

**SUGGESTED TEXTBOOK ANSWERS****Chapter 1 Investigating scientifically**

The following are suggested answers only. Other answers to the same question may also be correct.

**Science inquiry****Activity 1.1 Validating Pasteur's experiment****Studying your results**

- 1 Describe your results, giving a description of the broth in each flask.

*Answer:* Responses will vary.

However, it is expected that the broth in the flask with the S-shaped tubing will remain clear, while that in the flask with straight tubing will become cloudy.

- 2 Combine your results with those of other groups in the class. What is the advantage of combining results?

*Answer:* More results increase the reliability of the overall experiment. The more repetitions of the experiment the lower the risk of uncontrolled variables making an impact on the data/observations.

- 3 Were your results similar to Pasteur's? Were the class results similar to Pasteur's?

*Answer:* Responses will depend on the actual results; however, if done carefully, the experiment should yield results similar to Pasteur's.

- 4 If your results were not similar to Pasteur's, can you suggest any explanation?

*Answer:* Explanations could include the following.

- Different location compared with Pasteur's original experiment
- Broth is different from that used by Pasteur
- Temperature of broth may have been different
- Boiling the flasks may not have destroyed all micro-organisms
- Bacterial and fungal spores in the air different from those that Pasteur encountered.

- 5 If you were to repeat the experiment, how could you improve it?

*Answer:* Improvements could be:

- making sure that all measurements are accurate and precise
- leaving the flasks at a predetermined temperature that is controlled throughout the experiment
- controlling the environment; for example, making sure there is no animal or human contact
- sterilising the flasks in a pressure cooker/autoclave to make sure all spores are killed.

## Activity 1.2 Researching for Mightypharm

### Stage 1

Propose a hypothesis linking the two variables (chemical compounds and effect on bacteria). Describe how you would test the hypothesis to find out whether any of the compounds are effective in killing bacteria. Make your description detailed enough for someone else to follow and carry out the same tests that you propose. Describe how you would present your results and what sort of result would indicate that a compound had potential for use as an antibiotic.

*Answer:*

- Hypothesis: Compound A from the Brazilian toadstool will inhibit bacterial growth.
- Method: This could be tested using agar plates inoculated with various bacteria. A disc containing Compound A could then be placed in the centre of each plate.
- Results: If Compound A inhibits bacterial growth, there will be a ring of clear agar (no bacterial growth) around the disc. The wider the clear area, the greater the effect of the compound.
- Students may suggest a range of other methods, such as adding liquid containing Compound A to agar plates with bacterial species, or adding the liquid to bacterial cultures in test tubes.

### Stage 2

Suppose that one of the compounds tested in stage 1 showed promise as an antibiotic. Describe how you would test that compound on animals to find out whether it worked and whether there were any side effects from use of the compound. Make your description detailed enough for someone else to follow your procedure exactly, and remember there are ethical considerations relating to the use of animals in research.

*Answer:*

- Inject rats, mice or other test animals with bacteria. Wait for symptoms of disease to develop. Inject Compound A in varying doses into some test animals; other test animals to be kept as controls.
- Compare the test animals with the controls to determine whether there are any side effects associated with use of Compound A.

*Ethical considerations:*

- Minimise any harm and suffering to the test animals.
- Decide whether Compound A shows sufficient promise as an antibiotic to justify experimenting with it on test animals.
- Decide whether, despite any adverse effects on the test animals, the outcome will be for the greater good.

### Stage 3

The promising compound has successfully passed stages 1 and 2. Describe how you would carry out human trials on the compound. Also, describe how you would deal with any ethical issues that may arise.

*Answer:*

Repeat stage 2, but using human subjects. Perform a double blind experiment. All subjects to have bacterial infections to be as similar as possible in age, fitness and so on. To half the subjects, give antibiotic doses that were optimal on test animals, but take into account human body mass. To the other half of the subjects, give a placebo that looks identical to the antibiotic. Neither the experimenters nor the subjects are to know who is getting the antibiotic and who is getting the placebo.

*Ethical considerations:*

- Make subjects aware of the procedure and the possible risks; gain informed consent.
- Subjects must be of an appropriate age to give consent to participate.

- You need to consider how the study is to be funded. Sources of funding should have no link to the possible commercialisation of the new antibiotic.
- Are any rewards to be offered to participants?

## Review questions

1 Explain the difference between:

a observations and surveys

*Answer:* Observations are generally much broader than surveys. For example, a person may observe something and then propose a hypothesis to account for the situation observed. Observations may be more systematic such as when observing animal behaviour.

Surveys are directed towards collecting information about a specific subject. Large amounts of data can be collected, analysed and any patterns recognised.

b longitudinal studies and case studies.

*Answer:* A case study looks at one particular 'case' – a particular situation or person. Changes in the situation or person are documented.

A longitudinal study looks at a situation over a prolonged period of time – possibly many years. Patterns of change can then be recognised.

2 What is a controlled experiment?

*Answer:* In a controlled experiment, one variable is deliberately changed, while all the other variables are kept the same. Any differences between the results for the group in which the variable was changed and the group in which it was unchanged must be due to the changed variable.

3 a What is a hypothesis?

*Answer:* A hypothesis is a possible explanation for observations, or a possible solution to a problem. A hypothesis should be stated in such a way that it is capable of being tested.

b Can a hypothesis be proved? Explain.

*Answer:* A hypothesis cannot be proven although it may be disproved. The results of a correctly designed experiment will either support the hypothesis or will disprove the hypothesis.

4 What is a literature review and what are some of the reasons for carrying out such a review?

*Answer:* A literature review is a survey of the material that has been written about a subject under consideration. It is a way of finding out what is already known about a subject.

The purpose of a literature review is to:

- define the problem so that a suitable hypothesis can be proposed
- prevent duplication of effort by finding out what is already known about a problem
- allow the researcher to build on knowledge that is already available
- review research methods so that those used by other investigators may be used or adapted for the researcher's own investigation
- allow any findings from an investigation to be related to what is already known.

5 List four principles that must be satisfied if an investigation is to be ethical.

*Answer:* Some of the principles that an investigation involving humans must satisfy if it is to be ethically sound are:

- Any involvement in the investigation must be voluntary. There should be no coercion of subjects to take part.
- Potential subjects must be given all necessary information about the investigation, particularly any risks involved.
- There should be no risk of any physical or psychological harm to any of the subjects.
- The identities of participants and their particular results should not be revealed except to people directly involved in the study.

6 a Explain the difference between the dependent and the independent variable in an experiment.

*Answer:* A variable is any factor that may change during an experiment. The independent variable is the factor that is being investigated. It is deliberately changed to determine its effect. The dependent variable is the factor that changes in response to any changes made to the independent variable.

b Explain the difference between controlled and uncontrolled variables.

*Answer:* Controlled variables are the factors that are kept the same for both the control and experimental groups in an experiment. Uncontrolled variables are variables that are not kept the same for the control and experimental groups in an experiment. They may have been overlooked by the experimenter or may have been impossible to control.

7 What is the difference between the validity and the reliability of an investigation?

*Answer:* An experiment is valid when it tests the hypothesis that it is supposed to test.

Reliability is the extent to which an experiment gives the same result each time it is performed. If the result differs each time an experiment is performed then it is unreliable and the result is of little value.

8 Explain the difference between qualitative and quantitative data.

*Answer:* Data from an investigation can be either of the following:

- Quantitative data. This is expressed in numbers and usually involves measurement.
- Qualitative data. These are observations that do not involve numbers or measurement.

9 Describe how you would calculate the mean of a set of measurements.

*Answer:* To calculate the mean of a group of measurements, add up all of the measurements in the group and divide by the total number of measurements.

10 What are outliers? Should outliers be excluded when drawing conclusions from a set of data?

*Answer:* A set of measurements may contain values that are well beyond the range of the rest of the measurements. These are called outliers. If outliers were included in the calculation of the mean it would make the mean higher or lower than it would have been without the outlier included. If the outliers are clearly the result of an error, then researchers would be justified in excluding them when the mean is calculated.

11 What is a peer review? Why are peer reviews used?

*Answer:* Before a scientific report is published it is usually subject to a peer review. It is sent to one or more experts in the field to check for errors, ambiguities or misleading information. The review will then recommend whether the report be published or not. Such reviews are used to try to make sure that scientific reports are worthy of publication.

**12** Describe some of the points that should be included in the discussion section of a scientific report.

*Answer:* The discussion section of a report should address all aspects of the research including the methodology and the results.

Points that should be addressed in the discussion include:

- description of any defects in the design of the investigation or in the procedure
- results that differ from those expected
- analysis of how the results fit into the context of what is already known about the topic
- practical applications for the results
- relationship of the findings to earlier work in the same area
- whether the results support the hypothesis, or demonstrate that the hypothesis is incorrect
- description of any limitations in the research
- suggestions for improving the investigation
- description of any variables that could not be controlled
- an account of any bias in the results
- any information from other reliable sources that supports the results
- description of any further research needed to clarify the results.

**13** What is an 'error' when discussing a scientific investigation?

*Answer:* In an investigation an error is any deviation from the result that should have been obtained.

## Apply your knowledge

**1** Re-read the account of Florey's experiment in which he injected mice with penicillin (pages 3–4). What variables did Florey control in his experiment?

*Answer:* Florey's controlled variables included the following.

- All animals tested were mice.
- The mice were all the same weight.
- All mice were the same age.
- Each was injected with the same species of bacterium (streptococci).
- Each was injected with 100 million of the streptococci.
- Each was injected at the same time.

**2** What did Albert Einstein mean when he said: 'No amount of experimentation can ever prove me right; a single experiment can prove me wrong'?

*Answer:* A hypothesis may be disproved, but it cannot be proved. The results of an experiment can only provide support for the hypothesis. No amount of experimentation could prove a hypothesis to be correct, but one experiment could prove the hypothesis to be wrong.

- 3** What type of investigation would be best for finding a solution to the following problems? Explain the reasons for your choice in each case.
- a** Can people taste the difference between two different brands of milk chocolate?  
*Answer:* A controlled experiment. This problem requires one variable to be changed (the brand of chocolate) while all others are kept the same.
- b** What proportion of students in your school are left-handed?  
*Answer:* A survey. Students need to be questioned about their dominant hand.
- c** What is the ratio of males to females in your Human Biology class?  
*Answer:* A survey. A count needs to be made of the number of males and females.
- d** How has a particular person's growth rate changed from birth to age 15?  
*Answer:* A case study or longitudinal study. It will be necessary to review the data on one individual over 15 years.
- 4** In addition to physical activity that is part of their job or daily routine, many people deliberately exercise by going to a gym or by walking or jogging. Describe how you would conduct a survey to find out the average amount of time the teachers at your school spend on deliberate exercise.  
*Answer:* Create a survey form (a questionnaire) for each teacher to complete. The form could include a table in which the teacher records time spent on any 'deliberate' exercise done during each day over a week-long period. (This could also include the type of exercise, the time they started the exercise and the time they completed it). By adding the responses from all the teachers the average exercise time for teachers at the school could be calculated.
- 5** The table below shows the systolic blood pressure of students in a Year 12 Human Biology class.
- a** Are there any obvious outliers in the above data? If so, which are the outliers and why should they be regarded as outliers?  
*Answer:* Readings 49 and 195 are obviously outliers, because they are considerably lower and higher than most students' blood pressures.
- b** Calculate the mean systolic blood pressure for the class, excluding any outliers.  
*Answer:* The mean systolic blood pressure for the class is 123.6 mmHg.
- c** What is the range of blood pressures in the class?  
*Answer:* The range of blood pressures is from 49 to 195 or, if outliers are excluded, from 106 to 144 mmHg.
- d** What percentage of students had a blood pressure of 130 mmHg or higher?  
*Answer:* If the outlier is excluded, 30.4%; if included 34.7%.
- e** The average systolic blood pressure for adults is 120 mmHg. What proportion of students have blood pressures above this average?  
*Answer:* The proportion is 12:11, or 11:11 if the outlier is excluded. Students may legitimately say half or 50%.

6 In 2003 a team of Australian anthropologists discovered skeletal remains on the Indonesian island of Flores. One skeleton was of a small human with a small brain and dating showed it to be 18 000 years old. The team claimed it was a new species of human and named it *Homo floresiensis*. Experts are divided on whether the discovery is a new type of human or whether there is some other explanation for the small stature and small brain. This is a good example of scientific debate about the meaning of data. Use the Internet to find out some of the hypotheses put forward to explain why the skeleton is really our own species, *Homo sapiens*.

*Answer:* Three possible sites that students may find include the following.

- [www.crystalinks.com/hobbit.html](http://www.crystalinks.com/hobbit.html)
- <http://humanorigins.si.edu/evidence/human-fossils/species/homo-floresiensis>
- <http://australianmuseum.net.au/homo-floresiensis>

7 If you randomly draw a card from a standard pack of 52 playing cards,

a what is the probability that you will draw a spade?

*Answer:* There are 13 spades in a pack of cards so the probability of drawing a spade is 13 out of 52, which is 1 out of 4 or  $\frac{1}{4}$  or 25% or 0.25.

b what is the probability that you will draw a king?

*Answer:* There are 4 kings in a pack so the probability of drawing one is 4 out of 52 or  $\frac{1}{13}$ .

8 Researchers investigating the benefits of exercise in preventing heart disease studied the health outcomes for women after participating in an exercise program. They calculated the risk of heart disease at 0.18 with a confidence interval of 0.04 to 0.80 at the 95% confidence level. Explain what the data mean.

*Answer:* The data mean that for 95% of the participating women the risk of heart disease will be between 0.04 and 0.80.