Science Unit: *Water*
Lesson 5: *Daphnia*

School year:	2004/2005
Developed for:	Queen Alexandra Elementary School, Vancouver School District
Developed by:	Paige Axelrood (scientist), Trevor Wright and Jenny Lau (teachers)
Grade level:	Presented to grades 4 - 5; appropriate for grades 4 – 7 with age appropriate modifications.
Duration of lesson:	1 hour and 20 minutes
Notes:	Three classroom visits are required for this lesson (experimental set-up on a Thurs. and experimental delivery on the following Mon. and Fri.).

Objectives

1. Introduce how to do a science experiment.
2. Students will learn about *Daphnia*, and observe their life cycle using dissecting microscopes.
3. Students will determine if food source influences reproduction.

Background Information

Daphnia magna is the Latin name for a tiny crustacean animal. *Daphnia* grow to a length of 2-3 mm, live in fresh water, and are commonly found in ponds. *Daphnia* have one eye, 5 pairs of legs, and a second antenna that helps propel the body through water. *Daphnia* move in water with a jerking motion and this is the basis of their common name, the water flea, but they are not fleas. An outer, folded shell-like structure (carapace) protects the body and covers the legs. The *Daphnia* body is translucent and this enables microscopic observations of its beating heart and the growth and development of baby *Daphnia* from eggs that are incubated in a brood pouch. *Daphnia* reproduce asexually approximately every three days. After each molt (shedding of the shell), the mature female puts approximately 4 – 20 eggs in its brood chamber and these develop into baby female *Daphnia*. However, a brood can contain up to 100 baby female *Daphnia*. If conditions are adverse (such as low oxygen levels, low temperatures, or lack of food), males are produced and sexual reproduction takes place resulting in the production of resting eggs. *Daphnia* are very important to aquatic food chains. *Daphnia* eat algae and are therefore primary consumers, and *Daphnia* also eat bacteria. Fish and other aquatic predators rely on *Daphnia* as their main source of food. *Daphnia magna* is used as an indicator organism to detect toxic compounds.

Vocabulary

Students should be introduced to *Daphnia* and the vocabulary words prior to the lesson.

Pond:	A small body of fresh water (smaller than a lake) shallow enough for sunlight to reach the bottom and for rooted plants to grow.
Invertebrate:	Animal without a backbone.
Crustacean:	An invertebrate animal with a hard shell and many jointed legs.
Reproduction:	The process of generating offspring.
Brood:	The young of *Daphnia* are collectively called brood.

Carapace: A folded shell-like structure.

Toxic compound: A substance that causes injury to the health of a living organism.

Materials

- *Daphnia magna*
- water to culture *Daphnia*
- equipment to aerate culture water
- 30 ml plastic cups
- styrofoam boards with holes to hold 30 ml cups
- clear plastic tubing
- pipet bulbs
- beakers
- food for *Daphnia*
- shallow 1 cup plastic containers
- glass jars, 1 liter and 1 gallon
- 2 ml plastic pipets with attached bulb
- Dissecting microscopes
- clear plastic sheets (report covers)

In the Classroom

Introductory Discussion

1. Discuss background information about *Daphnia*, the features of the *Daphnia* body, *Daphnia* reproduction, and how to take care of *Daphnia*.
2. Discuss the *Daphnia* experiment and review how to do an experiment. Discuss the concept of a treatment and a replication.
    - Make an observation and then ask a question OR start with a question: Will the food source influence the reproduction of *Daphnia*?
    - Think about what you think will happen if *Daphnia* are fed algae compared to YCT mixture. Write down your hypothesis.
    - Set up the experiment, treat everything the same except for one thing--what you want to test, the type of food (this is a variable).
    - Make observations of *Daphnia* and the number of babies that are produced per brood.
    - Record observations and examine results.
    - Make conclusions.
    - Communicate results and conclusions. Compare results to your hypothesis to help you think deeper.

Science Activity/Experiment

Experiment Title: Comparison of *Daphnia* reproduction using two food sources.

Purpose of Experiment: The purpose of this experiment is to determine if the source of food (algae or YCT mixture) influences the number of baby *Daphnia* produced in two consecutive broods and to learn about *Daphnia*.

Experimental Treatments: Food source

Treatment 1: Two algae: *Selenastrum* and *Chlorella*

Treatment 2: YCT mixture: yeast, Ward's Cereal Grass medium and fermented trout chow (this food contains bacteria)

1. Four to six students will work together in a group. There will be 5 replications (5 cups) per treatment. Each student group will set up 5 replications for one treatment. Treatments will be divided evenly among student groups (3 groups per treatment).

2. Students will record their hypothesis prior to starting the experiment. The hypothesis can address the following question: Will *Daphnia* produce more babies, fewer babies, or the same number of babies when they are fed algae compared to YCT mixture? *Daphnia* eat algae and bacteria in ponds. YCT mixture contains bacteria and other nutrients.

Methods: Steps 1 – 6 are done to set up the experiment (on a Thurs. or Fri.). Step 5 (feeding) and step 7 (changing water) are done to rear *Daphnia* during the experiment. Students will examine *Daphnia* and their brood (babies) on Mon. and Fri. of the following week.

1. *Daphnia* were reared in two 1 liter glass jars and fed corresponding food for treatments 1 and 2 at Vizon SciTec Inc. Food (algae and YCT mixture) and moderately hard reconstituted water were prepared at Vizon SciTec for the experiment. *Daphnia* and food can be purchased from Aquatic BioSystems Inc. http://www.aquaticbiosystems.com/. Pond water can be filtered through a coffee filter and used for the experiment instead of reconstituted water.

2. Reconstituted water (or filtered pond water) is stored at room temperature in a plastic container and the water is aerated by using standard aquarium equipment.

3. Transparent plastic tubing pipets (approx. 5 mm opening and 5 cm long) are constructed using plastic aquarium tubing and a small pipet bulb.

4. Thirty ml plastic cups are labelled with a group number and a replication number. Aerated water is poured into a beaker for each group. Each 30 ml cup is filled with 25 ml of aerated water and placed in a styrofoam board with holes to hold each cup (1 styrofoam board per group). Labels on the board at each hole should correspond with labels on the cups. Cups should be kept in styrofoam boards to prevent the cups from tipping over. Water in cups should be changed on every Mon. and Fri. (see step 7).

5. Feeding: 0.5 ml each of *Selenastrum* and *Chlorella* are added to each Treatment 1 cup and 1.5 ml of YCT mixture is added to each Treatment 2 cup. This feeding procedure should be done on every Mon., Wed., and Fri. The food must be kept in a refrigerator. Feed *Daphnia* on Mon. and Fri. after the water has been changed.

6. Reconstituted water containing reared *Daphnia* (approx. 100ml) is poured into a shallow plastic container for each lab group. Students will use the tubing pipet to suck up one adult *Daphnia,* previously fed with food corresponding to the correct treatment. The *Daphnia* is then released into the water in a 30 ml cup. This process is repeated for all replications for both treatments. The 30 ml containers are then covered with a piece of clear plastic cut to the correct dimensions from a clear plastic report cover sheet. The plastic sheet can be large enough to cover the 5 plastic cups. The cups are covered to slow down evaporation and prevent an insect from flying into the cup. The plastic sheet must be clear to allow Daphnia to grown under daylight in the classroom. *Daphnia* can survive under a broad range of temperatures but 20 – 22℃ is optimal and they prefer temperatures below 26℃.

7. Changing water and collecting baby *Daphnia*: Aerated water (150 ml) is poured into a beaker for each group. Thirty ml cups are labeled in an identical manner as the previously labeled cups. Twenty-five ml of aerated water is poured into 1 clean cup. The cup is placed on a table and a student holds the cup so that it doesn't tip over. Another student uses the tubing pipet to suck up the adult *Daphnia* from one cup with the same label, and releases the adult into the cup with fresh water. The baby *Daphnia* from the used cup are poured into a labeled petri plate. This process is repeated for the five replications per treatment. At the end of the lesson, the used cups are rinsed with tap water, algae are wiped from the interior of the cup with a paper towel, and cups are rinsed again, and then air-dried.

8. Students will examine the adult *Daphnia* and the baby *Daphnia* using a dissecting microscope 3 (or 4) days and 6 (or 7) days after the experiment is set up. Students may also be able to see shed carapaces (shell-like coverings) in the water. Students will count the baby *Daphnia* in each petri dish and data will be recorded on an experiment sheet. If there are too many babies to easily count, students can pipet some of the babies back into the used 30 ml container and count small portions at a time, pouring counted *Daphnia* into a collection jar (see below) before counting more babies. Students will record other observations of *Daphnia* and look for carapaces. After examination is complete, the baby *Daphnia* and their water are poured into a 1 gallon glass jar containing 1 liter of aerated water and 7.5 ml each of *Selenastrum* and *Chlorella* and 15 ml of YCT mixture. A piece of clear plastic is placed over the opening of the jar. This amount of food should be added to the gallon jar 3 days after the first feeding.

9. The number of babies for each replication and other observations will be recorded individually by each student. Collectively, each group will record the number of babies for each replication for their treatment on a big piece of paper taped to the classroom wall. The class will analyze this data with help from the teacher to determine the number of babies for each replication (presented as a range) per treatment and the average number of babies for each treatment per lab group. All students will be given the data for the entire class and they can use data to record their conclusions.

10. At the end of the experiment, the *Daphnia* can be released in a home outdoor pond.

Closure Discussion

Review the results of the experiment. What did you learn about *Daphnia*? What role does *Daphnia* plays in the aquatic food chain? What did you like best about working with *Daphnia*?

Acknowledgments

Special thanks to Meg Lauder (Scientist, Vizon SciTec Inc.) for rearing *Daphnia*, supplying *Daphnia* and materials for the experiment, and for sharing her knowledge about *Daphnia*.

References

1. http://ebiomedia.com/gall/classics/Daphnia/daphnia_links.html BioMEDIA Associates, Learning Programs for Biology Education, [Information about *Daphnia*, excellent images, and *Daphnia* web links].

2. http://www.microscopy-uk.org.uk/mag/artmar02/fleanatomy.html Water-flea anatomy by Wim van Egmond, The Netherlands, web site hosted by Microscopy UK, [*Daphnia* anatomy with excellent images].

Extension of Lesson Plan

1. Examination of algae under a compound microscope.
2. The *Daphnia* experiment will provide opportunities to link with Water Pollution and Pond Ecosystem Field Trip lessons (see lessons 3 and 4 in the Water science unit, Earth Science curriculum area, available from the Scientist in Residence Program website http://www.scientistinresidence.ca).

A Freshwater Organism Experiment:
Comparing *Daphnia Reproduction*

Name of Scientist:_____

Purpose:
The purpose of this experiment is to learn about Daphnia and to determine if the source of food affects the number of babies Daphnia produce

Experimental Treatments: Food source

Treatment 1	Two algae: *Selenastrum* and *Chlorella*
Treatment 2	YCT mixture: yeast, Ward's Cereal Grass medium and fermented trout chow (this food contains bacteria)

Hypothesis:
Daphnia eat algae and bacteria in ponds. YCT mixture contains bacteria and other nutrients. Knowing this information, do you think Daphnia will produce more babies, less babies, or the same number of babies when they are fed algae compared to YCT mixture?

Initial hypothesis:

After you have observed the Daphnia and their babies on the fourth day in our classroom, you may make another hypothesis about the two treatments and the numbers of babies that will be produced.

Second hypothesis:

Materials:

Daphnia magna	styrofoam boards with holes to hold 30 ml cups	Shallow 1 cup plastic containers
Water to culture Daphnia	clear plastic tubing	Glass jars, 1 liter and 1 gallon
Equipment to aerate culture water	Pipet bulbs	2 ml plastic pipets with attached bulb
30 ml plastic cups	beakers	Dissecting microscopes
	Daphnia food	clear plastic sheets (report covers)

Methods:

Several steps were completed so that we could conduct our experiment today:

1. Daphnia were reared in two 1 liter glass jars and fed corresponding food for treatments 1 and 2 at Vizon SciTec Inc. Food (algae and YCT mixture) and moderately hard reconstituted water were prepared at Vizon SciTec for the experiment.
2. Reconstituted water (or filtered pond water) is stored at room temperature in a plastic container and the water is aerated by using standard aquarium equipment.
3. Transparent plastic tubing pipets (approx. 5 mm opening and 5 cm long) are constructed using plastic aquarium tubing and a small pipet bulb (1 per group).
4. Thirty ml plastic cups are labelled with a group number and a replication number. Aerated water is poured into a beaker for each group. Each 30 ml cup is filled with 25 ml of aerated water and placed in a styrofoam board with holes to hold each cup (1 styrofoam board per group). Labels on the board at each hole should correspond with labels on the cups. Cups should be kept in styrofoam boards to prevent the cups from tipping over. Water in cups should be changed on every Mon. and Fri. (see step 7).
5. Feeding: 0.5 ml each of *Selenastrum* and *Chlorella* are added to each Treatment 1 cup and 1.5 ml of YCT mixture is added to each Treatment 2 cup. This feeding procedure should be done on every Mon., Wed., and Fri. The food must be kept in a refrigerator.
6. Approximately 100 ml of reconstituted water containing reared Daphnia are poured into a shallow plastic container for each lab group. Students will use the tubing pipet to suck up one adult Daphnia, previously fed with food corresponding to the correct treatment. The Daphnia is then released into the water in a 30 ml cup. This process is repeated for all replications for both treatments. The 30 ml containers are then covered with a piece of clear plastic cut to the correct dimensions from a clear plastic report cover sheet. The plastic sheet can be large enough to cover the 5 plastic cups. The cups are covered to slow down evaporation and prevent an insect from flying into the cup. The plastic sheet must be clear to allow Daphnia to grown under daylight in the classroom.

These are the steps that we will be following today:

7. Changing water and collecting baby Daphnia:
8. Aerated water (150 ml) is poured into a beaker for each group
9. Thirty ml cups are labeled in an identical manner as the previously labeled cups
10. Twenty-five ml of aerated water is poured into 1 clean cup.
11. The cup is placed on a table and a student holds the cup so that it doesn't tip over
12. Another student uses the tubing pipet to suck up the adult Daphnia from one cup with the same label, and releases the adult into the cup with fresh water.
13. The baby Daphnia from the used cup may be poured into a labeled petri plate or left in the cup to examine under the dissecting microscope.
14. This process is repeated for the five replications per treatment.
15. Examine the adult Daphnia and the baby Daphnia using a dissecting microscope. After that, count the baby Daphnia in each cup or petri dish and record your observations on the experiment sheet. If there are too many babies to easily count, you can pipet some of the babies back into the used 30 ml container and count small portions at a time and pour counted Daphnia into a collection jar (see

below) before counting more babies. You will also record other observations of Daphnia and look for carapaces.

16. After examination is complete, the baby Daphnia and their water is poured into a 1 gallon glass jar containing 1 liter of aerated water and 7.5 ml each of *Selenastrum* and *Chlorella* and 15 ml of YCT mixture. A piece of clear plastic is placed over the opening of the jar. This amount of food should be added to the gallon jar 3 days after the first feeding. At the end of the lesson, the used cups are rinsed with tap water, algae are wiped from the interior of the cup with a paper towel, and cups are rinsed again, and then air-dried.
17. Each group will record the number of babies for each replication for their treatment on a big piece of paper taped to the classroom wall. The class will analyze this data with help from the teacher.
18. At the end of the experiment, the Daphnia can be released in a home outdoor pond.

Observations

Date: _____

Treatment: _____

Container #	**Babies** (note the number of babies and describe their movement, appearance, size …)	**Adult Daphnia** (record your observations of their appearance, size, movement…)	**Water** (i.e., Are there carapaces in the water? Note any other observations of the water)

Date: _____

Treatment: _____

Container #	**Babies** (note the number of babies and describe their movement, appearance, size …)	**Adult** (record your observations of their appearance, size, movement…)	**Water** (i.e., Are there carapaces in the water? Note any other observations of the water)

Diagrams:

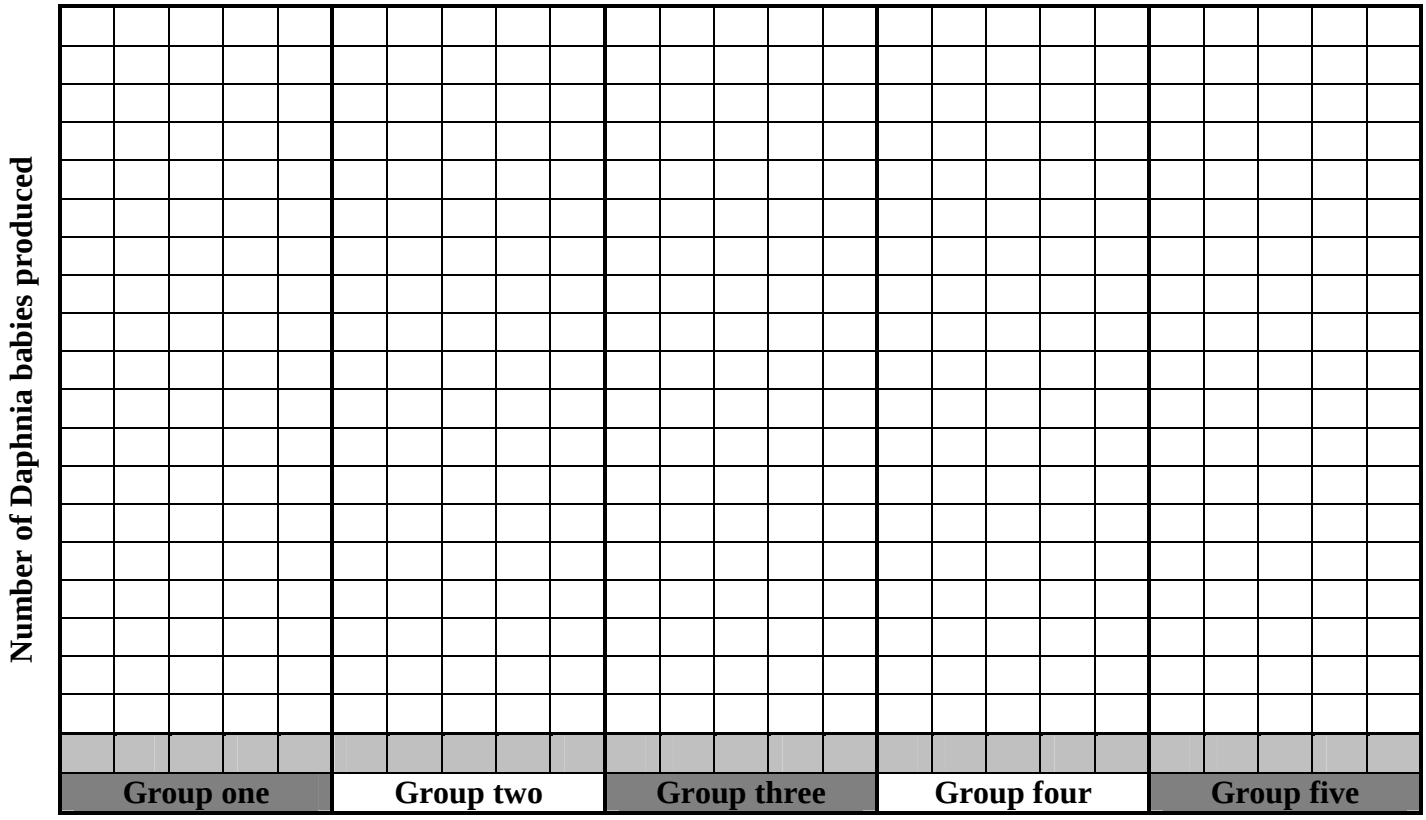
Date:

Baby Daphnia	Adult Daphnia
Labelled diagram of the microscope and daphnia being observed	
Labelled diagram of the baby daphnia under the microscope	Water

Full class data collection:

Date:
Treatment:

Daphnia Reproduction for Algae Treatment or YTC Treatment



Range:

Average:

Conclusion:

Does the food source affect Daphnia reproduction? Which treatment had the greatest affect on Daphnia reproduction?

My conclusion:

For Your Information:

Key vocabulary:

Pond	a small body of fresh water (smaller than a lake) shallow enough for sunlight to reach the bottom and for rooted plants to grow
Invertebrate	animal without a backbone
Crustacean	an invertebrate animal with a hard shell and many jointed legs
Reproduction	the process of generating offspring
Brood	the young of Daphnia are collectively called brood
Carapace	a folded shell-like structure
Toxic compound	a substance that causes injury to the health of a living organism

Background Information

Daphnia magna is the Latin name for a tiny crustacean animal. *Daphnia* grow to a length of 2-3 mm, live in fresh water, and are commonly found in ponds. *Daphnia* have one eye, 5 pairs of legs, and a second antenna that helps propel the body through water. *Daphnia* move in water with a jerking motion and this is the basis of their common name, the water flea, but they are not fleas. An outer, folded shell-like structure (carapace) protects the body and covers the legs. The *Daphnia* body is translucent and this enables microscopic observations of its beating heart and the growth and development of baby *Daphnia* from eggs that are incubated in a brood pouch. *Daphnia* reproduce asexually approximately every three days. After each molt (shedding of the carapace), the mature female puts approximately 4 – 20 eggs in its brood chamber and these develop into baby female Daphnia. However, a brood can contain up to 100 baby female Daphnia. If conditions are adverse (such as low oxygen levels, low temperatures, or lack of food), males are produced and sexual reproduction takes place resulting in the production of resting eggs. *Daphnia* are very important to aquatic food chains. *Daphnia* eat algae and are therefore primary consumers, and *Daphnia* also eat bacteria. Fish and other aquatic predators rely on *Daphnia* as their main source of food. *Daphnia magna* is used as an indicator organism to detect toxic compounds.

Daphnia Experiment		Class 1 - algae		Class 2 - YCT			
		Number of Baby Daphnia		Dead Adult Daphnia			
	Type of	Mon. May 30	Fri. June 3	Mon. May 30	Fri. June 3		
cup #	Food	Day 3	Day 7	Day 3	Day 7		
1	algae						
2	algae						
3	algae						
4	algae						
5	algae						
6	algae						
7	algae						
8	algae						
9	algae						
10	algae						
11	algae						
12	algae						
13	algae						
14	algae						
15	algae						
16	algae						
17	algae						
18	algae						
19	algae						
20	algae						
21	algae						
22	algae						
23	algae						
24	algae						
25	algae						
	Total						
	Average						
	Range						

		Number of Baby Daphnia		Dead Adult Daphnia			
	Type of	Mon. May 30	Fri. June 3	Mon. May 30	Fri. June 3		
cup #	Food	Day 3	Day 7	Day 3	Day 7		
26	YCT						
27	YCT						
28	YCT						
29	YCT						
30	YCT						
31	YCT						
32	YCT						
33	YCT						
34	YCT						
35	YCT						
36	YCT						
37	YCT						
38	YCT						
39	YCT						
40	YCT						
41	YCT						
42	YCT						
43	YCT						
44	YCT						
45	YCT						
46	YCT						
47	YCT						
48	YCT						
49	YCT						
50	YCT						
	Total						
	Average						
	Range						