ASLA'S CONFERENCE FOR SCIENCE TEACHERS

Program and Lab manual

August 25th, 2017, 9:00AM - 4:45 PM

NSERC CRSNG

DALHOUSIE UNIVERSITY
FACULTY OF SCIENCE

Engineers NOVA SCOTIA

Acknowledgements

ASLA would like to thank our sponsors:

NSERC CRSNG

DALHOUSIE UNIVERSITY
FACULTY OF SCIENCE

Engineers NOVA SCOTIA

We would also like to thank Dalhousie's Biology and Earth Sciences Departments for helping to make this project a success.

Schedule

8:30-9:00: Registration on the 5th floor biology lounge in the LSC

9:00-9:10: Opening words from ASLA's President; Welcome speech from the Dean of the faculty of Science.

9:10-10:25: Session 1: Group A: Cell biology in lab 2097
Group B: Ecology in lab 2098

10:25-10:40: Tea and coffee break in room 5th floor biology lounge

10:45-12:00: Session 2: Group A: Ecology in lab 2098
Group B: Cell biology in lab 2097

12:00-12:40: Lunch in 5th floor biology lounge

12:45-2:00: Session 3: Group A: Earth sciences in lab 2055
Group B: Chemistry in lab 2097

2:00-2:20: Tea and Coffee break in 5th floor biology lounge

2:25-3:40: Session 4: Group A: Chemistry in lab 2097
Group B: Earth sciences in lab 2055

3:45-4:25: Fish dissection with Neil Ross at lab 2112

4:30– 4:45: Concluding remarks, awarding of certificates in 5th floor biology lounge

LAB BOOKLET

TABLE OF CONTENTS

LAB 1: Cell Biology

Utilizing new model systems to understand cell growth, development and death

Developed by: Arunika Gunawardena, Adrian Dauphinee and Nathan Rowarth, Biology Department, Dalhousie University

Email: arunika.gunawardena@dal.ca

Introduction:

1. What are cells?

Every living organism is comprised of one or more cells. Plants and animals are made up of various types of eukaryotic cells, meaning that they have several membrane-bound organelles including true nuclei that contain chromosomes and DNA that can be considered the genetic blueprints necessary for life. Plants and animals are two of the major lineages of eukaryotic multicellular life. Plant and animal cells share many common features such as the nucleus, the endoplasmic reticulum, ribosomes, mitochondria, cytoplasm, cytoskeleton, peroxisomes and plasma/cell membranes. There are, however, a few key differences between plant and animal cells. Plant cells have a rigid cell wall that provides structural support, plastids that have specialized functions including photosynthesis and a large vacuole that contains water and nutrients and can be up to 90% of a cells volume!

2. How do we know cells are alive?

Healthy and living cells are able to maintain their structural integrity. Cells that are unable to maintain structural integrity and homeostasis (balance) will ultimately die. How do we detect cellular viability? There are many ways such as biochemical tests to detect gas exchange and metabolic processes. Another way we can assess cell viability is by observing the structural integrity using microscopy – healthy cells have intact membranes and are quite dynamic, organelles can be seen moving upon close investigation in a process known as cytoplasmic streaming. Under the proper conditions, living cells grow and reproduce by dividing and produc-

3. Lace plant: a new model to study cell death.

Programmed cell death (PCD) is an equal but opposing process to cellular division that is vital for the development and defense of multicellular organisms. Plants and animals need to be able to target and remove unnecessary or unwanted cells during development to shape their tissues so that they can be organized into functional organs. The lace plant (Aponogeton madagascariensis) is an aquatic monocot that has emerged as a new model organism to study developmentally regulated programmed cell death. The lace plant has unique leaves that utilize programmed cell death to form holes throughout its leaf blades in a precise and systematic fashion. Programmed cell death initiates in young leaves which are known as window stage leaves that are red in colour due to the pigment anthocyanin (Figure 1A, black arrow). Cells lose their anthocyanin and

then chlorophyll pigmentation as cell death progresses and radiates outward toward the vein before it stops at maturity when the perforation is complete (Figure 1B-F). The window stage of development (Figures 1A,C and 2) is where PCD begins and a unique gradient of death can be observed (Figure 2AB). Healthy lace plant window stage cells are known as non-PCD (NPCD; Figure 2C) since they don't die as the perforation forms – they can be identified easily by their proximity to the leaf veins, abundant anthocyanin pigmentation and large chloroplasts that can be seen streaming within the cytoplasm. Next to them are early-PCD (EPCD; Figure 2D) cells that have lost their anthocyanin pigment and are destined to die. In the center are the late-PCD (LPCD; Figure 2E) cells that are lacking nearly all pigmentation and on the verge of collapse. Some frequently observed features in plant cell death include a loss of anthocyanin and chlorophyll pigmentation, a cessation of movement (and cytoplasmic streaming), the breakdown of organelles which aggregate in the vacuole and the cell wall, the rupture of the tonoplast (the vacuole membrane) and shrinkage of the plasma membrane.

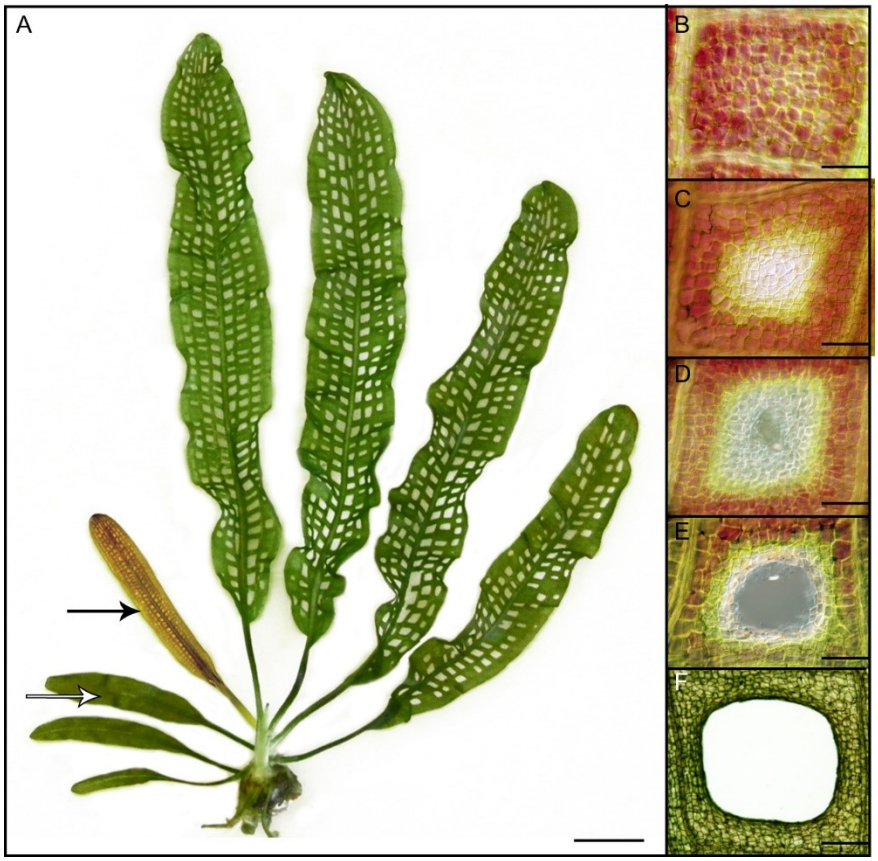


Figure 1. The lace plant programmed cell death model system. (**A**) The lace plant is an excellent model system for studying PCD due to the predictability of cell death and it's easy observation. The first 3–4 leaves of the plant are juvenile and do not form perforations (*white arrow*). The subsequent leaves to develop are adult leaves and emerge from the corm with a red pigmentation from the anthocyanins (*black arrow*). (**B**) There are no visible signs that PCD will occur in pre-perforation stage areoles (space between longitudinal and transverse veins). (**C**) During the window stage of development, a gradient of PCD is visible as cells in the late stages of death have lost nearly all of their pigmentation. Cells in the early stages of death are green, but have lost their anthocyanin, which is still present in the cells that will survive through maturity. (**D**) The perforation formation stage occurs when a physical tear is visible in the areole. (**E**) Cell death then radiates outward, and the hole widens significantly before the perforation expansion stage. (**F**) PCD halts 4–5 cell layers from the veins by the mature stage. Scale bars: (**A**) = 3 cm, (**B**) = 50 µm, (**C**–**D**) = 75 µm, (**E**) = 100 µm, (**F**) = 300 µm. Reproduced from Dauphinee and Gunawardena (2015).

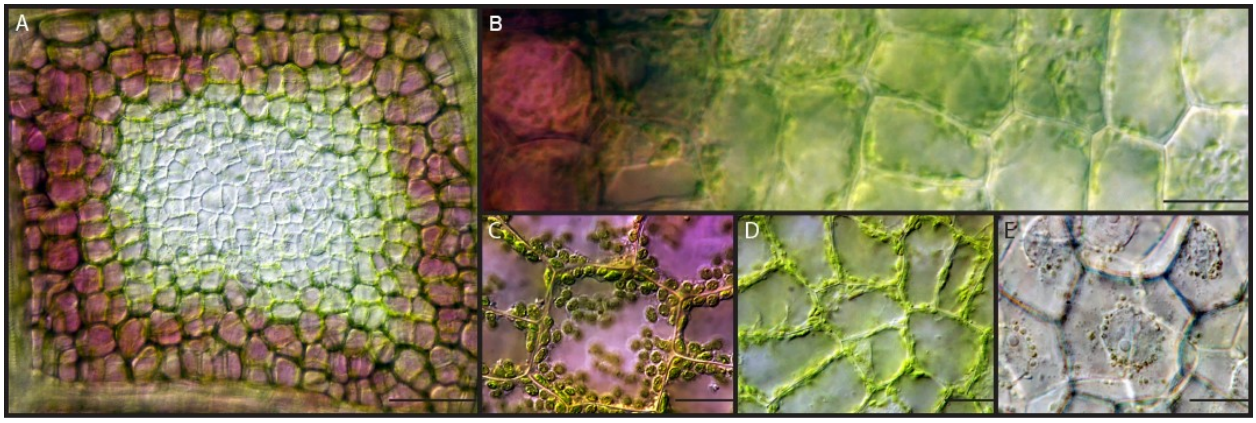


Figure 2. A gradient of programmed cell death. (A) Programmed cell death (PCD) initiates in the window. (**B**) Gradient of cell death in a window stage leaf of lace plant (*left* to *right*: N, E, and L or non, early, and late PCD, respectively). (**C**) NPCD stage cells have anthocyanin (in the mesophyll), as well as chlorophyll pigmentation, and do not undergo cellular death during leaf morphogenesis. (**D**) EPCD stage cells have lost anthocyanin pigmentation and are slated for destruction, but are in the early phases of the process. (**E**) LPCD stage cells are in the later stage of death and nearly transparent due to a reduction in chloroplasts and chlorophyll. Interestingly, perinuclear accumulation of chloroplasts can be seen during this stage. Scale bars: (**B**) = 30 µm, (**C**) = 40 µm, (**D**) = 50 µm, (**E**) = 40 µm. Reproduced from Dauphinee and Gunawardena (2015).

4. Artemia: a model to study animal dormancy and development

Dormancy is an evolved strategy used not only by plant seeds but also insect and crustacean embryos to survive and protect the animal from environmental stresses like freezing, drought or little oxygen until a more suitable enviroment is met. Adult female *Artemia franciscana* (commonly known as sea monkeys) lay their embryos in protective shells called cysts. These cysts cannot become active in order to hatch open and release the developing offspring (called nauplii) until they are exposed to stress like freezing, dehydration or hydrogen peroxide and then returned to their seawater habitat. Cell cycle and metabolism is paused under dormancy, and once the cysts are activated the cell cycle resumes thereby allowing growth and specilaziation of tissues for development. The cysts are essentially living time capsules. We can use sea monkeys as a model organism to study the sequences of cellular mechanisms that sense the environment to control the cell cycle and to understand critical events in animal development.

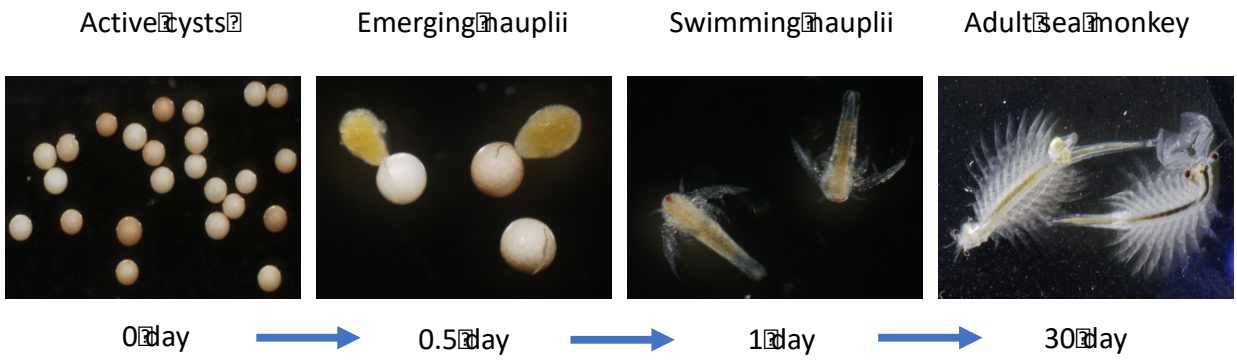


Figure 2. Sea monkey lifecycle. Active cysts that are no longer dormant hatch open for emerging nauplii once exposed to a healthy seawater environment. Within 30 days of incubation the sea monkey development reaches adulthood and is sexually mature to reproduce.

Objectives:

1. Illustrate how the cell is a living system and determine the unique features of plant cells
2. Observe the key cellular changes during plant programmed cell death
3. Learn about model systems and their importance for understanding critical life processes
4. Identify the differences between dormant and active cysts
5. Observe and describe the differences between sea monkey life history stages through development

Methods:

Part 1: Cellular dynamics and programmed cell death in plants

Required materials:

1) Aquatic plant window stage leaves (see Figure 1).
2) Forceps
3) Razor blade or scalpel
4) Transfer pipettes
5) Glass slides and coverslips
6) Water (distilled preferably)
7) Compound light microscope (40x objectives are sufficient)

Procedure :

Observing healthy and dying plant cells

i) Take an aquatic leaf specimen and rinse it thoroughly under tap or distilled water to remove algae, diatoms, etc.

ii) Cut out a small piece of tissue using a razor blade or scalpel. Remove any areas with large veins – the sample must be as flat as possible to avoid focal plane issues and to get a clear image.

iii) Use forceps to place the leaf piece on a clean glass slide, add a drop of water with a transfer pipette and then a glass coverslip.

iv) View the specimen with a compound light microscope (40x or 60x objectives will be sufficient).

v) Start at low magnification (10x objective) to see the gradient of cell death found at perforation sites between the leaf veins.

vi) Identify NPCD and PCD cells, go to higher magnification and complete the observations in Table 1.

Part 2: Animal cell cycle control, growth and development in a sea monkey model system.

Required materials:

1) Dry dormant and active cysts
2) Developing sea monkey nauplii
3) Transfer pipettes
4) Glass slides and coverslips
5) Glycerol stock
6) Water (distilled preferably)
7) Seawater (Halifax harbor or Northwest Arm will do)
8) Compound light microscope (40x or 60x objectives are sufficient)

Procedure:

1) Observe dormant vs active cysts, identify stresses that terminate dormancy
   i) Collect a petri dish labelled dry dormant and active cysts, place under microscope.
   ii) Note the morphology of the cyst changes between dormancy and activation, write these observations in Table 2.

2) Observe and compare sea monkey life history stages
   i) From the petri dishes take a drop of "emerging nauplii" and place it on a stage slide, place the cover slip on top.
   ii) From the petri dish labelled "swimming nauplii" take a drop and place it on a stage slide, use a drop of glycerol to stabilize the animals before placing a cover slip on top.
   iii) View the specimens with a compound light microscope (4x-10x objectives will be sufficient) and complete your observations in table 2 below. What characteristics do these swimming nauplii possess that separate them from emerging nauplii?

3) Observe female and male the "adult sea monkeys" station
   i) Under the dissecting microscope observe the adult sea monkeys and comment on specialize organs and appearance of adults vs their previous nauplii stage in Table 2.

Observations:

Table 1. Observations for *Part 1: Cellular structure, dynamics and cell death in plants.*

Organelles	Healthy Cells	Dying Cells
Cell colour		
Plasma (cell) membrane		
Chloroplast characteristics		
Cell wall		
Vacuole		
Additional observations		

Table 2. Observations for *Part 2:* Animal cell cycle control, growth and development in a sea monkey model system.

Life History Stage	Unique morphologies	Sketch the animal
Dormant cysts		
Active cysts		
Emerging nauplii		
Swimming nauplii		
Adult female vs male sea monkeys		

References:

Dauphinee AN, Gunawardena AH (2015) An overview of programmed cell death: from canonical to emerging model species. In: Gunawardena AHLAN, McCabe PF (eds). pp 1–31

Gunawardena AHLAN (2008) Programmed cell death and tissue remodelling in plants. J Exp Bot 59:445–51. doi: 10.1093/jxb/erm189

MacRae, Thomas H. "Molecular chaperones, stress resistance and development in Artemia franciscana." *Seminars in cell & developmental biology*. Vol. 14. No. 5. Academic Press, 2003

Robbins, Heather M., et al. "Diapause termination and development of encysted Artemia embryos: roles for nitric oxide and hydrogen peroxide." *Journal of Experimental Biology* 213.9 (2010): 1464-1470

Wertman J, Lord CEN, Dauphinee AN, Gunawardena AHLAN (2012) The pathway of cell dismantling during programmed cell death in lace plant (*Aponogeton madagascariensis*) leaves. BMC Plant Biol 12:115

LAB 2: Ecology

Evaluation of small scale ecosystems

Developed by: Rajesh Rajaselvam, Department of Biology, Dalhousie University

Email: rajesh.rajaselvam@dal.ca

Introduction

Ecology is the study of how organisms interact with the environment and each other. Usually activities in one area can influence the interactions among organisms and their environment in another. All abiotic and biotic factors are linked and keep a balance in undisturbed ecosystems. Destruction of one organism in the environment can lead to the destruction of other organisms.

Simple definitions

- Ecosystem: includes all organisms living in an area and the physical environment with which they interact.
- Community: the association of populations of two or more different species occupying the same geographical area in a particular time.
- Autotrophs: harvest light or chemical energy and store it in carbon bonds.
- Heterotrophs: eat other organisms.
- Detritivores: eat unconsumed plants, remains of animals, and waste products.
- Ecological network: describes interactions that occur among co-occurring species in a community.

Simple facts

- Communities are subject to biotic and abiotic factors.
- Abiotic diversity results in biotic diversity.
- Community assessment can be done initially by measuring of light, moisture, temperature and soil fertility, and how these factors are modified through interactions.
- A basic soil analysis describe the nature of the community.
- The success of an organism results from many cumulative selective pressures.
- There are a number of sampling methods used to obtain quantitative information about the composition- and structure of a community.

Objectives

In this field and lab exercise you will learn to evaluate and compare micro ecosystems in terms of soil, vegetation and both biotic and abiotic interactions. The importance of this exercise is to get students to look more closely at the community and the related environment, collect data and interpret scientifically.

A.

B.

C.

Assessment of Terrestrial Ecosystems

A. Soil profile: showing different soil horizons
B. Cutting a profile and collecting samples for soil nutrient analysis
C. Measuring environmental factors: Light intensity and pH

Activity

Measurements

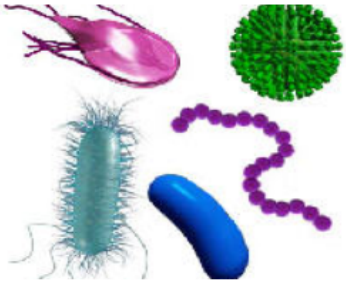
By using the tool-kits provided obtain data from the two contrasting micro ecosystems (tree & shrub land vs open grass land). At-least 3 readings per site are recommended.

	Tree/wood lot	**Open grass land**
Light Intensity (at ground level/GL and breast height/ BH) ***Light intensity meter***	GL:	GL:
	BH:	BH:
Soil Moisture Content (at 5-10 cm depth) ***Soil moisture meter***		
Soil Temperature (at 5-10 cm depth) ***Soil thermometer***		
Soil pH (at 5-10 cm depth) ***Soil pH meter***		
Soil Nutrients (at 5-10 cm depth) ***Nutrient test kits***	N:	N:
	P:	P:
	K:	K:

Observations

Cut a soil profile and explain the different soil horizons you find.
Get an idea about the diversity of the micro ecosystems to compare them. Use the field microscopes and hand lenses to identify the biotic components and record the numbers on the sheet provided.

Tree/Wood lot

Vegetation/Plants	Insects	Microbes
		
• Name/Number • ----------/---------- • ----------/---------- • ----------/---------- • ----------/---------- • ----------/----------	• Name/Number • ----------/---------- • ----------/---------- • ----------/---------- • ----------/---------- • ----------/----------	• Name/Number • ----------/---------- • ----------/---------- • ----------/---------- • ----------/---------- • ----------/----------

Open Grass-land

Vegetation/Plants	Insects	Microbes
		
• Name/Number • ----------/---------- • ----------/---------- • ----------/---------- • ----------/---------- • ----------/----------	• Name/Number • ----------/---------- • ----------/---------- • ----------/---------- • ----------/---------- • ----------/----------	• Name/Number • ----------/---------- • ----------/---------- • ----------/---------- • ----------/---------- • ----------/----------

Conclusion and discussion

By using all the data collected compare the two locations with explanation

A few important questions to be addressed are given below:

a) How does light differ among vertical levels of vegetation?
b) Does the community include shade-tolerant as well as shade-intolerant plants?
c) How might different amounts of light at different vertical levels within the community be important?
d) How might shade affect the temperature of the community?
e) How would you quantitatively describe the soil?
f) Does pH influence the nature of the ground cover?
g) Is there a layer of leaf litter on the ground?
h) Is the community generally a moist, moderate, or dry environment?
i) Which plant species are most abundant (numbers)?
j) What evidence do you see of biotic interactions? Explain the different kinds of interactions.
k) Would you describe this community as diverse? Explain your answer.

References

Rajaselvam, R. J. 2015. Terrestrial ecology: field guide, BIOL 3762 syllabus, Dalhousie University.
Vodopich, D. S. 2010. Ecology: laboratory manual: McGraw-Hill.

LAB 3: Earth sciences

Minerals and crystal structures

Developed by: Richard Cox, Department of Earth Sciences, Dalhousie University

Email: richard.cox@dal.ca

Introduction

Minerals are the building blocks of our planet. The rocks, sediments and soils that make up the surface and interior of the Earth are all composed of minerals and by studying them we can construct a record of the very long history of our planet. The natural resources which are used to make products we have become dependent on in our society, things we use on a daily basis, are all ultimately composed of, or are derived from, different minerals. The physical properties of minerals are controlled by their crystal structures, their chemical compositions, and these are in turn related to the wide range of different conditions under which minerals crystalize and grow. This module follows the format of a number of lectures given to our second year students in Mineralogy.

Definition of a Mineral: A naturally occurring inorganic element or compound having orderly internal structure and characteristic chemical composition, crystal form, and physical properties.

Objectives:

The goal of this module is to help students to understand what minerals are and that their physical properties such as hardness, their shapes, their colours, densities, etc., are all properties they have because of their crystal structures ***and*** chemical composition. This general concept in mineralogy is called ***crystal chemistry*** and is the way most modern mineralogy courses are taught. Following these exercises students can be encouraged to participate in follow-up exercises where they can begin to understand the continuing importance of minerals as natural resources for our modern world.

Materials:

Some of the materials for the exercises will be provided so that we can demonstrate the learning concepts. This will include:

Some minerals specimens for illustrating different properties;

A hardness testing kit;

Some HCl for reactivity tests.

Red/blue 3D glasses will be needed for looking at the 3D versions of the mineral models.

There are a number of additional items that may be obtained to help create more in-depth lessons for your students. These are:

Glass beakers or similar, and string for growing crystals.

A hand lens or pocket microscope.

Some graduated measuring beakers (preferably plastic and with a scale in ml).

An inexpensive digital balance available from most seasonal stores.

A small bottle of dilute HCl will be provided but it is advised that this only be used to demonstrate the reactions to the students (Ex.6). HCl is actually muriatic acid which can be purchased in hardware stores. It should be no more concentrated than 10% HCl for use in reactivity tests. So you may have to dilute this using appropriate plastic bottles and safety precautions. A WHIMS sheet with important safety information has also been provided.

Access to a Bunsen burner or a propane torch will be required for any simple flame emission tests. The latter can also be purchased at hardware stores.

Crystal Viewer is very important for several of these exercises and can be downloaded at: http://www.crystalmaker.com/index.html.

This is the free viewing software for looking at crystal structure models. We will provide the models (both 2D and 3D versions) that are related to the exercises on a download site for you to access.

It is recommended that a simple mineral guidebook be purchased and there are many available. One that is commonly recommended to students as an introductory guide is the National Audubon Society Guide to Rocks and Minerals. However, every mineral guide will be arranged in the same way, using the mineral's chemical grouping, and every guide will have the physical properties listed. Two excellent on-line databases are: https://www.mindat.org/ and, http://webmineral.com/. Both of these online resources are strongly recommended to our students and are routinely updated to provide the most comprehensive information.

Method/Hands-on activites:

PART 1:Crystal structures: Minerals have properties that are closely related to their crystal structure such as form, hardness and cleavage. In the first part of this module we will examine the properties which are largely controlled by the structure of a suite of minerals.

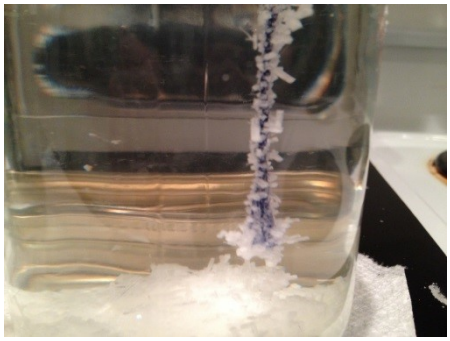
Ex. 1 Growing crystals (Halite (NaCl) and Sylvite (KCl))

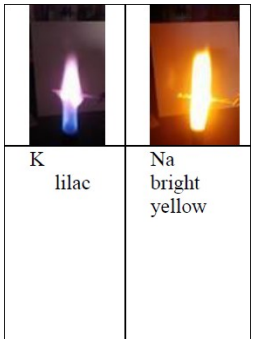
In order to show crystal growth and forms to the students you can also grow halite and sylvite crystals using table salt which is of NaCl and LoSalt which is 66% KCl. You will need a small beaker or glass (about the size of a small juice glass is fine).

1) Fill the glass about half way with warm water, add salt and stir until it dissolves.

2) Continue until it appears that the salt is no longer dissolving.

You have effectively made a saturated saline solution. You should now leave the beaker in a bright widow undisturbed. NOTE: The warmer the water the more salt you can dissolve and the larger and faster the crystals will grow. You can also place a pencil with some string or thread tied around it over the glass and let the string sit in the solution. It is interesting to compare the size and the rate of growth of crystals on the threads versus those that grow on the sides and bottom of the glass. If you are lucky they will look like the crystals in (a) below.





(a) Halite crystals in a saturated solution *(b) Flame emission colours for sylvite (K) and halite (Na)*

You can also get the students to look at the forms of the halite crystals. These will generally be small cubes stacked together. The crystals will be the same form (cubes) as for both halite and sylvite. So, how do we tell them apart?

For this test you will need a Bunsen burner or propane torch and a small fire-proof metal spatula.

1) Grind up some of the crystals and place a small amount of the powder on the the spatula

2) Hold the power over the flame. The pure NaCl will flare a bright yellow (see in (b) above).

3) The sample with the KCl will flare a lilac/white and will always be less bright (see in (b) above).

Ex. 2 Hardness, cleavage and crystal structures

Hardness: Following on from the discussion structures we can use the hardness kits which will be provided to create a Mohs Harness Scale. They can then be encouraged to look at the example of diamond and graphite using the 2D and 3D crystal models to determine why minerals have different harnesses and how this relates to crystal structures.

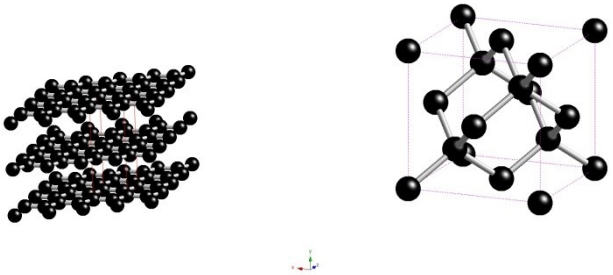
Use the common objects shown on the scale below to initially group the nine minerals, e.g. harder than a copper coin but softer than steel blade.

Once this is done the students can then test the mineral hardness against each other, i.e. 1 is softer than 2 and so on.

They should have created a Mohs Scale of minerals as show in the previous slide.

Note that the numbers on the mineral specimens do in fact correspond to their hardness but you can leave your students to figure this out themselves.

So what controls hardness in minerals? Examine graphite and diamond using Crystal viewer. It is clear that they are both made of carbon (native elements, the formula is simply C). Graphite is composed of single hexagonal (graphine) sheets which are only loosely bonded together essentially by electrostatic forces. Diamond is cubic and each carbon atom is bonded to four other carbon atoms to form small tetrahedral shapes. This means there are no clear weaknesses in the structure.

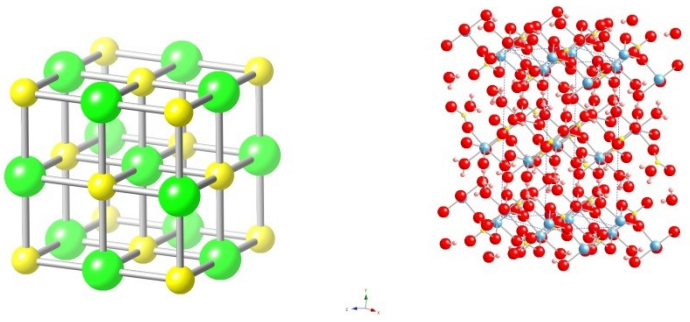


(a) Hexagonal graphite showing weak planes between the individual graphine sheets, (b) cubic diamond structure with no obvious planes of weakness.

Crystal cleavage is visible as a smooth break which can produce what appears to be flat crystal faces. Cleavage occurs in minerals that have specific planes of weakness and these are inherent in the structure of the mineral. Look at samples of gypsum (selenite, ($CaSO4.2(H_2O)$) and halite (NaCl) which are of a similar hardness, but break to form different shapes along cleavage planes.

Look at gypsum and halite using Crystal viewer (3D viewing might help here) and find the smallest reproducing unit (shape) in the model.

Halite is essentially a series of simple cubes. Gypsum forms thin rhombic shapes which is why the crystals have angular cleavage planes you can see in the real sample.



a) Cubic halite structure showing why is breaks into cubes and (b) the more complex gypsum structures which forms angular cleavage planes which can be seen in the mineral sample.

Part 1 Conclusion

Harness, and the way a mineral bends and breaks (cleavage), are controlled by the structure of the crystal, i.e. the way the atoms are bonded together within the mineral.

PART 2 Crystal chemistry: The properties of minerals which are in part related to their chemical compositions can now be examined. It should be noted that these properties are still controlled by the crystal structure of a mineral as well (hence the term crystal chemistry).

Colour can be a misleading property as it only takes a small amount of a chromophore (colour causing element) such as Fe, to cause significant changes to mineral colour. However, if two minerals have similar structures, then colour is more than likely due to the increase of a particular element.

Ex. 3 Color in minerals with the same structure

Look the two different samples of mica (a) muscovite and (b) biotite (see images below). You can also use Crystal viewer to show the small-scale structures as well.

What obvious physical property suggests that these mineral have a similar structure? The answer is that they have a very clear basal cleavage which causes them to break into flat sheets. These minerals are in fact called *sheet silicates*. What obvious physical property suggests that these minerals have different formulas, i.e. elements present in their crystal structures? The answer is of course that biotite is dark brown and muscovite is clear.

Look at the formulas for these minerals. Which is likely to represent muscovite and which is biotite?

1) $KAl_2(AlSi_3O_{10})(F,OH)_2$ 2) $K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$

Mineral (b) is biotite as shown by Fe in the formula. The lack of any transitional metals (including Fe) is why muscovite is generally colourless.

Specific gravity (SG) is a measure of the density of a mineral versus a reference material. For most tests a mineral's SG is determined using the density of the mineral divided by the density of water. Water's density is of course 1 gm/cm^3. Therefore a mineral's specific gravity is expressed in gm/cm^3.

Simply picking up two similar volumes of two minerals would tell you immediately that one was more dense (heavy) or less dense (light).

Ex. 4 Measuring specific gravity (SG)

Specific gravity (SG) is the density of a substance compared to a reference material. For minerals this is the density of the mineral compared to water. You will need a graduated measuring vessel of some kind and a simple digital balance. Two sulphate samples, barite ($BaSO_4$, *SG = 4.8*) and anhydrite ($CaSO_4$, *SG=2.97*) have been provided. The specific gravity of any material (in gm/cm^3) can be calculated as:

SG_{sample} = (Mass $_{Sample}$ / Vol $_{sample}$) / (Mass $_{water}$ / Vol $_{water}$)

Obviously the mass of water / volume of water would tend to be 1 as water has an SG of 1 gm/cm^3 at room temperature, i.e. if you measured out 100 ml of water it would weigh 100 gm. Measuring the mass of the sample is also easy, you can just weigh it on a balance.

So how do we measure the volume of an irregularly shaped sample?

(1) Put some water (say 200ml = Vol_{water}) in a graduated beaker.

(2) Place the beaker on the balance and tear (zero) the balance.

(3) Place the mineral specimen into the beaker and measure the new volume (Vol_2).

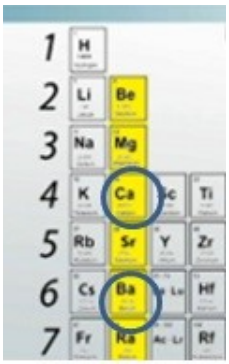
The volume of the mineral sample is: **$Vol_{sample} = Vol_2 - Vol_{water}$** ***(let's say the sample = 135 ml)***

(4) Record the sample's weight. (***say 400 gm***)

(5) Use the formula above to calculate the SG_{sample}.

So now it is simply mass (400) / volume (135) = 2.96 gm/cm$_3$. The sample would be anhydrite.

So why do these minerals have such different specific gravities (densities)?

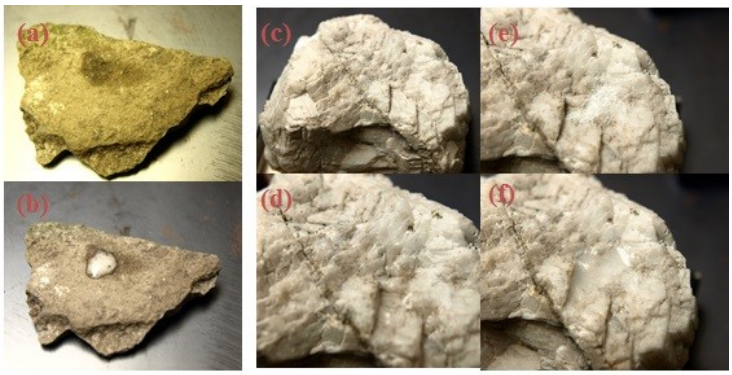


Reactivity: Minerals can be described in general terms such as soluble, normally in reference to water, or reactive in reference to another reagent (such as dilute HCl).

Ex. 5 Reactivity: The acid test

Limestone **(a)** is a rock composed essentially of ***Calcite***. A strong and instantaneous reaction:

$2HCl + CaCO_3 \rightarrow CO_2 + H_2O + CaCl_2$ is apparent in **(b)**.



Dolomite **(c)** and the carbonate rock dolostone is composed of $MgCa(CO_3)_2$. As shown in **(d)** there is no reaction with HCl. However, if a small portion is powdered **(e)** the reaction with HCl is strong **(f)**, although not quite as vigorous as with calcite. The reaction is:

$4HCl + MgCa(CO_3)_2 \rightarrow 2CO_2 + 2H_2O + CaCl_2 + MgCl_2$

From the above reactions it is clear that dolomite requires twice as much acid to produce a reaction as calcite, and also produces twice as much water and metal-salts. This explains why the observed reaction with HCl is less vigorous.

Part 2 Conclusion

Minerals are chemical compounds and have properties which record there chemical compositions. They have different colours, densities and can react with acids and other reagents just as any other material can. This provides a link between mineralogy and chemistry.

Summary and further exercises

Now that you have a basic understanding of crystal chemistry and tests that can be used to show the link between crystal structures and their physical properties you can construct simple diagnostic testing exercises for your students. One will be demonstrated in the presentation using some of the above tests, and materials supplied so that you can use this as a guide to build more of these exercises.

Acknowledgements

James Brennan, Lexie Arnott and Yana Fedortchouk are thanked for all their help and input while we prepared this module.

LAB 4: Chemistry

Fruit punch: How concentration affects flavour

Developed by: Jason Masuda, Department of Chemistry, Saint Mary's University

Email: jason.masuda@smu.ca

Introduction

In the preparation of foods and drinks, we often use recipes as a guide to make sure what we are preparing tastes good. Too much, or too little, of an ingredient can ruin the taste. For example, salt is often added to cookies, french fries, pretzels, etc to enhance their flavour; however people often add too much salt and the salt flavour overwhelms the overall taste. When it comes to juice and powdered drinks, concentration is important; thrifty parents often add too little powder and the drink tastes watered down and often bitter, kids often add too much powder and the flavour is overwhelming and the taste stays in your mouth for too long.

When thinking about concentrations AND taking into consideration safety and the availability of laboratory supplies, I have taken a popular experiment and modified it to work with relatively inexpensive items from the grocery store that are non-toxic and allow for the students to add a taste test to their observations about concentration. If your school has enough balances available, this experiment can easily be modified so that the students can weigh out the powdered drink and more accurately calculate concentrations in molarity (based on the powder drink being primarily sucrose) or in grams of powder/mL.

Objectives:

To provide students with a hands-on lab that has a safe, consumable component that studies the affect of concentration on taste and appearance of a fruit drink. This experiment has also been designed for schools that have minimal laboratory equipment – all supplies and tools can be purchased at a grocery store at a reasonable price. The experiment can easily modified for schools with access to items like scales (balances).

Materials:

The materials were purchased at my local supermarket for a reasonable price. The number of items needed will depend on the class size and if the students are working in groups.

Clear plastic cups ($4.99/50pack)

Mixing spoons ($2.79/48 pack) – I purchased white plastic mixing spoons since they are smaller than the clear spoons and will work better for measuring the crystals for this experiment

Fruit Punch crystals ($6.99 for 2.3 kg, any brand will work)

Water

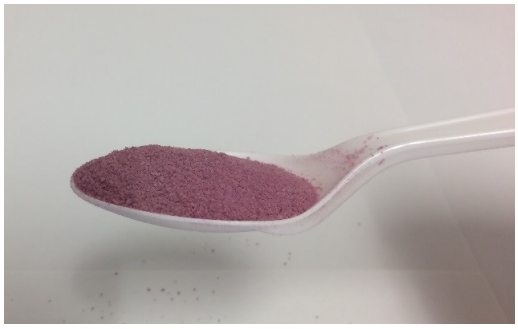
Method/Hands-on activity

Students will be asked to think about the concentration fruit punch flavouring and to make a hypothesis of which concentration will taste best. The students can also base their decision on if they had to make fruit punch for a large party of 100 people…more fruit punch powder = more money spent.

1. Obtain three plastic cups, three spoons, and a cup filled with powder. (The cup may be shared with a bench of multiple people.)

2. Have the students fill each cup half full with water. You can challenge them to figure out how to do this since the cups are tapered and filling to half the height is not half the volume of the cup. Fill one cup to the top and then pour it out into another cup until they are filled to the same height – now they are half full! Fill the third cup with water so that it matches the first two cups.

3. In the first cup, add 4 level spoons of crystals. (NOT HEAPING). Stir until dissolved. This may take some time and the student may want to move to the next step while the powder is dissolving and occasionally stir this mixture.



Non-heaping spoon size.

4. In the second cup, add two (2) level spoons of crystals. Stir until dissolved.
5. In the third cup, add ½ a spoon of crystals. Stir until dissolved.
6. The students should line up the cups in order of concentration. They can now record their observations: visual, smell, touch (did they get warm or cold), etc. The students may want to put the cups on a white piece of paper to better visualize the intensity of the color.

0.5 spoons of crystals 2 spoons of crystals 4 spoons of crystals

Now here is the fun part that many science experiments don't allow for anymore: TASTE!

Have the students taste the cups in increasing concentration (IMPORTANT). They should record their observations: bitter, sweet, overly sweet, tastes too dilute, the feeling in their mouth, etc.

Conclusion

In the end have the students write up a mini-report of their findings with their conclusions as to which cup tastes the best. Some may say that the 4 spoon cup is the best (because it is the sweetest) and if you feel that your class is up for the challenge, have them calculate the cost of crystals for 100 kids each drinking 2 cups.

Useful numbers:

1 spoonful is approx. 6.5 grams of fruit punch drink mix

.5 grams/spoon * 8 spoons (for a full cup) * 100 kids * 2 cups per person = 10,400 grams or 5 cans of fruit punch drink mix.

Acknowledgements:

Thanks to my kids Rebecca, Ethan, and Cordelia for helping me test this experiment.

Will it float? (aka - How much table salt (NaCl) does it take to suspend or float an egg in water?)

Developed by: Jason Masuda, Department of Chemistry, Saint Mary's University

Email: jason.masuda@smu.ca

Introduction

The concentration of salt in water has an impact on if an object will float or sink. If you have ever went swimming in a fresh water lake and then went into an ocean, you will notice that your body is more buoyant in the salt water. Fresh water has negligible amounts of salt(s) dissolved in it. For example, typical freshwater from ponds, lakes, rivers and streams contain 0-0.5 parts per thousand (ppt) of various salts. Sea water (saline water), on the other hand, contains on average 35 ppt of salts and swimmers can feel the buoyancy difference when compared to fresh water. Finally, briny water, has greater than 50 ppt of salts dissolved in them. One of the most famous examples is the Dead Sea, where the salt concentration is ca. 315 ppt![1] In the Dead Sea, the density of the salt water is so high (1.24 g/cm^3), it can be difficult to stand on two feet in deep water.

The concentration of salt (NaCl, sodium chloride) in water plays an important role in our everyday lives, even if we do not realize it. For example, ships that travel from oceans upriver to a fresh water body have to take into account the change in the density of the water since the ship will float higher in ocean water than in fresh water. For cities that salt their roads with NaCl, this salt is only effective at temperatures above -19°C. In colder climates, sand is typically applied for traction since the application of NaCl will not melt the ice/ snow on the roads.

Table of properties of salt and water mixtures2

NaCl part per thousand	NaCl, % by weight	Tsp of NaCl per ½ beer cup	Density (g/cm^3)	Freezing point
0	0	0	1.00	0
50	5	1.89	1.03	-3.05
270	27	10.2	1.19	-19

For the purposes of this experiment, we will assume sodium chloride (NaCl, table salt) is the salt present.

For this in class laboratory experiment, students will be preparing solutions of sodium chloride (NaCl) and determining if an egg will sink or float in solutions that are close to fresh water, sea water and Dead Sea water concentrations. Additionally, if a balance is available, students could add salt to water with an egg present and determine how much salt is needed to float the egg and from the mass of salt added, they can calculate the density of the egg.

Objectives:

To provide students with a hands-on lab that uses what are typically considered non dangerous items (eggs, water, salt (sodium chloride) that studies salt solutions and what concentration is needed to suspend an egg. This experiment has also been designed for schools that have minimal laboratory equipment – all supplies and tools can be purchased at a grocery store at a reasonable price. The experiment can easily modified for schools with access to items like scales (balances), graduated cylinders, etc.

Materials:

Clear(-ish) plastic beer cups

Mixing spoons ($2.79/48 pack) – I purchased white plastic mixing spoons since they are smaller than the clear spoons and will work better for measuring the salt for this experiment

Water

Kosher salt or pickling salt – the smaller the grains the better for quicker dissolving times. If it can be prevented, do not use regular table salt as it contains fillers to prevent caking and these fillers do not dissolve well.

Optional, but useful if you can obtain enough: Teaspoon measure salt

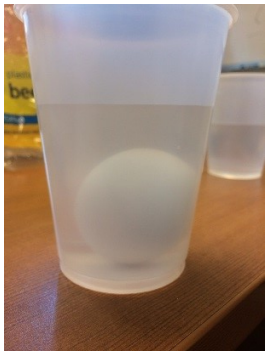
Eggs (raw, in shell or hard boiled to reduce the mess!)

Method/Hands-on activity

Students will be asked to think about the concentration of salt in water and to make a hypothesis of which concentration of salt will be needed to float the egg. If you have enough teaspoons or scales to weigh salt, the students can make a prediction in grams of salt or teaspoons of salt. 1 tsp = 6 grams of salt. For the purposes of this experiment to keep costs down, we will be using plastic disposable spoons. Students can also make a saturated solution of salt that would be similar to the concentration of the Dead Sea and they can see how their egg floats in that salt solution.

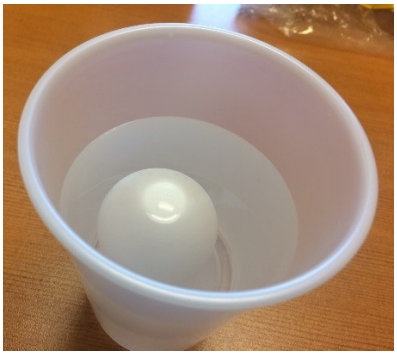
1) Obtain 1 plastic cups, two spoons, an egg, and a cup half filled with salt. (The cup may be shared with a bench of multiple people.)
2) Have the students fill each cup half full with water. You can challenge them to figure out how to do this since the cups are tapered and filling to half the height is not half the volume of the cup. Fill one cup to the top and then pour it out into another student's cup until they are filled to the same height – now they are half full!
3) Have the student carefully place their egg into the water. Have them take observations of the egg. Is the egg tilted? Is the narrow tip down or up? What does this tell you about the egg on the inside?
4) Remove the egg and add 1 level spoon of salt (1 spoon total). Stir until dissolved.
5) Have the student carefully place their egg into the water with 1 scoop of salt. Have them take observations of the egg.
6) Remove the egg and add 1 level spoon of salt (2 spoons total). Stir until dissolved.
7) Have the student carefully place their egg into the water with 2 scoops of salt. Have them take observations of the egg.
8) Remove the egg and add 1 level spoon of salt (3 spoons total). Stir until dissolved.
9) Have the student carefully place their egg into the water with 3 scoops of salt. Have them take observations of the egg.
10) At this point the egg should be floating. The students can estimate the amount of egg that is above the water.
11) Remove the egg and add 1 level spoon of salt (4 spoons total). Stir until dissolved.
12) Have the student carefully place their egg into the water with 4 scoops of salt. Have them take observations of the egg.
13) Remove the egg and add 1 level spoon of salt (5 spoons total). Stir until dissolved.
14) Have the student carefully place their egg into the water with 5 scoops of salt. Have them take observations of the egg. *****STEPS 13 and 14 are OPTIONAL. Depending on the scoop size (meaning heaping scoops), the students may already have a saturated solution (step 15)*******

No salt



2 scoops

3 scoops



3 scoops (top view)

5 scoops

Saturated (side view)

Saturated (top view)

15) You can now have the students half fill another cup with water and add 11 tsp (62 grams, or 7 scoops) of salt. They will have to stir this for 3-5 mins to get most of the salt to dissolve. There will be extra salt in the bottom of the cup as this is a saturated solution (ca. 270 ppt).
16) Have the student carefully place their egg into the saturated salt solution. Have them take observations of the egg.

Conclusion

In the end have the students write up a mini-report of their findings with their conclusions as to the amount of salt needed to float the egg. Included, you could ask why the egg floated in the position it did[3] and ask them to discuss how far the egg was out of the water in the saturated solution.

Useful numbers:

There are approximately 6 grams of salt in a teaspoon. The plastic scoops that I used measure just under 2 tsp each.

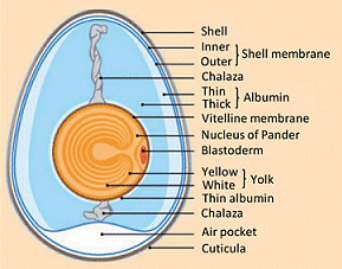
Ppt – part per thousand – meaning that there is X grams of salt per kg of water. This means that in the Dead Sea there are 315 grams of salt in a kilogram of water. Saturated NaCl solutions are around 270 ppt.

References

https://en.wikipedia.org/wiki/Dead_Sea; accessed 2017-08-08.

https://en.wikipedia.org/wiki/Saline_water; accessed 2017-08-08.

See the air pocket at the bottom of the image below. This is the end of the egg that will be stick out of the solution.



http://www.chemistryviews.org/SpringboardWebApp/userfiles/chem/image/2012_February/Focus_Egg/

Compiled and edited by Arunika Gunawardena,
Rajesh Rajaselvam, and Michaela Kember

2017

http://atlanticsciencelinks.dal.ca/