Top-Down Trophic Cascade Experiment
Algae, Daphnia, & Fish

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https://www.cebc.ku.edu/education/RET-2010.shtml

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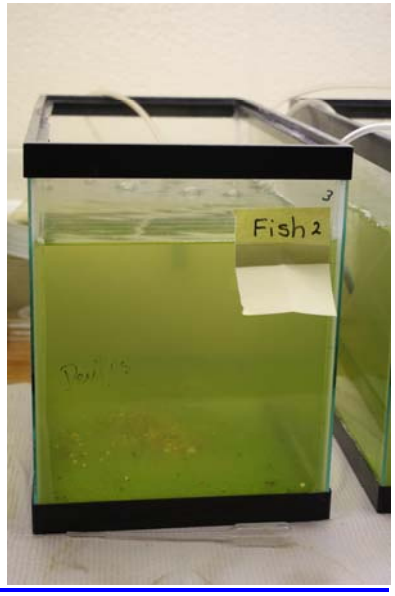


Photos by – Mary C. Criss

Revised June 6, 2010/LB

Learning Experience Description:

The experiment is a hands-on lesson that introduces students to the environmental concept of top-down control of a simulated freshwater pond or lake ecosystem. The purpose of the experiment is two fold, either controlling algal growth and limiting eutrophication or maximizing algal growth for the intended use for biofuels. The experiment uses planktivores fish, daphnia, and freshwater algae.

Bioscience Connection:

A research scientist in the ecology, evolutionary biology department at the University of Kansas has been studying algae for years. Another scientist in the environmental engineering department is especially interested in growing algae on waste water. Together they are testing how well algae can be grown on effluence from the city of Lawrence's Waste Water Treatment Plant, as well as, the population dynamics between the algae (phytoplankton), daphnia (a zooplankton) that graze upon the algae, and the fish that consume the daphnia. These studies are important in the low cost, maximum production of algae, and therefore algal lipids for a future source of biofuels. Our students will be investigating the following concepts related to bioscience / biotechnology:

Bioscience:

Top Down Trophic level study

Carrying Capacity of algae, Daphnia, & fish

Biomanipulation of lake food webs

Biotechnology:

Use of various Vernier probe:

Spectrovisor - Spectrophotometer probe

Use of Microsoft Excel for graphing data

Background Information:

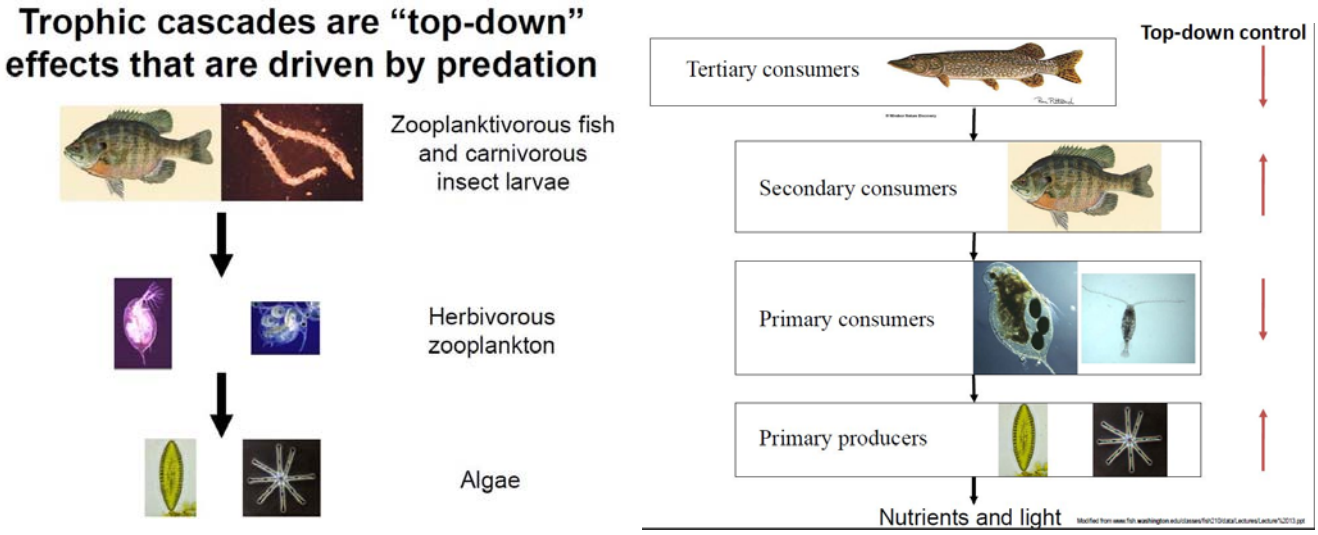
Students should have an understanding of basic biology. All of the activities involve collecting and culturing living micro-organisms.

Collection & Culturing of Algae and Daphnia

Biofuels made from Algae compared to other biofuels.

The environmental effects of the current BP oil spill in the Gulf of Mexico – the world's largest environmental disaster.

Top-down Trophic Cascade - 'Top-down' means the effect of a consumer (e.g., zooplankton) on a resource (e.g., phytoplankton).



Modified from www.fish.washington.edu/classes/fish210/data/Lectures/Lecture%2013.ppt

Trophic Level Interactions and Requirements

Primary Producers (autotrophs) – Phytoplankton – algae

Primary Consumers (hetertrophs) – Zooplankton – Daphnia

Secondary Consumers (planktivorous) – small fish that feed on the Daphnia

Grade Level:

Grades 9 -12. Biology, Environmental Science, Zoology. The activities could be modified to reach younger or older students.

Duration of Learning Experience:

4 to 6 weeks for the experiment

Pre-Lab set up = 2 weeks to set up the experimental design – Collect the algae & Daphnia and start cultures growing prior to starting the experiment.

4 to 6 weeks of observations and data collection

Once the experiment is set up, the students will only take 10 to 15 minutes to make daily observations and record the Spectrovis-Plus data on the computer.

Pre-Visit Classroom Information:

Provide students with the needed background knowledge (presented above).

Any information about the KU Biofuels program and labs will help the students understand the importance of the information presented in this activity.

Post-Visit Classroom Information:

Set up long term studies dealing with Top-down trophic cascade experiments.

Concept / Topic:

This activity will address the experimental design of a top-down trophic cascade study of a simulated freshwater pond or lake ecosystem, utilizing algae, daphnia and fish. This activity will address the factors affecting desired algal growth in a natural setting for the purpose of creating algal based biofuels.

Vocabulary:

Autotroph	Effluents	Phosphorus Cycle
Blue – Green Algae	Eutrophication	Phytoplankton
Carrying Capacity	Exponential Growth	Primary Consumer
Copepods	Food Web	Primary Producer
Cyanobacteria	Green Algae	Secchi Disk
Cyanotoxins	Heterotroph	Secondary Consumer
Daphnia	Hypothesis	Spectrophotometer
Diatoms	Nitrogen Cycle	Trophic level
Dinoflagellates	Planktivorous Fish	Water Pollution
Ecosystems	Photosynthesis	Zooplankton

Content Standards, Benchmarks, and Indicators Addressed:

STANDARD 1: SCIENCE AS INQUIRY Grades 8-12

SCIENCE AS INQUIRY – The student will develop the abilities necessary to do scientific inquiry and develop an understanding of scientific inquiry.

Benchmark 1: The student will demonstrate the abilities necessary to do scientific inquiry.

Grades 8-12 Indicators The student…

1. Actively engages in asking and evaluating research questions.
2. ▲ Actively engages in investigations, including developing questions, gathering and analyzing data, and designing and conducting research
3. ▲ Actively engages in using technological tools and mathematics in their own scientific investigations.
4. Actively engages in conducting an inquiry, formulating and revising his or her scientific explanations and models (physical, conceptual, or mathematical) using logic and evidence, and recognizing that potential alternative explanations and models should be considered.
5. Actively engages in communicating and defending the design, results, and conclusion of his/her investigation.

STANDARD 3: LIFE SCIENCE Grades 8-12

LIFE SCIENCE – The student will develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems, and the behavior of organisms.

Benchmark 4: The student will understand the interdependence of organisms and their interaction with the physical environment.

Grades 8-12 Indicators The student …

1. ▲ Understands atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.
2. Understands energy is received, transformed and expended in ecosystems.
3. ▲ understands the distribution and abundance of organisms and populations in ecosystems are limited by the carrying capacity.
4. Understands organisms cooperate and compete in complex, interdependent relationships
5. Understands human beings live within and impact ecosystems.

STANDARD 5: SCIENCE AND TECHNOLOGY Grades 8-12

SCIENCE AND TECHNOLOGY – The student will develop understandings about the relationship between science and technology.

Benchmark 1: The student will develop an understanding that technology is applied science.

Grades 8-12 Indicators The student …

1. ▲ Understands technology is the application of scientific knowledge for functional purposes.
2. Understands creativity, imagination, and a broad scientific knowledge base are required to produce useful results.
3. Understands science advances new technologies. New technologies open new areas for scientific inquiry.

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES Grades 8-12

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will develop an understanding of personal and community health, population growth, natural resources, environmental quality, natural and human induced hazards, and science and technology in local, national, and global settings.

Benchmark 2: The student will demonstrate an understanding of population growth.

Grades 8-12 Indicators The student …

1. Understands the rate of change in populations is determined by the combined effects of birth, death, emigration, and immigration.
3. Understands populations have limits to growth.

STANDARD 7: HISTORY AND NATURE OF SCIENCE Grades 8-12

HISTORY AND NATURE OF SCIENCE – The student will develop understanding of science as a human endeavor, the nature of scientific knowledge, and historical perspectives.

Benchmark 2: The student will develop an understanding of the nature of scientific knowledge.

Grades 8-12 Indicators The student …

1. Understands scientific knowledge describes and explains the physical world in terms of matter, energy, and forces. Scientific knowledge is provisional and is subject to change as new evidence becomes available.

2. Understands scientific knowledge begins with empirical observations, which are the data (also called facts or evidence) upon which further scientific knowledge is built.
3. Understands scientific knowledge consists of hypotheses, inferences, laws, and theories.
4. Understands a testable hypothesis or inference must be subject to confirmation by empirical evidence

Environmental Education

Standard 1: Learners demonstrate an understanding that the earth is a physical system.

9-12 Benchmark 2: Learners analyze and communicate the basic properties of matter and energy.

9-12 Indicators:

By the end of the twelfth grade, the students:

1. Explain how the process of photosynthesis transforms the sun's energy in plants and releases oxygen into the air.
2. Explain how the process of respiration releases energy and carbon dioxide for growth and other life processes in plants and animals.
3. Illustrate how energy and matter flow in the biosphere.

Standard 2: Learners demonstrate an understanding of the relationships and interactions between organisms and the environment.

9-12 Benchmark 1: Learners analyze complex relationships among organisms and habitats.

9-12 Indicators:

By the end of the twelfth grade, the students:

1. Explain how habitat changes influence the size of plant and animal populations.
3. explain how biodiversity of species in an environment increases the chances of survival of at least a few species.

9-12 Benchmark 3: Learners analyze the interdependence of living organisms with each other and with the physical environment.

9-12 Indicators:

By the end of the twelfth grade, the students:

1. Explain how plants, animals, and all the physical components of ecosystems are connected.
2. Describe how ecosystems remain stable over long periods of time through interdependence, cyclic fluctuations, and equilibrium.

Standard 4: Learners develop the abilities necessary to conduct scientific inquiries.

9-12 Benchmark 2: Learners demonstrate scientific inquiry skills.

9-12 Indicators:

By the end of the twelfth grade, the students:

1. Connect questions with appropriate means of inquiry, including scientific investigations, historical inquiry, and social science observation and research.
2. Use sampling techniques.
3. Apply observation and measurement skills in field situations,
4. Gather information from a variety of sources.
5. Perform basic statistical analyses to describe data using quantitative measures.
6. Look for and explain inconsistencies, such as faulty or misleading use of statistics, misrepresentation of data that is presented graphically, or biased selection of data to support a claim.

7. Use technology to interpret and communicate, e.g., database and mapping software.
8. Integrate and summarize information using a variety of media,
9. Create models and simulations.
10. Differentiate between causes and effects and identify when causality is uncertain.
11. Develop new questions to stimulate further inquiry based on experience.

Math Standards

Standard 4: Data NINTH AND TENTH GRADES

Data – The student uses concepts and procedures of data analysis in a variety of situations.

Benchmark 2: Statistics – The student collects, organizes, displays, explains, and interprets numerical (rational) and non-numerical data sets in a variety of situations.

Ninth and Tenth Grades Application Indicators The student…

1. ▲ Uses data analysis in real-world problems with rational number data sets to compare and contrast two sets of data, to make accurate inferences and predictions, to analyze decisions, and to develop convincing arguments from these **data displays** (2.4.A1i) **($)**:

a. ■ Frequency tables and line plots;
b. Bar, line, and circle graphs;
d. Charts and tables;

2. Determines and describes appropriate data collection techniques (observations, surveys, or interviews) and sampling techniques (random sampling, samples of convenience, biased sampling, census of total population, or purposeful sampling) in a given situation.
3. Uses changes in scales, intervals, and categories to help support a particular interpretation of the data
5. Analyzes the effects of: a. outliers on the mean, median, and range of a real number data set; b. changes within a real number data set on mean, median, mode, range, quartiles, and interquartile range.

www.ksde.org

Technology Standards Addressed:

STANDARD 5: SCIENCE AND TECHNOLOGY Grades 8-12

SCIENCE AND TECHNOLOGY – The student will develop understandings about the relationship between science and technology.

Benchmark 1: The student will develop an understanding that technology is applied science.

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3. Understands science advances new technologies. New technologies open new areas for scientific inquiry.

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Learning Experience Objectives:

After completing these experiments, The students will be able to (TSWBAT):

- Explain and diagram the top-down cascade trophic interactions in a freshwater lake using algae, daphnia, and planktivorous fish.
- Describe Daphnia behavior, anatomy and physiology.
- Follow the experimental set-up described in the step by step procedures.
- Make detailed observations, gather data, use data analysis, and display it in a graph.
- Use the following lab probe to analyze their data: Vernier Spectrovisor (Spec 20).
- Write a lab report on the experiment.
- After finishing the experiment the students will be able to design their own experiment to test top-down cascade trophic interactions using various conditions, such as, light intensity, numbers of fish, amount of light received per day, amount of daphnia, etc… They will also be able to explain how this top-down study can be used to both control unwanted algal growth as well as promote algal growth for biofuels research.

Required Materials for the Aquaria Setup:


- 4 to 6, 2.5 to 5 gallon, Frameless All Glass Aquariums w/ lids, $15.00 to $17.00, from PETCO www.petco.com
- Clear Air Line Tubing for Aquariums, $3.00 - $5.00, from PETCO www.petco.com


- PETCO Bubbling Airstone 1" Length, Pack of 4 stones, SKU: 1191055, $1.97 each www.petco.com
- Lok-Tite ® Non-Corrosive (plastic) Aquarium 5 Gang Air Valve, SKU: 90212, $6.97 each www.petco.com

- Air pump – Petco 2-Way For 12-93 gallon Aquariums, $10.97, Model 9902 SKU: 1191330, www.petco.com

Required Materials for the growth chamber / lighting set up

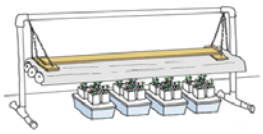
If you have enough under cabinet space you will need the following supplies:



- 2 - Fluorescent Light fixture, Metalux 4' 2-Lamp, T12 Strip Light, Item #: 163717 | Model #: SSF240, $20.00, from Lowes, www.lowes.com
- Utilitech Mechanical Programmable Timer, Item #: 144082 | Model #: TM12DOLBL, $10.97, from Lowes, www.lowes.com
- 4, GE 40-Watt Plant & Aquarium T12 Fluorescent 48" Bulb, Item #: 149116 | Model #: 49893, $9.98 each, from Lowes, www.lowes.com

(All photos for the supply list were taken from their respective websites)

If you don't have enough under cabinet space to mount the lights you will need to make a light stand with the following supplies:

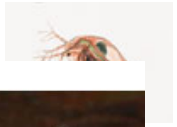


- Instructions and materials for building the light stand: http://www.fastplants.org/pdf/grow/pvc_light_stand.pdf
- All of the supplies can be purchased from Lowes or online at www.lowes.com or any local hardware store. The total cost is ~ $25.00.

Required Materials to fill the Aquaria:

- 5 gallon bucket, Item #:43770 | Model #:PN0011, $2.34, from Lowes www.lowes.com
- Encore Plastics 3.5 & 5 Gallon Snap On Lid, Item #: 276477 | Model #: 53000, $0.99, from Lowes, www.lowes.com
- Oxo Good Grips Turkey Baster with Cleaning Brush, $8.99 www.amazon.com
- Miracle-Gro 4-1/2 Lb. Shake 'n Feed® All Purpose Plant Food, Item #: 188366 | Model #: 1008191, Slow time release, 10–10–10, $13.98, from Lowes, www.lowes.com
- Charlotte Pipe 6" PVC Coupling, Item #: 52002 | Model #: PVC 00100 1600, $7.28, from Lowes, www.lowes.com
- Ecoglue® Power Glue (56011), Item # 1338060, $4.99 each, from Ace Hardware, www.acehardware.com
- Ultra Sheer Pantyhose, White color, $1.00 - $2.00, from any department store, Wal-Mart, Target, K-Mart, etc…

- Freshwater algae – from a freshwater pond or lake or purchased from Fisher Scientific www.fishersci.com
  - *Mixed Algal Pond Collection – Catalog #* S212501 Biological Resource Center No. : DCS212501, Each $10.46



- Daphnia magna – from a freshwater pond or lake, or purchased from Fisher Scientific, www.fishersci.com
  - Daphnia magna, for a class of 120, Catalog # S98724 NASCO FT ATKINSON No.:LM00039CM, Each $36.00

- Female Fancy Guppies, 1.25"-1.75" Length, SKU: 1032062, $1.69 each, from Petco, www.petco.com
- Male Fancy Guppies, 1.25"-1.75" Length, SKU: 1032070, $2.37 each, from Petco, www.petco.com

(All photos for the supply list were taken from their respective websites)

Required Materials to Test the Aquaria water:

- SpectroVis Plus SpectroVis Plus, #SVIS-PL, $449.00, from Vernier, www.vernier.com/products.html
- Plastic Cuvettes (visible range), Plastic Cuvettes, #CUV, $15.00, from Vernier, www.vernier.com/products.html
- Fisherbrand* Standard Disposable Transfer Pipets Graduated; Capacity: 7.5mL; Length: 6 in., Length: 6 in., Catalog # 13-711-9D, Pack of 500 for $43.02, www.fishersci.com

(All photos for the supply list were taken from their respective websites)

Lab Safety:

- Students may want to wear vinyl gloves when dealing with the pond water or algae.
- Students should wear goggles when dealing with the 70% Alcohol.
- No eating food or drinking beverages in the lab. Other common lab safety as long pants; tied-back hair; closed-toe shoes, etc.)

Technology Connection:

Students will use a Spectrovis Plus Vernier probe to determine algal concentration differences in the aquaria. The students will use Excel to record, graph, and analyze data from their experiments. Students will also make counts of the algal growth in each tank by using random sampling techniques and a microscope. Field of view for the microscopes will be calculated for each sample tested.

Anticipatory Set:

Have students fill out the Prediction Guide for Algae and Daphnia (worksheet attached).
Show video clips about eutrophication from the following websites. These videos explain the problem caused by increased nutrients, nitrogen and phosphorus, in aquatic ecosystems. The videos also highlight the negative effects on the ecosystem and human health.

- Phosphates and Eutrophication.m4v
  http://www.youtube.com/watch?v=Uht-jLhWUrE&NR=1
- Dead Zone
  http://www.youtube.com/watch?v=3n7yyJinlNw&feature=related
- The Dead Zone
  http://www.youtube.com/watch?v=a8ae2vq45eA&NR=1
- Eutrophication in Lake Macatawa: Environmental Issues Project
  http://www.youtube.com/watch?v=BKJZtKnRo9w&feature=related

The next two video clips show an extreme algal bloom and the extent of the problem that can occur anywhere there are aquatic habitats with the optimal conditions.

- Green Tide http://www.youtube.com/watch?v=B4IAAa667EM&feature=related
- Olympic Venue Covered with Algae
  http://www.youtube.com/watch?v=LJHKQlqVd1U&feature=related

To connect the concept of eutrophication to the desired growing of algae for algal biofuels, students will be shown the following PowerPoint,

- "The Ecology of Algal Biodiesel Production", by Dr. Val H. Smith, Department of Ecology and Evolutionary Biology, University of Kansas

Step-By-Step Procedures: Pre-Lab Set Up (TEACHER SECTION)

Step #1 through Step #3 → 2 to 3 weeks prior to the start of the lab

1. **Set up for the lighting system:**
   a. Mount the fluorescent lights under a cabinet if you have the space OR
   b. Create a light stand as shown in the diagram on the following web page.

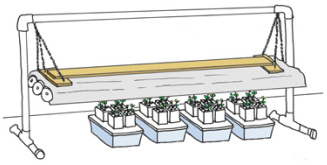


Photo by – Mary C. Criss

- http://www.fastplants.org/pdf/grow/pvc_light_stand.pdf

2. **Locate a local pond or lake that is sufficiently green with algae:**
   a. Take several large clean buckets, a container to pour the water and your filter apparatus.
   b. Pour the water through the filter apparatus and into an empty bucket to strain out the zooplankton.
   c. Collect enough pond water to fill your aquaria to approximately 1" from the top.

Photo by – Mary C. Criss

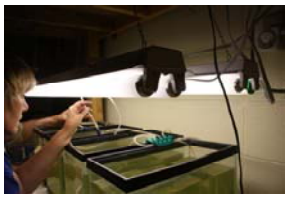
Photos by – Mary C. Criss

3. **Aquaria set up:**
   a. Fill each aquaria with the filtered algal pond water.
   b. Add a couple of spoonfuls of fertilizer to the bottom of each aquarium. Use the same amount of fertilizer in each aquaria.
   c. The aquaria should be spaced evenly apart from one another under the duel bank of fluorescent lights. They should be centered under the lights.
   d. Cut enough clear tubing to reach from the gang valve to the bottom of each tank.
   e. Attach one end of the tubing to the 4 gang valve and the other end to an air stone.
   f. Cut enough clear tubing to reach from the 4 gang valve to the air pump.
   g. Set up the air stones (or bubblers) into each aquarium to allow the fertilizer to dissolve and thoroughly mix.
   h. The fluorescent lights should be hooked up to a timer to allow only 12 hours of light during the daytime hours.

Photos by – Mary C. Criss





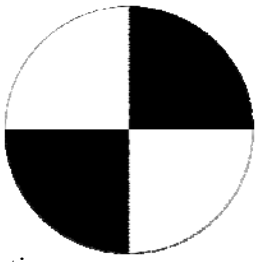


i. Loosely cover each aquaria with Seran wrap to prevent evaporation of the water.
j. Do NOT use any metal in the aquarium set up → Daphnia are very sensitive to metals and do not fair well. You may kill your entire population of Daphnia!!!

Step-By-Step Procedures: Top Down Trophic Cascade Experiment

Step #4 through Step #13 (STUDENT SECTION)

4. **A modified version of a Secchi disk will be used to plot algal concentration.**
   a. Read the following information about "What is a Secchi Disk?" http://www.mlswa.org/secchi.htm
   b. The teacher will provide 4 laminated copies of the following diagram. The Secchi diagram should be enlarged so that it closely matches the width of the aquarium. http://upload.wikimedia.org/wikipedia/commons/thumb/0/0b/Secchi_disk_pattern.svg/600px-Secchi_disk_pattern.svg.png
   c. Tape the Secchi diagram to the back of each aquaria so that the black & white markings face through to the front of the aquaria. This will add to the visual difference in algal concentration.

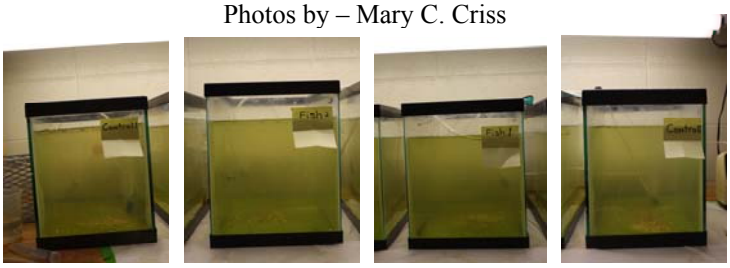


   d. Tape a standard clear plastic metric ruler to the top left of each aquaria. The fixed ruler should be placed with the lowest numbers facing the front.
   e. This will be used in conjunction with a dark (not see through) plastic metric ruler.
      - Assign one person (with 20/20 vision) to take the manual measurements each day.
      - This person will use the dark ruler and place it vertically in the tank and put it to the furthest point that they can clearly it clearly.
      - Record the distance in cm that the dark ruler is from the front of the tank.
      - **Create a data table and display the information in a line graph**.

5. **Randomly choose which 2 aquaria will have the treatments and which 2 aquaria will serve as the controls.**
   a. Treatment tanks → Fish 1 and Fish 2
   b. Control tanks → Control 1 and Control 2
   c. Tape the labels onto the tanks.

6. **<u>Let the algae in the aquaria grow for several weeks to allow a carpet of algae to accumulate at the bottom of the tank.</u>**
    - **a.** After 2 to 3 weeks the aquaria should look like the following pictures:

Photos by – Mary C. Criss



    - **b.** Take pictures of each aquaria on a daily basis to show progress of algal growth.

7. **<u>Place the cuvette into the Spectrovis-Plus, Vernier probe and Generate a Calibration Curve for Chlorophyll *a*. *This should only be done at the beginning of the experiment.* Use the following procedures:</u>**
    - **a.** Set the wavelength to 635 nM.
    - **b.** With no sample in the Spec 20 (and the cover closed) set the %T at 0%.
    - **c.** Put a blank (solvent with no chlorophyll) in the Spec 20 and set the %T at 100%. The concentration of this solution is 0g/mL.
    - **d.** Place each cuvette with the chlorophyll solutions in the Spec 20. Read the (%T)
    - **e.** Convert %T to absorbance using the following equation; A = -logT.
    - **f.** Plot absorbance (y axis) vs. Concentration (x axis) including the 0g/mL point.
    - **g.** Draw the best straight line through these points.

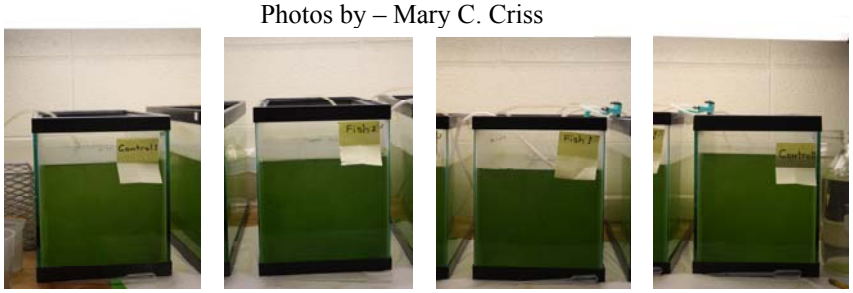
8. **<u>Using the Spectrovis-Plus Vernier probe to measure algal concentration of each tank.</u>**
    - **a.** Label a disposable plastic pipette for each tank. To prevent cross contamination be sure to use the correctly labeled pipette & rinse with spring water after each sampling.
    - **b.** Fill a cuvette with 3 mL of the tank water by squeezing the pipette bulb several times under water to ensure mixing of the water and algae.
    - **c.** Click on the Logger Pro icon to open the program.
    - **d.** Place the filled cuvette into the Spectrovis-Plus making sure to put the clear sides facing the direction of light.
    - **e.** At the top of the screen click <u>Experiment</u>
        - From the drop down menu select <u>Start Collection</u>
        - Then select <u>Stop Collection</u> (after a few seconds).
    - **f.** At the left side of the screen, double click <u>Latest</u>
        - <u>Name the data point with the treatment and date</u>
    - **g.** At the top of the screen click <u>Experiment</u>
        - From the drop down menu select <u>Store Collection</u>
    - **h.** Repeat steps d – g for each aquaria.
    - **i.** The Data table and data points will appear on a graph on Logger Pro.
    - **j.** Then transfer the data to an **<u>excel spreadsheet to create a line graph</u>** of all the data points collected.

9. **Spectrovis-Plus Vernier Probe Information**
    a. Logger Pro 3 Quick Reference Manual
    http://www2.vernier.com/manuals/LP3QuickRefManual.pdf
    b. SpectroVis Spectrophotometer Reference Manual
    http://www2.vernier.com/booklets/svis.pdf

10. **Adding the adult Daphnia to the tanks labeled Fish 1 and Fish 2.**
    a. Use a plastic pipette to obtain the adult Daphnia from their container.
    b. Add 10 adult Daphnia to only the tanks labeled Fish 1 and Fish 2.

11. **Each day make observations of each tank.**
    a. If possible, take digital photos of each tank from a set distance away.
    b. Repeat step # 8 – Spectrovis-Plus measurements for each of the tanks.
    c. Repeat step # 4e – Manual Measurements using plastic rulers.
    d. Let the experiment run for 3 weeks. The tanks should look similar to the following:

Photos by – Mary C. Criss



12. **The fish treatment:**
    a. After 3 weeks, add one male guppy and one female guppy to the tanks labeled Fish 1 and Fish 2, each of these tanks should only have 2 fish.
    b. Each day make observations of each tank.
        - If possible, take digital photos of each tank from a set distance away.
        - Repeat step # 8 – Spectrovis-Plus measurements for each of the tanks.
        - Repeat step # 4e – Manual Measurements using plastic rulers.
        - Let the experiment run for another 3 weeks.

13. **Lab Report (Materials attached)**
    a. Lab Report Evaluation Rubric
    b. Line Graph Evaluation Rubric (Excel and Paper)

Assessment:

Learning will be assessed by using the following rubrics:

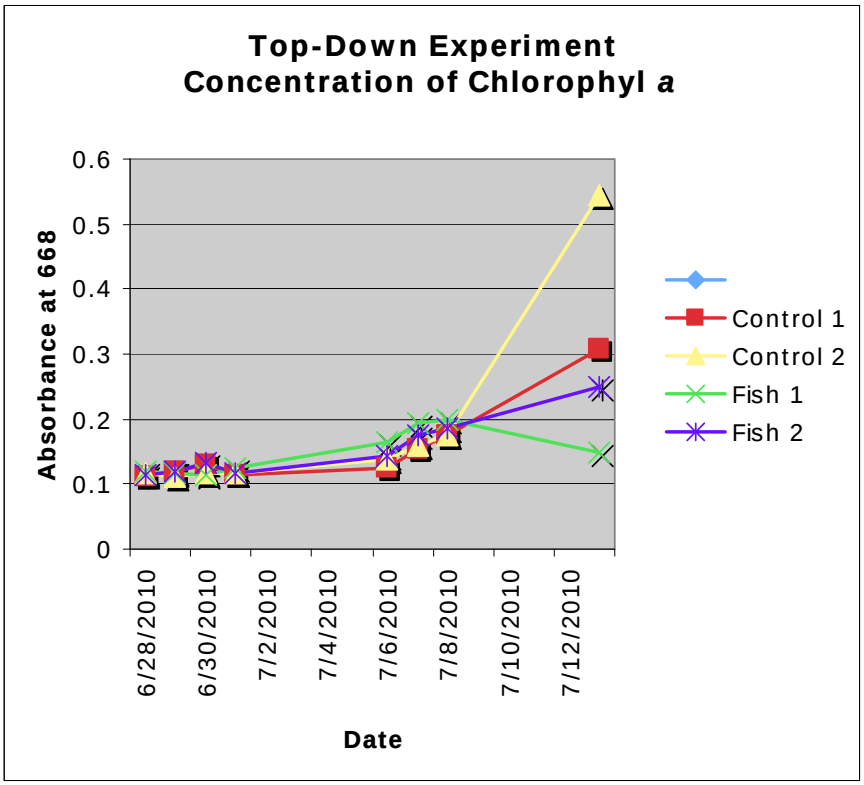
- Lab Report Evaluation Rubric

- Line Graph Evaluation Rubric (Excel and Paper)

Examples of Excel Data Table & Line Graph.

These examples are only of the first half of the experiment, which include the algae and daphnia treatments only.

Top - Down Experiment Concentration of Chlorophyl *a*						
Date		**Control 1**	**Control 2**	**Fish 1**	**Fish 2**	**Wave length**
6/28/2010		0.1126257	0.11667975	0.1197	0.113	668
6/29/2010		0.119	0.111	0.118	0.12	668
6/30/2010		0.129	0.116	0.114	0.133	668
7/1/2010		0.113	0.118	0.124	0.118	668
7/6/2010		0.126	0.138	0.165	0.144	668
7/7/2010		0.153	0.159	0.193	0.175	668
7/8/2010		0.174	0.174	0.2	0.187	668
7/13/2010		0.309	0.545	0.15	0.25	668
7/14/2010		0.228	0.243	0.178	0.221	668



Closure (Reflect Anticipatory Set):

Students will use the knowledge gained during the step by step procedures to develop an experimental design with variables of their choosing (approved by the teacher), and write up a detailed lab report of their findings.

Resources:

- Ecology: Concepts and Applications, 5th ed, McGraw Hill, author Molles, Manuel, ISBN # 978-0-07-338322-4
- The Biology of Lakes and Ponds: Biology of Habitats, 2nd ed. Oxford, author Christer Brönmark and Lars-Anders Hansson, ISBN # 978-0-19-851613-2
- How to Know the Freshwater Algae, 3rd ed. WCB McGraw Hill, author G.W. Prescott, ISBN # 0-697-04754-7
- Daphnia: An Aquarist's Guide, written & compiled by John Clare, B.A., Ph.D. www.caudata.org/daphnia/
- Trophic cascades revealed in diverse ecosystems, Michael L. Pace, Jonathan J. Cole, Stephen R. Carpenter and James F. Kitchell http://www.nd.edu/~underc/east/publications/documents/Pace_99TREE.pdf
- Trophic Cascades in Lakes: Lessons and Prospects by Stephen R. Carpenter, Jonathan J. Cole, James F. Kitchell and Michael L. Pace – Paper Attached.

Student Sheet

Top-Down Trophic Cascade Experiment – Algae, Daphnia, & Fish

Date: _____ **Class:** _____ **Hour:** _____

Student Name	Contact Information	Colored Pen	Signature
		Dark Blue	
		Green	
		Purple	
		Black	

PROBLEM: What are the effects of Algae, Daphnia, and Fish on a Top-Down Freshwater Trophic Cascade Experiment?

STUDENT HYPOTHESIS:

Tanks with Daphnia Magna and Algae only - _____

_____

_____

_____

Tanks with Daphnia Magna, Zebra Fish, and Algae - _____

_____

_____

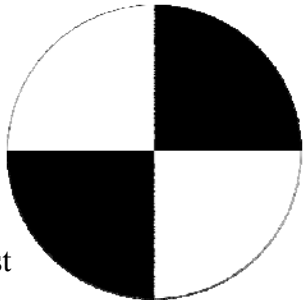
_____

EQUIPMENT:

- Daphnia Magna (the largest ones available)
- 4 – 2.5 gallon aquaria → completely set up with freshwater algae
- Light Stand → completely set up
- 4 plastic pipettes
- 4 laminated Secchi disks
- 4 plastic metric rulers
- Waterproof tape
- 4 dark plastic metric rulers
- Spectrovis-Plus Vernier sensor
- 4 cuvettes
- Spring water
- Seran Wrap
- 2 Male Zebra Fish (1 per treatment tank, Fish 1, Fish 2)
- 2 Female Zebra Fish (1 per treatment tank, Fish 1, Fish 2)

Step-By-Step Procedures: Top Down Trophic Cascade Experiment

1. **A modified version of a Secchi disk will be used to plot algal concentration.**
   a. Read the following information about "What is a Secchi Disk?" http://www.mlswa.org/secchi.htm
   b. The teacher will provide 4 laminated copies of the following diagram. The Secchi diagram should be enlarged so that it closely matches the width of the aquarium. http://upload.wikimedia.org/wikipedia/commons/thumb/0/0b/Secchi_disk_pattern.svg/600px-Secchi_disk_pattern.svg.png

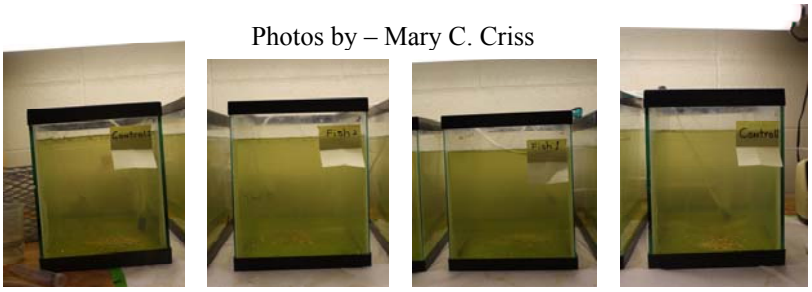


   c. Tape the Secchi diagram to the back of each aquaria so that the black & white markings face through to the front of the aquaria. This will add to the visual difference in algal concentration.
   d. Tape a standard clear plastic metric ruler to the top left of each aquaria. The fixed ruler should be placed with the lowest numbers facing the front.
   e. This will be used in conjunction with a dark (not see through) plastic metric ruler.
   f. Assign one person (with 20/20 vision) to take the manual measurements each day.
   g. This person will use the dark ruler and place it vertically in the tank and put it to the furthest point that they can clearly it clearly.
   h. Record the distance in cm that the dark ruler is from the front of the tank.

2. **Randomly choose which 2 aquaria will have the treatments and which 2 aquaria will serve as the controls.**
   a. Treatment tanks → Fish 1 and Fish 2
   b. Control tanks → Control 1 and Control 2
   c. Tape the labels onto the tanks.

3. **<u>Let the algae in the aquaria grow for several weeks to allow a carpet of algae to accumulate at the bottom of the tank.</u>**
    a. After 2 to 3 weeks the aquaria should look like the following pictures:

Photos by – Mary C. Criss



    b. Take pictures of each aquaria on a daily basis to show progress of algal growth.

4. **<u>Place the cuvette into the Spectrovis-Plus, Vernier probe and Generate a Calibration Curve for Chlorophyll *a. This should only be done at the beginning of the experiment.* Use the following procedures:</u>**
    a. Set the wavelength to 635 nM.
    b. With no sample in the Spec 20 (and the cover closed) set the %T at 0%.
    c. Put a blank (solvent with no chlorophyll) in the Spec 20 and set the %T at 100%. The concentration of this solution is 0g/mL.
    d. Place each cuvette with the chlorophyll solutions in the Spec 20. Read the (%T)
    e. Convert %T to absorbance using the following equation; A = -logT.
    f. Plot absorbance (y axis) vs. Concentration (x axis) including the 0g/mL point.
    g. Draw the best straight line through these points.

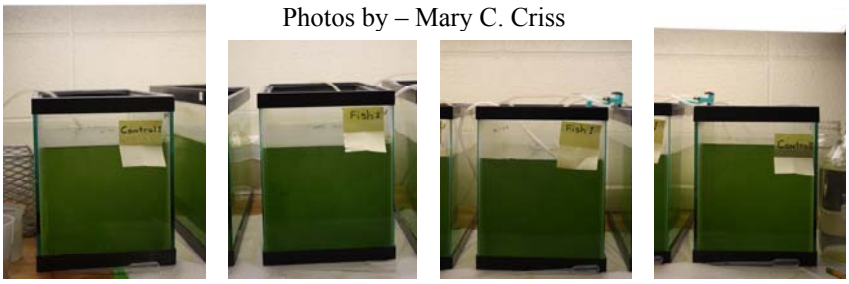
5. **<u>Using the Spectrovis-Plus Vernier probe to measure algal concentration of each tank.</u>**
    a. Label a disposable plastic pipette for each tank. To prevent cross contamination be sure to use the correctly labeled pipette & rinse with spring water after each sampling.
    b. Fill a cuvette with 3 mL of the tank water by squeezing the pipette bulb several times under water to ensure mixing of the water and algae.
    c. Click on the Logger Pro icon to open the program.
    d. Place the filled cuvette into the Spectrovis-Plus making sure to put the clear sides facing the direction of light.
    e. At the top of the screen click <u>Experiment</u>
        i. From the drop down menu select <u>Start Collection</u>
        ii. Then select <u>Stop Collection</u> (after a few seconds).
    f. At the left side of the screen, double click <u>Latest</u>
        i. <u>Name the data point with the treatment and date</u>
    g. At the top of the screen click <u>Experiment</u>
        i. From the drop down menu select <u>Store Collection</u>
    h. Repeat steps d – g for each aquaria.
    i. The Data table and data points will appear on a graph on Logger Pro.
    j. Transfer the data to an excel spreadsheet to create a line graph.

6. **Spectrovis-Plus Vernier Probe Information**
    a. Logger Pro 3 Quick Reference Manual
    http://www2.vernier.com/manuals/LP3QuickRefManual.pdf
    b. SpectroVis Spectrophotometer Reference Manual
    http://www2.vernier.com/booklets/svis.pdf

7. **Adding the adult Daphnia to the tanks labeled Fish 1 and Fish 2.**
    a. Use a plastic pipette to obtain the adult Daphnia from their container.
    b. Add 10 adult Daphnia to only the tanks labeled Fish 1 and Fish 2.

8. **Each day make observations of each tank.**
    a. If possible, take digital photos of each tank from a set distance away.
    b. Repeat step # 8 – Spectrovis-Plus measurements for each of the tanks.
    c. Repeat step # 4e – Manual Measurements using plastic rulers.
    d. Let the experiment run for 3 weeks. The tanks should look similar to the following:

Photos by – Mary C. Criss



9. **The fish treatment:**
    a. After 3 weeks, add one male guppy and one female guppy to the tanks labeled Fish 1 and Fish 2, each of these tanks should only have 2 fish.
    b. Each day make observations of each tank.
        i. If possible, take digital photos of each tank from a set distance away.
        ii. Repeat step # 8 – Spectrovis-Plus measurements for each of the tanks.
        iii. Repeat step # 4e – Manual Measurements using plastic rulers.
        iv. Let the experiment run for another 3 weeks.

10. **Lab Report (Materials attached)**
    a. Interactive Research Planning Form #1 (for exploratory level experiments)
    b. Lab Report Evaluation Rubric
    c. Line Graph Evaluation Rubric (Excel and Paper)

CONCLUSION: (ANSWER THESE QUESTIONS USING COMPLETE SENTENCES)

A. COMMENTS

1. What effect do the Daphnia have on the algae population?

2. What effect did the Zebra fish have on the Daphnia population?

3. And in turn what happened to the concentration of algae after the Zebra fish were added?

4. Does your data support your hypothesis'?

5. Was there anything you noticed that caused you to question your results?

B. Application

1. Why might it be useful to know this information?

2. What other hypotheses could you make based upon your observations?

3. What information might you need to know before you test these hypotheses?

When the lab is turned each lab group MUST have the following information:

a. **Lab Notebook Properly Labeled with Group Members names**
b. **Student Sheet Filled out (one per student)**
c. **Prediction Guide for Algae and Daphnia (one per student)**
d. **Definitions for Vocabulary words (one per student)**
e. **Data Tables for all observations**
f. **Handwritten Line Graph for Manual Algal Concentration Measurements**
g. **Excel Line Graph for Spectro-vis Vernier Probe Algal Concentrations**
h. **Lab Report**
i. **Lab Report Rubric**
j. **Line Graph Rubrics (1 for Paper & 1 for Excel**

RESOURCES:

Daphnia: An Aquarist's Guide, written & compiled by John Clare, B.A., Ph.D.
www.caudata.org/daphnia/

Trophic cascades revealed in diverse ecosystems
Michael L. Pace, Jonathan J. Cole, Stephen R. Carpenter and James F. Kitchell
http://www.nd.edu/~underc/east/publications/documents/Pace_99TREE.pdf

Ecology: Concepts and Applications, 5th ed, McGraw Hill, author Molles, Manuel,
ISBN # 978-0-07-338322-4

The Biology of Lakes and Ponds: Biology of Habitats, 2nd ed. Oxford, author Christer Brönmark and Lars-Anders Hansson, ISBN # 978-0-19-851613-2

How to Know the Freshwater Algae, 3rd ed. WCB McGraw Hill, author G.W. Prescott,
ISBN # 0-697-04754-

Name_____ Date_____ Period_____

PREDICTION GUIDE FOR ALGAE AND DAPHNIA

Directions: Read each statement and place a check in the **ME** column if you agree with it and a minus if you do not agree with it. Then, read the textbook pages related to algae and again use a check or a minus, except place it in the **AUTHOR** column. Compare your opinions with those of the author.

Taking it further: Change all the minus statements in the author column so that they agree with the textbook, and write down the page number where you found the information.

Me	Author	Statements	Page
		1. Algae are Heterotrophs.	
		2. Algae produce carbon dioxide.	
		3. Algae can produce toxins.	
		4. Some algae have health benefits.	
		5. Algae can grow in salt water and freshwater.	
		6. Algae can be used as a biofuels.	
		7. Daphnia are crustaceans.	
		8. Daphnia can only reproduce asexually.	
		9. Daphnia eat algae.	
		10. Daphnia are eaten by piscovores fish.	
		11. Daphnia give live birth.	
		12. Daphnia cannot sense predators that are hunting them.	

Modified from: http://www.somers.k12.ny.us/intranet/reading/fungi.pdf

Revised June 6, 2010/LB

Lab Report Evaluation Rubric			assignment #	
Student Names:			**Self-evaluation Score:**	
Instructions: (1) This analytic rubric is used to verify that specific tasks have been performed. (2) If a task has been successfully completed, all points are awarded. (3) No points are awarded if a task is not complete. (4) Awarding partial points is not an option.				
Category	**Scoring Criteria**	**Points**	**Student Evaluation**	**Teacher Evaluation**
Lab Introduction ***15 points***	The question to be answered during the lab is stated.	**5**		
	The hypothesis clearly shows it is based on research. *(Not just a wild guess.)*	**5**		
	Research references used to prepare the lab are listed. *(There are always research references.)*	**5**		
Procedures ***15 points***	Procedures are written during pre-lab preparation and clearly state what is planned. *(Procedures are not written in past tense form.)*	**5**		
	There are no "understood" procedures. *(Such as: get out equipment or turn on gas.)*	**5**		
	Specific formulas or equations for reactions during the lab are shown. *(Write these as procedures on the lab report.)*	**5**		
Observations ***15 points***	"Results" of a procedure are clearly recorded. *(Some procedures might not have observations)*	**5**		
	Measurements, when required, show proper units. *(Show these as **observations** on the lab report.)*	**5**		
	Calculations, when required, are clearly shown. *(Show these as **observations** on the lab report.)*	**5**		
Conclusion ***20 points***	Summarize the essential lab data.	**5**		
	Show how the essential data answers the lab question.	**5**		
	Identify **the one area** of the lab **most likely responsible** for measurable experimental error. *(Think carefully about this one.)*	**10**		
Presentation ***25 points***	Report is neatly printed in ink, with no visible corrections.	**10**		
	A diagram of the essential apparatus used in the lab is drawn in the largest white space on the lab report. *(There is always something to draw.)*	**10**		
	Report is written in such a way that others could accurately duplicate the experiment.	**5**		
Lab Safety ***10 points***	No group members were sited for safety violations. *(PPE must be worn **at all times**.)*	**10**		
Score	**Total Points**	**100**		
Self-evaluation	Students are expected to honestly evaluate their own work. If the difference between the student evaluation and the teacher evaluation is more than 10 points, 5 points will be deducted from the teacher's score when the grade is recorded.			
Deadline	Lab reports are due at the beginning of class the day after lab. Reports will be accepted at the beginning of class the second day after lab for 3/4 credit. No credit will be given after that time.			

http://www.crescent.k12.ok.us/staff/jaskew/ISR/rubrics/evalab.htm

Manual Algal Concentration Measurement Using a Plastic Metric Ruler

Line Graph Evaluation Rubric (Paper)	assignment # _____
Student Name:	**Score:**

- This analytic rubric is used to verify that specific tasks have been performed.
- If a task has been successfully completed, all points are awarded.
- No points are awarded if a task is not complete.
- Awarding partial points is not an option.

Category	Scoring Criteria	Points	Student Evaluation	Teacher Evaluation
Remember that to qualify as "neat", there can be no visible corrections!				
Variables ***20 points***	The independent variable is drawn on the X axis.	**10**		
	The dependent variable is drawn on the Y axis.	**10**		
Layout ***12.5 points***	The scale is such that the graph covers most of the page.	**10**		
	Rectangular graph paper is turned so that the variable with the widest range is drawn along the widest side of the paper.	**2.5**		
Axis Identification ***5 points***	Grid lines on each axis are clearly and neatly numbered.	**2.5**		
	Each axis is clearly and neatly labeled, including the units in which each variable is measured.	**2.5**		
Graph Data ***7.5 points***	Each data point is indicated by an obvious, but not overly large dot.	**2.5**		
	The value of the data for the dependent variable is neatly written by each data point. *(These numbers must be done without cluttering the graph.)*	**2.5**		
	The line plotted for the graph is neatly done and appropriate. *(Most graphs should be drawn as "best-fit" lines or curves.)*	**2.5**		
Title & Key ***10 points***	A descriptive title is neatly printed in the largest area inside the graph area. *(Graph titles are not printed in the margin of the paper.)* If more than one line is drawn on a single graph, a "key" is provided near the title to identify the lines. *(This is only done if there is more than one line on the graph.)*	**10**		
Score	**Total Points**	**55**		
Self-evaluation	Students are expected to honestly evaluate their own work. If the difference between the student evaluation and the teacher evaluation is more than 10 points, 5 points will be deducted from the teacher's score when the grade is recorded.			
Deadline	All "turn-in" assignments are expected to be completed by the assigned deadline. Graphs will be accepted at the beginning of class the day after the deadline for 3/4 credit. No credit will be given after this time.			

http://www.crescent.k12.ok.us/staff/jaskew/ISR/rubrics/evagraph.htm

Spectro-vis Plus Vernier Probe Data Table and Excel Line Graph

Line Graph Evaluation Rubric (Excel)	assignment # _____
Student Name:	**Score:**

- This analytic rubric is used to verify that specific tasks have been performed.
- If a task has been successfully completed, all points are awarded.
- No points are awarded if a task is not complete.
- Awarding partial points is not an option.

Category	Scoring Criteria	Points	Student Evaluation	Teacher Evaluation
Variables ***10 points***	The independent variable on the X axis.	**5**		
	The dependent variable on the Y axis.	**5**		
Plot Area ***10 points***	The plot area covers most of printed page.	**5**		
	Plot area background is white. *(White is not Excel's default color.)*	**5**		
Axis Identification ***7.5 points***	Major grid lines for both X and Y axis. *(Excel does not do this automatically.)*	**2.5**		
	Grid lines have appropriate data numbers.	**2.5**		
	Each axis is labeled, including the measurement units for each variable.	**2.5**		
Graph Data ***15 points***	Data points labeled with "marker".	**2.5**		
	The "value" of the dependent variable is shown at each data point. *(Numbers must not clutter the graph.)*	**2.5**		
	Data lines appropriate width and color. *(Most graphs should be drawn as "smoothed line".)*	**2.5**		
	The data table printed on page. *(The data table is not included if it makes graph print on two pages.)*	**2.5**		
	If more than one data line is drawn on a single graph, a "legend" is provided to identify the lines. (Points automatic for single-line graphs.)	**5**		
Graph Title ***10 points***	A descriptive title is printed in an open area inside the graph. *(Titles are not in the margin of the paper.)*	**10**		
Personal Information ***2.5 points***	Student name and assignment number are included. *(This information must be printed in the upper left-hand margin of the paper, not inside the graph plot.)*	**2.5**		
Score	**Total Points**	**55**		
Self-evaluation	Students are expected to honestly evaluate their own work. If the difference between the student evaluation and the teacher evaluation is more than 10 points, 5 points will be deducted from the teacher's score when the grade is recorded.			
Deadline	All "turn-in" assignments are expected to be completed by the assigned deadline. Graphs will be accepted at the beginning of class the day after the deadline for 3/4 credit. No credit will be given after this time.			

http://www.crescent.k12.ok.us/staff/jaskew/ISR/rubrics/exceleva.htm