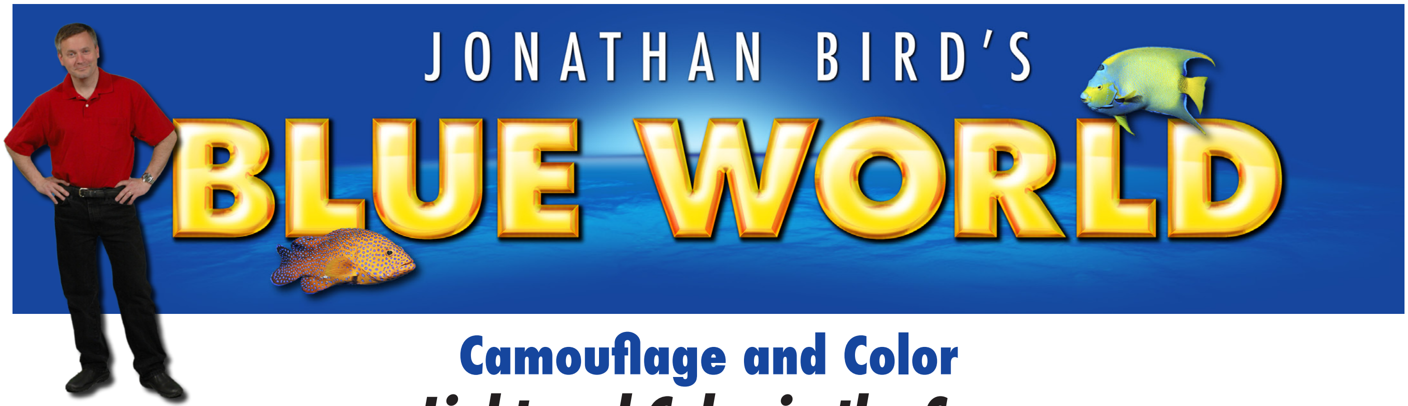


Camouflage and Color
Light and Color in the Sea

by Bill Andrake

Science Lesson: Light and Color in the Sea - Based on Webisode 42
Grade Level: 6-8
Time: Three to four (45-50 minute) class periods

Introduction

Camouflage allows animals to become less visible to their predators or their prey. Color patterns in an animal can confuse or even scare off potential predators. Some species such as the octopus can instantly change its appearance to perfectly match a variation in its background. All of these survival strategies are dependent upon light in the ocean.

No matter how clear the water, light is very limited in the aquatic environment as water molecules interfere with the travel of all forms of electromagnetic radiation including the only form that we see; visible light. This video segment highlights the many amazing adaptations in undersea animals that take advantage of the light and color available to them in different undersea habitats.

Science Standards

National Science Education Standards
Physical Science:
- Transfer of energy

Life Science:
- Diversity and adaptations of organisms

Ocean Literacy Principles
- ***Principle #5:*** The ocean supports a great diversity of life and ecosystems.

Objectives

- To gain a better understanding of light energy and color in our world.
- To learn how water affects the transmission of light.
- To understand the importance of color in the sea and how the life is adapted to take advantage of the limited light and color changes with depth.

Partial support for this work was provided by the National Science Foundation Grant DUE/NSDL #1043823. Any opinions, findings, or conclusions expressed are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Eliciting Prior Knowledge

- Ask students what they think light is?
  A working definition for light might be: *Light is something that allows us to see.*
- What is the color of light?
- What is the color of the light emitted by the lights in our classroom?
- What is the color of the light emitted by the Sun?
- Why do objects have different colors ?

Helpful Vocabulary

Absorption: When photons from light hit atoms and molecules and cause them to vibrate turning into heat.

Electromagnetic Energy: Energy that is reflected or emitted from objects in the form of tiny packets of energy that travel in electrical and magnetic waves. These waves travel through space as radiant energy and covers a broad range **spectrum** from very long radio waves to very short gamma rays. It includes microwaves, infrared, visible light, ultraviolet and x-rays.

Frequency: The number of waves passing a point per second.

Light: Electromagnetic energy that allows us to see.

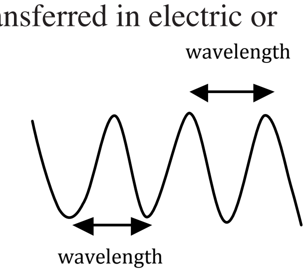
Photon: A packet or massless particle that carries the energy from a disturbance in the electromagnetic charges of protons and electrons in atoms. Photons transfer electromagnetic energy traveling in waves.

Reflection: When light hits an object and bounces off

Refraction: When light waves change direction or bend as they pass from one medium to another. As light travels into a different medium, the change in speed bends the light. Different wavelengths of light are slowed at different rates, which causes them to bend at different angles, revealing the full spectrum of color when passing through a glass prism.

Wave: A disturbance that transfers energy as it travels through a medium from one location to another. It is important to note that the medium through which the wave travels experiences some sort of motion as the wave passes, but the particles in the medium **do not** travel with the wave. Electromagnetic waves do not transfer energy through a medium. The disturbance is transferred in electric or magnetic fields through space.

Wavelength: The distance between corresponding parts of successive waves such as crest to crest or trough to trough.



Activity: What is White Light and Color? "ROY G BIV" The Visible Spectrum

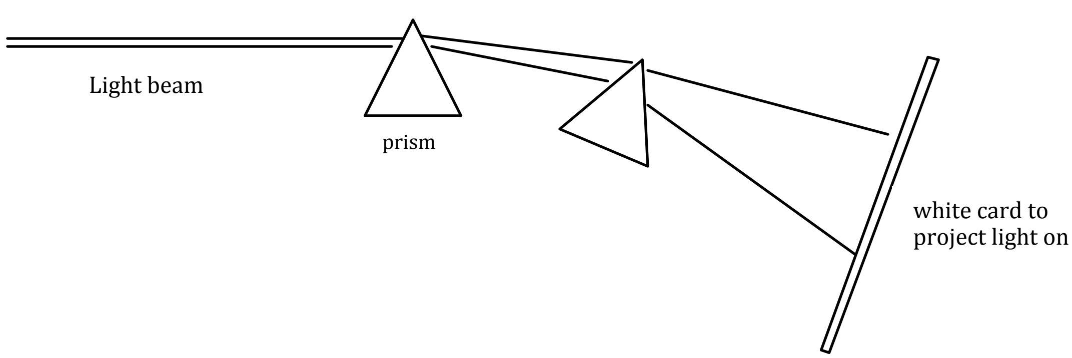
Materials:

Option 1: In a darkened room-- as dark as possible

- Light source to provide a narrow beam of light.
  Some options for light sources:
  1. *A light ray box that emits narrow beams of light can be purchased from a science supply company. It is good for this activity and other light refraction demonstrations.*
  2. *Insert a homemade cardboard slide with a vertical 1/16" slit into a carousel slide projector. Focus to make a bright narrow beam.*
  3. *A bright flashlight such as a small "Maglight." Cover the lens with black electrical tape leaving a 1/8"- 1/16" slit to get a narrow beam of light from the device.*
- Two or three triangular glass or acrylic prisms to bend the light beam and separate the different wavelengths of light to show the visible spectrum.
- White card stock, poster, or foam board on which to follow the light beam and project the light.

Procedure:

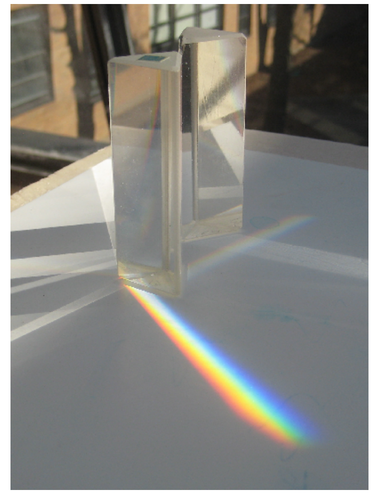
1. Place a piece of white poster or foam board flat on a table.
2. Shine your light source in a way to get a narrow beam across the surface of a white poster or foam board.
3. Stand a prism on its end with one edge cutting into and bending the beam. (see below)
4. Place a second prism in position to bend and spread out the beam further until you see the colors of the visible spectrum.
5. Adjust light beam and prism angles/positions until the light beam is spread out sufficiently to project the spectrum of colors (rainbow) on to a white card or board.
6. It usually requires a bit of trial and error and multiple prisms to get this effect (see below).



Activity: What is White Light and Color? "ROY G BIV" The Visible Spectrum (cont'd)

Option 2: Use the Sun to see the visible spectrum

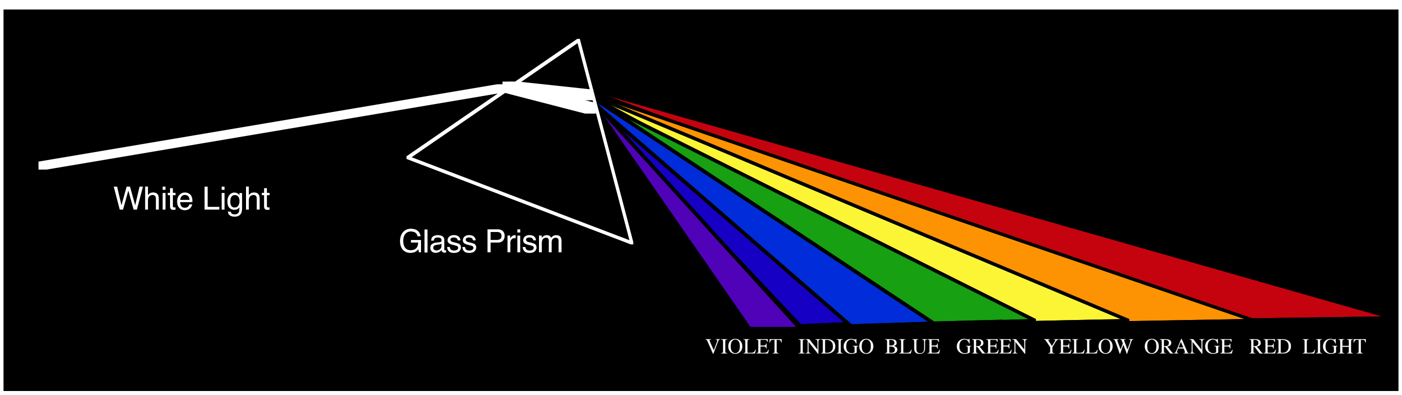
1. Lay a large piece of white foam or poster board on a table or window ledge in direct sunlight.
2. On the foam board place a glass prism upright on its edge and turn it until you're able to bend a beam of light through the prism.
3. With a second prism, refract the beam again until you see the colors of the rainbow... the visible spectrum.



Option 3: Use a CD or DVD to see the visible spectrum.

The colors in white light or visible spectrum can be easily seen by reflecting light off the surface of a CD or DVD.

Light Refraction Through a Glass Prism:



The white light bends or is **refracted** as it passes through the glass at an angle. This separates white light into the colors of the "**visible spectrum**" of light.

The demonstration shows that white light is actually composed of seven separate forms of light energy. Each form of energy has different properties. Each bends at a different angle when passed through the prism and each appears as a different color to our eyes. The seven different colors or forms of light energy are Red, Orange, Green, Blue, Indigo, and Violet… *a.k.a.* "ROY G BIV"

Which form of energy bends or refracts the most when passing through the prism? ____________________

Which bends the least? ____________________

Activity: What is White Light and Color? "ROY G BIV" The Visible Spectrum (cont'd)

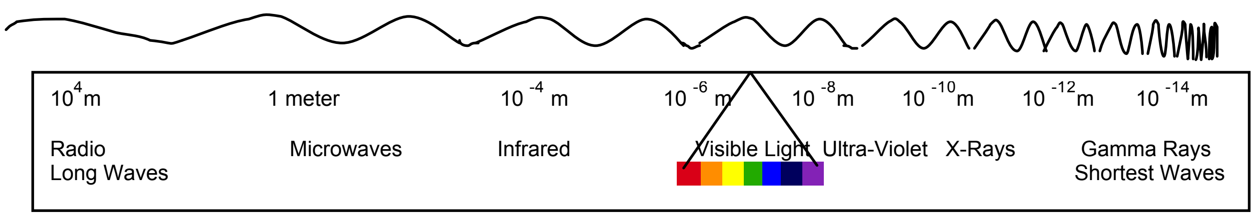
Background: Electromagnetic Energy

Visible light is a form of **electromagnetic energy** and it is the only form of this energy that we can see. This energy is carried in tiny "packets" called **photons**. Traveling at the speed of light (186,000 miles per sec.), the energy in photons is transferred in the form of waves. Electromagnetic waves do not require a medium to transfer their energy such as that in ocean waves or sound. These waves travel best through the vacuum of space.

There are many types of electromagnetic wave energy which make up the **electromagnetic spectrum** (see below). What distinguishes one type of wave in the spectrum from another is the amount of energy in their photons. The more energy each photon carries, the shorter the wavelength and the higher the frequency of the wave. Gamma rays have the highest energy with wavelengths that are smaller than atoms whereas the low energy radio waves have wavelengths over a mile long.

Visible light wavelengths are measured in billionths of meters or nanometers. With violet having the shortest wavelength (380 nanometers) and red light with the longest 700 nanometers). *The difference in wavelength between red and violet wavelengths is smaller than the size of a bacterial cell.*

The Electromagnetic Spectrum *(waves not to scale)*



Other forms of electromagnetic energy include short wave, high frequency x-rays and ultra-violet radiation, which along with gamma rays damage the organic molecules and as a result, are very harmful to living things. We feel the longer invisible infrared waves as heat and microwaves not only heat up leftovers, but are used in Radar and communications.

Depending on their frequency, various forms of electromagnetic energy can pass through certain materials but not others. For example, dangerous gamma, ultra-violet, and x-rays from our Sun cannot penetrate our atmosphere very well, but the longer waves from visible light, infrared, and radio waves can. Imagine all of the electromagnetic radio waves carrying signals from cell phones and radios passing through our bodies!

The following are links to useful resources for enhancing lessons in light and the electromagnetic spectrum:

- "Light and color" Harvard Smithsonian Center for Astrophysics
  http://www.teachersdomain.org/resource/lsps07.sci.phys.energy.lightcolor/
- "The Electromagnetic Spectrum" adapted form the PBS Series: "FRONTLINE."
  http://www.teachersdomain.org/resource/phy03.sci.phys.energy.emspectrum/
- This interactive activity from the *NOVA* Web site provides a self-guided tour of the electromagnetic spectrum, including examples of some of the most common uses of different types of waves.
  http://www.teachersdomain.org/asset/phy03_int_spectrum/
- Mission Science from NASA. Webpage on the Electromagnetic Spectrum.
  http://missionscience.nasa.gov/ems/02_anatomy.html

Activity: What is White Light and Color? "ROY G BIV" The Visible Spectrum (cont'd)

Background: Light and Color

Why is there color in our world? The answer is that different materials react to light in different ways. Molecules will either **absorb** the photons of certain colors or they won't. When they don't **absorb (take in)** a certain color of light, that color of light will **reflect or bounce off** that material to your eyes, and you see reflected colors.

For example, a blue shirt is blue because the molecules in the dye of the shirt are reflecting blue photons and absorbing the other forms of visible light. Red, orange, green, yellow, etc. are being taken in and the blue energy is not.

Discussion Questions:

1) Why is yellow paint yellow?

____

____

2) What colors are reflected off paper that appears white?______________________

3) What do you suppose causes a material to be black in the presence of light?

____

____

4) What color(s) of **the visible spectrum** are USED by GREEN plants for photosynthesis? *(these are colors that would have to be absorbed by the plant).*

____

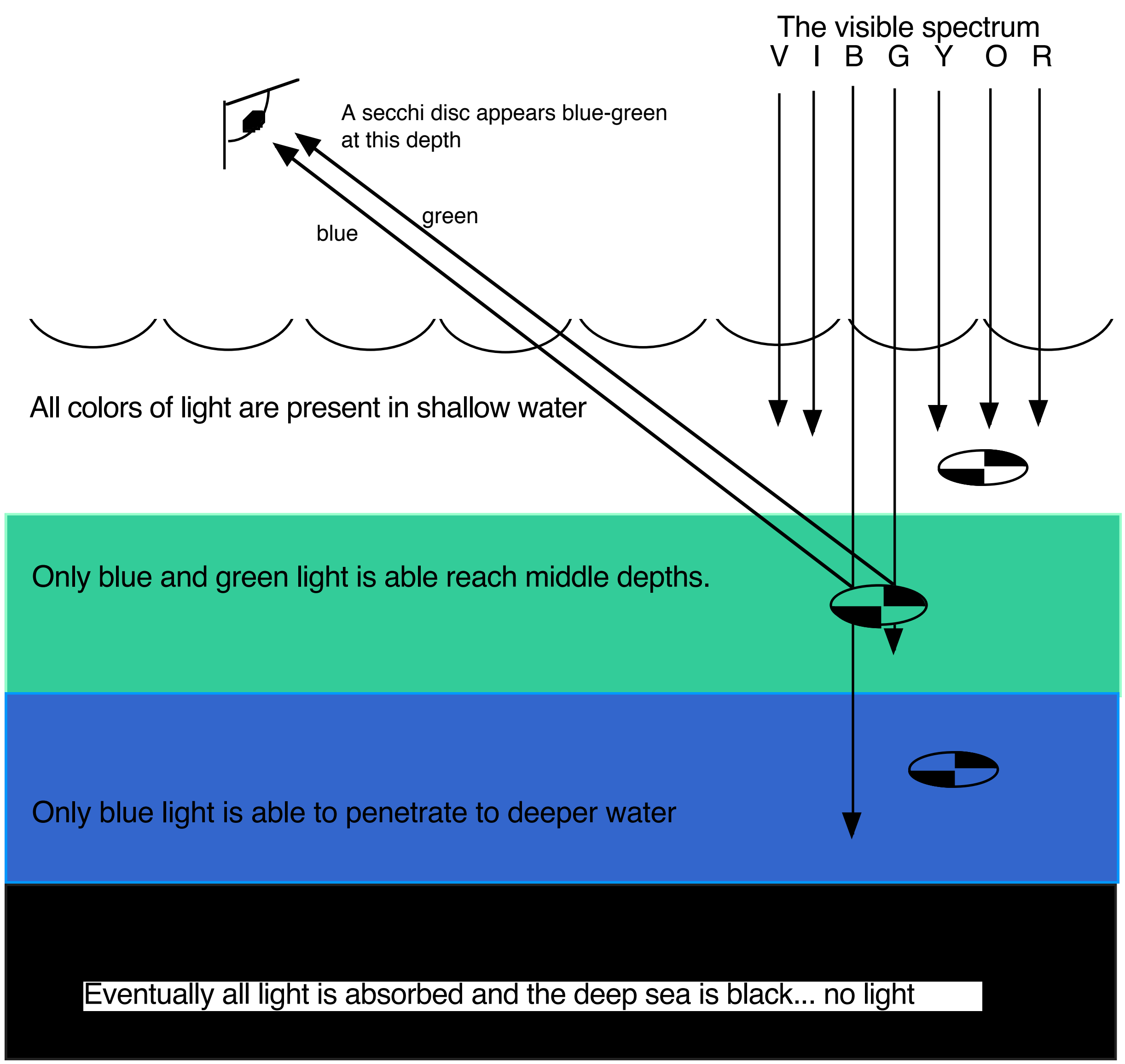
5) What color(s) of **the visible spectrum** are NOT USED by GREEN plants for photosynthesis? *(these are colors that would have to be REFLECTED by the plant).*

____

JONATHAN BIRD'S BLUE WORLD

Light and Color in the Sea

In the ocean most of the colors of the visible spectrum are absorbed near the surface. However, blue and green light energy are able to penetrate deeper into the water than the other colors such as violet, red, orange, or yellow. A secchi disc is used to measure transparency in water. See the diagram below.



Light and Color in the Sea (continued)

1. Where in the sea would you see living things reflecting all colors of the visible spectrum?

2. How does the **color** of your surroundings change as you move deeper into the sea?

   Explain your answer:

3. Red seaweeds reflect red, orange, and violet colors. Which colors would they absorb for photosynthesis?

   Why are red seaweeds able to live in deeper waters?

4. A yellow fish needs its yellow color to be recognized by others of its own kind. Would this animal be found in shallow or deeper waters?

   Explain

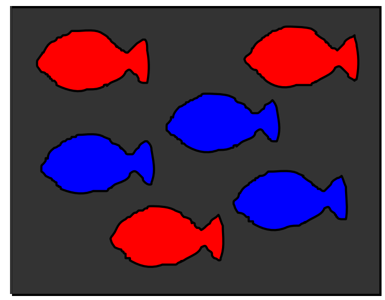
5. Watching a *Jonathan Bird's Blue World* video you see animals with bright yellow, orange, or red colors in deeper water. Since these forms of energy are not available in deeper water, how can we explain their color on camera?

Activity: Disappearing Fish

By looking through blue cellophane, you will simulate what it looks like in deeper water where only blue wavelengths of light are available. Without red wavelengths available to reflect off red fish in deeper waters, are they visible?

Materials:

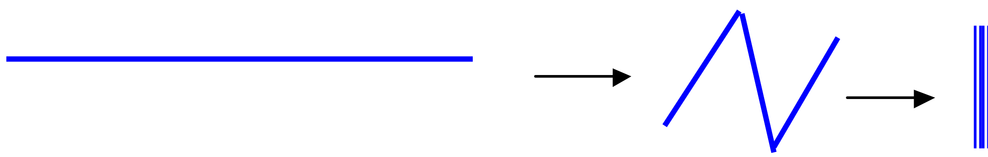
- Black, blue, and red construction paper
- Scissors
- Paper glue or tape
- Roll or sheets of blue cellophane



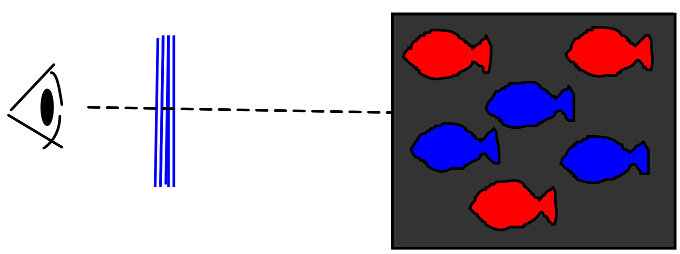
Procedure:

1) Mount several fish cut out from blue and red construction paper on a black background.

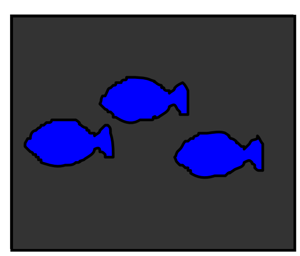
2) Cut out a 12 inch x 12 inch piece from a roll of blue cellophane and fold it in thirds.



3) Holding the cellophane over your eyes. Look through the three layers of blue cellophane at the blue and red fish on the black construction paper.



Describe what happens to the fish.



Activity: Disappearing Fish (continued)

1) What happens to white light when it passes through blue cellophane?

2) In what way does the blue cellophane simulate the conditions in deeper water?

3) What happen to the visibility of the red fish when viewed through the blue cellophane? Explain your answer.

4) What happen to the visibility of the blue fish when viewed through the blue cellophane? Explain your answer.

To explore this concept further, visit the following website from the Voyage to Puna Ridge and see what happens when you drop different colored M&M's into the ocean.

"Light and the Color of Water" http://www.punaridge.org/doc/factoids/Default.htm

The Color of Water

Compare the color underwater between two *Jonathan Bird's Blue World* Videos:

Green Water: Webisode 18: *Whale Sharks of Holbox*
Blue Water: Webisode 4: *The Shark and the Whale*

When water is green or brown, light may be reflecting of tiny particles such as sediment or plankton in the water. With these particles in the water the visibility is reduced.

Why is the ocean blue?
Since water absorbs red, yellow, and orange wavelengths so easily, only the blue part of the light spectrum is available to see. Without particles in the water to reflect light, the visibility of the water is high.

Helpful Resources

Light, Color, and the Electromagnetic Spectrum

1) "Light and color" Harvard Smithsonian Center for Astrophysics.
http://www.teachersdomain.org/resource/lsps07.sci.phys.energy.lightcolor/
In this video segment adapted from Shedding Light on Science, learn about the dispersion of light, the electromagnetic spectrum, and how sunlight contains a range of wavelengths (photons of differing energy).

2) "The Electromagnetic Spectrum: FRONTLINE"
http://www.teachersdomain.org/resource/phy03.sci.phys.energy.emspectrum/
This video segment is adapted from the PBS Series, FRONTLINE and explores the different types of radiation represented by electromagnetic waves and how their properties vary.

3) Interactive Tour of the Electromagnetic Spectrum http://www.teachersdomain.org/asset/phy03_int_spectrum/
This interactive activity from The NOVA Web site provides a self-guided tour of the electromagnetic spectrum, including examples of some of the most common uses of different types of waves

4) Teachers' Domain http://www.teachersdomain.org/
Teachers' Domain is an online library of more than 1,000 free media resources from the best in public television. These classroom resources, featuring media from *NOVA*, *Frontline*, *Design Squad*, *American Experience*, and other public broadcasting and content partners are easy to use and correlate to state and national standards. Teachers' Domain resources include video and audio segments, Flash interactives, images, documents, lesson plans for teachers, and student-oriented activities. Teachers' Domain strives to strengthen teacher knowledge by providing innovative teaching methods that incorporate technology in the classroom and inspire students to learn

5) Mission Science from NASA. Webpage on the Electromagnetic Spectrum
http://missionscience.nasa.gov/ems/02_anatomy.html

Color and Light in the Sea

1) Voyage to Puna Ridge. "Light and the Color of Water." http://www.punaridge.org/doc/factoids/Default.htm
2) NOAA Ocean Facts. Why is the Ocean Blue? http://oceanservice.noaa.gov/facts/oceanblue.html
3) Light Penetration in Ocean Waters. Ocean Explorer NOAA
http://oceanexplorer.noaa.gov/explorations/04deepscope/background/deeplight/media/diagram3.html

Answer Guide: Light and Color in the Sea

Activity: What is White Light and Color? "ROY G BIV" The Visible Spectrum.

Which form of energy bends or refracts the most when passing through the prism? ***_Violet Light_***
Which bends the least? ***_Red Light_***

1) Why is yellow paint yellow?

The paint is reflecting yellow photons (light) and absorbing the other colors of the visible spectrum.

2) What colors are reflected off paper that appears white?

All of the colors of the visible spectrum

3) What do you suppose causes a material to be black in the presence of light?

All of the colors of the visible spectrum are being absorbed

4) What color(s) of **the visible spectrum** are USED by GREEN plants for photosynthesis? *(these are colors that would have to be absorbed by the plant).*

The chlorophyll is absorbing the colors of the visible spectrum other than green light energy. Chlorophyll primarily absorbs red and blue wavelengths.

5) What color(s) of **the visible spectrum** are NOT USED by GREEN plants for photosynthesis? *(these are colors that would have to be REFLECTED by the plant).*

Since they reflect green light energy, plants do not use this energy for photosynthesis.

Light and Color in the Sea:

1. Where in the sea would you see living things reflecting all colors of the visible spectrum?

In the surface waters.

2. How does the **color** of your surroundings change as you move deeper into the sea?

The water becomes more blue in color.

Explain your answer.

As light from the surface travels to the bottom, water absorbs the red, orange, and yellow wavelengths first, followed by green light energy whereas blue wavelengths penetrate to deeper water.

3. Red seaweeds reflect red, orange, and violet colors. Which colors would they absorb for photosynthesis?

Greens and Blues

Why are red seaweeds able to live in deeper waters? ***Unlike red, yellow, and orange wavelengths green and blue penetrate to deeper water. Since Red Algae absorb blue and green light energy for photosynthesis they can survive in deeper waters. However at some point light levels are too low and photosynthesis is not able to take place.***

Answer Guide: Light and Color in the Sea

4. A yellow fish needs its yellow color to be recognized by others of its own kind. Would this animal be found in shallow or deeper waters? ***Shallow***

Explain: ***Yellow light is unable to penetrate to deeper waters, thus if an animal needs to appear yellow, then it would be limited to life in shallow water where all wavelengths of light are available.***

5. Watching a *Jonathan Bird's Blue World* video you see animals with bright yellow, orange, or red colors in deeper water. Since these forms of energy are not available in deeper water, how can we explain their color on camera?

Jonathan uses an artificial light source as he is filming. With natural light the yellow, red, and orange light energy are absent from deeper water.

Activity: Disappearing Fish

1) What happens to white light when it passes through blue cellophane?

All of the colors from the visible spectrum are filtered out leaving only blue light to pass through.

2) In what way does the blue cellophane simulate the conditions in deeper water?

As light from the surface travels to deeper water, most of the colors from the visible spectrum are filtered out leaving only blue light available to reflect of of objects in deeper water.

3) What happen to the visibility of the red fish when viewed through the blue cellophane? Explain your answer.

The red fish became invisible when viewed through the blue cellophane as the red light being reflected off of the red fish was filtered by the blue cellophane. Thus no light from the fish gets to our eyes.. the fish become invisible.

4) What happen to the visibility of the blue fish when viewed through the blue cellophane? Explain your answer.

The blue fish were visible and blue when viewed through the blue cellophane as the blue light being reflected off of the blue fish passes through blue cellophane. Thus the blue color from the fish gets to our eyes.