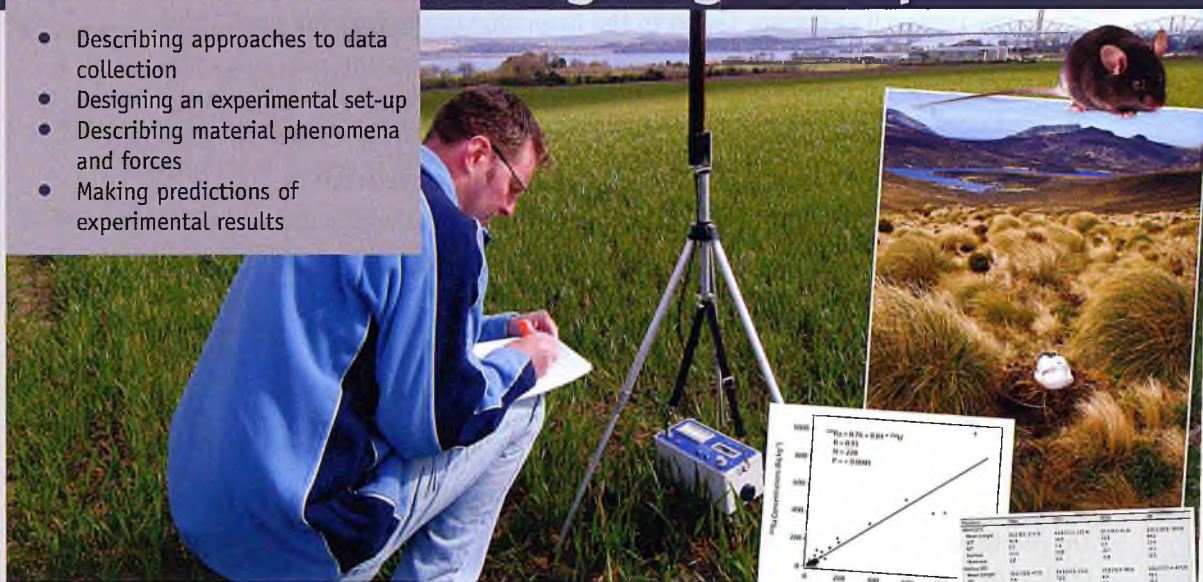


UNIT 4

Designing an experiment

- Describing approaches to data collection
- Designing an experimental set-up
- Describing material phenomena and forces
- Making predictions of experimental results



Describing approaches to data collection

- 1 a** The scientific method is a process in which experimental observations are used to answer questions. Complete the collocations for describing the stages in the scientific method using the words and phrases in the box.

a hypothesis an experiment (x2) conclusions data (x3) the question

- | | |
|---|--|
| ☐ analyse _____ | ☐ design _____ |
| ☐ collect _____ | ☐ draw _____ |
| ☐ conduct (or run) _____ | ☐ form _____ |
| ☐ define _____ | ☐ interpret _____ |

- b** Number the stages (1–8) in the order you would normally do them.

- c** Read this extract from a student website and check your answers to Exercise 1b.

The scientific method is a process in which experimental observations are used to answer questions. Scientists use the scientific method to search for relationships between items. That is, experiments are designed so that one variable is changed and the effects of the change observed. While the exact methodologies used vary from field to field, the overall process is the same. First, the scientist must define the question – what exactly they are trying to find out. Next comes the formation of a hypothesis, which is an idea or explanation for a situation based on what is currently known. The next stage of the method is the design of an experiment which will allow this hypothesis to be tested. Usually a primary run of the experiment is conducted, and any changes to the experimental set-up made. In each experimental run, data collection takes place, followed by data analysis. Finally the data is interpreted and from this, the scientist is able to draw conclusions.

- d Read the extract again to find the noun forms of the verbs in the box. Which word(s) in the box use(s) the same form for the verb and the noun?

analyse collect design explain form observe relate run vary

- 2 a Below are the summaries of five experiments. Read each summary and then choose which word correctly completes the heading.

1 **Practical / Theoretical research**

Murray Gell-Mann and George Zweig proposed that particles such as protons and neutrons were not elementary particles, but instead were composed of combinations of quarks and antiquarks.

2 **Field / Laboratory experiment**

Mark-and-recapture models were used to measure seasonal and habitat changes in house mouse densities on sub-Antarctic Marion Island.

3 **External / Internal validity**

The students were carefully matched for social status, subject area, ethnicity, education level, parental smoking, and exposure to targeted advertising.

4 **Descriptive / Experimental study**

The amount of soy products eaten by each participant was assessed at the start of the study. During the 30 years of the study, the women's incidence of breast cancer was recorded.

5 **Qualitative / Quantitative research**

To investigate the effect of eating dark chocolate on stress levels, a blood sample was taken and the levels of stress hormones measured. After eating the chocolate, a second sample was taken and hormone levels measured again.



A proton may consist of *quarks* and *antiquarks*

- b In pairs, can you think of an example of an experiment which describes the alternative heading in 1–5 of Exercise 2a (for example, an experiment which is practical not theoretical)?

- 3 a Silvana is a research assistant working as part of a team investigating methods of storing hydrogen (H_2) for use as an energy source. In pairs, answer the following questions.

- 1 What do you think are the benefits of using hydrogen as an energy source?
- 2 In what situations or applications could hydrogen fuels be used?

- b Hydrogen could be an ideal energy source, but is difficult to store. In pairs, look at three possible methods of hydrogen storage below and discuss what you think the advantages and disadvantages of each one might be.

- a contained as a gas in a high-pressure tank
- b condensed into a liquid and stored in a tank
- c adsorbed onto a porous material

- c ► 4.1 Silvana is talking to her supervisor Dominique about the next phase in her research. Listen and answer the following questions.

- 1 Which method of hydrogen storage from Exercise 3b do they discuss?
- 2 What property of carbon fibres does Silvana think is most important to her research?
- 3 How many possible variables do they discuss?
- 4 At the end of the conversation, how does Dominique suggest Silvana should begin this phase of her research?

d ▶ 4.1 Listen to the conversation again and tick the variables Silvana agrees to investigate in the next phase of her research.

- | | |
|--|--|
| ☐ carbonisation temperature | ☐ type of hydroxide – potassium (KOH) |
| ☐ heating rate | ☐ or sodium (NaOH) |
| ☐ nitrogen flow rate | ☐ ratio of KOH or NaOH to carbon fibres |

e What reasons did Dominique give for *not* investigating all the possible variables? Do you agree with her?

f Complete the following summary on variables using the words in the box.

affects collecting controlled data dependent independent

How much a variable (1) _____ a relationship can be discovered by (2) _____ experimental (3) _____ on changes to the relationship as the variable is changed. In an experiment, there will be:

- one (4) _____ variable – this is the feature you are measuring
- one or more (5) _____ variables – these are the variables which you change
- one or more (6) _____ variables – these are not being tested and so they stay the same.

g Silvana wants to investigate the effect of the different hydroxides (NaOH or KOH) on hydrogen adsorption in the carbon fibres.

- 1 In this investigation, which of the variables in Exercise 3d will be independent and which controlled?
- 2 What will be the dependent variable?

4 a Look at the extracts (a–f) from Silvana and Dominique's discussion. Then answer the questions below.

- a Maybe you could look at the adsorption of hydrogen.
- b Perhaps I should look at the 1273 K and 973 K temperatures.
- c I could make different ratios of hydroxide to carbon fibres another variable.
- d Perhaps I could start with looking just at a couple of different ratios.
- e You might be able to just look at the papers you mentioned.
- f Maybe I'll have a talk to Mauritz about the adsorption protocols he's been using.

- 1 Do these sentences refer to the present or the future?
- 2 Are they used to discuss plans or suggestions?
- 3 What parts of speech are the underlined words?
- 4 What part of speech are the words in bold?

b In pairs, role play a discussion between a researcher and a supervisor about the effect of temperature and rainfall on the population of the mosquito *Aedes albopictus*. First, decide which type of experiment (from Exercise 2a) should be used to investigate the effects. Then discuss what the variables in the experiment might be. Use the language you studied in Exercise 4a to help you.



The Mosquito *Aedes albopictus*

Designing an experimental set-up

5 a Match the instruments (1–8) to the pictures (a–h).

1 calipers

2 dynamometer

3 geiger counter

4 interferometer

5 litmus paper

6 oscilloscope

7 seismograph

8 spectrometer



b What meaning do the following suffixes add to the words in Exercise 5a?

-graph -meter -scope

c 4.2 Match an instrument in Exercise 5a to what it measures. Then listen to the conversations and check your answers.

pH radiation changes in voltage over time light intensity distance torque motion wavelengths of light

d Do you take measurements as part of your research? What do you measure? What instruments do you use?

6 a Silvana is going to discuss her design for an experimental set-up with Mauritz, a more experienced researcher. In pairs, look carefully at Silvana's diagram and notes. Then discuss what words you think might complete the gaps (a–h).

Carbon Fibre (CF) (a) _____ plan

CF carbonised @ 1273 K or 973 K

activate CF with KOH or NaOH

ratio 4:1 & 10:1 based on (b) _____

1 Sample tray - use unreactive material, e.g. (c) _____ or (d) _____ (ask Mauritz)

2 Tube (e) _____

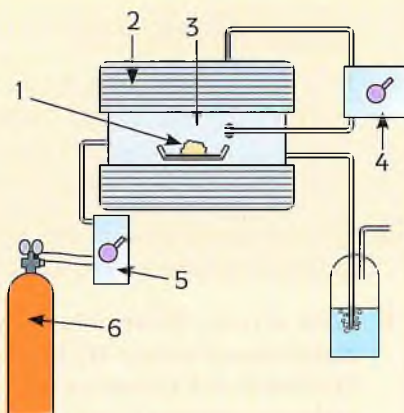
3 Inner tube - What material? What size? (ask Mauritz)

4 (f) _____ controller (for furnace)
Increase temperature 5 K/min. up to 1025 K - for how long? (ask Mauritz)

Maybe add (g) _____ mechanism later

5 Flow controller

6 (h) _____ flow - 500 ml/min.



- b** ▶ 4.3 Listen to Silvana and Mauritz talking. Complete each space in Silvana's notes using one word from their conversation.

- 7 a** Match the beginnings (1–7) to the endings (a–g) of some of Silvana's sentences from the conversation. Then look at Audioscript 4.3 on page 95 to check your answers.

1 I'm going to	a have the sample on a tray in an inner tube.
2 I was thinking of	b simply mixing the fibres with the hydroxides in pellet form, at the relevant ratios.
3 I think I'll try	c relying on natural convection first.
4 I thought I should	d running it through at 500 ml a minute, through the entire heat treatment.
5 I'm planning to	e start off with fibres which have been carbonised at two different temperatures.
6 I'll try	f stick with that.
7 I was planning on	g using those quantities first.

- b** Phrases 1–7 in Exercise 7a can all be used to discuss future plans. In pairs, answer the following questions.

- Which phrases can we use to sound more confident about a future plan? Which are used to sound more tentative (i.e. less confident, more cautious)? Divide the phrases into two groups (more confident and more tentative).
- Which phrases are followed by the INFINITIVE? Which are followed by a VERB-*ing* form?

- 8 a** ▶ 4.4 In her notes in Exercise 6a, Silvana had four questions for Mauritz. Listen to an extract from the conversation and answer the questions.

Sample tray: ceramic or steel? Use (1) _____

Inner tube: what material? Use (2) _____

what size? length (3) _____ m/diameter _____ cm

Keep temperature constant for (4) _____ minutes

- b** Look at the responses Mauritz gives Silvana. Put a verb from the box into the space in each sentence. What is the function of these sentences?

don't think were would

- If I _____ you, I'd use steel.
- Why _____ you try that to start with?
- I _____ use less than 10 cm.
- I _____ you should maintain the temperature for 75 minutes.

- 9 a** Think of an experiment you are planning to do or would like to do in the future. Draw and label a sketch of the set-up as you plan it.
- b** Work in pairs. Student A, use your sketch to explain your plans for the experimental set-up. Try to use some of the phrases in Exercise 7a. Student B, ask questions for clarification (be sure to interrupt politely) and make suggestions if you can. Try to use some of the phrases in Exercise 8b. Then change roles.

Describing material phenomena and forces

- 10 a Complete the table below using the extract from the following research paper to help you.

A promising candidate among the different adsorbent materials are activated carbons. Through activation, highly porous materials can be prepared. Due to their high porosity, activated carbon materials are able to adsorb large amounts of hydrogen. Following adsorption, hydrogen molecules can be found at two possible locations: (i) on the surface of the adsorbent, or (ii) as a compressed gas in the void space between adsorbent particles.
adapted from Konowsky *et al.* 2009

noun	verb	adjective
compression	compress	
	adsorb	
	activate	
		porous

- b In pairs, answer the following questions.

- 1 What noun suffixes are used in the words in the table? Can you think of other words with these suffixes?
- 2 What adjective suffixes are used in the words? Can you think of other words with these suffixes?
- 3 Why is it useful to know the suffixes for different parts of speech?

- c The gapped words below all describe physical or chemical properties of substances. The meaning of each word is given on the right. Complete the words with the correct vowels (a, e, i, o, u).

1 br_ttl_n_ss	how easily something can be broken
2 c_p_c_t_nc_	how well something holds an electrical charge
3 c_nc_ntr_t_n	how much of one substance is found in another
4 c_nd_ct_v_ty	how well something allows heat or electricity to go through it
5 d_ns_ty	how much mass a given volume of a substance has
6 fl_mm_b_l_ty	how easily something burns
7 l_m_n_nc_	how much light passes through or comes from a substance
8 m_ss	how much matter is in a solid object or in any volume of liquid or gas
9 p_rm_ _b_l_ty	how easily gases or liquids go through a substance
10 p_r_s_ty	how many small holes are in a substance
11 pr_ss_r_	how much force a liquid or gas produces when it presses against an area
12 r_ _ct_v_ty	how easily a chemical substance reacts
13 s_l_b_l_ty	how easily something can be dissolved to form a solution
14 v_l_c_ty	how quickly an object is travelling
15 v_sc_s_ty	how thick a liquid is
16 v_l_m_	how much space is contained within an object or solid shape

- d In pairs, answer the following questions.

- 1 Which is more **reactive**, aluminium or gold?
- 2 Which is more **brittle**, glass or steel?
- 3 Which is more **luminescent**, copper or neon?
- 4 Which is more **dense**, hydrogen or oxygen?
- 5 Which is more **flammable**, ethanol or water?
- 6 Which is more **viscous**, blood or water?

- e Look at the adjectives in bold in Exercise 10d and the related noun forms in Exercise 10c. Divide the suffixes in the box below into those which usually indicate a noun form and those which are used in adjective forms.

-able -ance -bility -ent -ity -ive -ness -osity -ous -tion

noun suffixes: _____

adjective suffixes: _____

- f In pairs, mark the following statements true (T) or false (F).

- 1 To **concentrate** a solution, add more solvent. To dilute it, add more solute. _____
- 2 Copper **conducts** heat better than aluminium. _____
- 3 Silver salts do not **dissolve** well in water. _____
- 4 Water can **permeate** limestone more easily than it can granite. _____

- g Match the verbs in bold in Exercise 10f to the correct noun forms in Exercise 10c.

- h Choose the correct word to complete the sentences.

- 1 It is possible to **extraction/extract/extracted** hydrogen from a widespread source – water.
- 2 A dye appears coloured because its molecules **absorb/absorbent/absorption** light from a part of the visible spectrum.
- 3 Pewter is an alloy of usually 80% tin and 20% lead. Adding the lead gives the alloy a blueish tinge and increases the **malleability/malleable**.
- 4 In the near-infrared waveband the **reflective/reflect/reflectivity** of water drops to almost zero.
- 5 New analyses on Antarctic samples have found no **detect/detectable/detection** iridium imprint above background due to cosmic dust.

11

Think of three different materials you often use in your research. Explain to a partner the physical or chemical properties of the materials and how you use them in your research.

Making predictions of experimental results

12

- a ► 4.5 Silvana is about to start running her experiment. She is discussing possible results with Dominique. Listen to the conversation and say which of the three variables below Silvana thinks will *not* improve H_2 adsorption.

- carbonisation temperatures
- ratio of hydroxide to carbon fibres
- the type of hydroxide (KOH or NaOH)

- b ► 4.5 Complete Silvana's predictions from the conversation using the words and phrases in the box. Then listen again to check your answers.

allow any between expect If lead to more My prediction is that will probably

- (1) _____ lower temperatures increase porosity, the fibres which are carbonised at lower temperatures (2) _____ adsorb (3) _____ hydrogen.
- I really don't (4) _____ there to be (5) _____ difference (6) _____ the sodium and potassium hydroxides.
- (7) _____ the higher ratio will (8) _____ better activation of the fibres and I think better activation will (9) _____ more adsorption.

- 13 a Sentences like prediction (a) in Exercise 12b are useful for talking about the relationship between a possible situation and the expected result of that situation. Read the following sentence and then answer the questions below.

If/When the fibres are more porous, they adsorb more hydrogen.

- 1 Which part of the sentence tells us about a possible situation?
- 2 Which part tells us about the result of that situation?
- 3 Can you rewrite the sentence with 'Fibres' as the first word?

- b Now look at four more sentences and answer the questions which follow.

- a If/When the fibres are more porous, they **adsorb** more hydrogen.
- b If the fibres are more porous, they **will adsorb** more hydrogen.
- c If the fibres are more porous, they **will probably adsorb** more hydrogen.
- d If the fibres are more porous, they **might adsorb** more hydrogen.

- 1 What is the difference in meaning between:
a sentences a and b? b sentences b and c? c sentences b and d?
- 2 Does the tense of verb change in the *if*-clause in sentences a–d?

- 14 Look at the description of the experiment below. Note down your predictions about what will happen at each stage.

- 1 Hang a 1 m length of string to a fixed point. Tie a weight to the end. Pull the string back to the release point (a 45° angle) and time how long it takes to swing forward and back 5 times. Add a second weight and repeat. Make sure the release point is the same.

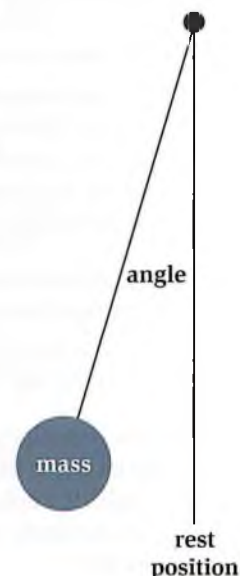
Prediction: _____

- 2 Pull the string back to an angle of 90°. Release and time how long it takes for 5 swings. Change the release angle to 20° and repeat. Make sure the weight used is the same.

Prediction: _____

- 3 Shorten the string to $\frac{2}{3}$ of its original length. Pull the string back to 45°. Release and time how long it takes for 5 swings. Shorten the string again to $\frac{1}{3}$ of its original length and repeat. Make sure the weight and release angle are the same.

Prediction: _____



- 15 Look back at the experimental set-up you sketched in Exercise 9a. Make notes on your predictions of what will happen in the experiment. Then, explain your predictions to a partner.