Science investigation skills

Have you ever wondered...

- whether scientists always collect their own data for analysis?

- how scientists conduct research?

- how best to present investigation findings?

LS

After completing this chapter you should be able to:

- develop and understand scientific research questions
- source reliable information
- understand possible sources of bias
- take notes and organise them
- determine the most appropriate presentation format for scientific work
- acknowledge sources of information and use standard referencing conventions.

This is an extract from the Australian Curriculum **AC**
Victorian Curriculum F–10 © VCAA (2016); reproduced by permission

AB
1.1

Scientific research

Scientific investigation can take different forms. Scientists may conduct experiments where they test a hypothesis, collect and analyse primary data and reach a conclusion. Scientists may also research scientific information in books, journals and other sources. Investigations may involve a combination of experiments and research.

Taking the time to carefully plan and design a research investigation before you begin will help you to maintain a clear and concise focus. Preparation is essential.

The research investigation process

Research investigations may be assigned by the teacher or may be topics that you choose to investigate. All research investigations require that you think carefully about the topic, collect and organise information, analyse and synthesise findings and present your ideas.

The research investigation process is summarised in Figure 1.1.1. Note that the research process is not necessarily a simple, straightforward process. You can move between any of the steps as the need arises. For example, while you are analysing the information that you have found you may realise that you need to clarify the research question or that you need to find some more information. Often your research will raise more questions and you might be tempted to keep doing further research; however, at some point you must decide to end the research cycle and present what you have found out.
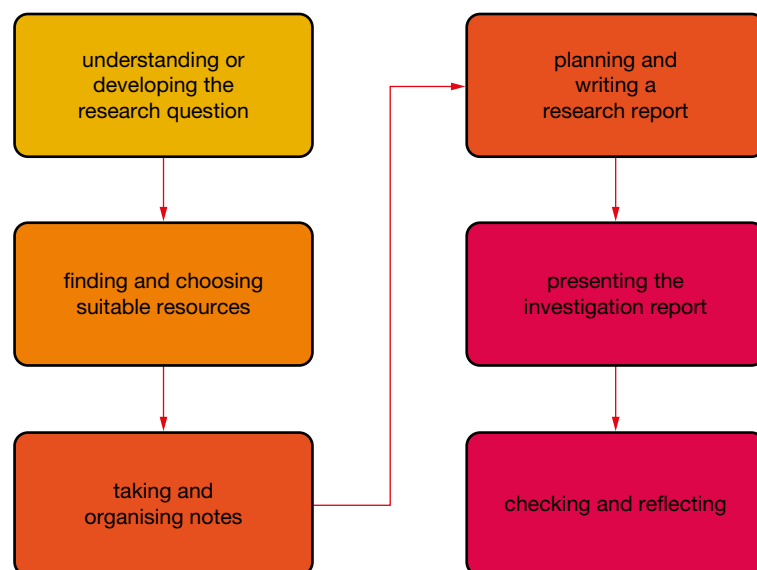
FIGURE 1.1.1 The process of planning a research investigation

Understanding the research investigation task

When planning an investigation, you need to clearly understand what you are investigating and get your time and resources organised.

Understanding key words

Begin by making sure you understand the investigation question. Underline any unfamiliar words and look up their meanings. Identify the instructional terms and be sure you understand what you are being asked to do. Table 1.1.1 lists some common instructional words and their meanings. It will be easier to understand the investigation task if you rewrite the task in your own words.

TABLE 1.1.1 Common instructional words and meanings

Key word	Meaning
analyse	identify components and the relationships between them; to examine in detail
calculate	ascertain/determine from given facts, figures or information
classify	arrange or include in classes/categories
compare	show how things are similar or different
construct	make, build, put together items or arguments
contrast	show how things are different or opposite
define	state meaning and identify essential qualities
describe	provide characteristics and features
discuss	identify issues and provide points for and/or against
distinguish	recognise or indicate as being distinct or different from; to note differences between
evaluate	make a judgement based on criteria; determine the value of
explain	provide a sequence to make the relationships between things evident; provide why and/or how
justify	support using an argument or conclusion
list	write down phrases or items only without further explanation
outline	describe in general terms; indicate the main features of
predict	suggest what may happen based on available information
propose	put forward a point of view, idea, argument or suggestion for consideration or action

SkillBuilder

Understanding the question

Break down the research task

'Evaluate whether it is ethical to use genetic engineering to produce chickens that grow faster and produce more meat.'

First, underline the key words:

'Evaluate whether it is ethical to use genetic engineering to produce chickens that grow faster and produce more meat.'

Second, define the key words:

evaluate—a judgment must be made

whether—indicates there are choices between alternatives

ethical—morally right to do, decent, respectable, proper

genetic engineering—intentional changes to DNA by inserting or deleting genes to produce particular characteristics in a living thing

Third, rewrite the investigation question in your own words:

'Is it right or wrong that humans change the DNA of chickens to breed faster and produce more meat? What are the two sides of the argument? Explain which has the stronger case and why.'

Getting organised

There are a number of things you should think about before looking for resources.

- First plan how you will manage your time. It is easy to spend most of your time finding information and then to rush at the end to complete the presentation. A well-managed timeline would allocate more time to the later stages of the research process, as shown in Figure 1.1.2.
- Secondly, read through the assessment criteria for the task. This helps you identify exactly what is expected and requirements you must meet.
- Finally, consider how your investigation may be presented. Often this will be specified by your teacher. However, knowing your options will help you decide what and how much information you need to collect and work with.

1/10 of time ← Understand the research task
2/10 of time ← Find and select resources
4/10 of time ← Organise information
3/10 of time ← Check and present information

FIGURE 1.1.2 Time management plan

Effective group work

In preparing to begin the research task consider whether individual or group work is to be conducted. Group work situations may include laboratory investigations, research tasks and debates. Working effectively as a group can be difficult. Effective group work requires careful organisation and planning, as explained in Table 1.1.2.

TABLE 1.1.2 Effective group work

Strategies for effective group work	
Role of group members: assign roles to members and give each person responsibility for a particular part of the task so they are accountable for it	Strategies: • manager: moderates discussion, keeps the group on task • recorder: takes notes summarising team discussions and decisions, and keeps records • speaker: serves as group spokesperson to the class or instructor, summarising the activities of the group • questioner: raises counter-arguments and (constructive) objections, introduces alternative explanations and solutions • innovator: encourages imagination and contributes new and alternative perspectives and ideas • prioritiser: makes sure group focuses on the most important issues and does not get caught up in details
Planning and managing project: develop a set of rules to guide the team through the task	Strategies: • establish the acceptable behaviour of group members such as not laying blame on individual members, listening to others and being positive towards others • check assessment criteria for the task • prepare a schedule identifying work flow and due dates • plan how the task will be tackled—what resources are needed, how and where notes will be taken, and how notes will be organised • set up regular meetings to check group progress at regular intervals • plan who will write up the project, who will do editing and who will submit it • at the end of the project, reflect on what behaviours were helpful or harmful to how the team worked on the task
Engaging with team members: establish the purpose of the group and how conflict will be resolved	Strategies: • be respectful to team members • keep an open mind • view criticism as constructive instead of a personal attack on you • if conflict arises then identify what the cause of the problem is • as a group brainstorm solutions to a problem

Finding and choosing suitable resources

The quality of your research is fundamental to the success of your investigation. Research provides the foundation for the investigation and allows you to propose an accurate hypothesis and a reasonable conclusion.

Primary and secondary sources

Primary and secondary sources can both provide valuable information for research. For example, a scientist's journal article on a clinical trial of treatments for gastric reflux is a **primary source**, while a general magazine article about the use of antacids for the treatment of gastric reflux written by a journalist and referring to the scientific study is a **secondary source**. Table 1.1.3 compares primary and secondary sources.

TABLE 1.1.3 Summary of primary and secondary sources

Primary sources	
Characteristics	• first-hand records of events or experiences • written by the people who observed or experienced the events • written at the time the event happened • original documents or direct copies
Examples	• results of experiments • scientific journal articles • reports of scientific discoveries • photographs, specimens, maps and artefacts • interviews with experts • websites that contain the sorts of information listed above
Secondary sources	
Characteristics	• interpretations of primary sources • written by people who did not see or experience the event • information from original documents but reworked
Examples	• textbooks • biographies • newspaper articles • magazine articles • radio and television documentaries • websites that interpret the scientific work of others • podcasts

In researching your topic for investigation you will find a range of sources of information. Look critically at each source and judge if it is:

- current and up-to-date
- reputable—from a source such as a university, research and education organisation, or **peer-reviewed** journal
- **reliable**, by considering who else uses this source
- unbiased—some sources of information, such as interest groups or companies, may have a specific agenda or cause that they support.

Generally, school, university and specialist-area textbooks are good secondary sources to start with. Sections of some specialist texts are available online.

Science magazines

The best source of experimental data and up-to-date information comes from peer-reviewed scientific journals published in the last 10 years. In a peer-reviewed journal, other scientists have checked the information and have agreed that it is appropriate for publication.

As many peer-reviewed journals require a subscription, you may not have access to the original articles in full but can probably access the **abstract,** which is a summary of the study. Using Google scholar is a good way to search for and source such abstracts (scholar.google.com.au).

Original articles can be very complex and hard to interpret if you are not an expert in the field. An alternative way to access current information that non-experts can understand is from reputable science magazines. Look in your school library for *New Scientist*, *The Scientist*, *COSMOS*, *Scientific American* and *Helix* (Figure 1.1.3).

FIGURE 1.1.3
Reputable online and print science magazines

Books and the internet

Your textbook should be your first source of reliable information. The internet is another commonly used source of information.

You should be aware of the features and limitations of using book and internet resources (Table 1.1.4).

TABLE 1.1.4 Advantages and disadvantages of book and internet resources

Book resources	
Advantages	• written by experts • authoritative information • have been edited, so information is accurate • logical, organised layout • all content is relevant to the same topic • contain a table of contents and index to help find relevant information
Disadvantages	• may not have been published recently • usable by only one person at a time • can be expensive
Internet resources	
Advantages	• quick and easy to access • allows access to information which may be difficult to find • access to the whole world; millions of websites • usually up-to-date information • may be interactive and use animations to enhance understanding
Disadvantages	• can be time consuming looking for relevant information • a lot of 'junk' sites and biased material • search engines may not display the most useful sites first • cannot always tell how up to date information is • difficult to tell if information is accurate • hard to tell who has responsibility for authorship • information may not be well ordered • need subscriptions to access some sites

Online searching

Online sources include online magazines, the websites of print magazines such as those described above, the news and education sections of major journals such as *Science* magazine and *Nature-Scitable*, and podcasts and blogs (institutional, company and personal). Animations can also be found at the Walter and Eliza Hall Institute's WEHI-TV, the Tree of Life web project, Phet interactive simulations and the education and resource sections of museum and university websites.

Although a scientific journal is a reliable source of scientific information, you may not be able to access journal papers without a journal subscription. 'Open access' sources are science papers and/or databases that are made available to everyone, without the need to purchase a subscription. **Open access journals** and databases such as the Public Library of Science are good sources of primary information.

Online information credibility checklist

Credibility:
- Who is the author?
- What are the author's qualifications or areas of expertise?
- Does the author provide an email address or other contact information?
- Does the web address show that the source is reliable?

  Some common endings for web address are .edu (education), .gov (government), .mil (military), .com (commercial), .org (organisation) and .au (Australia). Websites using .com may have a bias towards selling a product (but this product could be a reputable science magazine or journal), and .org sites might have a bias towards one point of view (although these sites can be a good starting points for general information).

Currency:
- Is a date given for the creation of the site?
- Is this date recent?
- Is the information current?

Content:
- Is the information fact or opinion?
- Is the information accurate? You should compare it with information from other sources if you are unsure of a website's accuracy.
- Is the information properly referenced?
- Are the grammar and spelling correct?
- Are there links to other quality sources?

When searching for relevant information online, you will need to enter appropriate search terms into a search engine. Here are some tips when searching online:
- Break your search statement into concepts and key words.
- Find synonyms, other related terms and concepts that apply to the topic.
- Create concepts of 1 to 3 words to enter into the search engine.
- Try different combinations of terms.
- Don't settle for the first sites on the list or from your first attempt; look through the results for sites from science organisations and research institutions such as CSIRO, WEHI, NIH, (.gov, .org), universities (.edu) and science journals and magazines.

Remember that anyone can publish anything on the internet, so it is important to evaluate the credibility, currency and content of online information. Although Wikipedia is a popular site, remember that nearly anyone can edit information on that site at any time, so the information may not be accurate. To evaluate online information, follow the credibility checklist to the left.

Prac 1 p. 8

AB 1.2

Scifile

Resource relevance

Not so long ago, libraries like the one shown in Figure 1.1.4 were the only option for students to do background research on a topic. Reference books were multi-volume sets written by a team of authors and editors who could spend several years in preparing a new edition. Because these references took so long to be produced, they often contained outdated information by the time they were printed. Although time is still required to gather, write, and edit new reference information, electronic publishing technology has dramatically reduced the time needed to produce an updated reference.

FIGURE 1.1.4

Remembering

1 Define the terms:
   a open access journal
   b abstract

2 What term best describes each of the following?
   a professional work that is reviewed by others working in the same field
   b a first-hand record of the event or experience, written at the time.

3 Why do scientific journals have more credibility than other sources?

Understanding

4 Why would you use a science magazine as a source rather than a peer-reviewed journal?

5 Explain why an article written in a health magazine may have bias.

Applying

6 The research task is to work in a group of three to 'Describe characteristics of Rube Goldberg machines, then design and create your own machine.'

Analysing

7 In a table, summarise the advantages and disadvantages of using the internet as a source of scientific information.

8 Classify the sources in the following list as primary or secondary sources of information:
   a a scientific paper
   b an article in New Scientist magazine
   c an article in the local paper on scientific research occurring in the area
   d an online article written by a scientist at CSIRO about their current research.

9 Read the following extract written by Laura Faye Tenenbaum, a science communicator at NASA's Jet Propulsion Laboratory and teacher of oceanography at Glendale Community College, and then answer the questions that follow. A micrograph (a photograph or digital image taken through a microscope) of a phytoplankton is shown in Figure 1.1.5.

So you can imagine how psyched I was to smack talk with plankton expert and principal investigator of NASA's North Atlantic Aerosols and Marine Ecosystems Study (NAAMES), Mike Behrenfeld.

He's interested in the link between the blooming plankton food web and its influence on global climate. See, when animal plankton and bacteria munch on the plant plankton, organic compounds the plants produce get broken into itty bitty pieces. These small particles become aerosolized, which means they get lofted out of the ocean and into the atmosphere by wind and breaking waves, where they become the condensation nuclei around which water droplets form. So when these tiny creatures of the sea multiply, those bloom events end up influencing clouds.

Extract taken from: Tenenbaum L, (2016) Plankton and you: The Science of how we're all connected to climate. Blogged 6 May 2016, http://climate.nasa.gov/blog/2439 (accessed 11 June 2016).
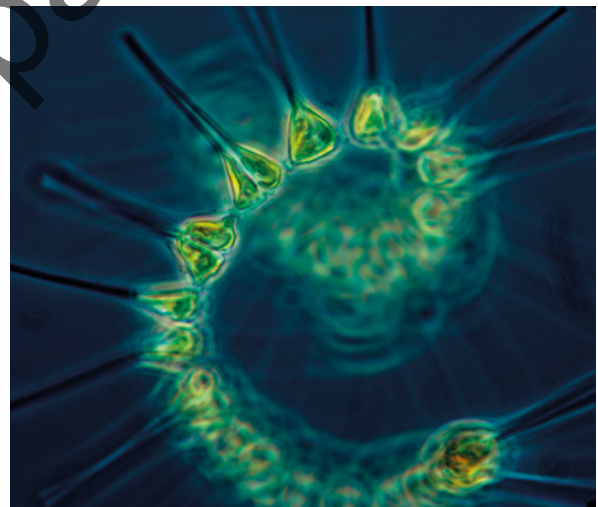
FIGURE 1.1.5 Micrograph of phytoplankton

   a Is the article based on current research?
   b Does the article come from a credible website?
   c Is the information about plankton from a reliable source? Explain what information you used to make your judgment.

Evaluating

10 Access the NASA website and select an article such as 'Curiosity Mars Rover Crosses Rugged Plateau' and evaluate it using the credibility checklist.

Practical investigations

• STUDENT DESIGN •

1 • Can you drop an egg without breaking it?

Planning & Conducting   Evaluating

To drop an egg without breaking it, you need to find a way to minimise the force of the impact and its effect on the delicate eggshell.

Purpose

To identify the best way to support an egg so that it will not break when it is dropped from a height of 2 metres.

Timing 45 minutes

Materials

- 1 egg
- tarp and grassed area to drop eggs onto

SAFETY

Ensure there is nobody walking in the egg 'drop zone'.

Materials will vary depending on research, however the finished product should be limited by size (and/or mass!). A structure no larger than a tissue box is suggested.

Procedure

1 Research the egg-drop process: From what height are you dropping the egg, and what will the acceleration, deceleration and force be? How will you slow the fall or cushion the impact?

2 Draw the design and check it with your teacher.

3 Build your design.

4 Test your design—with no egg! If your design is not effective at this stage you may have to go back to the research and design phase.

5 Test your design with an egg.

Use the STEM and SDI template in your eBook to help you plan and carry out your investigation.

Review

1 Compare your design with those of other prac teams and determine who had the best design for the protection of their egg.

2 Discuss the design features that enabled the eggs to 'survive' the drop.

Taking and organising notes

Note taking and organising information are important skills. Good note-taking skills will help you to collect sufficient information, avoid plagiarism, and prepare the bibliography.

science 4 fun

Plagiarism detectors

Do you know that many universities, use plagiarism checkers to detect cheating?

Do this…
1   Go online and key in *plagiarism detector*
2   Search *how a plagiarism detector works*
3   Find an example of a plagiarism detector that is available free of charge.

Record this…
1   Describe how a plagiarism detector works.
2   Explain why the invention of the internet has increased the need for plagiarism detectors.

Plagiarism

Plagiarism is taking someone else's ideas and words and presenting them as your own work. You plagiarise if you copy sections or sentences from books, or copy, cut and paste from the internet. Always write in your own words when taking notes. It is acceptable to get ideas from others but you must clearly state where the information came from.

Consider the following example (Table 1.2.1) of an original text, a plagiarised version of that original text and a student's appropriately rephrased notes in their own words.

TABLE 1.2.1 Examples of plagiarised text and rephrased notes

Original text	Plagiarised text	Rephrased notes
Dogs have sweat glands on their feet. Dogs pant when they are hot because their sweat glands are not sufficient to cool down their bodies. In addition, their tongues allow the water from their bodies to evaporate and cool down their bodies.	Dogs have their sweat glands on their feet. When dogs get hot they pant because their sweat glands are not enough to cool down their bodies. Their tongues let the water from their bodies evaporate and cool their bodies.	Dogs pant in order to cool down. Water evaporates off their tongues and this lowers their body temperature. Dogs cannot get cool enough through just the sweat glands on their feet.

Note taking

Good note-taking skills are an essential part of the research process. Notes are a short summary of the main ideas found in print and non-print sources. Before starting to take notes, be clear about what information you are looking for. Remember also to record the details of your information sources for the **bibliography**.

Summarising information

You will probably find a lot of information available about any topic you choose for a research investigation. It is important to be able to identify and focus on the main ideas in order to make a summary.

To summarise information, read it carefully and then pick out the main idea or theme. Generally, each paragraph should cover a different aspect of the topic, so you should look for the main focus of each paragraph. The focus is usually in the topic sentence or the first sentence in each paragraph. Examples need not be included in a summary.

One way to effectively summarise information is to:

- read the original text and underline or highlight the most important terms and wordings
- look up the terms you don't understand in a dictionary
- find synonyms (other words that mean the same) for some of the important words, for example: sufficient = enough

- write a list of the key words on a separate piece of paper so you are not tempted to copy the phrasing of the original text
- talk about the words out loud to ensure you understand their meanings
- write a draft of the key points using a sentence starter you have thought of
- check your draft against the original and change any wordings that are too close to the original.

Summarising also helps you to write notes in your own words and avoid plagiarism. You might find it useful to read the resource information, cover it up and then write your summary notes. When summarising, you should also make a note of the sources of information for your bibliography. Table 1.2.2 provides an example of an original text and a sample of what the summary of it could be.

Methods of note taking

Notes can be written using different methods. The method you choose may vary depending on the purpose of the task and your own personal preference. Figure 1.2.1 demonstrates three common examples of ways to take notes: highlight/underline, point form and concept map. Table 1.2.2 shows how a long section of text can be summarised using point form notes.

When taking notes it is a good idea to look for headings, subheadings and key words. It also helps to look at the paragraphing. Each new paragraph should have one main idea that is developed and possibly supported by examples.

Common approaches to note taking

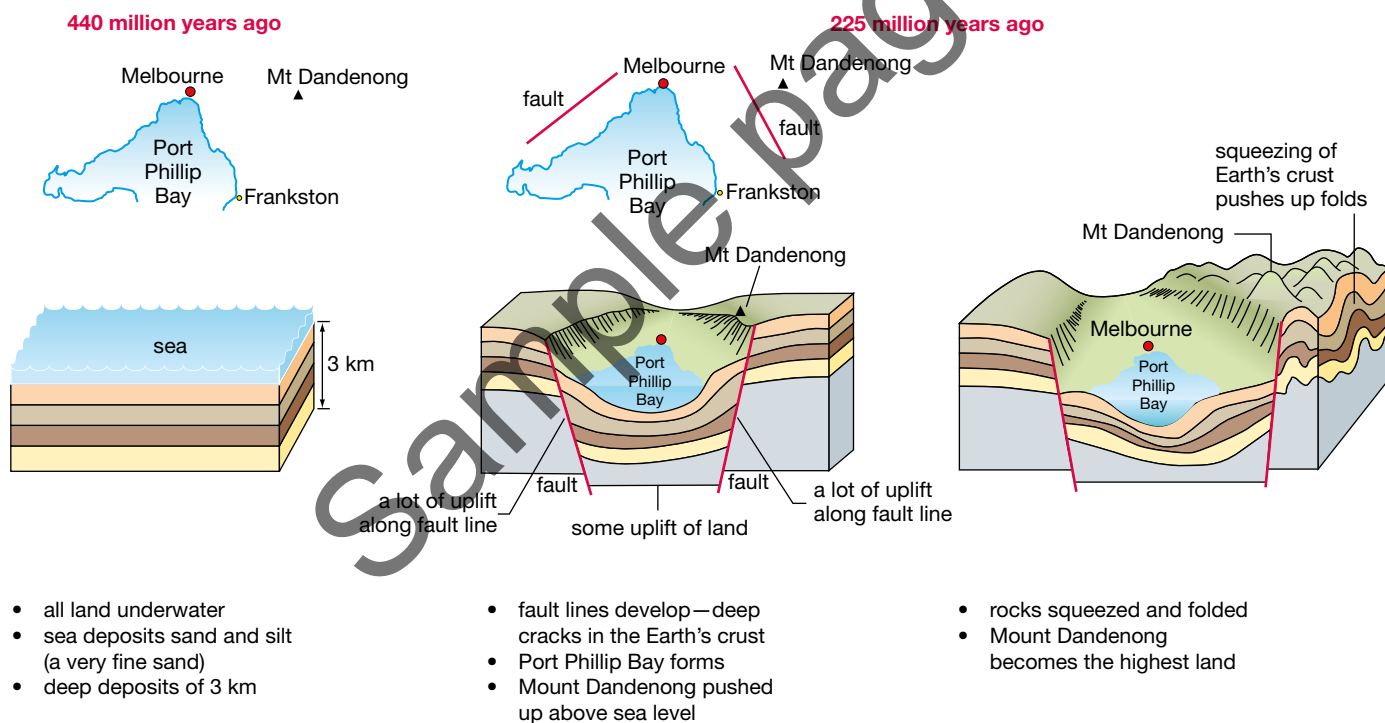Highlight/underline   Point form   Concept map
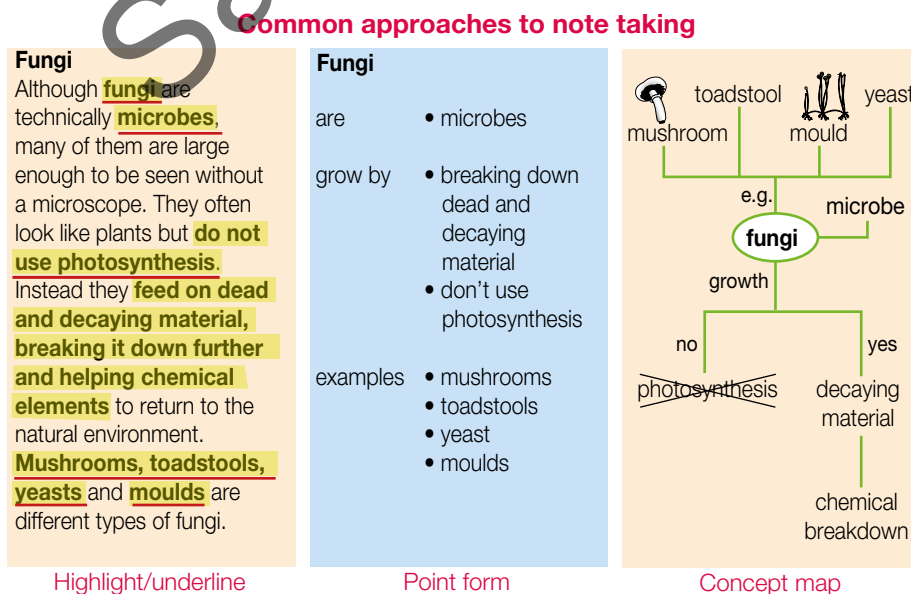
FIGURE 1.2.1 Common methods of note taking

TABLE 1.2.2 Investigation research notes taken using point form.

Text	Notes using point form
The Dandenong Ranges, in Victoria, Australia, are located a short 33 kilometres east of the city of Melbourne. The exact location is at latitude 38 degrees south and longitude 145 degrees east. This area is part of the Woiwurung Aboriginal land and the mount was called Tanjenong. The present name of Dandenong is derived from this Aboriginal name. The word tanjenong means lofty or high, although by world standards Mount Dandenong at a height of 633 metres, is actually not very high at all.	Mt Dandenong: • located in Victoria, Australia • 33 km east of Melbourne • lat 38 degrees S, long 145 degrees E • part of Dandenong Ranges • derived from Aboriginal name, *tanjenong*; means lofty, high • height is 633 metres

Visual representation

Visual representations are an important feature of science. Visuals such as diagrams can also be very helpful ways to make summaries and to take notes. Diagrams, alone or used with another note-taking method, can be very powerful note-taking tools.

Diagrams are particularly useful for describing patterns or processes that might be difficult or time consuming to put into words. Figure 1.2.2 demonstrates how combinations of diagrams and dot-point notes can be used to condense and focus on the key geological processes that formed Mount Dandenong. The diagrams show the steps in the process while the dot points name the features and describe details that might not be clear in the diagram.

440 million years ago

- all land underwater
- sea deposits sand and silt (a very fine sand)
- deep deposits of 3 km

225 million years ago

- fault lines develop—deep cracks in the Earth's crust
- Port Phillip Bay forms
- Mount Dandenong pushed up above sea level

- rocks squeezed and folded
- Mount Dandenong becomes the highest land

FIGURE 1.2.2 A combination of diagrams and dot points used for note taking

Retrieval charts

Retrieval charts help to organise thinking, ideas and information in a visual way. They are useful tools for making summaries and for gathering information from a variety of resources. There are different types of retrieval charts and you will need to think about which is best for your task.

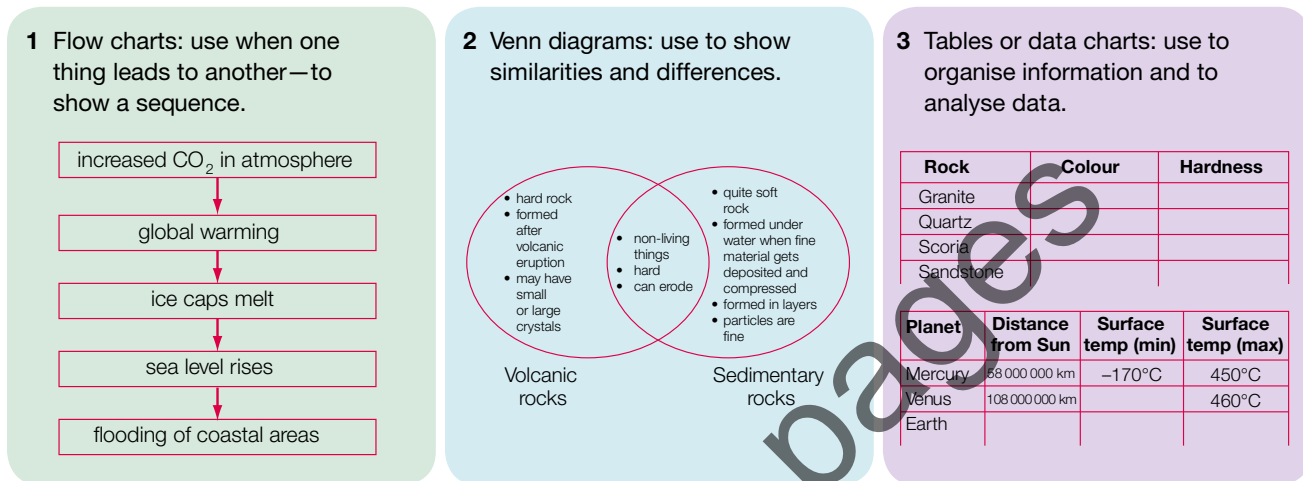Three types of retrieval charts are shown in Figure 1.2.3.

1 Flow charts: use when one thing leads to another—to show a sequence.
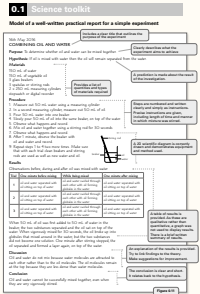
increased CO_2 in atmosphere

↓

global warming

↓

ice caps melt

↓

sea level rises

↓

flooding of coastal areas

2 Venn diagrams: use to show similarities and differences.

- hard rock
- formed after volcanic eruption
- may have small or large crystals

- non-living things
- hard
- can erode

- quite soft rock
- formed under water when fine material gets deposited and compressed
- formed in layers
- particles are fine

Volcanic rocks   Sedimentary rocks

3 Tables or data charts: use to organise information and to analyse data.

Rock	Colour	Hardness
Granite		
Quartz		
Scoria		
Sandstone		

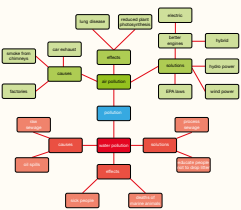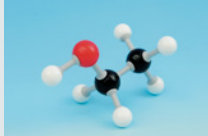| Planet	Distance from Sun	Surface temp (min)	Surface temp (max)
Mercury	58 000 000 km	−170°C	450°C
Venus	108 000 000 km		460°C
Earth			

FIGURE 1.2.3 Examples of retrieval charts

Presenting the research

Presenting your research is a very important part of the investigation. The style of presentation gives the reader their first impression of your research. Be sure that you have met all the requirements of the format of presentation and that you have included a bibliography.

Your teacher might tell you how to present the research investigation or you may have the opportunity to decide for yourself. There are many ways in which your work can be presented. Table 1.2.3 provides some options and hints for presenting each format correctly. Some of these formats will be unpacked in more detail in the next module.

TABLE 1.2.3 Various presentation formats

Format	Characteristics	Things you should include or remember
poster	• a visual display of information • suitable for presenting information to many people • a summary of ideas	• a title that attracts attention • large headings that stand out • subheadings of a smaller size • attractive presentation • a balance of written and visual material • writing large enough to read from a distance
pamphlet	• a small folded booklet with facts and diagrams • a summary of ideas • an easy way to access information • suitable for providing people with take-home information	• consistent layouts and fonts • dot points (if appropriate) • diagrams • attractive presentation

Format	Characteristics	Things you should include or remember
reports	research report: • a presentation of clear and detailed information on a topic • suitable for providing detailed information experiment report: • has set subheadings • includes data • requires accuracy and detail	research report: • an introduction, paragraphs and a conclusion • subheadings • mainly text, but can include diagrams, maps, tables and/or graphs experiment report: • include purpose, hypothesis, materials, procedure, results, discussion, conclusion • use subheadings • use tables, graphs, diagrams, photos
essay	• formal writing • can be used for discussion of a topic or to argue a point of view • suitable for formal writing to present to a single person • an essay may have different purposes; presenting an argument or point of view, a descriptive essay, an analysis of a topic	• an introduction that gives the focus of the essay • a series of paragraphs—each paragraph should make a new point and support it with evidence • each paragraph starts with a topic sentence that states the point of the paragraph • each paragraph ends with links back to the topic • a conclusion that ties all the ideas together but does not include any new information • include a bibliography
retrieval chart	• a table of information • useful for summaries of notes • useful for organising statistics or data • a way of collecting information that can then be presented in another format • suitable for use with a large audience or for presenting ideas to a single person	• information in sentences, point form or diagrams
multimodal (e.g. slide show, PowerPoint, Prezi)	• an easy-to-follow format • a good format for presenting to a large audience • involves a visual component (slides) and a spoken component (oral presentation) • able to be printed as a set of notes to be given to the audience	• visual and spoken information should be different, i.e. do not just read the slides • use consistent backgrounds, formats and colours throughout • minimise the amount of text on any one slide
oral presentation	• can inform and possibly persuade the audience • engaging and can be entertaining • good for presenting a point of view on an issue • suitable for presentation to a large audience • opportunity to answer questions from audience • audience can be given notes	• relevant anecdotes • Use palm cards to glance at if needed • eye contact with the audience (use palm cards if needed). • speak clearly and at a volume that can be heard • stand up straight and look confident
model	• a three-dimensional visual display • a good way to provide information with very little text • suitable for communicating information to a lot of people	• title, labels and explanations
website	• can present visual and written information • accessible to a worldwide audience • easy to follow • easily updated	• hyperlinks to related information • multimedia, such as video clips and audio, if appropriate • consistent backgrounds, formats and colours throughout • headings that stand out • give publication date and author credentials

Acknowledging sources

A bibliography is a list of all the resources you have referred to in the research investigation. A bibliography serves a number of purposes.

It provides important information about:

- whether you used credible sources
- the date or age of the sources you used
- the types of resources that you used—that is books, journal articles, magazines etc.

It also shows that you:

- did some research to establish the key facts
- acknowledge that you are using the work of other people
- have not plagiarised.

The list of resources in a bibliography is set out in a standard way. Table 1.2.4 provides a summary of the information that needs to be provided in a bibliography about the books and internet sites that you have used.

All the resources listed in the bibliography are arranged in alphabetical order.

AB 1.3   AB 1.4

TABLE 1.2.4 How to write a bibliography

Resource type		
book	**Information needed**	
	author's surname and initials date of publication title publisher's name place of publication	
	Examples correctly formatted for a bibliography	
	Book with one author: Pyers, G. (2002), *Gold*, Echidna Books, Carlton, Vic. Book with more than two authors: Rickard, G. et al. (2005), *Science Dimensions 1*, Pearson Education, Melbourne, Vic. Book with an editor: Uhling, R. (ed). *The Complete Health Book*, (1999), Penguin Books, Camberwell, Vic.	
internet	**Information needed**	
	author's surname and initials, or name of organisation, or title (if there is no author) year website was written or last revised date website was accessed website address	
	Examples correctly formatted for a bibliography	
	PBS (2002) [online], The Merchants of Coox cl, accessed 20 June 2009, from www.pbs.org/wgbh/pages/frontline/shows/	

Checking and reflecting

Even when you have completed your research and your presentation, your job is not quite finished. It is time to check, think and reflect on what you have done.

Proofreading and checking

Before submitting any work you must **proofread** it. This helps to minimise errors and maximise communication of your information. When checking your work, ask yourself the following questions:
Have I …

- completed all parts of the research investigation?
- explained the work clearly enough so the reader will understand what I am trying to say?
- written well-constructed sentences?
- used the scientific voice in my writing?
- made sure my work make sense?
- set out my work correctly for the type of presentation format I have used?
- checked my spelling, punctuation and grammar?
- written my name on my work?

You can proofread by doing a spell check, reading aloud and/or asking someone else to check your work. If you have used a computer to write your research investigation, use a spell check to find spelling mistakes. Don't trust the computer to find all the mistakes. The software will find words that are misspelt; however, a word can be spelt correctly but may not mean what you intend to say. Always do your own check as well as an electronic spell check. Table 1.2.5 shows a student's work before and after a spell check and the final corrected piece.

TABLE 1.2.5 Original work, spell-checked work and final corrected work

Student's original work	Student's work after spell check	Corrected work
Globle warming is causing extreem whether. As temperatures rises the see level will rise and desserts will get biger.	Global warming is causing extreme whether. As temperatures rises the see level will rise and desserts will get bigger.	Global warming is causing extreme weather. As temperatures rise the sea level will rise and deserts will get bigger.

Reflecting

Doing the investigation is only one step in your learning. Consider what you did well and what you need to improve on. Reflect by doing a self-evaluation using the form shown in Table 1.2.6.

TABLE 1.2.6 Student self-evaluation form

Skill	Achievement	Satisfied with this	Can improve this
understanding	I understood the question/topic/key words.		
finding	I was able to locate relevant resources on the topic.		
choosing	I chose resources that were up-to-date.		
	I was able to find the information I needed in my resources.		
organising	I was able to take notes in my own words.		
	I kept bibliographic details of the resources I used.		
writing	I planned the sequence the information my report would follow and sorted my notes into those sections.		
	I wrote in a formal and factual style.		
	I included relevant information that addressed the research topic.		
presenting	I included a bibliography.		
	I met the requirements of the presentation format.		
general	I used my time well.		
	I proofread my work.		

Remembering

1 Define the terms:
  a plagiarism
  b bibliography.

2 What term best describes each of the following descriptions?
  a reading work before submitting or publishing and correcting errors
  b investigating systematically to gain knowledge about a subject.

Understanding

3 Select the most appropriate retrieval chart to use to:
  a compare plant and animal cells
  b show the speeds of different animals measured every 1 second, as each chased its prey
  c compare the scientific concepts studied in chemistry and physics
  d show movement of moisture through the water cycle
  e demonstrate the life cycle of a star.

Applying

4 You have just finished researching how global warming might affect the Earth. This is a major research task that must be presented to the rest of the class. Identify a format that could be used to present this research.

5 Summarise the 'Hand dryers versus towels' article below in 15 words or less. The heading gives a very strong clue about the article's topic.

Hand dryers versus towels

Most people do not hold their hands under hand dryers for long enough to completely dry them. They walk out of the bathroom with hands that are still wet and often wipe them on their clothes to finish drying them. In addition, bacteria love the warm, moist atmosphere in the dryer and when you hold your freshly washed hands underneath the dryer the bacteria are blown all over them. American researchers have found that a hand dryer increases the bacteria count on your hands by up to 255%, while paper towels and continuous-loop cotton towels reduce bacteria counts by about half.

Analysing

6 Proofread the following work. Find one mistake that a computer spell check would correct and one mistake it would not correct.

Mutations may involve only a single jean, with a section of DNA being incorrectly copied as is the case with sickle-cell anaemea.

Evaluating

7 a Assess the three common methods of note taking. Rank them in order of the one you prefer to use at the top of the list, and the one you least like at the bottom of the list.
  b Justify why you ranked the note-taking methods in this order.

Creating

8 Refer to Figure 1.2.2 on page 11, which demonstrates the use of a combination of diagrams and dot points for note taking. Create a written description of the formation of Mount Dandenong using these research notes. Write one paragraph of approximately 100 words.

Acknowledging the work of others
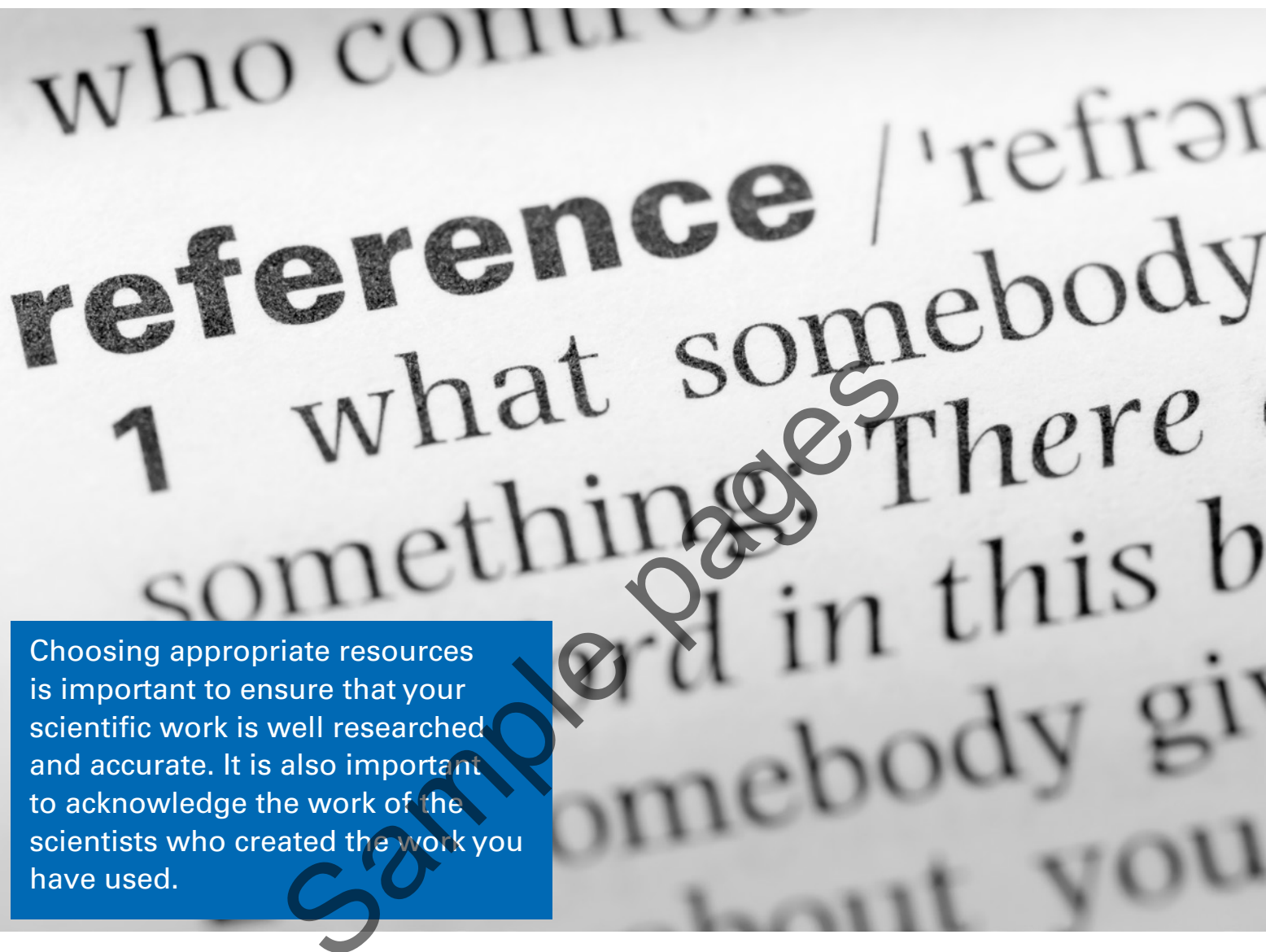
Choosing appropriate resources is important to ensure that your scientific work is well researched and accurate. It is also important to acknowledge the work of the scientists who created the work you have used.

Acknowledging sources of information

Acknowledging sources of information is an important aspect of report writing. It shows that you have explored the topic and are ethical in acknowledging the work of others. There are two aspects to consider when writing a report:

- in-text referencing which occurs in the body of the report.
- end-text referencing which occurs at the end of the report as a bibliography or reference list.

In-text referencing

In-text referencing (also called in-text citation) is used at the exact point you used the thoughts, images, text or words of another person. This type of referencing occurs within the body of the report, usually when you make reference to the work of somebody else to support a statement or compare results.

What does in-text referencing look like?

- If there are quotation marks around the section of writing, it is directly copied from the source. In brackets at the end of the quote or at the end of the paragraph you should include the authors surname, the year of publication and the page number. For example: 'In-text referencing (also called in-text citation) is used at the exact point you used the thoughts, images, text or words of another person.' (Parsons et al, 2016, p. 28)

- If the work has been **paraphrased** (rephrased or put into your own words) then quotation marks are not needed. However, you will still need to reference it at the end of the paragraph. For example, if you copy somebody else's words exactly, you should put quotation marks around them and use in-text referencing at the exact point where you used them (Parsons et al, 2016).

- If the source is from the internet or if it has been paraphrased then you should still include the author's surname and the year of publication, but there is no need to include a page number. For example, 'If you stop seeking to improve, you will eventually find yourself going backwards.' (Naomi Dwyer, 2015).

- If there is no author's name, then give the title of the article or paper and the year of the publication. For example, 'stopping vaccine preventable diseases in their tracks is one of the key strategies worldwide for improving health outcomes, particularly in pregnant women and children' ('Healthy Focus', Women's and Children's Health Network, 2015).

- If there is no publication date available then use the initials n.d. (for 'no date') in place of a date.

End-text referencing

End-text referencing is the inclusion of a reference list or bibliography at the end of the report.

A **reference list** and a **bibliography** are alphabetical lists of resources that were used for research to complete your report. Each entry in this list is called a citation. Reference lists and bibliographies come at the end of the report and are not written as a table or as a bulleted list. Figure 1.4.1 shows one way that a reference list could be formatted.

Allen, P., Couglin, J., Dougal, C.J., Highbury, A., Kell, E., Mann, G., et al. (2008). *Schooling in the 21ˢᵗ Century*. Perth: Living Press

Bennet, P. (2009). Internet. In *Encyclopaedia Britannica* (Vol. 20, pp. 81–82). Chicago: Encyclopaedia Britannica.

Smith, J. (2009, January 21). Obama inaugurated as President. *Time*, 171, 21–23. Retrieved February 21, 2009, from http://www.time.com/news/obama_inaugurated.htm

FIGURE 1.4.1 A correctly formatted reference list. Note that all sources are in alphabetical order, and indented after the first line.

A bibliography will list all sources of information that were used in the research process. In comparison, a reference list will only list the sources that are quoted or referred to within the body of the report. You would usually be asked to use either a reference list or a bibliography (not both) at the end of your report.

Accepted methods for referencing vary, but your reference list should provide all the information necessary to locate the source, it should be consistently presented and should contain only the sources that you quoted or referred to in your investigation.

Remembering

1 Define the terms:
   a paraphrasing
   b reference list.

2 What term best describes the following description?

   Type of referencing that occurs within the body of the report, usually when making reference to the work of others.

Applying

3 Explain why you need to reference and acknowledge documents, ideas and quotations in your investigation.

4 a Outline the differences between writing a bibliography and a reference list.
   b Why is it important to only include the references you have read in a reference list?

Analysing

5 Read the reference list below and suggest any areas that could be improved.

   Bennet, P. (2009). Internet. In "Encyclopaedia Britannica" (Vol. 20, pp. 81–82). Chicago: Encyclopaedia Britannica.

   Allen, P., Couglin, J., Dougal, C. J., Highbury, A., Kell, E., Mann, G., et al. (2008). Schooling in the 21st Century. Perth: Living Press

   Smith, J. Obama inaugurated as President. Time, 171, 21–23. Retrieved February 21, 2009, from http://www.time.com/news/obama_inaugurated.htm

Evaluating

6 You interview a scientist and use their information in a report. Assess whether the conversation needs to be referenced.

7 Set up an in-class debate with the following topic:

   'It is okay to use images off the internet without referencing—they are free.'
   a Research both sides of the topic fully. How will you identify the winner of the debate? Decide on criteria that will identify the winning side.
   b Formulate the argument based on the predetermined criteria.
   c Set up the debate with the three best speakers from each side, a timekeeper and three to four people to assess the debate using the predetermined criteria.

Creating

8 Citing evidence is a good way to strengthen your argument. The following sentence starters are a great way to include evidence on your scientific work.
   a According to the text …
   b On page _____, it states …
   c The author states …
   d The data found in _____ supports the argument that …

   There are many ways to include references support in your work. Try to create your own paragraph using two of the above sentence starters, or you may like to include your own!

9 Create a slideshow or keynote presentation explaining how to reference different sources of information. Ensure that you include a:
   a journal
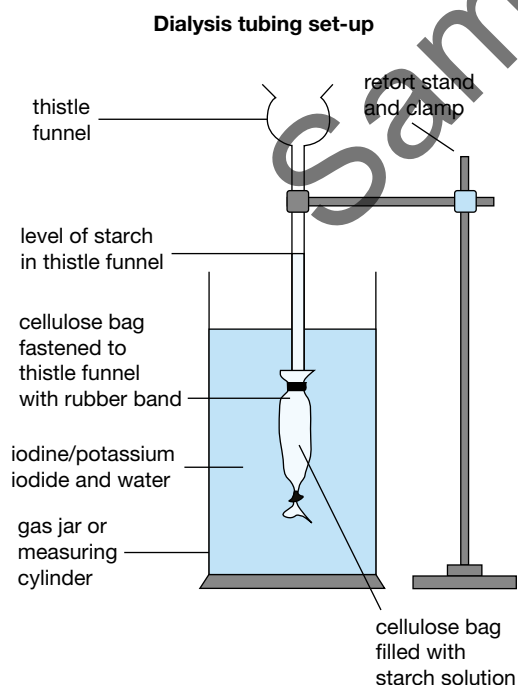   b website
   c book
   d magazine.

Remembering

1 Define the terms:
   a concise
   b risk assessment.

Understanding

2 When planning an experiment you may need to know if students have any allergies or medical conditions. Why would you need to know this information?

3 Are the following statements relating to research time management true or false?
   a The time devoted to understanding the research task should be about one-tenth of the total time for the whole task.
   b Organising the research information should take more time than other parts of the research process.
   c The presentation of the research task is very important, so at least half of the time should be spent creating a beautiful presentation.

Applying

4 Explain why using a diagram like the one in Figure 1.5.1 may be helpful in a procedure.

Dialysis tubing set-up

thistle funnel

retort stand and clamp

level of starch in thistle funnel

cellulose bag fastened to thistle funnel with rubber band

iodine/potassium iodide and water

gas jar or measuring cylinder

cellulose bag filled with starch solution

FIGURE 1.5.1 Experimental set-up diagram

Analysing

5 Explain the difference between primary and secondary sources.

6 Look at the research topics below and for each, complete the following:
   a identify and underline the key words
   b explain what action each key word is directing you to do
   c rephrase the topic or question in your own words.

Research topics

- Identify the worst three natural disasters in the last decade.
- Contrast living and non-living things.
- Compare the planets Mars and Venus as possible locations for future human settlements.
- Discuss the reliability of DNA gene matching for criminal identification.
- Propose what action could be taken to combat global warming.
- Design a chemical experiment to observe an exothermic reaction.
- Evaluate the possible human impact on a local ecosystem.

Evaluating

7 Refer to the list of research investigation topics in question 6. Evaluate which is the most suitable format of presentation for each topic. Explain why you chose that format.

8 a Assess whether you can or cannot answer the questions on page 1 at the start of this chapter.
   b Use this assessment to evaluate how well you understand the material presented in this chapter.

Creating

9 Use the following terms to construct a visual summary of the information presented in this chapter.

abstract

active voice

bibliography

concise

in-text citation

paraphrased

passive voice

peer-reviewed

primary source

reference list

secondary source

subjective writing

AB
1.7

CHAPTER
1 **Inquiry skills**

Research

1 **Evaluating** **Communicating**

Work in a group of four students. Find out about the type of statistical evidence collected by the World Health Organization on global vaccination.

a Each group member should focus on one of the questions below.

Use a web-based document sharing application, such as Google Docs, Slack or Trello, to collaborate and record your findings.

i Where is the data collected?

ii Who performs the research?

iii What is the purpose of the research?

iv What practical benefits could be derived from such research?

b Outline the advantages of using this type of application over other forms of communication and sharing platforms such as email or file repositories.

2 **Processing & Analysing** **Communicating**

Science fairs such as the Google Science Fair show some amazing work done by students just like you.

Visit this site and review some of the previous years' shows.

a Which story did you find inspiring?

b What was the common element of all the stories you watched?

c How does this change your perception of working scientifically?

Thinking scientifically [LS]

1 Some students had cited Google images for the source of diagrams and pictures they had used in their scientific report. Discuss why it is not appropriate to cite Google images as the source of the diagram or picture.

2 Jane's list of references for her investigation is listed below. Identify the resource that was correctly cited:

A Barrans, R. E. (2012, March). Surface Area and Rate of Reaction. Retrieved March 8, 2012, from newton.dep.anl.gov: http://www.newton.dep.anl.gov/askasci/chem00/chem00021.htm

B Clark, J. (2002). THE EFFECT OF SURFACE AREA ON REACTION RATES. Retrieved March 8, 2012, from chemguide.co.uk

C Gallagher, R., & Ingram, P. (2001). *Chemistry for higher tier: New coordinated science*. New York: Oxford University Press.

abstract: a summary of the report or study

accurate language: expressed precisely, exactly and correctly

active voice: in the active voice, the subject is doing the action

bibliography: a list of all sources of information that were read or referred to in the research process

concise: writing in short sentences with a simple structure

formal language: language used in more official situations such as speeches as opposed to the common language used in text messages and amongst friends

in-text citation (or **in-text referencing):** a type of referencing that occurs within the body of the report, usually when making reference to the work of others

objective writing: writing in an unbiased and factual style

open access journal: free scholarly publications available online

paraphrasing: rephrasing or putting their work into your own words

passive voice: in the passive voice the subject is receiving the action

peer reviewed: work that is reviewed by others working in the same field. A peer-reviewed journal is one in which other scientists have checked the information and have agreed that it is appropriate for publication.

plagiarism: to take someone else's ideas and writing and pass them off as your own

primary source: a first-hand record of the event or experience, written at the time

proofread: to read work before submitting or publishing and correcting errors

reference list: a list compiled at the end of the report to list all sources that are quoted or referred to within the body of the report

reliability: the ability to consistently reproduce results

risk assessment: a systematic way of identifying potential risks

secondary source: an interpretation of the primary source of information, written by someone who did not see or experience the event

subjective writing: writing influenced by personal feelings and opinions

AB
1.6

Sample pages