Title: H_2O that Glows!

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Abstract:
These series of lessons take the idea of Chromatography that is already covered in the Honors and Regular Chemistry class and builds on it to integrate new biotechnology techniques and emerging pathogens.
The first lesson gives the background information about techniques used to separate mixtures. Paper chromatography will be performed using markers, as well as the dye obtained from a glow stick. In the second lesson, a video clip will introduce the concept of bioluminescence in some organisms, and how they use the green fluorescent protein to communicate with other organisms in their environment. A Web Quest will follow which will highlight some of the bioluminescent organisms of our world. Finally, all of the lessons will be tied together to reinforce student learning. Using *E. coli* cells transformed with the Green Fluorescent Protein (GFP) gene from jelly fish prepared by the AP Biology class, the protein will be isolated and the GFP Chromatography Kit from BioRad will be used to analyze the bands.

Rationale:
The area of biotechnology is expanding and is being heavily relied on for much of the research that is going on today. This research and potential discoveries may have an impact on you or someone you know in the near future. Students may have heard of "biotechnology" but may not know what it is or think that they are capable of performing some of these same techniques that scientists use in the research laboratories.
With the implementation of these technologies, use of the simulations and/or equipment lockers provided by the University of Florida to ICORE participants and their students, these children will have the first-hand experience that is relevant to them. This will be highly engaging and open the doors to not only their curiosity and questions, but maybe open their eyes to their potential and their interests they may not have known they had without these experiences.
It is our hope as teachers, that our students have the passion and enthusiasm for science that we do. With this introduction to this biotechnology and the amazing science that goes far beyond what we teach them, students will hopefully invest an interest in finding more solutions to problems and "what is out there" in a really fun and remarkable way.

Day 1-3: Separation of Mixtures
During this first lesson, the students will view a Power Point to learn about different separation techniques for mixtures and compounds. (Some of these processes used to separate mixtures include decantation, filtration, distillation and paper chromatography. Those used to separate compounds include electrolysis and intense heat.) The students will perform a hands-on activity to make sense of one of the processes used to separate mixtures.

Assignment: The students will complete the Paper Chromatography Lab Activity which is used to separate the dyes in various colors and brands of markers. In addition, another component will be added where the students will complete a chromatogram of the dyes various colored glow sticks. The students will then take home the reading Creatures that Glow, and answer the questions for homework.

Assessment: The students will answer pre-lab and post lab analysis questions to show their understanding of chromatography as it's used in the separation of mixtures. These lab reports will be turned in and graded. The reading questions will be turned in and graded.

Day 4: Application of "Glowing Chemicals" to Organisms
A connection will be made between the "glowing chemicals" in glow sticks, and the use of chemicals by bacteria in communication. They will be introduced to many microorganisms of our world, and how they have an impact on their surroundings. The students will complete a Web Quest researching several luminescent organisms of our world.

Assignment: The students will view a Power Point (Tiny Organisms, Enormous Effect) to be introduced to the idea of bioluminescence, and learn about the various microorganisms (including various *Vibrio* species, *E. coli* and Dinoflaggelates) that have an impact on the environment. They will then watch an 18 minute video with Bonnie Bassler on "How Bacteria Talk" from http://www.ted.com/talks/bonnie_bassler_on_how_bacteria_communicate.html.

Assessment: Students will turn in the Web Quest question sheets to be graded.

Day 5 - 7: GFP expression and isolation from transformed *E. coli*
If the AP Biology teacher has completed the transformation lab of *E. coli* with the GFP (Green Fluorescent Protein) gene from Jelly Fish, use the *E. coli* harvested for this portion of the lesson. (If this lab has not been done, a transformation of *E. coli* with the GFP gene from Jellyfish must be performed first, or already transformed bacteria may be purchased. Either the kit to transform the *E. coli* or the already transformed *E. coli* can be purchased from BioRad.)

Assignment: The students will then use the GFP Chromatography Kit from BioRad to isolate and analyze the GFP from Jellyfish that was transformed into the *E. coli*. The process of chromatography will be discussed.

Assessment: The students will complete the lab assignment and answer pre & post-lab (analysis) questions which will be collected and graded.

Extensions
Possible/Optional Field Trip:

A Day Away Kayak Tours – 321-268-2655 or 321-302-3810
Haulover Canal Launch, Merritt Island National Wildlife Refuge, FL 32780
Adults & Young Adults $34.00 ($38.00 on Saturday); Child $26.00 ($28.00 on Saturday)

You can see bioluminescence during the warmer summer/fall months on the waters of the Indian River and Mosquito Lagoon. Move your paddle through the water to see the light green glow of the water. Watch the bright greenish-blue speeding rockets swim under your kayak, which are the schools of mullet beneath you. The kayak tour lasts between 1.5 and 2 hours. (For the best results, go when there it is overcast, or when there is little moonlight.)

Depending on the Brevard County School District's approval, students will be taken on a field trip to see first-hand how bioluminescence occurs in "their own backyard".

Chromatography: To have another variable for the chromatography lab, students can use multiple brands of markers to see if the various brands of markers use the same dye compounds for each color.

Podcasts: Video clips on Bioluminescence in Organisms and/or Green Fluorescent Proteins can be viewed at http://www.conncoll.edu/ccacad/zimmer/GFP-ww/podcasts9.html#HERE.

Data Collection & Expected Outcomes:

- A Chapter Test will assess the students' knowledge of the processes used to separate mixtures.
- A set of reading questions will be used to assess the students' understanding of what organisms in their world use bioluminescence for.
- A Web Quest with questions about bioluminescent organisms of our world will be completed and graded.
- Pre and Post Lab questions will be used to determine the whether or not the student understands the concepts the lab was illustrating.

- After these lessons the students' answers to the analysis (pre & post-lab) questions should be well thought out and demonstrate an understanding of chromatography.

ICORE / UF Equipment Lockers Needed:

- Designer Plates – Micropipetting Techniques (Unrelated Activity)
- Antigen/Antibody Immunoassay: Food Allergy Simulation from Dr. Chuck Lawrence – (Unrelated Activity) Testing allergy to Casein, Gluten, Red Food Coloring, and Peanuts.

Literature Cited:

Images (for Power Points)**:** www.images.yahoo.com

Berger, Melvin, and Damon Hertig. *Creatures That Glow: a Book about Bioluminescent Animals*. New York: Scholastic, 1996. Print.

Video - "How Bacteria Talk":
http://www.ted.com/talks/bonnie_bassler_on_how_bacteria_communicate.html

Definitions & Background Information:

Mills, C.E. 1999-present. Bioluminescence of *Aequorea*, a hydromedusa. Electronic internet document available at http://faculty.washington.edu/cemills/Aequorea.html. Published by the author, web page established June 1999, last updated 11 January 2009.

Web Quest & Bioluminescent Organisms:

http://pinktentacle.com/2006/05/rainy-season-brings-glow-in-the-dark-mushrooms/
http://scienceblogs.com/notrocketscience/2009/06/glowing_squid_use_bacterial_flashlights_that_double_as_an_ex.php
http://www.pbs.org/wgbh/nova/sciencenow/0305/04-glow-05.html
http://www.lifesci.ucsb.edu/~biolum/organism/photo.html
http://en.wikipedia.org/wiki/Aequorea_victoria
http://en.wikipedia.org/wiki/Lampyris_noctiluca
http://animals.howstuffworks.com/insects/question554.htm

A Day Away Kayak Tours: http://www.adayawaykayaktours.com/

Podcasts (for more information on Bioluminescence & GFP)**:**

http://www.conncoll.edu/ccacad/zimmer/GFP-ww/podcasts9.html#HERE

Budget & Budget Justification:

Company	Item #	Quantity	Description	Unit Price	Total
BioRad	166-0005EDU	6	Green Fluorescent Protein Chromatography Kit (8 student work stations)	$126.25	$757.50
Flinn Scientific	AP1901	4	Ultraviolet Lamp, Hand Held	$33.50	$134.00

Title: H_2O That Glows!

Key Questions: This lesson will address the following questions:

- What is Chromatography?
- What is Bioluminescence?
- What types of organisms glow, and what are the benefits to glowing?
- What is Gel Electrophoresis?
- How are Paper Chromatography and Gel Electrophoresis similar?

Science Subject: Chemistry

Grade & Ability Level: 9th - 10th Graders (enrolled in Honors & Regular Chemistry)

Key Science Concepts: This lesson will address the following scientific concepts:

- Paper Chromatography (Identify mobile phase & stationary phase)
- Separation of Mixtures using Chromatography (Using dyes in markers, and glow sticks)
- Bioluminescent Organisms (Benefits to glow proteins. How organisms use light to communicate.)
- Transformation of *E. Coli* bacteria with GFP from Jelly Fish (*E. Coli* produced from AP Biology class will be used, or already transformed *E. Coli* will be purchased.)
- GFP Protein Chromatography from transformed *E. Coli*

OVERALL TIME ESTIMATE: This series of lessons will be covered over a 7-day period.

Day 1 will be the discussion of the "Separation Techniques" Power Point, background information reading on paper chromatography and Pre Lab questions.

Day 2 is the Paper Chromatography Lab.

Day 3 will be where the students compare their chromatograms and look at their glow stick chromatogram under the ultraviolet light. The Post Lab questions will also be completed. For homework, students will read Creatures that Glow, and answer questions based on the reading.

Day 4 is devoted to background information on bioluminescence and green fluorescent proteins (GFP). A video clip "How Organisms Talk" at http://www.ted.com/talks/bonnie_bassler_on_how_bacteria_communicate.html will be played.

Day 5 - 7 students complete the GFP Chromatography Activity (BioRad Kit) from the already transformed *E. Coli.*

LEARNING STYLES:

This unit plan will address visual, auditory and kinesthetic learners. The visual and auditory learners will benefit from the video clip, power point and the web quest. The kinesthetic learners will benefit from the hands-on Chromatography and Protein Gel Electrophoresis activity.

VOCABULARY:

Paper Chromatography: a method of separating and identifying the components of a mixture by movement through a two-phase (mobile and stationary) system.

Immiscible: not able to be mixed.

Mobile Phase: the phase that is moving in chromatography.

Stationary Phase: the phase in chromatography that is not moving.

Capillary Action: the process in which a liquid is able to travel along the surface of a solid, usually against gravity, and is caused by the attraction of the molecules of the liquid to the molecules of the solid

Affinity: an attraction for an object

Chromatogram: the developed paper containing a pattern of separated chemicals located at different positions created using paper chromatography.

Bioluminescence: production and emission of visible light by a living organism resulting from a chemical reaction that converts chemical energy to light energy. The Greek term *Bios* means "living" and the Latin term *lumen* means "light".

Green Fluorescent Protein: a protein composed of 238 amino acids that glows green under fluorescent light. It is commonly found in the jellyfish *Aequorea victoria*.

LESSON SUMMARY: A power point will be used cover the concepts of separation of mixtures using various procedures. The paper chromatography lab will be used to separate the different dyes of various colored markers as well as the components of different colored glow sticks. An online Video Clip and Web Quest will be used to illustrate the process of chemilumenescence and bioluminescence in a variety of organisms. Finally, the students will complete a hands-on activity of purifying Green Fluorescent Protein from the E. coli transformed from the AP Biology class. This GFP Chromatography uses HIC columns is purchased from BioRad.

STUDENT LEARNING OBJECTIVES WITH STANDARDS:

OBJECTIVES:

The student will be able to...

1. Identify the methods for separating mixtures versus pure substances.
2. Explain how the process of paper chromatography is used to separate components of mixtures.
3. Identify if there are similarities in the components of various colored markers and glow sticks once they are separated on the chromatograms.
4. Define bioluminescence and give examples of what organisms are bioluminescent and why they use it.
5. Explain how the process of chromatography can be used to isolate the green fluorescent protein from the *E.coli* bacteria that has been transformed with the GFP gene from jellyfish.

STANDARDS:

SC.912.N.1.1: Define a problem based on a specific body of knowledge. Pose questions about the natural world, conduct systematic observations, examine books and other sources of information to see what is already known, review what is known, plan investigations, use tools to gather, analyze and interpret data, pose answers, explanations or descriptions of events, generate explanations, or descriptions of events that describe natural phenomena, use appropriate evidence and reasoning to justify these explanations to others.

SC.912.P.8.2: Differentiate between physical and chemical properties and physical and chemical changes of matter.

MA.912.S.1.2: Determine appropriate and consistent standards of measurement for the data to be collected in an experiment.

LA.910.2.2.3: The student will organize the information to show understanding or relationships among facts, ideas and events.

MATERIALS:

ESSENTIAL MATERIALS: *(per lab group of 2-4 students)* 2 pieces of (5.0 cm x 10.0cm) Chromatography Paper, 2 petri dishes, 1-50mL reagent bottle of Solvent A(isopropyl alcohol), 5 Q-Tips or toothpicks. 1 paper towel. Computer Lab (1 computer per student or per pair is ideal.) BioRad Kit: GFP Chromatography from transformed *E. Coli*
(shared between several lab stations of 6-12 students) 1 package of 8-10 Crayola Markers, 4-8 various colored glow sticks. 1 hand-held ultraviolet light.
(per class) 1 tube of GFP Gene Transformed *E. Coli.* Centrifuge.

SUPPLEMENTAL: Power Point on Separating Techniques, Chromatography Lab Procedure with background information, pre and post lab questions, Creatures that Glow reading with questions, Power Point on "Tiny Organisms Enormous Impact", Video Clip on "How Organisms Talk", Web Quest worksheet, GFP Chromatography Lab Procedure.

BACKGROUND INFORMATION:

Chromatography – *see attached Chromatography Lab*

***Vibrio, E. coli* and Dinoflagellates –** *see Tiny Organisms, Enormous Effects Power Point attached.*

Bioluminescence in *Aequorea victoria* – *See attached document.*

ADVANCE PREPARATION:
In advance the teacher should check the listed websites for the video clip and web quest to be sure they are not blocked by the school server so their students can access them. Chromatography paper (5.0cm x 10.0cm) should be measured and cut – two papers for each lab group. Solution A (isopropyl alcohol) for the Paper Chromatography lab put into the 50ml reagent bottles.

PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES:

Day 1:

1. Show the Power Point on "Separation Techniques". (*attached*) ~ 15 minutes
2. Have the students read the background information on Paper Chromatography. (*attached*) ~ 5 minutes
3. On their own paper, the students should set up their lab paper by writing out the Title, Problem, coming up with a hypothesis (in if/then form) and write out and answer the Pre Lab questions. ~ 20 minutes
4. If time allows, discuss the answers to the pre-lab questions: ~ 10 minutes

Pre-Lab Questions: *Write out the following questions and answer them on your paper.*

1. Define Chromatography.
   Answer: a technique used for separating mixtures of compounds through a two-phase system
2. Name *two* phases found in chromatography.
   Answer: mobile phase and stationary phase
3. According to the textbook, what is a solvent?
   Answer: the dissolving medium in a solution
4. What is the mobile phase in this lab?
   Answer: the solvent (isopropyl alcohol)
5. What is the stationary phase in this lab?
   Answer: the chromatography paper (more specifically, the water molecules attached to the paper)

Day 2:

1. Students will complete the Paper Chromatography Lab following the lab procedure. (*attached*) ~ 40 minutes
2. While the students are waiting for the chromatograms to develop, they should begin writing down the Post Lab questions on their lab papers. ~ done during lab
3. Be sure to designate an area of your classroom for the students to put the developed chromatogram (standing up on a paper towel) to sit overnight.
4. Students will begin writing out and complete answering the Post Lab questions. ~10 minutes

Day 3

1. This is the second day of the Paper Chromatography Lab where the students will analyze their chromatograms. Tell the students to look for similarities in their two chromatograms (Crayola markers vs. glow sticks). ~ 5 minutes
2. The students will look at their glow stick chromatograms under the ultraviolet light. ~ 5 minutes
3. Students will finish writing out and complete answering the Post Lab questions. ~20 minutes
4. If time allows, review answers to Post Lab questions (below) ~ 20 minutes
5. Homework: Send students home with Creatures that Glow reading, and have them answer the questions (document attached, and answers are provided).

Post-Lab Questions: *Write out the following questions and answer them on your paper.*

1. How does the solvent travel up the paper?
   Answer: by capillary action caused by the attraction of the molecules of the liquid to the molecules of the solid.
2. Explain how the separation of mixtures occurs.
   Answer: the physical interaction of each compound in the mixture with the solvent and with the water molecules attached to the paper determines the distance the dye travels.
3. What happened to the ink spots as the chromatogram develops? Why?
   Answer: they dissolve in the solvent, and travel up the paper by capillary action. They will adhere to the paper (the water molecules attached to the paper) when the attraction for the water molecules becomes greater than the ability for it to be dissolved in solution. This will leave the components of the mixture separated at different heights on the chromatogram.
4. If one dye moves up farther than another, which one dissolves more readily in the solvent?
   Answer: Substances that dissolve better in the solvent will travel farther than substances that have a higher attraction for the water attached to the paper.
5. Which marker(s) and glow stick(s) (specify original color and marker/glow stick) are probably made of only one compound? How can you tell?
   Answer: (answers may vary.) If the marker and/or glow stick is made up of only one compound, there will only be one spot of color or dye on the chromatogram along the column that corresponds to that color.
6. How can you tell which marker(s) and glow stick(s) (specify original color and marker/glow stick) are made up of more than two compounds? Which are they?
   Answer: (answers may vary.) If the marker and/or glow stick is made up of more than two compounds there will be more than two marks of color/dye on the chromatogram along the column that corresponds to that color.
7. Compare the two chromatograms. Did both markers and glow sticks use the same combination of dyes to make the same colors? How can you tell?

Answer: (answers may vary.) There should be a similarity in the colors of the markers and glow stick color components. This is seen by having the spots on the two chromatograms in similar locations.

Day 4:

1. Collect Creatures that Glow reading and the student's answers to the questions.
2. The students will view a Power Point on "Tiny Organisms, Enormous Effects" (attached) to be introduced to a few microorganisms in their world and the effects they have on people. ~ 10 minutes
3. The students will be introduced to the concept of bioluminescence (and the green fluorescent protein) by watching a video clip "How Organisms Talk" at: http://www.ted.com/talks/bonnie_bassler_on_how_bacteria_communicate.html . ~20 minutes
4. The students will then begin a Web Quest (attached document). ~ 30 minutes **They can finish these Web Quests for homework, or you can allow more class time another day.**

Day 5 – 7:

1. The students will read through and become familiar with the procedure for the GFP Chromatography (ordered through BioRad) from *E. coli* transformed with the GFP gene. Discuss the procedure. ~ 10 minutes
2. The students will then complete the GFP Chromatography Lab Procedure (BioRad Kit) from the already transformed *E. Coli. ~ 3 classes of 40 minutes*
3. The students will then analyze their data and try to locate the extracted protein band using an ultraviolet light. ~ 10 minutes
4. Discuss the significance of the results of the lab. ~ 10 minutes
   I have not done this lab before, so these are estimations on time limits

ASSESSMENT SUGGESTIONS:
Objective 1 will be assessed during the Chapter Test.

Objective 2 & 3 will be assessed through the Pre and Post Lab questions of the Paper Chromatography Lab which addresses the student's comprehension of the concept of separation of mixtures. Answers will be graded with answer key provided.

Objective 4 will be assessed by the reading questions based on Creatures That Glow, which introduces the idea of bioluminescence and what organisms use bioluminescence for. Grade answers with answer key provided. The Web Quest will also be used to assess mastery of Objective 4. These will be graded using the answer key provided. .

Objective 5 will be assessed by the GFP Chromatography Lab questions. *I have not done this lab before to know what probing questions I can ask based on the background and procedure information provided with the kit.*

EXTENSIONS:

ACTIVITIES: **Chromatography**: Add another "variable" and have the students make a third chromatogram to analyze another brand of markers (Roseart) to see if there are similarities or differences in the different dyes that make up the different colors between brands of markers.

Field Trip: A bioluminescent kayak tour at A Day Away Kayak Tours in Titusville, FL. (www.adayawaykayaktours.com). This could be an organized field trip or just an extra activity you tell students to go to, or meet you at.

Podcasts: View a video clip on Bioluminescence and/or Green Fluorescent Proteins at http://www.conncoll.edu/ccacad/zimmer/GFP-ww/podcasts9.html#HERE

LITERATURE: **Creatures that Glow: A Book About Bioluminescent Animals** by Melvin Berger

RESOURCES/REFERENCES:

Images (for Power Points)**:** www.images.yahoo.com

Berger, Melvin, and Damon Hertig. *Creatures That Glow: a Book about Bioluminescent Animals*. New York: Scholastic, 1996. Print.

Background Information:

Mills, C.E. 1999-present. Bioluminescence of *Aequorea*, a hydromedusa. Electronic internet document available at http://faculty.washington.edu/cemills/Aequorea.html. Published by the author, web page established June 1999, last updated 11 January 2009.

http://micro.magnet.fsu.edu/primer/techniques/fluorescence/fluorescentproteins/fluorescentproteinshome.html

Web Quest

Additional resources used for Web Quest:

http://pinktentacle.com/2006/05/rainy-season-brings-glow-in-the-dark-mushrooms/
http://scienceblogs.com/notrocketscience/2009/06/glowing_squid_use_bacterial_flashlights_that_double_as_an_ex.php
http://www.pbs.org/wgbh/nova/sciencenow/0305/04-glow-05.html
http://www.lifesci.ucsb.edu/~biolum/organism/photo.html
http://en.wikipedia.org/wiki/Aequorea_victoria
http://en.wikipedia.org/wiki/Lampyris_noctiluca
http://animals.howstuffworks.com/insects/question554.htm

Online Video Clip: "How Bacteria Talk" with Bonnie Bassler:
http://www.ted.com/talks/bonnie_bassler_on_how_bacteria_communicate.html

Extension Activity:

Field Trip www.adayawaykayaktours.com

Podcasts (for More information on Bioluminescence & GFP)**:**

http://www.conncoll.edu/ccacad/zimmer/GFP-ww/podcasts9.html#HERE

Chemistry
Bioluminescent Web Quest

Name: _____
Date: _____

Directions: Complete the following Web Quest.

1.) During which country's rainy season do the Mycena lux-coeli mushrooms grow from chinquapin trees that have fallen? _____
2.) These mushrooms glow _____, and are prone to _____.
3.) *Click* on (Link) at the end of the paragraph about the Glowing Mushrooms. The light-emitting pigment which causes the mushrooms to glow is called _____. *[Close this link.]*

4.) The Hawaiian Bobtail squid, also known as _____, has a symbiotic relationship with the bacteria _____ which are luminous organisms contained in special light organs.
5.) Essentially, the squid is equipped with a pair of _____.
6.) *Click* on (Link) at the end of the paragraph about the Bobtail squid. What do the "iris" and "lens" do? _____ _____.
7.) The light organs could also help the Bobtail squid with the deceptive technique of "*counterillumination*" in which light is produced to make it less visible. By the light organs acting as flashlights as well as _____, the squid is able to give off light on the underside of its body that matches the _____ filtering down to the deep ocean where it lives. *[Close this link.]*

8.) If the Alarm Jellyfish is caught, it uses a technique referred to as "_____" to try to attract the attention of another larger predator that may attack what it is caught by.
9.) *Watch* the video clip of the *Atolla wyvillei.* *Click* on (Link) below video. *Scroll* down and *click* the back button until you get to Slide 1.
10.) What is the basic definition of bioluminescence? _____
11.) The viperfish uses bioluminescence as a _____ to _____ prey.
12.) Deep-sea shrimp, known as _____, use their bioluminescence to distract their predators by _____ _____.
13.) Various other sea creatures, such as _____ _____, are able to use the process of *counterillumination*. *[Close this link.]*

14.) The *Omphalotus olearius* is commonly known as a(n) _____ mushroom.
15.) The enzyme _____ is exuded as waste through the mushroom's orange-to-yellow gills. This enzyme is used for bioluminescence by _____.

16.) The luminescent *Panellus stipticus* is a hardwood-rotting mushroom that is typically found in _____.
17.) This saprobe, which is said to have luminescent gills, has been used as a _____, or blood thickening, agent.

18.) The genus *Bathocryoë* can produce _____ luminescence.

19.) The photo is of the organism *Bathocryoë* _____.
20.) *Click* on (Link) underneath these photos of this organism. On the left hand side of this new link, *click* on each of the photos. Which organism produces the green fluorescent protein that is used for clinical and laboratory applications? _____
21.) The *Pyrocystis fusiformis* is a tropical _____ that produces a red glow by _____.
22.) *Scroll* up to the top of the photos in the left column. *Click* on "Organisms". What type of dinoflagellate caused an inch-thick orange slick (red tide) in Monterey Bay, California in May 2011? _____
23.) *Click* on the squid. On their ventral surfaces, squids have _____ which emit a soft glow. Watch how the squid behaves during the day, and then click on "Bring on the: Night"
24.) Which tiny, single-celled dinoflagellate makes the ocean glow? _____
25.) How is the photosynthesis and bioluminescence of these organisms controlled? _____ _____. *[Close this link.]*

26.) Dinoflagellates are characterized by _____. The dinoflagellates that exist in a symbiotic relationship in coral are called _____.

27.) The Crystal Jelly is another name for the _____.
28.) This hydromedusa contains the _____-activated photoprotein and the _____ -fluorescent protein (GFP).
29.) *Click* on (Link). This species is located _____.
30.) The jellyfish quickly releases _____ which reacts with the photoprotein _____ to produce a blue light. The GFP then transforms the blue color to _____. *[Close this link.]*

31.) The *Lampyris noctiluca* is considered to be a _____ because of its hard shell that covers the wings.
32.) List the differences between the males and females of the Common Glow-worm of Europe.
_____
_____
33.) *Click* on (Link) underneath the glowworm photo. What do the female glowworms use their bioluminescence for? _____
34.) How does the insect control the light it emits? _____
_____ *[Close this link.]*

35.) The scientific name for fireflies is _____. These lightning bugs make light with _____.
36.) *Click* on (Link) below the Fireflies photo. To make the light in the specialized cells of their _____, the luciferin combines with _____ to produce inactive oxyluciferin, _____ (AMP), and light.
37.) The light produced ranges from _____ to _____.
38.) The abdominal trachea supplies the _____ to the abdomen, but it is uncertain whether the switching of the light on and off is controlled by the oxygen supply or the _____.
39.) The gene for the luciferase enzyme has been placed in _____ and used as a _____ to follow the expression of other genes. *[Close these links.]*

Turn in your completed Web Quests.
Chemistry Name: _____Answer Key_____

Bioluminescent Web Quest Date: _____

Directions: Complete the following Web Quest.

1.) During which country's rainy season do the Mycena lux-coeli mushrooms grow from chinquapin trees that have fallen? ____Japan_____
2.) These mushrooms glow ____green_____, and are prone to _____dehydration_____.
3.) Click on (Link) at the end of the paragraph about the Glowing Mushrooms. The light-emitting pigment which causes the mushrooms to glow is called ___luciferin____. *[Close this link.]*

4.) The Hawaiian Bobtail squid, also known as __*Euprymna scolopes,* has a symbiotic relationship with the bacteria __*Vibrio fischeri*__ which are luminous organisms contained in special light organs.
5.) Essentially, the squid is equipped with a pair of ___flashlights__.
6.) Click on (Link) at the end of the paragraph about the Bobtail squid. What do the "iris" and "lens" do? _the" iris" controls how much light escapes the light organ, and the "lens" diffuses the light that the bacteria produces_____
7.) The light organs could also help the Bobtail squid with the deceptive technique of "*counterillumination*" in which light is produced to make it less visible. By the light organs acting as flashlights as well as ___sensors__, the squid is able to give off light on the underside of its body that matches the _natural light___ filtering down to the deep ocean where it lives. *[Close this link.]*

8.) If the Alarm Jellyfish is caught, it uses a technique referred to as "__burglar alarm__" to try to attract the attention of another larger predator that may attack what it is caught by.
9.) *Watch* the video clip of the *Atolla wyvillei.* Click on (Link) below video. *Scroll* down and *click* the back button until you get to Slide 1.
10.) What is the basic definition of bioluminescence? __visible light made by living creatures_____
11.) The viperfish uses bioluminescence as a __lure_____ to ___attract_____ prey.
12.) Deep-sea shrimp, known as __*Acanthephyra purpurea*_____, use their bioluminescence to distract their predators by __vomiting light into the face of the attacker, temporarily "blinding" them, while the shrimp swims backwards into the darkness__.
13.) Various other sea creatures, such as _the hatchetfish, the benttooth bristlemouth, lantern fish, viperfish, scaly dragonfish, krill and squid,__ are able to use the process of *counterillumination*. *[Close this link.]*

14.)The *Omphalotus olearius* is commonly known as a(n) _Jack-O-Lantern_____ mushroom.
15.)The enzyme _luciferase____ is exuded as waste through the mushroom's orange-to-yellow gills. This enzyme is used for bioluminescence by __fireflies_____.

16.) The luminescent *Panellus stipticus* is a hardwood-rotting mushroom that is typically found in _eastern North America_____.
17.) This saprobe, which is said to have luminescent gills, has been used as a _styptic_, or blood thickening, agent.

18.)The genus *Bathocryoë* can produce __blue and green__ luminescence.

19.) The photo is of the organism *Bathocryoë fosteri* .

20.) Click on (Link) underneath these photos of this organism. On the left hand side of this new link, click on each of the photos. Which organism produces the green fluorescent protein that is used for clinical and laboratory applications? hydromedusa, *Aequorea victoria*, (a jellyfish)

21.) The *Pyrocystis fusiformis* is a tropical dinoflaggelate that produces a red glow by chlorophyll fluorescence .

22.) *Scroll* up to the top of the photos in the left column. *Click* on "Organisms". What type of dinoflagellate caused an inch-thick orange slick (red tide) in Monterey Bay, California in May 2011? *Noctiluca scintillians*

23.) *Click* on the squid. On their ventral surfaces, squids have photophores which emit a soft glow. Watch how the squid behaves during the day, and then click on "Bring on the: Night"

24.) Which tiny, single-celled dinoflagellate makes the ocean glow? *Pyrocystis fusiformis*

25.) How is the photosynthesis and bioluminescence of these organisms controlled? circadian rhythm . *[Close this link.]*

26.) Dinoflagellates are characterized by two flagella . The dinoflagellates that exist in a symbiotic relationship in coral are called zooxanthellae .

27.) The Crystal Jelly is another name for the *Aequorea victoria* .

28.) This hydromedusa contains the calcium -activated photoprotein and the green -fluorescent protein (GFP).

29.) *Click* on (Link). This species is located off the west coast of North America (Washington – Pudget Sound) .

30.) The jellyfish quickly releases calcium (Ca^{2+}) which reacts with the photoprotein aequorin to produce a blue light. The GFP then transforms the blue color to green . *[Close this link.]*

31.) The *Lampyris noctiluca* is considered to be a beetle because of its hard shell that covers the wings.

32.) List two differences between the males and females of the Common Glow-worm of Europe. Females are twice the size of males, do not have wings, and they emit a glow. Males are half the size of females, have wings, and do not glow.

33.) *Click* on (Link) underneath the glowworm photo. What do the female glowworms use their bioluminescence for? to attract a mate

34.) How does the insect control the light it emits? by controlling the oxygen supply to the light emitting membranes that contain luciferin *[Close this link.]*

35.) The scientific name for fireflies is *Photinus pyralis* . These lightning bugs make light with their bodies .

36.) *Click* on (Link) below the Fireflies photo. To make the light in the specialized cells of their abdomen , the luciferin combines with oxygen to produce inactive oxyluciferin, adenosine monophosphate (AMP), and light.

37.) The light produced ranges from pale yellow to reddish green .

38.) The abdominal trachea supplies the oxygen to the abdomen, but it is uncertain whether the switching of the light on and off is controlled by the oxygen supply or the nerve cells .

39.) The gene for the luciferase enzyme has been placed in genes of other organisms and used as a reporter gene to follow the expression of other genes. *[Close these links.]*