ASELL Advancing Science and Engineering through Laboratory Learning

ASELL Schools Science Workshop

Experiment Manual

Elisabeth Murdoch College, Langwarrin

1 June 2015

WWW.ASELL.ORG

ACKNOWLEDGEMENTS

We would like to thank:

THE ROYAL AUSTRALIAN CHEMCAL INSTITUTE

WELCOME

Welcome to 2015 ASELL Schools Science Workshop!

ASELL (Advancing Science and Engineering through Laboratory Learning) has developed over the last 10 years. This project developed from its physical chemistry APCELL predecessor and then expanded to incorporate all of chemistry (ACELL). After successful trials of using ASELL principles at workshops in physics and biology, the project has now expanded to include biology and physics, hence the name change.

The ASELL project has been designed to help address challenges in student learning which arise in science laboratories. By bringing together diverse expertise and resources, it is possible to develop a collection of experiments, which can facilitate student learning, whilst also taking into account variations in student differences. In 2010, the first national ASELL Science Workshop was held at the University of Adelaide.

This ASELL Schools workshop will be the first Victorian and the second nationally to be run under the Australian Mathematics and Science Partnership Funding Grant which was awarded to ASELL in 2014. This phase of the project has been initiated by Deakin University in conjunction with the University of Sydney with support from the Australian Council of Deans of Sciences. With the introduction of the new Australian Curriculum now in place, an opportunity exists to address current school-based experimentation and incorporate science inquiry. ASELL Schools will provide the following three outcomes:

- A resource, a repository of experiments with all associated documentation necessary to run them, ranging from health and safety notes, necessary equipment and resources, notes for technical staff to the science learning objectives and how the experiment achieves them.
- Authentic professional learning workshops on experimentation in schools.
- An interface and interaction between school and university staff.

Today, you will be participating in laboratory activities and discussion sessions to expand your understanding of issues surrounding learning in the laboratory environment. In particular, it is important to be able to experience the experiments as learners.

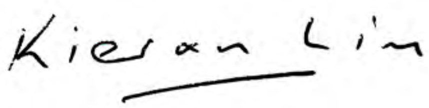
In addition to the formal program, please take the opportunity to exchange ideas about science and education and get to know each other, as an additional aim of the ASELL Schools project is to build a community of educators interested in laboratory-based education and other aspects of science education.

Up-to-date information concerning the ASELL Schools Project is provided on the project's NEW website at www.asell.org. The website provides public access to all experiments which have completed their testing process. Any teacher-delegate attending this workshop is entitled to an Academic user on the web site, and can request their account be upgraded using the contact form on the site. Gradually, more resources for the school sector will be added to the website.

We would like to gratefully acknowledge the efforts of the submitters in presenting their experiments, as well as the assistance of technical staff and others in making this workshop possible. A very big thank you to the team at Elisabeth Murdoch College, Langwarrin, for hosting this Workshop. Each person has put in a lot of hard work to get this workshop set up and running. I personally want to thank everyone!

If you have any questions about the project, please speak with me or one of the ASELL Directors, who are present.

Sincerely,



Kieran Lim
ASELL Director on behalf of the ASELL Team

CONTENTS

TEAM FOR ASELL WORKSHOP

ASELL Directors

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Jasmine Williamson (Gleneagles Secondary College)

Technical Staff

Damon Kennedy (Elisabeth Murdoch College)

Monday 1 June 2015 ***Elisabeth Murdoch College, Langwarrin, VIC***		
9:15 – 9:30	**Arrival/Registration**	
9:30 – 9:45	Welcome and Introduction A/Prof. Kieran Lim	
9:45 – 10:45	***Laboratory Session 1 – Exemplar experiment (Baggie Science)*** (see experiment allocations for your group)	
10:45-11:05	**Morning Tea**	
11:05-11:50	**Teachers:** Science Inquiry A/Profs Kieran Lim and Manju Sharma • What is Science Inquiry? • How can we incorporate more science inquiry into experiments? • Analysing inquiry from the exemplar experiment	**Students:** Pasta-and-marshmallow challenge Dr John Long
11:50-12:50	***Lab Session 2 Green gunge*** (see experiment allocations for your group) **15 minutes for discussion/feedback** Students move to at 12:35 for separate discussion/feedback	
12:50 -1:30	**Lunch**	
1:30-2:30	***Lab Session 3 Stomata on Leaves*** (see experiment allocations for your group) **15 minutes for discussion/feedback** Students move to at 2:15 for separate discussion/feedback	
2:30 – 2:45	**Teachers:** Overall debrief A/Profs Manju Sharma and Kieran Lim	**Students:** Overall debrief, student feedback, student survey Dr Peta White
2:45 – 3:45	**Teachers:** Discussion and Wrap Up A/Profs Manju Sharma and Kieran Lim	**Students:** Optional student activity Mr Evan Hefer

LABORATORY SESSION 1

		Group 1	**Group 2**	**Group 7**	**Group 8**
Expt 1	**Baggie Science** Demonstrators: Kieran Lim, Manju Sharma	Chris Alley, Denise Raven, Carol Cartwright		Lizzie Halton, Nipun Thenuwara, Jarrod Neves, Jasmine Williamson	Marta Ivkov, Janet Whitby, Jo Vincent, Michelle Wills
		Group 3	**Group 4**	**Group 9**	**Group 10**
		Sandy Abey, Amy Dean, Rob Blakis, Patrick Sanders	Ben Frazer, Georgina Slater, Ryan Simpson	Nick Holmes, Lachlan Ross, Bella Perry	Jodie Ashby, Keryn Rooke, Venkata Kalva, Lucie Turner
		Group 5	**Group 6**	**Group 11**	
		Peter Beissmann, Jennifer Rice, Ellen Fisher, Catherine Tuxen	John Bass, Mercedes Phillips, Emily Christie, Bree Rogers	Natasha Pollard, Jacob Smith, Pippy Schuller	

LABORATORY SESSION 2

Expt 2	**Green Gunge** Demonstrators: Amy Dean, Michelle Wills	**Group 1** Peter Beissmann Keryn Rooke Rob Blakis	**Group 2**	**Group 7** Emily Christie Georgina Slater Bella Perry	**Group 8** Carol Cartwright Lucie Turner Patrick Sanders
		Group 3 Sandy Abey Jennifer Rice Venkata Kalva Jo Vincent	**Group 4** Ben Frazer Natasha Pollard Nick Holmes Bree Rogers	**Group 9** John Bass Lachlan Ross Jarrod Neves	**Group 10** Jodie Ashby Marta Ivkov Ellen Fisher Denise Raven
		Group 5 Chris Alley Janet Whitby Catherine Tuxen	**Group 6** Mercedes Phillips Nipun Thenuwara Pippy Schuller	**Group 11** Lizzie Halton Jacob Smith Ryan Simpson Jasmine Williamson	

LABORATORY SESSION 3

Expt 3	**Stomata on Leaves** Demonstrators: Peta White,	**Group 1** Chris Alley, Venkata Kalva Ellen Fisher	**Group 2** Ben Frazer, Pippy Schuller Bella Perry	**Group 6** Mercedes Phillips, Jasmine Williamson Lachlan Ross	**Group 7** Amy Dean, Keryn Rooke Marta Ivkov, Catherine Tuxen
		Group 3 Denise Raven, Patrick Sanders Jennifer Rice, Michelle Wills	**Group 4** Emily Christie, Ryan Simpson Nick Holmes, Nipun Thenuwara	**Group 8** Jarrod Neves, Georgina Slater Bree Rogers, Jacob Smith	**Group 9** Sandy Abey, Lucie Turner Peter Beissmann, Janet Whitby
		Group 5 Jodie Ashby, Carol Cartwright Rob Blakis, Jo Vincent		**Group 10** John Bass, Natasha Pollard Lizzie Halton	

Laboratory Session 1

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BAGGIE SCIENCE

Teacher Notes

Contact: Alexandra Yeung
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Website: www.asell.org

BAGGIE SCIENCE

ORIGINALLY PRESENTED BY JOSEPH COLLINS – TRINITY CATHOLIC COLLEGE (NSW)

(Written by Dr Jenny Jones)

ASELL EDUCATIONAL TEMPLATE – SECTION 1 (SUMMARY OF THE EXPERIMENT)

1.1 Experiment Title

Baggie Science

1.2 Introduction and Description of the Experiment

Substances may be created by chemical change and may also undergo chemical change. If a substance is produced as a result of a chemical change, or reaction, it is a product. If a substance is the subject of a chemical change, it is a reactant. The same substance can be either a reactant or a product, depending on the chemical reaction. One way of knowing that a chemical change has occurred is by observing that the properties of the product are different from those of the beginning reactant. There are 4 simple ways the students can recognise a chemical reaction has occurred.

- A colour change. A new colour appears, which indicates that a new substance is present. This substance was not present before the reaction, because its colour was not observed.
- The formation of a gas. Sometimes you will see a gas emerge from a solution as bubbles form and rise and release gas at the surface.
- The formation of a precipitate. A precipitate is an insoluble product, which forms as a result of chemical change. Typically, you will see a precipitate when two solutions are mixed. You will see a solid form, which will fall to the bottom of the test tube (the precipitate). Usually, a colour change will be associated with the formation of a precipitate.
- Energy change. In an energy change, heat will be given off or absorbed. In an exothermic reaction, energy is given off - the solution will get hot. In an endothermic reaction, heat will be absorbed - the solution will feel cold.

In this experiment two different white powders and a green liquid are added to a bag and the bag is sealed. The mixture changes from green to yellow, one powder cools the liquid as it dissolves, the other powder warms the liquid, bubbles are produced and the bag pressurizes.

This experiment is intended to lead onto further investigation.

1.3 Reasons for Submission

The experiment was successfully completed by our students without too teacher intervention. The feedback from the students was very positive and they enjoyed learning about the scientific process whilst being able to apply their knowledge and skills. The experiment allowed the students to perform an experiment and identify and complete follow up experiments.

When asked for a submission of an experiment, which involved students controlling the direction of their learning, this particular one seemed ideal.

1.4 Experiment Aims and Objectives

To initial aim is for students to look for visual and tactile clues that would suggest that a chemical change has occurred.

The experiment allows students to follow a procedure, record observations and then propose a hypothesis. Students then follow correct scientific method for further investigation. Students will hopefully gain a greater understanding of scientific inquiry.

For example the students may decide to try using water to see what the effect of the green liquid is (all it does is change colour – the other effects occur as previously observed).

Students explore what happens when the chemicals are mixed in bags or test tubes. Show how to level a teaspoon and measure using a measuring cylinder so that students can record how much of a substance is used. For example, a student could mix a teaspoon of sodium bicarbonate with 10 ml of Universal Indicator solution. What happens? How does this compare with the results of mixing a teaspoon of calcium chloride with 10 ml of Universal indicator? What if a teaspoon of each solid and the indicator are mixed? Students should record what they mixed, including quantities, the time involved to see a reaction.

Using this type of questioning will increase their scientific literacy and foster their understanding of the 'nature of science, that all scientific knowledge is based, at least partially, on and/or derived from observation of the natural world.

1.5 Level of the Experiment

(NSW) Stage 5 students - (the only experience we have had is with our extension science students in year 9. They were suitably motivated to continue investigating their ideas))

Victorian AusVELS level 8 (year 8).

- Chemical change involves substances reacting to form new substances (ACSSU225)
- Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS140)

1.6 Keyword Descriptions of the Experiment

Domain keywords: chemistry, chemical reactions

Specific Descriptors: observation, chemical change, reactant, product, physical change,

1.7 Course Context and Students' Required Knowledge and Skills

The experiment involves all the skills components of the current Stage 5 syllabus in NSW. It is appropriate for the level 8 (year 8) AusVELS syllabus in Victoria.

This activity is excellent for discussions about observing changes in matter and is not linked to prior knowledge of chemical equations or the processes involved.

1.8 Time Required to Complete

Prior to Lab: 30-40mins
In Laboratory: 50-80mins
After Laboratory:
1.9 Authors of Educational Analysis

Joseph Collins
Trinity Catholic College

1.10 Experiment History

Dr Jenny Jones showed the experiment to Chemistry teachers at a recent Chemistry course in Sydney. After using it at our school, we decided it would be an excellent experiment to start the year with our new Year 9 students.

1.11 Any Other Comments

- See students worksheet
- See teacher notes

Some Possible Inquiry Questions:

1. What happened when the indicator mixed with the baking soda and calcium chloride?

2. What are at least five observations?

3. Do you think a chemical reaction occurred?

4. How would you define a chemical reaction?

5. What safety precautions will you take doing this activity?

6. What are some additional activities that you could do with these chemicals that would build on this initial activity? Propose a hypothesis you could test based on your observations

1.12 References

Dr Jenny Jones - Student and Teacher Worksheets

http://www.lopezlink.com/lapexp2.htm

http://www.edu.pe.ca/threeoaks/science/grassroots/sci421/LabObservingChemReactions.pdf

http://artofteachingscience.org/mos/cheminbag.html

http://mysciencebox.org/reactionsbox/evidence

Note: Starred outcomes are those that are the principal focus of the exercise. Non-starred outcomes may either be less important, or be outcomes, which could be the focus of the experiment if it were modified. Please restrict yourself to no more than 10 outcomes, with no more than 5 starred, and include at least one outcome in each section.

Learning Outcomes		**Process**	**Indicators**
What will students learn?	**(*)**	**How will students learn it?**	*How will staff **and** students know that the students have achieved the learning outcomes?*

2.1 Theoretical and Conceptual Knowledge

Students learn about the principles of chemical reactions that involve changes in properties and changes in energy that you can observe during experimentation		Students complete a procedure to investigation a chemical reaction	For teachers the data reported back to the group and observations made by the students will provide evidence. For students successful completion of the experiment and observing and recording results will provide evidence.

2.2 Scientific and Practical Skills

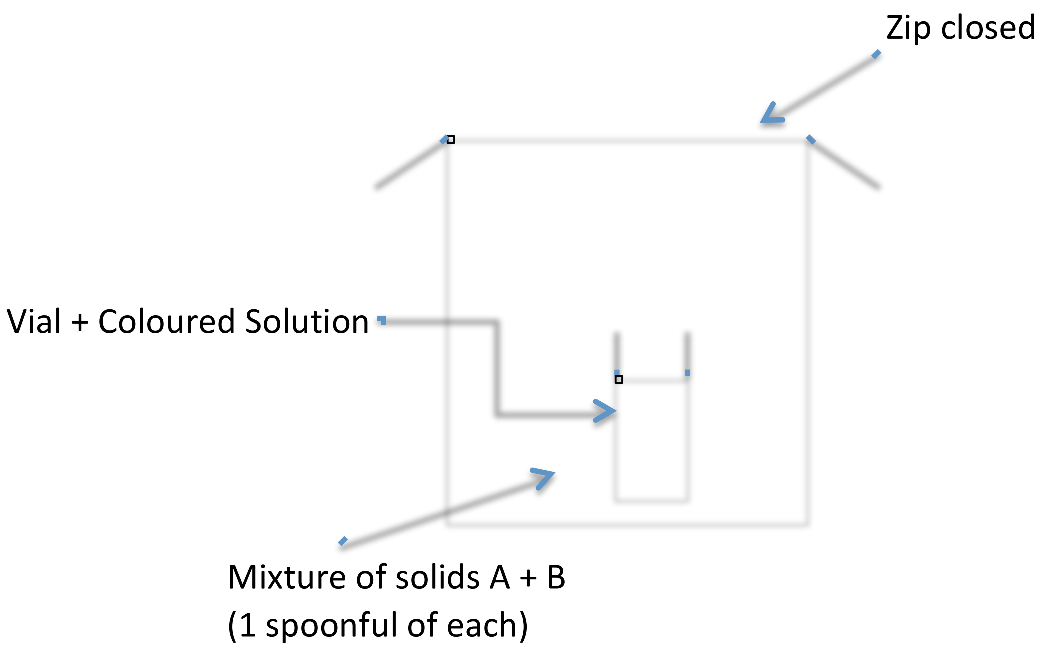
Students can create and complete and perform a planned procedure Communication – with each other in the group. Observation – detailed and accurate. Working in cooperative groups		Creating and following steps in the procedure to successfully complete the experiment	Observations will be recorded and shared with the class. Teacher observation of how students recognise changes and how they record their results will be evidence.

2.3 Thinking Skills and Generic Attributes

Students can propose a hypothesis and create a procedure test their ideas		Planning a simple investigation. If things change – students can work out what caused a particular change by doing more experiments	Evidence is achieved if the follow up experiment can successfully support of refute the hypothesis

BAGGIE SCIENCE (PART 1)

Work in co-operative groups and allocate the roles. Use the materials provided on your bench, to assemble the experiment shown in the diagram below.



- Be careful not to spill the liquid out of the vial as you press the air from the plastic bag and close the zip.
- Shake the bag carefully so that all the coloured liquid mixes thoroughly with the mixture of solids.
- Make as many OBSERVATIONS as you can. The recorder should write these on the piece of paper provided.
- When you can make no more observations, the reporter should write ONE your observations on the board. Choose one, which is not already listed.
- Each member of the group should record the diagram and the observations in their science journal.

BAGGIE SCIENCE (PART 2)

- Your group task now is to design experiments to find out which of the 'ingredients' is responsible for each of the observations.
- There are some important decisions to make – for example:
  - Is it necessary to make it a 'fair test'?
  - If yes, then how do you do that?
- Discuss in your group how you will do your investigation and carry out the procedures.

Remember your group roles.

- When you have decided what is causing the particular observation, write your answer in your own journals and in the appropriate place on the board.

Student Activity

Advancing Science and Engineering
through Laboratory Learning

PASTA AND MARSHMALLOW CHALLENGE

Teacher Notes

Contact: Kieran Lim
kieran.lim@deakin.edu.au
Website: www.asell.org

PASTA AND MARSHMALLOW CHALLENGE

ORIGINALLY PRESENTED BY KIERAN LIM – DEAKIN UNIVERSITY

ASELL EDUCATIONAL TEMPLATE – SECTION 1 (SUMMARY OF THE EXPERIMENT)

1.1 Experiment Title

Pasta and marshmallow challenge

1.2 Introduction and Description of the Experiment

The objective of the practical activity is simple. Each team needs to construct a free-standing tower uing only a limited supply of pasta and marshmallows. The team that builds the highest free-standing tower wins the competition.

- The spaghetti and small marshmallows can be broken or torn into smaller pieces to construct the tower.
- Students will have a 10-minute period to read the instructions and complete the preliminary questions.
- Students will have to use a 5-minute planning period to sketch a blueprint of their design.
- Students will have 25 minutes to build their tower.
- The suggested team size is three.

This practical activity investigates compression and tension forces, and the rigidity of various shapes.

This practical activity is intended to lead onto further investigation.

1.3 Reasons for Submission

The practical activity allows students to plan, build and test a structure from limited simple resources. There is the opportunity for follow up practical activities.

1.4 Experiment Aims and Objectives

To aim is for students to plan, build and test a structure using only limited simple resources.

The activity seems like play, but requires students to informally make a hypothesis (we think this will work) in a student-centred inquiry setting. Teachers can vary the extent of inquiry by giving more clues and background knowledge in previous lessons, or by having this as the introduction to the topic.

1.5 Level of the Experiment

XXXXX

1.6 Keyword Descriptions of the Experiment

Domain keywords: engineering, physics, technology

Specific Descriptors: compression, tension, forces, construction.

1.7 Course Context and Students' Required Knowledge and Skills

XXXXX

1.8 Time Required to Complete

Prior to Lab:
In Laboratory: 40mins
After Laboratory:

1.9 Authors of Educational Analysis

Kieran Lim, Deakin University

1.10 Experiment History

This activity is based primarily on: C. Yakacki, B. Heavner, M. S. Zarske, D. Carlson, 2004, *Hands-on Activity: Leaning Tower of Pasta*, TeachEngineering, University of Colorado <https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_mechanics/cub_mechanics_lesson10_activity1.xml>.

It also incorporates ideas from similar activities various sources: see references.

1.11 Any Other Comments

- See students worksheet
- See teacher notes

Some Possible extensions:

1. As a class, graph the maximum load of each structure as a function of the mass as well as the height of the structure. Discuss different trends and use the graphs to lead in to the other discussion questions.
2. Which geometric shapes seemed the strongest for holding weight — triangles, squares, or circles?
3. Have the students build models using materials other than marshmallows and pasta, such as toothpicks, gumdrops, caramels, Popsicle sticks, etc. Which materials made even better buildings than spaghetti and marshmallows, and why? Have the students discuss these materials in terms of compression and tension.
4. Add an additional level to the investigation by giving each group half a packet of jelly babies as well as the other materials. Because jelly babies and marshmallows differ there is more scope for investigation: jelly babies are stronger, but also heavier, so there is the opportunity to discuss the real-life dilemmas that scientists and engineers face when designing structures..
5. Give each material a cost and give groups a budget (i.e. spaghetti noodle $0.10 and marshmallows $0.20 with a $10.00 budget). Let groups pick how much of each material they want with the given budget and create a structure.
6. Have the students design their own experiment to look at the geometry behind different structures. Which shape can hold the most weight — a triangle, square or circle? Challenge the

students to explain their answers by creating diagrams showing the compression and tension forces on each shape.

7. Students could design their towers on paper before starting to build them. They could use this research time to look at other tall structures (see the links to everyday life below) and how they are built. Impressive ones include the Eiffel Tower, the London Eye, the Blackpool Tower, cranes, etc. When discussing what kind of tower they want to build they could tie this into what they have observed from these other structures.
8. Investigate comparisons and fair testing of strength by using different brands of spaghetti. Is an economy brand necessarily less strong than a premium brand? Check the ingredients and see if you can work out why.

Some Possible Inquiry Questions:

1. Does the placing of the marshmallows affect the strength of the tower?
2. Could you build a stronger tower with more of the same materials? What alternative materials You can test the force needed to break a piece of spaghetti by pushing down on an electric set of scales with one vertical piece of spaghetti, noting down what mass is on the scales when it breaks. Try using a half length and then a quarter length and compare the difference. This will help to demonstrate that a taller structure is not as strong as a shorter one.
3. Does the size of the base alter the strength of the tower?
4. Is it possible to make a bridge using a similar method? How could you test it?
5. What safety precautions will you take doing this activity?
6. What are some additional activities that you could do with these chemicals that would build on this initial activity? Propose a hypothesis you could test based on your observations

1.12 References

The British Association for the Advancement of Science, *Spaghetti Tower*, <http://kats.org/wp-content/uploads/2014/07/Spag_towers_instructions.pdf>.

C. Kesler, *Spaghetti and Marshmallows Tower Lab*, KeslerScience.com, <http://www.keslerscience.com/spaghetti-and-marshmallows-tower-lab/>.

Loras College, 2012, *Leaning Tower of Pasta*, Communities of Exemplary Practice (CEP) Program, Loras College, Dubuque (IA), <http://loras.edu/LorasCollege/files/aa/aaffeff5-0fdc-490b-9db3-b17b6594a3d4.pdf>.

Science Museum, *Spaghetti Challenge*, London, <http://www.sciencemuseum.org.uk/educators/teaching_resources/activities.aspx>.

M. Whitman, *Leaning Tower of Pasta*, Engineering Technology Department, Bigelow Middle School, Newton (MA), <http://www2.newton.k12.ma.us/~mike_whitman/curriculum/pdfdownloads/Leaning_Tower_of_Pasta.pdf>.

C. Yakacki, B. Heavner, M. S. Zarske, D. Carlson, 2004, *Hands-on Activity: Leaning Tower of Pasta*, TeachEngineering, University of Colorado <https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_mechanics/cub_mechanics_lesson10_activity1.xml>.

SECTION 2 – EDUCATIONAL ANALYSIS

Note: Starred outcomes are those that are the principal focus of the exercise. Non-starred outcomes may either be less important, or be outcomes, which could be the focus of the experiment if it were modified. Please restrict yourself to no more than 10 outcomes, with no more than 5 starred, and include at least one outcome in each section.

Learning Outcomes		**Process**	**Indicators**
What will students learn?	**(*)**	**How will students learn it?**	*How will staff* ***and*** *students know that the students have achieved the learning outcomes?*

2.1 Theoretical and Conceptual Knowledge

2.2 Scientific and Practical Skills

2.3 Thinking Skills and Generic Attributes

TECHNICAL NOTES

Equipment requirements (per group of students)

- 20 pieces of spaghetti per group
- 20 small marshmallows per group
- Writing material, for example laboratory notebook and pens/pencils

Equipment requirements (for extension)

- Small weights and some means to attach the weights to the constructed towers (paperclips, string, etc)
- Graph paper

Equipment requirements (for teacher)

- Metre ruler or tape measure
- Stopwatch or classroom clock
- Camera (optional)

Hazards

- The rigid, long pasta could injure an eye. Although this is an activity with a lot of freedom, students should not horseplay with the spaghetti.
- The pasta and marshmallows are used as construction materials in an environment that does not satisfy food hygiene standards. Students should not consume the pasta and marshmallows.

Experimental NOTES

- This investigation can cause some mess, so have cleaning materials and black bin bags available for clearing up afterwards. If you cut open bin liners you can use them as tablecloths or floor mats and this will enable you to roll up the mess ready for the bin at the end of the activity.
- If you want to limit the mess further you can tell students that they have to use the marshmallows whole.
- Have some hand wipes available as things will get sticky (especially in a hot room).
- Try and keep the room you are working in cool to limit the mess further.
- Group sizes should be between 3 and 5 – which makes for a really good team-building exercise.

PASTA AND MARSHMALLOW CHALLENGE – RISK ASSESSMENT

Hazards

- The rigid, long pasta could injure an eye. Although this is an activity with a lot of freedom, students should not horseplay with the spaghetti.
- The pasta and marshmallows are used as construction materials in an environment that does not satisfy food hygiene standards. Students should not consume the pasta and marshmallows.

PASTA AND MARSHMALLOW CHALLENGE

ORIGINALLY PRESENTED BY KIERAN LIM – DEAKIN UNIVERSITY

The objective of the lab is simple. Each team needs to construct a free-standing tower. The team that builds the highest free-standing tower wins the competition.

- The spaghetti and small marshmallows can be broken or torn into smaller pieces to construct the tower.
- You will have a 10-minute period to read the instructions and complete the preliminary questions.
- You will have to use a 5-minute planning period to sketch a blueprint of their design.
- You will have 25 minutes to build their tower.
- The suggested team size is three.

Background information

Have you ever wondered how really tall buildings stay up? Why do skyscrapers not fall down when wind hits them? Engineers work with architects and scientists to understand what makes materials break, and then use what they learn to design strong structures. Today, you will have the opportunity to figure out how to make a strong structure, too. Sometimes, engineers may be able to find very strong materials, but they cannot use them in a structure because the materials are too expensive. Sometimes, engineers cannot use as much material as they might like due to budget or supply limitations. Just like an engineer, today you will be constrained; you can only use a limited amount of materials. Your job is to design and build a structure that is as tall and strong as possible, using only marshmallows and spaghetti.

The shapes that are used to build strong structures are very important. Think about the shapes that have been used to construct bridges and towers that you have seen or know about. Start to practice building with spaghetti and marshmallows by testing out different basic shapes such as squares and triangles. You will discover that squares collapse easily under compression. Four pieces of spaghetti joined in a square give way at their joints the weakest points. But, if you make a spaghetti triangle, the situation changes. To make the triangle collapse you have to push very hard. You can build very large structures from squares and cubes, but they will be weak and will usually loll down quite easily. II you try to make a structure out of triangles and pyramids, it will be strong but you will use a lot of materials before the tower gets very tall! The best way to build a tall tower is to use both triangles and squares - that way you can build big structures that are less wobbly. A diagonal piece of spaghetti put across a square turns a square into two triangles and makes it more rigid.

Even though a tower you build may be standing perfectly still, the individual parts are always pushing and pulling on each other. Large structures remain standing because some parts are being pulled or stretched (tension members) at the same time as others are being pushed or squashed (compression members). The vertical pieces of spaghetti in your tower will be in compression, and the compression will be greatest at the base of the tower. The horizontal and diagonal pieces of spaghetti in the tower may be in tension. The strength of these tension members will not depend on how strong the spaghetti is, but on how well the marshmallows can grip it (and hold it in place). The marshmallows are most likely to change shape and fail at the bottom of the tower, where there is most weight on them (from the compression and tension members).

How will you design the tallest (and/or strongest) structure using limited resources?

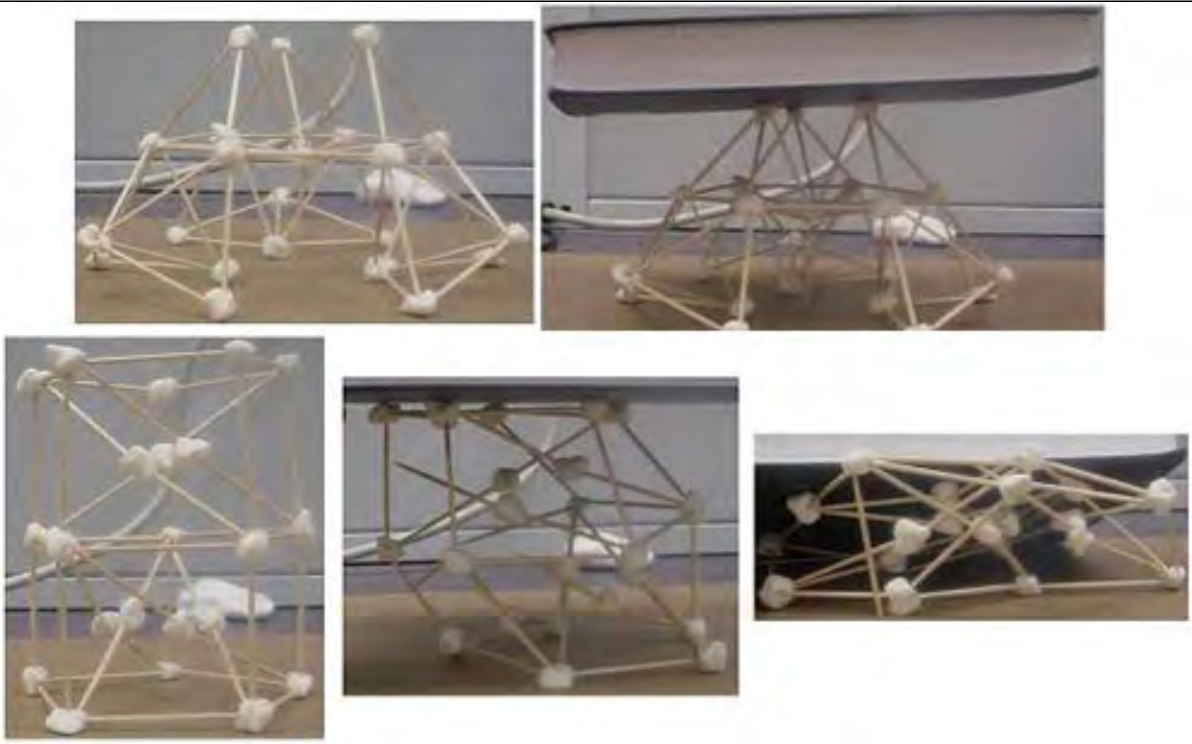


Figure 1. Some structures are strong.... and, some are not.

Preliminary questions

1. Define **compression**:

2. Define **tension**:

3. Define **load**:

4. Is spaghetti stronger in tension or compression? Why?

5. Are marshmallows stronger in tension or compression? Why?

Instructions

The object of this activity is to build a tower as high as you can, using only a limited supply of spaghetti (or linguine or fettuccini) and marshmallows. There are no step-by-step instructions for this project, only the constraints of limited resources! You can do whatever you want with the materials to try to build a structure as tall and stable as possible.

Results

6. How tall was your structure?

7. Now having built a tower, how would you build a new, better tower?

8. How do you think you worked as a group? Did you assume different roles? Did all groups work in the same way?

Extension activities

How much mass can your structure support?

A good way to comparatively measure the effectiveness of each structure is by measuring the load the structure can support and dividing the load by the mass of the structure. The higher this number, the more effective the structure. For example, 30g (maximum mass structure could hold) divided by 10g (mass of structure alone) = 3.

9. What is the mass of your structure?

10. What is the maximum load that your structure can support?

11. What is the mass divided by the maximum load of your structure?

12. Why do you think some towers supported more load than others before falling?

13. What materials would you choose next time if you were to build a structure? Why?

Laboratory Session 2

ASELL Advancing Science and Engineering through Laboratory Learning

GREEN GUNGE

Teacher Notes

Contact: Amy Dean
dean.amy.a@edumail.vic.gov.au
Website: www.asell.org

GREEN GUNGE

ORIGINALLY PRESENTED BY AMY DEAN – ELISABETH MURDOCH COLLEGE

ASELL EDUCATIONAL TEMPLATE – SECTION 1 (SUMMARY OF THE EXPERIMENT)

1.1 Experiment Title

Green Gunge

1.2 Introduction and Description of the Experiment

The objective of the practical activity is to separate a mixture of pebbles, ground chalk, copper sulfate and water. Students investigate the separation of insoluble solids from liquids using techniques of sieving, decanting, and filtering. They investigate the separation of soluble solids from solutions by evaporation.

1.3 Reasons for Submission

This investigation combines several aspects of Science Inquiry Skills (SIS) and Science as a Human Endeavour (SHE) in an activity that is strongly linked to content in Science Understanding (SU).

1.4 Experiment Aims and Objectives

This is a junior science (year 7) activity, and also introduces students to solutions, solubility, suspension and sediment; decanting, filtration; examples of mixtures and separation in everyday life; evaporation of water from a copper sulfate solution; formulating a simple hypothesis; and report writing.

1.5 Level of the Experiment

Victorian Year 7.

Links to AusVELS:

- Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)
- Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations (ACSHE120)
- Science understanding influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management (ACSHE121)
- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)
- Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)
- Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method (ACSIS131)
- Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate (ACSIS133)

Partial links to AusVELS:

- Water is an important resource that cycles through the environment (ACSSU222)

1.6 Keyword Descriptions of the Experiment

Domain keywords: chemistry, junior secondary science.

Specific Descriptors: separation of mixtures, solutions, solubility, decanting, filtration, evaporation.

1.7 Course Context and Students' Required Knowledge and Skills

This practical activity occurs in the fifth session of a 6-lesson sequence, in term 2 of year 7 (first year of secondary school in Victoria). The home institution has 70-75 minute class periods.

In the first three lessons of the sequence, students are introduced to: mixtures, solutions, solute, soluble, insoluble, scum, suspension and sediment; dissolved, concentrated, dilute, miscible, immiscible; decanting, filtration; examples of mixtures and separation in everyday life; evaporation of water from a copper sulfate solution.

In the lesson, which immediately precedes this activity, there has been an explanation of the experiment, students formulate a hypothesis, and they start writing report.

1.8 Time Required to Complete

Prior to Lab: 280 minutes (4 class periods)
In Laboratory: 70 minutes (one class period)
After Laboratory: 70 minutes (one class period)

1.9 Authors of Educational Analysis

Kieran Lim, Deakin University

1.10 Experiment History

This experiment was developed by Amy Dean, Elisabeth Murdoch College.

1.11 Any Other Comments

- See student worksheet

Some Possible extensions:

9. .

Some Possible Inquiry Questions:

7.

1.12 References

SECTION 2 – EDUCATIONAL ANALYSIS

Note: Starred outcomes are those that are the principal focus of the exercise. Non-starred outcomes may either be less important, or be outcomes, which could be the focus of the experiment if it were modified. Please restrict yourself to no more than 10 outcomes, with no more than 5 starred, and include at least one outcome in each section.

Learning Outcomes		**Process**	**Indicators**
What will students learn?	**(*)**	**How will students learn it?**	*How will staff **and** students know that the students have achieved the learning outcomes?*

2.1 Theoretical and Conceptual Knowledge

Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113).	*	Students will separate a mixture of pebbles, ground chalk, copper sulfate and water into its components using some combination of sieving, decanting, filtering, and evaporation.	Students will obtain separate components. Each component will look different from the starting mixture and from each other. The components will be familiar to the students so they will know that separation of the pure components has been achieved.

2.2 Scientific and Practical Skills

Students will consolidate separation skills of sieving, filtering, and evaporation, that they have learnt from previous lessons .	*	Students will separate a mixture of pebbles, ground chalk, copper sulfate and water into its components using some combination of sieving, decanting, filtering, and evaporation.	Students will obtain separate components. Each component will look different from the starting mixture and from each other. The components will be familiar to the students, so they will know that the separation skills have been successfully used.
Students will communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate (ACSIS133)	*	Students will write a report using a template to present the outcomes of their investigation using scientific language that is appropriate for the target audience.	The report will use scientific language correctly. The report will be a concise and precise description and discussion of what was done in the experiment.

Learning Outcomes		Process	Indicators
What will students learn?	**(*)**	**How will students learn it?**	*How will staff **and** students know that the students have achieved the learning outcomes?*

2.3 Thinking Skills and Generic Attributes

Using information and knowledge from previous investigations to predict the expected results from an investigation (part of ACSIS124). Working collaboratively to decide how to approach an investigation (part of ACSIS125).	*	Students will propose (hypothesise) a sequence of separation steps to separate a mixture of pebbles, ground chalk, copper sulfate and water into its components.	Students will have knowledge of each separate separation step, so they should be able to analyse the combined procedure and know if it is likely to achieve the desired separations. They will also experimentally test the combined procedure and experimentally verify if their prediction is correct.
Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method (ACSIS131).	*	Students will reflect on what they have done in the experiment in Task 3 of the exercise, and may suggest improvements to inquiry methods based on experience.	Students will have knowledge of separation steps, so they can use that pre-existing knowledge and the experience of this experiment to judge if their suggestions are reasonable.

TECHNICAL NOTES

GREEN GUNGE – RISK ASSESSMENT

There are risks associated with heat when evaporating the water. Normal care must be taken during heating of the solution.

There are minor risks associated with use of and disposal of copper sulfate. Disposal risks can be minimized by recycling the copper sulfate for the same practical in another class group, or in a future term or year.

Copper sulfate will corrode steel. Students need to keep workbenches clean.

MSDS - Copper Sulfate **Page 1 of 4**

MATERIAL SAFETY DATA SHEET

Common Name	**COPPER SULFATE**
Manufacturer	Old Bridge Chemicals, Inc.
	P.O. Box 194
	Old Bridge, New Jersey 08857
Telephone	(732) 727-2225
Emergency Telephone	1(800) 275-3924

This document is prepared pursuant to the OSHA Hazard Communication Standard (29 CFR 1910.1200).

SECTION I. MATERIAL IDENTIFICATION

Common Name	Copper Sulfate
Synonyms	Blue Vitrol, Bluestone, Cupric Sulfate
Molecular Formula	$CuSO_4 \bullet 5H_20$
EPA Reg. Number	46923-4
CAS Number	7758-99-8
SIC Number	28199 C 29

SECTION II. PHYSICAL DATA

Physical State	Blue crystals or powder
Boiling Point	-5 H_2O @ 150° F
Melting Point	-4 H_2O @ 110° F
Specific Gravity	2.284
Solubility in H_2O	22.37% @ 0° C
	117.95% @ 100° C
Solubility in other solvents	Soluble in methanol, glycerol and slightly soluble in ethanol
Appearance	Blue crystals or powder
Odor	Odorless

msdscuso4.doc **Old Bridge Chemicals, Inc.**

SECTION III. FIRE AND EXPLOSION DATA

Flash Point	Not applicable
Flammable Limits	Not flammable. If heated above 400° C it can decompose to emit toxic fumes of oxide and sulfur.
Extinguishing Media	Copper Sulfate does not burn nor will it support combustion. If stored with other combustible products use water, CO_2 or dry chemical.
Special Fire Fighting Instructions	If dry heated above 600° C, SO_2 is evolved. If water is used it will solubalize the Copper Sulfate and care should be taken to keep such water out of streams or other water bodies.
Fire and Explosion Hazards	None

SECTION IV. REACTIVITY DATA

Stability	Stable
Conditions to Avoid	Product is highly soluble, but does not react with water.
Incompatibility	None know when product remains dry. Product readily dissolves in water. Solutions are mildly corrosive to steel. Store solutions in plastic or rubber or 304, 347 or 316 stainless steel. Iron and moisture should be avoided. Store in a dry area. With exposure to air it will oxidize and turn whitish.
Hazardous Decomposition Products	None at normal production temperatures and pressures. If dry heated above 600° C toxic sulfur may evolve.
Polymerization	Will not occur.

SECTION V. HEALTH AND HAZARD INFORMATION

Swallowing	Toxic orally in accordance with FHSLA regulations. Acute oral LD50 (male rats) = 472 mg/kg.
Skin	Non-toxic. Skin irritation index is zero in accordance with FHSLA regulations.
Eyes	Corrosive in accordance with FHSLA regulations. Eye irritation score: 24 hours = 41.67; 48 hours = corrosive
Inhalation	Inhalation of dust may cause irritation to the upper respiration tract.
Carcinogenicity	None as per NTP, OSHA, and IARC.

This product contains Copper Sulfate subject to the reporting requirements of Section 13 of the Emergency Planning and Community-right-to-Know-Act of 1986 (40 CFR 372).

SECTION VI. FIRST AID PROCEDURES

Swallowing	Give large amounts of milk or water. Induce vomiting. Call Poison Control Center or a physician.
Skin	Wash thoroughly with soap and water. Remove and wash contaminated clothing before reuse.
Eyes	Immediately flush eyes with plenty of water for 15 minutes. Hold eyelids apart during irrigation. Call a physician.
Inhalation	Remove person to fresh air and call a physician.
Carcinogenicity	None

SECTION VII. HANDLING PRECAUTIONS

Personal Protective Equipment	Chemical safety goggles. Rubber gloves and rubber apron may be worn.
Ventilation	TWA = 1 mg/l for Copper Sulfate. When TWA exceeds this limit in the workplace, provide appropriate ventilation. Wear an approved respirator for dusts or mists: MSHA/NIOSH approved number prefix TC-21C, or a NIOSH approved respirator with any R, P or HE filter.

Alternatively, provide respiratory protection equipment in accordance with Paragraph 1910.134 of Title 29 of the Code of Federal Regulations.

SECTION VIII. ENVIRONMENTAL AND DISPOSAL INFORMATION

Aquatic Toxicity	LC50, 24 hours, Daphnia magna equals 0.182 mg/l. Rainbow Trout equals 0.17 mg/l. Blue Gill equals 1.5 mg/l. All values are expressed as Copper Sulfate Pentahydrate. Test water was soft.
Spills and Leaks	Comply with Federal, State and local regulations on reporting spills. Do not wash away crystals or powder. Recover dry if possible. If product is in a confined solution, react with soda ash to form an insoluble Copper Carbonate solid that can be scooped up.
Waste Disposal	Do not reuse container. Comply with Federal, State and local regulations. Sweep up crystals, powder or insoluble Copper Carbonate and dispose of in an approved landfill.
Environmental Effects	May be dangerous if it enters the public water systems. Follow local regulation. Toxic to fish and plants. Fish toxicity critical concentration is 235 mg/l and plant toxicity is 25 mg/l.

SECTION IX. <u>SPECIAL PRECAUTIONS</u>

Storage	Store in a dry place.
Other Precautions	None other than those stated in the MSDS or on the package.

SECTION XI. <u>REGULATORY INFORMATION</u>

NOTICE: The information herein is presented in good faith and believed to be accurate. However, no warranty, expressed or implied, is given. Regulatory requirements are subject to change and may differ from one location to another. It is the buyer's responsibility to ensure that its activities comply with Federal, State and local laws.

U.S. REGULATIONS: SARA 313 Information. This product contain the following substance subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372: **COPPER COMPOUND** 63.3%.

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA "Hazard Categories" promulgated under Sections 311 and 312 of the Superfund Amendments and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following category: **AN IMMEDIATE HEALTH HAZARD.**

SECTION XII. <u>SHIPPING INFORMATION</u>

DOT Shipping Name: RQ, Environmentally Hazardous Substance, Solid, N.O.S., (CUPRIC SULFATE), 9, UN3077, PGIII, Marine Pollutant, ERG 171.

SECTION XIII. <u>MSDS PREPARATION INFORMATION</u>

Prepared by	Joel L. Goldschmidt, Vice President
Updated	March 16, 1999

GREEN GUNGE

ORIGINALLY PRESENTED BY AMY DEAN – ELISABETH MURDOCH COLLEGE

Year 7 Science
Graded Assessment Task – Green Gunge.

Wow, lucky our class is great. A student from another class has not correctly followed the directions on their prac and has mixed the pebbles, ground chalk and copper sulphate crystals that were on the equipment trolley together in a large beaker of water!

Our job is to separate the mixture into three individual containers.

Task One : The method.

1. How will you separate the mixture? Using the table provided, complete your method and see your teacher before proceeding.

Task Two: Separation of the green gunge.

1. With a partner, complete the separation of the gunge.
2. Keep each substance as you separate it – you will need to show your teacher the three substances as part of your assessment.

Task Three: Report

1. Heading: Green Gunge
2. Aim:
3. Background Theory: Provide definitions for the following words:
   a. Sediment
   b. Solution
   c. Suspension
   d. Decanting
   e. Evaporation
   f. Filtering
4. Method: Stick in the table from Task one.

5. Safety: List 3 safety rules you should follow in this task.
6. Results: Draw a picture or insert a photo of your results, describe what each substance looks like.
7. Discussion: Answer the following questions in full sentences.
    a. Why is filtering better than decanting?
    b. Explain how the colour of the solution changed during your prac?
    c. What worked really well in your practical task and what didn't? Why do you think this happened? How could you avoid the things that didn't work well next time?
8. Conclusion: Have you achieved your aim? What have you learnt?

Name: ____________

Substance that you will separate and collect	Name of the process you will use	List of Equipment you will use	List of any risks with substances or equipment or process being used	Labelled sketch of Equipment (use pencil please)
1.				
2.				
3.				

Title: Year 7 Green Gunge Separation of Mixtures Experiment

Introduction:

In Chemistry we have been studying __________.

Mixtures are_____________________.

The key terms that we learnt about were s________________, s________________ and s_____________.

The separation techniques we have used are___________,_____________ and _____________.

Aim: To use the skills that we have been using in Chemistry to separate the mixture of pebbles, ground chalk and copper sulphate crystals. The mixture will be separated using ________, _______ and ___________techniques.

Hypothesis: It is expected that the following techniques will separate these specific parts of the mixture.

Solid Substance	Term	Separation technique	Reason
1. Pebbles			
2. Ground Chalk			
3. Copper Sulphate			

Equipment: See Handout

Risk Assessment: See handout

Results:

Solid Substance	Term	Separation technique	Observation
1. Pebbles			
2. Ground Chalk			
3. Copper Sulphate			

Discussion:

1. Did you achieve your aim? Why Why not? Use examples to support your understanding.
2. How did your hypothesis compare to your actual results? Discuss in detail the differences and similarities
3. Was the method that you planned the most suitable for this experiment? Why? Why not?
4. Explain what the results showed and observations that you made.
5. What were the factors/variables that influenced your results?
6. What improvements would you make if you were to re-do this experiment?

Conclusion

Overall, this experiment further taught me _________about Chemistry and mixtures.

The aim was/was not achieved because _____________ .

The expected outcome was _________, and the actual results showed_________. Therefore, the experiment proved ________________.

Laboratory Session 3

ASELL Advancing Science and Engineering through Laboratory Learning

Stomata on Leaves

Contact: Katherine Harris
katherine.harris@une.edu.au
Website: www.asell.org

STOMATA ON LEAVES

ORIGINALLY PRESENTED BY KATHERINE HARRIS – UNE

Key Concepts

- Plants generally have an impermeable epidermis and a waxy cuticle to prevent uncontrolled water loss.
- Stomata provide a way for the plant to (a) exchange gases to and from the cells and (b) control their release of water to the atmosphere.

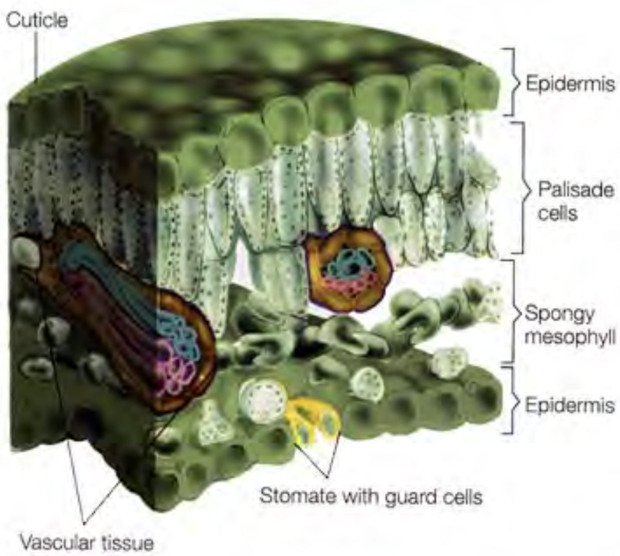
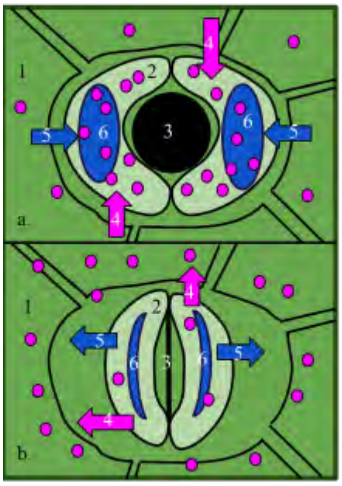


Figure 12-9. Cross section of a typical leaf. Palisade cells and spongy mesophyll are sandwiched between layers of epidermal cells. The surfaces are coated with a waxy cuticle.



An open stoma (a) and a closed stoma (b)
1 Epidermal cell
2 Guard cell
3 Stoma
4 K+ ions
5 Water
6 Vacuole

Summary

In Part 1 students will look at an impression of a leaf's surface under a microscope. They will make a connection between structure and function of stomata. In Part 2 students will design a new experiment to investigate whether Australian native plants show adaptations for the Australian climate with respect to their stomata.

Objectives

Stage 4 Australian Curriculum

LIVING WORLD
Outcome
relates the structure and function of living things to their classification, survival and reproduction SC4-14LW

LW1 There are differences within and between groups of organisms; classification helps organise this diversity. (ACSSU111)

f. explain how the features of some Australian plants and animals are adaptations for survival and reproduction in their environment

Part 1

Experiment

Materials and Equipment

Microscope

Microscope slides

Clear Sellotape

Clear quick-dry nail polish

Freshly picked leaf

Procedure

1. Collect a leaf from a plant.
2. Get a 2cm piece of tape and fold over the top 2-3mm and stick it to itself. Stick the tape on the underside of your leaf.
3. Take the nail polish and paint on a thin coat covering an area equivalent to a 20c piece. Note: half the nail polish should be on the tape and half on the leaf itself.
4. When the nail polish is completely dry and not tacky carefully and slowly peel off the tape – the layer of nail polish should come with it.
5. Without touching it, place the layer of dried nail polish on the microscope slide.

Results

Draw a picture of what you see in the "field of the microscope" (what is visible through the eyepiece on high magnification without moving the slide).

H

Are the stomata open or closed?

____

____

____

____

____

____

Describe the arrangement of the stomata on your leaf? Do you think other plants might have different arrangements?

____

____

____

____

____

____

What do you think is the purpose of stomata on leaves of plants?

____

____

____

____

____

____

Part 2

Design and carry out an experiment that will address the following question.

Do Australian native plants show adaptations for the Australian climate with respect to their stomata?

You will need to include a hypothesis

Advancing Science and Engineering through Laboratory Learning

Optional Student Activity

Advancing Science and Engineering through Laboratory Learning

THE COLOUR OF STARS

-THEY'RE STELLAR

Contact: Evan Hefer

Website: www.asell.org

THE COLOUR OF STARS - THEY'RE STELLAR!

ORIGINALLY PRESENTED BY EVAN HEFER – USYD

The Colour of Stars - They're Stellar!

Throughout the universe, stars of many different sizes and colours exist. There are the Red Giants, White Dwarfs and even yellow Main Sequence stars like our Sun. The colour of a star gives astrophysicists important information about the properties of the Sun. To find out what the colour of a star can tell us, let's think of an example a little closer to home.

Activity 1 Hibernating Bats

After viewing Sir David Attenborough's documentary on hibernating bats answer the following questions.

1. When the bats were dormant, meaning they were hibernating, what kind of electromagnetic radiation were they emitting from their bodies?

2. When the bats started to become active, what changed in regard to the electromagnetic radiation they emitted?

3. What temperature do you estimate the bats' were **before** and **after** they became active?

4. A normal camera relies on the visual part of the electromagnetic spectrum. When the bats were being filmed they could still be seen with the naked eye but if we were to block out all external light (such as from the moon and stars) would we be able to see the bats with just our eyes? Justify your answer.

5. Using the same scenario as questions 4, would we be able to see the bats if we instead use an infrared camera instead of the naked eye.

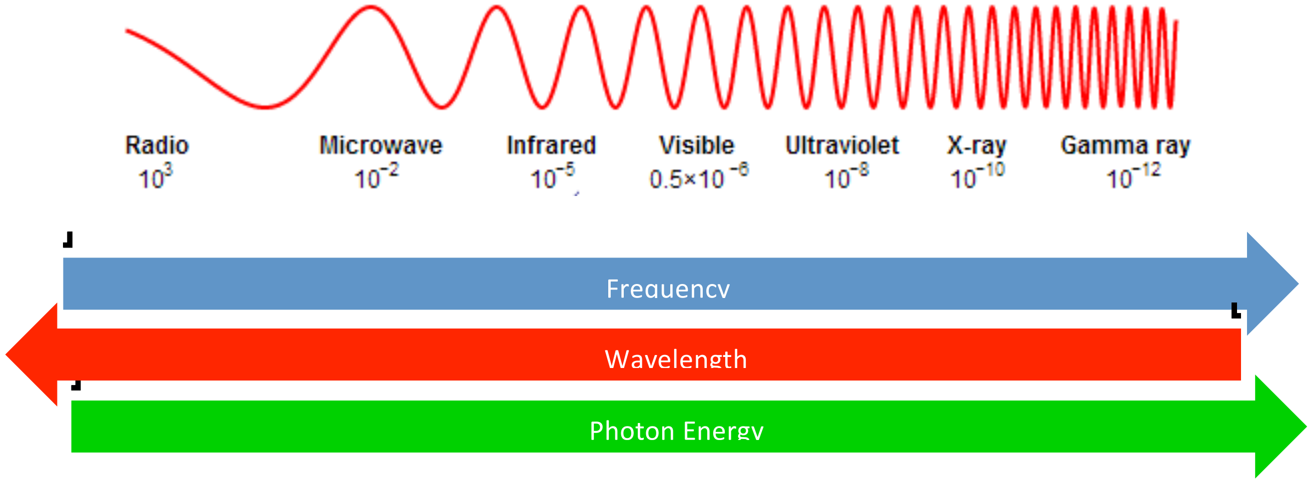
Activity 2- Heating Metal

Using an infrared heat gun or thermocouple, measure the temperature of a piece of nichrome wire when heated with a Bunsen flame over time and note any changes you observe in colour. Summarise your results in a table below.

6. What happened to the piece of copper as its temperature was increased?

7. How do the conditions and results vary from the previous activity with the hibernating bats?

8. If a piece of steel was to be heated to the same temperature as the copper, do you think it would emit the same wavelength of electromagnetic radiation?



Considering the previous two cases, what conclusions can be drawn about the relationship between temperature and the frequency, wavelength and photon energy of the electromagnetic radiation emitted?

As the temperature increases, the frequency of electromagnetic radiation emitted ____________.

As the temperature increases, the wavelength of electromagnetic radiation emitted ___________.

As the temperature increases, the photon energy of electromagnetic radiation emitted _________.

Activity 3- Filament of an Incandescent Bulb

Incandescent light bulbs produce light energy but also a high level of heat/thermal energy. It was for this reason that they were phased out in the early 21^{st} Century in favour of more energy efficient bulbs. The filament of a light bulb can reach in excess of 2500 degrees Celsius emitting a white light.

9. From viewing the clip of a filament heating, how would you describe the light emitted as the filament increased in temperature.

10. There is no specific wavelength of white light. It is a mixture of different wavelengths of light. Considering this and the fact that the light bulb in the clip produced a white light, is the electromagnetic radiation emitted from objects ever just one wavelength?

11. Considering question 10, if viewed through an infrared camera do you think that the light bulb would emit radiation in the infrared part of the spectrum? If so would there be more or less infrared radiation compared to when the filament was at room temperature.

Homework Task

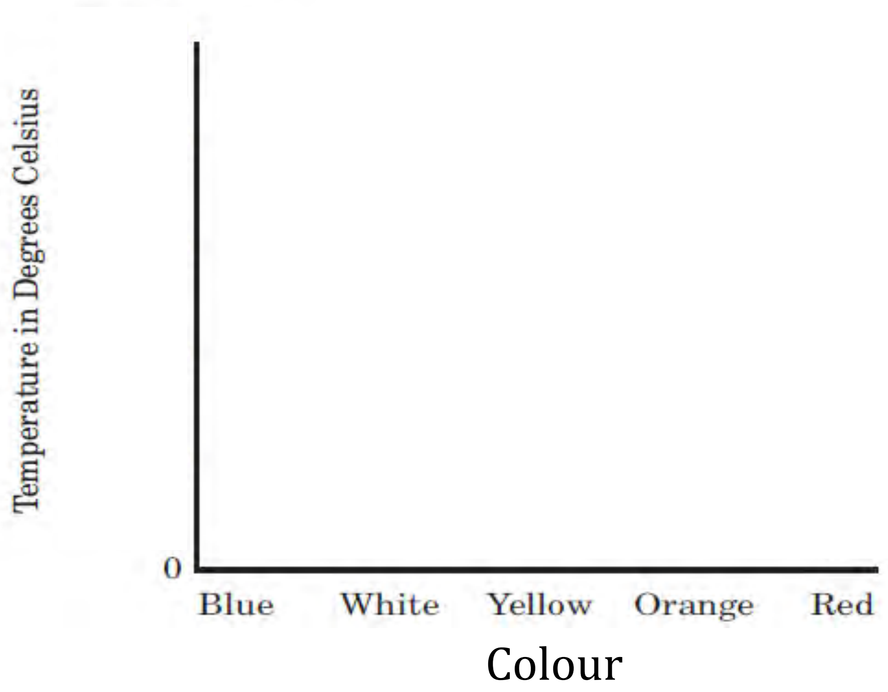
The process of bodies emitting electromagnetic radiation with frequency proportional to their temperature is known as Blackbody Radiation. All things in the universe emit this radiation, including stars. The relationship between temperature and emitted wavelength is demonstrated in the Blackbody Spectrum Simulator available at https://phet.colorado.edu/sims/blackbody-spectrum/blackbody-spectrum_en.html.

12. Use the Simulator to determine a relationship between the temperature of the body, the dominant (main) frequency of electromagnetic radiation (colour) and the amount of radiation (the intensity) emitted from the body.

13. The Table contains colour, temperature and mass values of a range of different stars found in our galaxy, the Milky Way.

Star	Colour	Temperature (°C)	Mass of star (in solar masses)
Sun	Yellow	5,700	1
Proxima Centauri	Red	2,300	0.1
Barnard's Star	Red	3,000	0.1
Epsilon Eridani	Orange	4,600	0.1
Alpha Centauri	Yellow	6,000	1
Altair	White	8,000	3
Vega	White	9,900	3
Sirius	White	10,000	3
Rigel	White	10,000	3
Regulus	White	11,000	8
Hadar	Blue	25,500	20
Alnilam	Blue	27,000	20

On the axis, plot the temperature vs. colour of the stars listed in the table. Label the stars as you plot them.



14. From the graph, what is the relationship between the temperature and the colour of stars?

15. Looking at the table what is the relationship between temperature, colour and mass of stars?

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NOTES