**Scientific investigations**

**Scientific Report Scaffold (Remember all scientific reports are written in third person)**

|  |  |
| --- | --- |
| **Scaffold** | ***Notes*** |
| Title  *e.g. The effect of UV light on the rate of growth of mould on bread* | *Communicate what your investigation is about i.e. the title should include: the effect, the independent variable and the dependent variable.* |
| Introduction / Hypothesis | *Describe the problem/question and current research related to the problem.*  *Explain what it is you are trying to address that is different to what has already been done.*  *State the hypothesis.* |
| Method | *Describe how you conducted your investigation mentioning all appropriate variables and controls, the materials and any technologies you used.*  *Write the method as a procedural recount for the steps that you followed in order to collect data. A procedural recount is written in the past tense.* |
| Results | *Report the results you observed for the procedure. Present average values (from number of trials or number of samples) rather than every measurement that was made. Use graphs where appropriate.*  *Do not interpret the results in this section. Do that in the Discussion section.* |
| Discussion / Conclusion | *Assess your results (trends and patterns) and summarise the most important findings. Conclude how well the results supported your hypothesis. Provide plausible explanations for your findings.*  *Suggest additional research that might be considered in the future.*  *Discuss how your results fit into a broader context or relate to a broader context.* |
| References and acknowledgements | *Acknowledge the assistance you have received from other people.*  *Provide references for any published secondary sources that you used, such as books, newspapers, journals, CD ROMs and the Internet.*  *Use a standard referencing style.* |
| Appendix | *Could be your log book or appendix of results* |

Mind mapping

Scientists make observations about how things work in the natural world and in the technological world around them. From these observations, they pose questions and then try to pose answers to these questions. Scientists use many tools to help them solve problems and find answers to their questions. One of these tools might be the use of mind maps.

Mind maps can be described as a learning theory-based instructional tool that serves to clarify links between new and old knowledge and force the learner to externalise those links in a visual display that tends to be more easily remembered. Mind maps can show the relationships between concepts. They:

* help students visualise how ideas are connected and how knowledge is organised,
* can be used to gather information in a random but organising manner,
* can be used to generate ideas towards solving a problem by identifying issues related to the problem. (Can use copy in word to copy picture below and add boxes if necessary)

**Sample mind map 1: (What do we know?)**

***Why does bread go mouldy***

The bread starts to decay

Because its in the dark

When its hot and humid

It gets wet

Water condenses in the plastic bag

Because it gets old

Because its made with yeast

It gets fungus on it

**Sample mind map 2: (What do we need to know?)**

Is mould useful?

Does all kind of bread go mouldy?

How does mould get there?

Is mould harmful?

What is mould?

Is all mould the same?

What else goes mouldy?

How can we stop mould?

***Why does bread go mouldy?***

Will mould grow in the freezer?

Does mould only grow in the dark?

Will mould grow in bright light?

What stops mould from growing?

**A scientific investigation - the process**

Collect data

Design a procedure

Form an hypothesis

From observations, ask a question or pose a problem.

Analyse data and draw conclusions

Evaluate the Investigation

Publish

Find out what is currently known.

Trial method

Summarising

Creating a summary is a very important learning process as it facilitates a more focused and concise understanding of the information that has been gathered.

# Summarising

### A summary:

* is an essential condensation in your own words.
* answers the question "what is the author really saying?"
* is the result of careful "listening" to the author.
* remains faithful to the author's emphasis and interpretation.
* does not disagree with or critique the author's opinions.

### How to summarise a paragraph

* Read the paragraph twice.
* Isolate the topic sentence; if it conveys reliably the meaning of the paragraph, consider it your summary.
* Underline key phrases and look for any crucial distinctions or contrasts which form the framework of the paragraph.
* Write your own summarising sentence which makes use of those key phrases or distinctions.

### How to summarise an article

* Ask yourself why the article was written and who is the intended audience.
* Consider the author's background. Does he have a special bias or point of view?
* Compare the opening and closing paragraphs.
* Read the entire article more than once, if necessary.
* Underline key or repeated words and phrases.
* Distinguish the author's main idea from details which support that idea or are repetitions and variations on the same theme.
* Draft a several-sentence summary which defines the author's main idea broadly enough to account for most of the supporting material introduced.

### Remember, your summary should: read like a coherent, unified paragraph in its own right, account for most of what the author says in your own words and maintain a neutral, impartial tone.

The hypothesis

One of the crucial steps in planning and conducting a scientific investigation is the determination of the *hypothesis.* You need to introduce your experiment to your presenter and your theories. This step requires focus towards the identification of the variables involved, and from there, the formulation of an hypothesis.

**What is an HYPOTHESIS**?

*An hypothesis is a statement that describes a relationship between two or more variables that can be tested.*

It can be worded using the following scaffold.

**changed**

**independent variable**

If the is ,

**dependent variable**

**something happens**

Then in the .

**Example:**

If the independent variable is (increased, decreased, changed), then the dependent variable will (increase, decrease, change.)

Hypothesis: *If the* ***size of the projectile*** *is* ***increased*** *then there is* ***an increase*** *in the* ***size of the crater formed.***

This hypothesis could be worded in other ways as well, e.g.

*As a meteorite increases in size, the size of the crater formed also increases.*

or

*When the size of a meteorite increases, there is an increase in the size of the crater formed.*

***An hypothesis is not the same as a guess or an inference as it is made after considering all the information available. It is not the same as a prediction as it tries to explain more than one observation or one situation.***

A *prediction* may be made after an hypothesis has been formulated and it is related to the particular situation being tested and may therefore be proven, however the hypothesis which is related to more general situations or observations cannot be proven through one testing procedure. For example, an hypothesis might be *That smaller balls bounce higher than larger balls.* Data obtained by testing a number of different sized balls over a number of trials may support this hypothesis or the data may not support it. However the data from one testing procedure will not prove whether the hypothesis is correct or not. On the other hand, a prediction might be made that the tennis ball (one of the balls being tested) will bounce the highest of those balls that are being tested. This can, in fact, be proven to be correct or not.

Fair testing

**What is a fair test?**

A fair test is a test that is structured to ensure constant conditions in order to obtain a valid and reliable result.

A fair test should ensure:

* 1. the control of variables other than the dependent and independent variables
  2. use of an *experimental control (*where appropriate*)*
  3. the use of either *repeat trials* ***or*** *replication*

1. Variables

* The independent variable is the variable you purposely manipulate (change). This may be referred to as the *manipulated variable.*
* The dependent variable is the variable that is being observed, which changes in response to the independent variable. This may be referred to as the *responding variable*.
* Controlled variables are those variables that are not changed. They are the variables that are held constant.

**Cows Moo Softly** is a useful scaffold to remember how to plan a fair test.

* **C**hange something
* **M**easure something
* Keep everything else the **S**ame

Collecting data

**How will data be collected?**

**Types and examples of data collection**

Not all investigations have the same structure and approach to data collection. Each type of investigation will provide opportunities to practise different approaches to the collection and analysis of data. Observations and measurements of variables can be presented as discrete or continuous.

* Discrete data are in categories like gender, type of animal, brand of paper towel, colour.
* Continuous data are associated with measurement involving a standard scale with equal intervals such as height of plants in centimetres, the amount of fertiliser in grams and the length of time in seconds.

**Data handling skills in science**

Data may be represented in tables or graphs. A table emphasises the absolute value of the component data; a graph emphasised the relative value of the data, i.e. a graph is a visual representation of comparative data.

* It is often appropriate and useful to show relevant totals, subtotals, and/or percentages.

Reprinted from the Board of Studies Science Stages 4-5 Support Document (1999) Available at: http://www.boardofstudies.nsw.edu.au/syllabus\_sc/pdf\_doc/science45\_sup99.pdf

***Tables***

Information is presented in tabular form to facilitate access to the information and to identify any distinguishing patterns or trends with the data. Tables give information in a matrix, that is, columns and rows, organised for easy comparison. The deciding factor in the organisation of information in tabular form should be whether it assists the reader or viewer to access or interpret the information.

Students should consider the following when presenting information on a table.

* The table should have a title.
* Every column should have a heading.
* The units of measurement should be identified for all columns or rows containing figures.
* Figures in each column or row should be aligned.
* A zero should be used only when a measurement of zero was obtained; a dash should be used when no reading was recorded.
* Identical results should be written again, not shown with ‘ditto marks’.
* The same item should not appear in more than one category in any one table (categories should not overlap).

Ref: NSW Board of Studies *Science Stages 4-5 Support Document* (1999) Available at:

http://www.boardofstudies.nsw.edu.au/syllabus\_sc/pdf\_doc/science45\_sup99.pdf

**Tables (*Features)***

Title

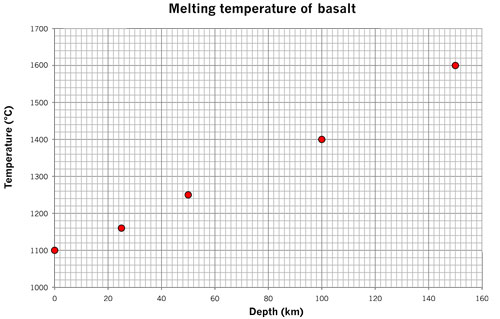
This is where the dependent data goes.

Column

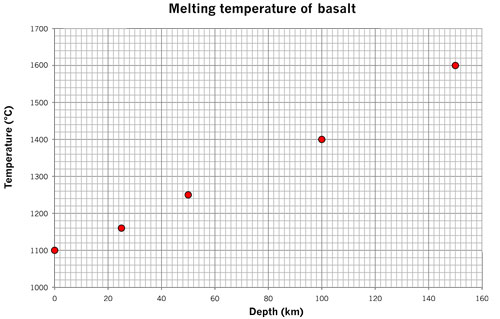
This is where the Independent Variable goes. (the thing you changed)

|  |  |
| --- | --- |
| ***Depth (km)*** | ***Basalt melting temperature ( ᴼC)*** |
| 0 | 1100 |
| 25 | 1160 |
| 50 | 1250 |
| 75 | 1400 |
| 100 | 1600 |
| 0 | 1100 |

Plotting data

[](http://serc.carleton.edu/details/images/12772.html)

Line of best fit

[](http://serc.carleton.edu/details/images/12772.html)

Notice how the as the curve approached the y axis it doesn’t go through point (0,0)

Tables E.g (Example; Effect of light on the growth of mould)

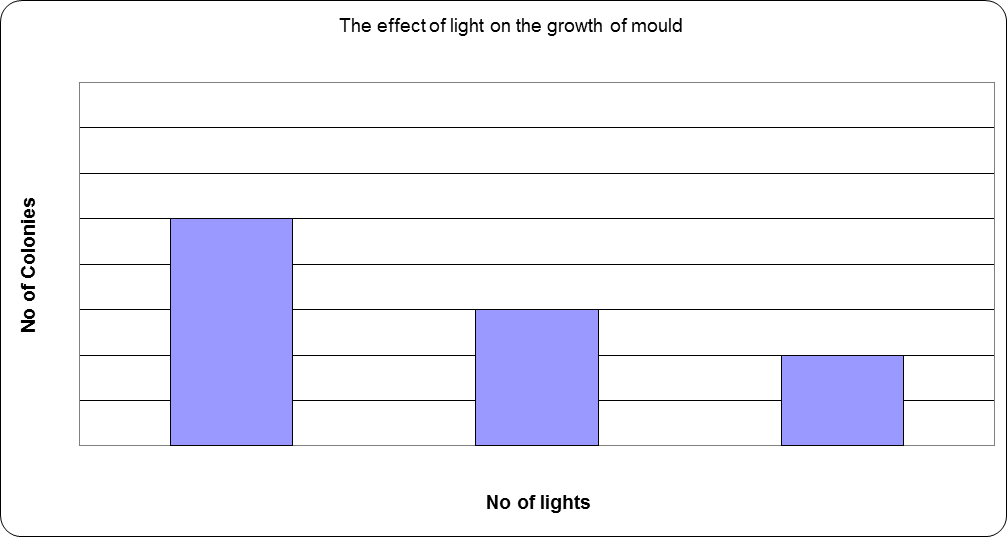
Data collected

|  |  |  |  |
| --- | --- | --- | --- |
| Effect of light on the growth of mold | | | |
| ***Bread Sample*** | ***Number of colonies*** | | |
| ***No light source*** | ***One UV light*** | ***Two UV lights*** |
| ***1*** | **4** | **4** | **2** |
| ***2*** | **6** | **3** | **1** |
| ***3*** | **7** | **3** | **2** |
| ***4*** | **3** | **2** | **2** |
| ***5*** | **5** | **3** | **3** |
| **Average** | **5** | **3** | **2** |
| **Range** | **3-7** | **2-4** | **1-3** |

N.B. This an example of quantitative data. It does not include how much UV light but has many extra lights.

The average is used to produce the column graph.

Column Graphs



Dependant variable

Columns

Object

scale

Numerical scale

Independent variable (Qualitative)

***Column Graphs***

This graph type may be used to display data which consist of separate or distinct parts (discrete data). In this graph type, the horizontal axis in equal intervals and vertical columns of equal width are drawn to the appropriate height of the vertical scale.

Ref: NSW Board of Studies *Science Stages 4-5 Support Document* (1999) Available at: http://www.boardofstudies.nsw.edu.au/syllabus\_sc/pdf\_doc/science45\_sup99.pdf

***Bar Graphs and Sector Graphs***

These graph types may be used to display the component parts of a total. A simplified way of displaying this type of data is by the division of a rectangle (bar) into the proportions of the component parts. In a sector graph (pie chart), a circle is divided into sectors where the angles at the centre are in the same proportion as the component parts.

Ref: NSW Board of Studies *Science Stages 4-5 Support Document* (1999) Available at: http://www.boardofstudies.nsw.edu.au/syllabus\_sc/pdf\_doc/science45\_sup99.pdf

Graphs

**USING LINE GRAPHS**

(most commonly used in scientific investigations )

**Mean growth of pansies**

0

1

2

3

4

5

6

7

8

9

10

10

12

14

16

18

20

22

**Temperature (0C)**

**Mean Growth Rate (mm)**

Label

Numerical

scale

Object

scale

Title

***Line Graphs***

This graph type may be used to display the relationship between two variables for which the obtained data are samples of a continuum (continuous data).

Ref: NSW Board of Studies Science Stages 4-5 Support Document (1999), page 40

Available at: http://www.boardofstudies.nsw.edu.au/syllabus\_sc/pdf\_doc/science45\_sup99.pdf

Graphs

**Graphs checklist**

Consider the following when presenting information graphically.

* The graph should have a title
* The x-axis should display the independent variable (where the experimenter controls the cause); the y-axis should display dependent variable (which measures the effect)
* Axes should be clearly labelled to indicate the relevant variable, including units (where applicable)
* Axes representing numerical quantities should have a linear or logarithmic scale, clearly marked with at least three or more points on each scale
* Scales should be selected which allow the range of data displayed to extend over most of the available grid
* An axis does not need to be continuous if a discontinuity marker is shown
* An axis doe not need to start from zero
* Data points should be accurately plotted
* Where appropriate, the trend demonstrated by the plotted points on a graph should be shown, merely marking the plotted points may not be acceptable
* Extrapolations, if used, should not be joined to the origin or axes unless this is given in the data or can be reasonably assumed
* If there is more than one line shown on the graph, or if symbols are used, a key must be given so that each line or symbols is readily identifiable.

Identifying trends and patterns

Do the results show any trends?

Has the most appropriate graph been used to show the results?

Is there any significant difference between the different conditions of UV light?

How reliable are the results? How accurate were the measurements?

How valid are the results?

How well were all variables identified and controlled?

Were the number of trials / samples appropriate?

Analysis and conclusion

Having conducted an investigation, the important process of analysing the results and forming conclusions follows. In writing their discussion, students may find the following scaffold useful.

Write the answers to these questions in paragraph form.

* What was the purpose of your experiment?
* What were the major findings? What significant trends or patterns were observed in your data?
* How accurate were you in collecting data?
* How well was the hypothesis supported by the data? (Answer in a complete sentence, NOT using the word yes or no!)
* How did your findings compare / contrast with your research?
* What possible scientific explanation can you offer for the findings?
* What recommendations do you have for improving your experiment? (This is ways to correct problems you encountered in this experiment.)
* What recommendations do you have for further study? (this is another experiment based on your experiment, but different.)
* What significance do your findings have for you and others in your community?

Sample Conclusion

**CONCLUSION:**

In the experiment the hypothesis was (supported/not supported), as the mass of the marble representing a meteorite or comet increased so did the size of the impact crater it made in the tray of sand represent the surface of a terrestrial body. In experiment three marbles of with different relative masses) were all dropped form a height of 50cm (control) and the resulting impact craters diameter was measured. The wood marble (least mass), created an impact crater that was 3.3cm in diameter (see Table 1 and Graph 1). The plastic marble (intermediate mass) created an impact crater that was 4.25cm in diameter (see Table 1 and Graph 1). While the glass marble (most mass) created and impact crater of 5.25cm in diameter (see Table 1 and Graph 1). The evidence strongly supports the problem statement that as the mass of a meteorite/comet increases the diameter of an impact crater created during an impact event on a terrestrial body (planet/moon) will also increase. It is this increase in impact crater size due to an increase in mass that may be responsible for mass extinctions over Earth’s geologic history.

Limitations and Validity: Several sources of error were observed during the course of this experiment. First, the preparation of the sand texture was not accurately determined. Wetting the sand needed to be more regulate. Secondly, due to the small size of the marbles it was difficult to be sure which had the most mass. A possible solution would be to vary the size of the marbles more.

Adapted, 11 December 2011, from Curriculum K-12 Directorate, NSW Department of Education and Training, Dec 2004