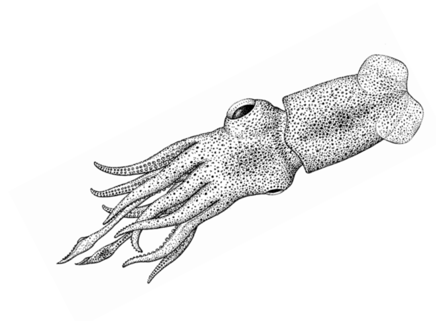
# Light in the Deep Sea



**Topics**
Light, Adaptations

**Grades**
6-8

**Site**
Indoors

**Duration**
2-3 class periods

**Materials**
For each group:
- **Deep Sea Photos**
- **Deep Sea Data Sheets #1, #2, #3, #4, #5**
- Deep Sea Glasses (**Deep Sea Glasses template**, blue plastic film, file folders, tape, scissors, binder clips or staples)
- Colored pencils

**Vocabulary**
camouflage, midwater, visible light, wavelength

**Next Generation Science Standards**

| Practices |
| --- |
| Analyze and interpret data |
| **Core Ideas** |
| LS4.C Adaptation<br>PS4.B Electromagnetic radiation |
| **Crosscutting Concepts** |
| Patterns |
| **Performance Expectations** |
| See page 4 |

## Focus Question

*What patterns are there in the colors of deep sea animals?*

## Overview

Why are so many deep sea organisms red? Why are so many deep sea organisms bioluminescent? Students discover these patterns in deep sea organism adaptations. They then explore how the adaptations increase chances of survival through an examination of light properties in ocean waters.

## Objectives

Students will:
- Describe two patterns of survival in the deep sea.
- Define visible light as being made of many different colors and their corresponding wavelengths.
- Describe how the wavelength of light determines its ability to penetrate seawater.
- Investigate how deep sea organisms use properties of light to help them survive.

## Background

### The Deep Sea Habitat

The deep sea is the largest and least understood habitat on Earth. It begins approximately 200 meters (or 660 feet) below the surface of the ocean and reaches down, on average, 3,800 meters (12,500 feet) to the ocean floor. The deepest part of the ocean, in the Marianas Trench, is 11,033 meters (36,201 feet) deep. Darkness is one of the defining characteristics of the deep sea because sunlight is absorbed and scattered by ocean water. In clear water, some sunlight can penetrate into the **midwater**, or "twilight," zone between approximately 200 to 1,000 meters (660 to 3,300 feet). Light intensity is low but does allow for some animals to see. Sunlight cannot reach below 1,000 meters (3,300 feet) making this area eternally dark. Despite the darkness, deep sea organisms in these zones possess many **camouflage** strategies that help them both find food and avoid becoming someone else's meal. One camouflage technique utilized by deep sea organisms is red coloration. The red **wavelength** of the light spectrum is unable to penetrate into deep ocean waters, effectively camouflaging those red organisms in the darkness of the deep sea.

## The Light Spectrum

In order to understand camouflage in the deep sea, one must have a basic understanding of the **visible light** spectrum and how it penetrates ocean waters. Visible light represents a narrow band of electromagnetic radiation that appears white when all colors are present.

The colors of the spectrum (red, orange, yellow, green, blue, indigo and violet) can be remembered using the mnemonic device: ROY G BIV, which uses the first letter of each color. Light travels in waves at a very rapid speed. Each color of the spectrum has specific wavelength ranges.

The colors in the middle of the visible spectrum (yellow, green and blue) penetrate seawater to the greatest depth, while colors of longer (violet) and shorter (red and orange) wavelengths are absorbed and scattered more rapidly. This property of light influences the coloration patterns and distribution of marine organisms.

During this activity, students use blue filters in order to simulate the behavior of light at varying ocean depths. A colored filter allows only one color of light to pass through the filter; all other colors are absorbed and therefore blocked from the eyes of the viewer. In the case of the blue plastic filter, all colors except blue are absorbed and the only color that can pass through is blue. This simulates blue light being the only light that penetrates into deeper water. On land, an item will appear a specific color because it is absorbing all other colors and reflecting back its color to our eye.

## Deep Sea Camouflage

The wavelengths of light that can penetrate into the depths of the ocean are yellow, green and blue. Because other wavelengths are not present in the deep sea, they cannot be seen. A color must be present in the surrounding environment in order to be seen by the eye. Several organisms living in ocean depths have red coloration. Their red color effectively makes them invisible in the inky darkness, because no red wavelengths are present.

Red coloration is not the only camouflage strategy used by deep sea organisms. Many deep sea organisms are able to produce their own light, called bioluminescence. Some animals, like the viperfish, possess bioluminescent organs on their bellies. As they migrate upwards to find food in shallower depths, where some visible light does penetrate, the bioluminescent organs on their bellies brighten. This matches the downwelling light making the fish disappear into the background. Some deep sea animals are transparent which allows them to blend into their surroundings. Many of these transparent animals also utilize the color red for camouflage, especially around digestive organs. These red guts hide bioluminescent prey, effectively camouflaging the predator from becoming prey itself!

# Teacher Preparation

1. Make color copies of **Deep Sea Photos** for each student group. You may choose to source additional animal photographs found in the Animal Guide on the Monterey Bay Aquarium website: [www.montereybayaquarium.org](www.montereybayaquarium.org).

2. Prepare deep sea glasses materials, enough for every group of students to have at least one pair with four layers of blue film.
   Directions for glasses construction:

### VOCABULARY

**Camouflage:**
a behavior, shape, color and/or pattern that helps an organism blend in with its surroundings

**Midwater:**
an ocean zone 200 - 1,000 meters (660 - 3,300 feet) in depth

**Visible Light:**
the section of electromagnetic radiation that can be seen by the human eye

**Wavelength:**
the distance between successive crests of a wave

### TEACHER TIP

Save paper (and time copying) by having students record their observations in a notebook rather than printing out the attached data sheets.

- Print out the **Deep Sea Glasses Template** found on page 10. Students will use this template to cut out glasses from recycled file folders.
- Source blue film and cut into strips, approximately 5.5 inches long by 1.5 inches wide. Either blue plastic report folders or gels used for stage lights from theater supply companies will work.
- Students will tape one blue film strip onto each pair of glasses, covering the eye holes. Then, attach one side of the three additional layers of film together with tape. Make sure they DO NOT tape down all sides of the additional film layers, as students will need to utilize them separately during the activity.

## Procedure

1. **Introduce the focus question to the class.**
Show students pictures and videos (from MBARI—see **Resources**) of deep sea animals. Share the question: *What patterns are there in the colors of deep sea animals?* You may write it up on the whiteboard or have students add it to their science notebook. Give students time to write their initial thoughts down or discuss with a partner.

2. **In small groups, students find patterns in the coloration of deep sea organisms.**
Distribute a set of **Deep Sea Photos** (pages 12-19) to each group or allow students to search for images of deep sea organisms on the internet. Collect student responses to what colors they find most common among deep sea organisms, allow them to ask questions about what they see.

3. **Students create a tool to allow them to simulate the deep sea.**
Pass out the **Deep Sea Glasses Template**, scissors, tape, blue film, and let students create their own deep sea glasses. Tell them this is a tool that will simulate the way light behaves in the deep sea.

4. **Give a set of felt pieces to each student group.**
Make sure each group has one large black background and one square each of red, orange, yellow, green, blue and purple felt. Have student groups use **Data Sheet #1** (page 5) to record changes in their ability to see the colors of felt through the Deep Sea Glasses as they add layers of blue film (representing increasing ocean depth). Students should observe that the red, orange and yellow felt pieces become harder to see as they add layers of blue film (go deeper). Students may also notice that the black background becomes difficult to see.

5. **Introduce the visibility scoring rubric.**
The rubric on **Data Sheet #2** (page 6) is an example of a way scientists convert qualitative observations to quantitative data, which is often easier to analyze. In small groups, students use this rubric to score the eight photos four times each, with one, two, three, and four layers of blue film on their goggles.

6. **Record class data.**
After student groups collect data and calculate the averages per film, record the class data using a Google form or other method. Show a bar graph of the red animal data and another from the bioluminescent animal data. Students can copy the graph on to **Data Sheet #3** (page 7). Begin a whole-class science talk about the patterns students see in the data. Have them annotate their graphs to indicate where they see patterns. Ask them what the difference is in the red animals and the animals with bioluminescence.

### CONSERVATION TIPS

As far away as the deep sea seems, our actions on land have a direct impact on the health of this ecosystem. Some ways you can help care for the deep sea are:

- Reduce the amount of trash you generate.
- Be energy efficient.
- Recycle as much of your trash as possible.

### ELL TIPS

Visual scaffolding is helpful for English language learners. Demonstrate that all colors are present in white light by shining a light through a prism in a darkened room. A rainbow should appear.

**THE MISSION OF THE MONTEREY BAY AQUARIUM IS TO INSPIRE CONSERVATION OF THE OCEANS.**

7. **INTRODUCE THE LIGHT SPECTRUM AND EXPLORE THE PROPERTIES OF LIGHT IN WATER.**
   In the science talk students will bring up the challenges to life in the deep sea (pressure, light, and temperature). Explain that this wavelength of light investigation helps us understand just one of those challenges. Explain that light travels in wavelengths, and we see objects because specific light wavelengths reflect off of them and enter our eyes. Visible light contains a range of colors, including red, orange, yellow, green, blue, indigo and violet. Each of these colors has a different wavelength. Have students complete **Data Sheet #4** (page 8). You may go into greater detail by discussing light penetration in shallow versus deep ocean waters. There is a **Spectrum of Light in the Ocean** chart on page 11 that you may share with students. This may also be a good time to introduce a piece of informational text on the light spectrum.

8. **STUDENTS DEMONSTRATE UNDERSTANDING.**
   Use **Data Sheet #5** (page 9) as a formative assessment. Draw students' attention to the photograph of the Immortal Jelly. Ask students to explain why being transparent with a red stomach might be advantageous in the deep sea. (It is transparent with a red stomach which hides the color of its prey.)

9. **RETURN TO THE FOCUS QUESTION.**
   Now that students have explored the light spectrum in the ocean, have them revisit the question: *What patterns are there in the colors of deep sea animals?* Students may think on their own or discuss with a partner. Then in their science notebook, you may have them draw a line of learning and under it add to their original thoughts about the question.

## Resources

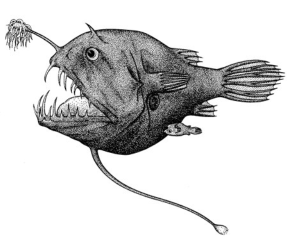
### Websites

*Monterey Bay Aquarium* www.montereybayaquarium.org

Learn more about red, bioluminescent and/or transparent deep sea organisms in the Animal Guide on Monterey Bay Aquarium's website.

*Monterey Bay Aquarium Research Institute* (MBARI) www.mbari.org

View pictures and videos of deep sea organisms and read current research projects and findings from a cutting-edge oceanographic research and engineering organization.



## Standards

### Next Generation Science Standards www.nextgenscience.org

*Performance Expectation*
Relates to MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed or transmitted through various materials

## Acknowledgements

Adapted from "All that Glitters" in NOAA's *Learning Ocean Science Through Ocean Exploration.*

# Data Sheet #1
# Colors of the Deep

Name:

Look at the photographs of deep sea organisms and answer the questions below.

- What do you notice about each organism's coloration?
- How might their coloration help these organisms survive?
- What do you wonder about them?

Now use the **Deep Sea Glasses** to observe how colors appear in the ocean. Record what happens to your ability to see the colored felt pieces with varying layers of blue film in the chart below. Each layer of blue film represents a deeper depth in the ocean.

| # of blue film layers | Red | Orange | Yellow | Green | Blue | Violet |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |

Summarize your results in the space below.

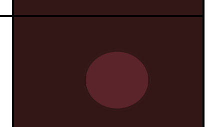
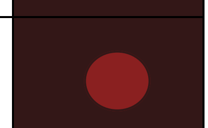
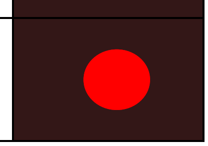
How might your results relate to the coloration of deep sea organisms?

# Data Sheet #2
# Visibility in the Deep Sea

Use the **Visibility Rubric** below to score each organism's level of visibility.

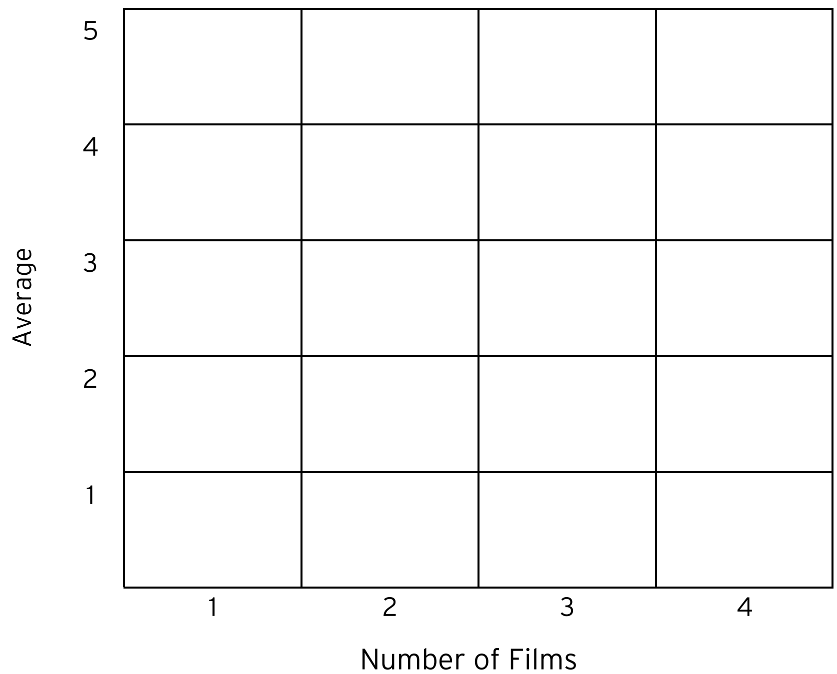
| | Red Organisms | | | | | Bioluminescent Organisms | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Films | Giant Red Mysid | Flapjack Octopus | Comb Jelly | Vampire Squid | Average | Colobo-nema Jelly | Fanfin Anglerfish | Siphon-ophore | Pacific Black-dragon | Average |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |

## Visibility Rubric

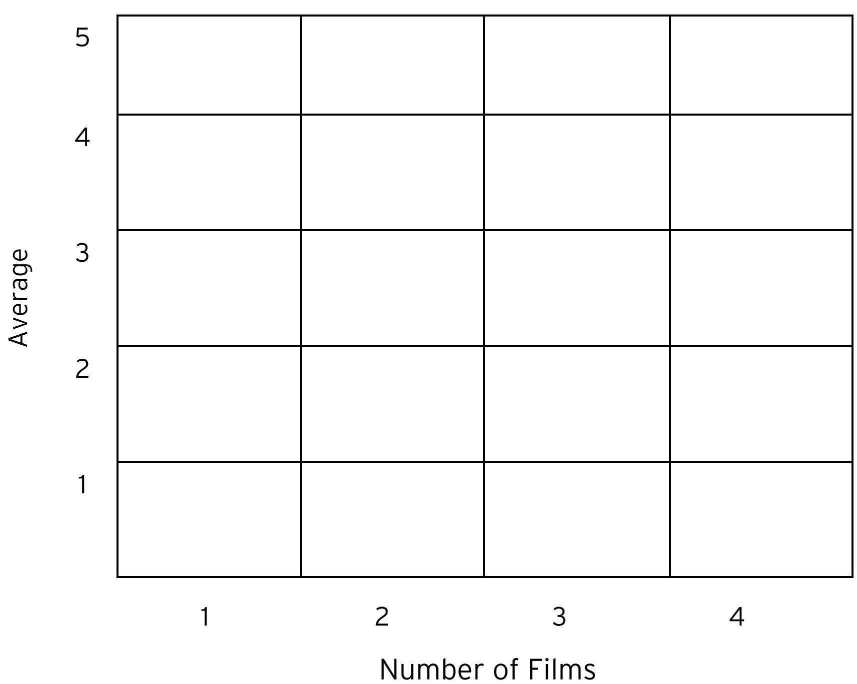
| Score | Description | Notes | Example |
|---|---|---|---|
| 0 | Nothing is visible | |  |
| 1 | Almost nothing is visible | |  |
| 2 | Majority of the animal is not visible | |  |
| 3 | Can see some of the shape of the animal and little to no color | |  |
| 4 | Can see most of the shape or parts of the animal and/or some of the color | |  |
| 5 | Very clear, can see defined shape of all of the animal and color | |  |

# Data Sheet #3
# Data Analysis

Visibility of deep-sea animals with bioluminescence




Visibility of deep-sea animals with red coloration

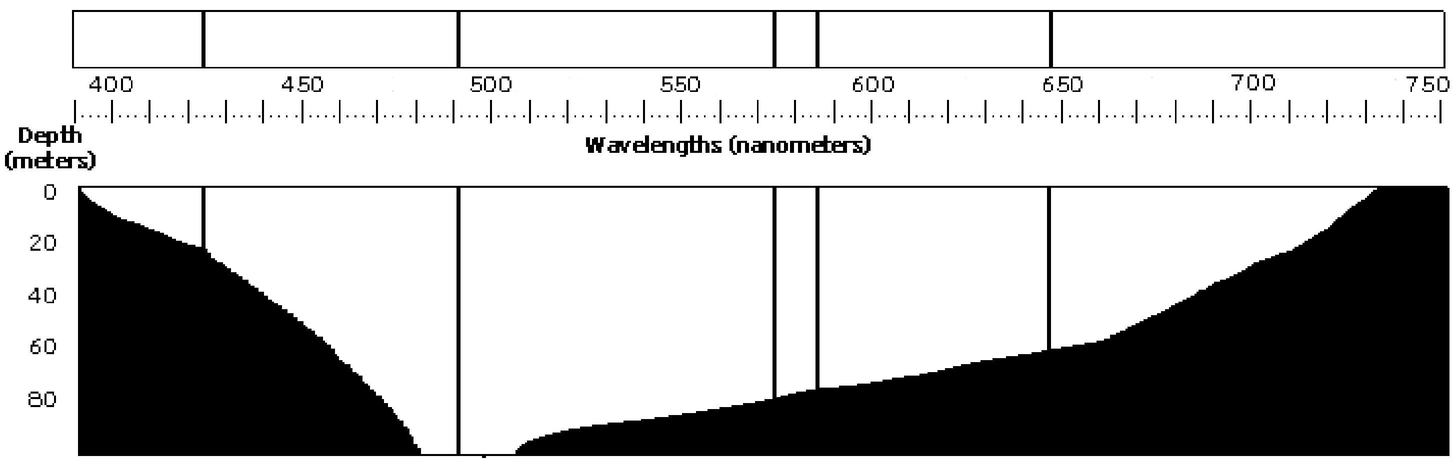


# Data Sheet #4
# Light Wavelength and Depth

Look at the table and diagram below. The table shows light radiation and its wavelengths. The diagram depicts a cross-section of the ocean.

Use your colored pencils to color the sections in the diagram so that they correspond to the wavelength ranges listed in the table. Notice that some colors of light penetrate deeper than others.

| Type of radiation | Wavelength (in nanometers) |
|---|---|
| violet | 380-424 |
| blue | 424-491 |
| green | 491-575 |
| yellow | 575-585 |
| orange | 585-647 |
| red | 647-750 |




Which color penetrates deepest into ocean waters?

What is happening to the other wavelengths of light as they penetrate the water?

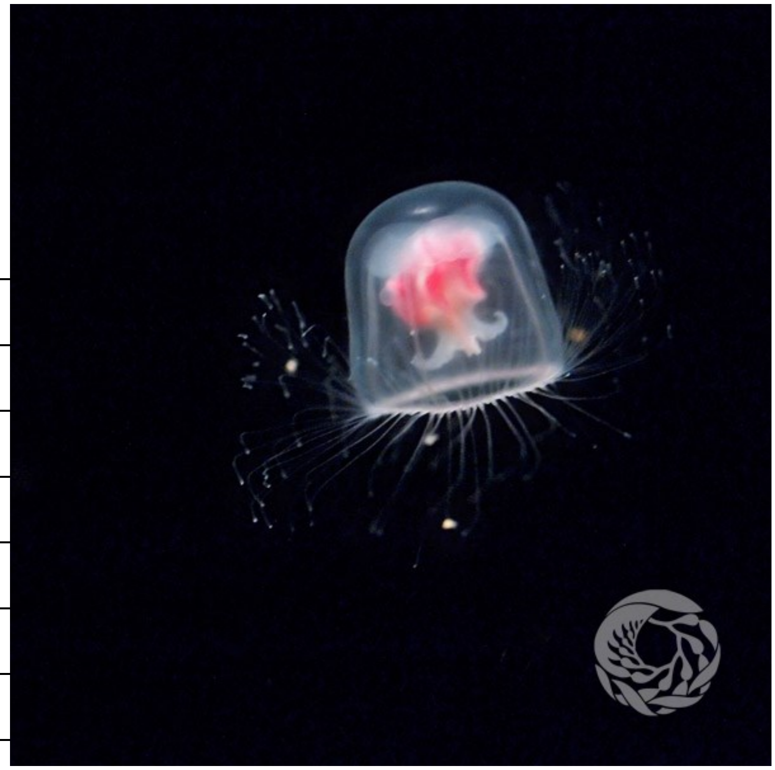
Does this diagram support your observations on the other data sheets? Why or why not?

Describe the relationship between depth and an organism's coloration.

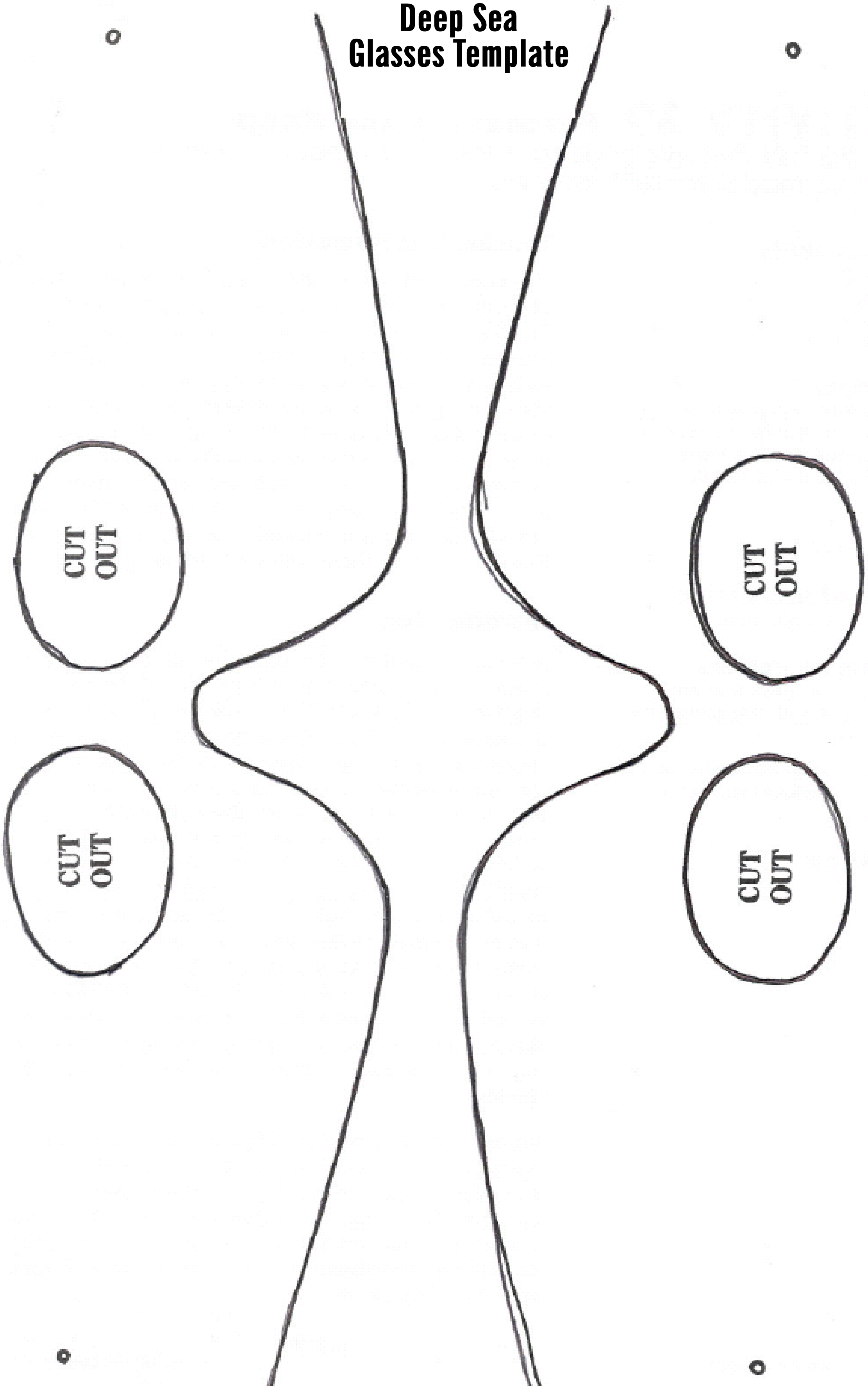
**BONUS:** On land, where the entire light spectrum is visible, what makes a red apple appear red?

# Data Sheet #5
## *Assessment*

This is the Immortal Jelly. Look at its coloration. The colored section is the jelly's stomach. Explain why this animals coloration is suited to its habitat. Why might having a red stomach be advantageous in the deep sea?



# Deep Sea Glasses Template



# Spectrum of Light in the Ocean

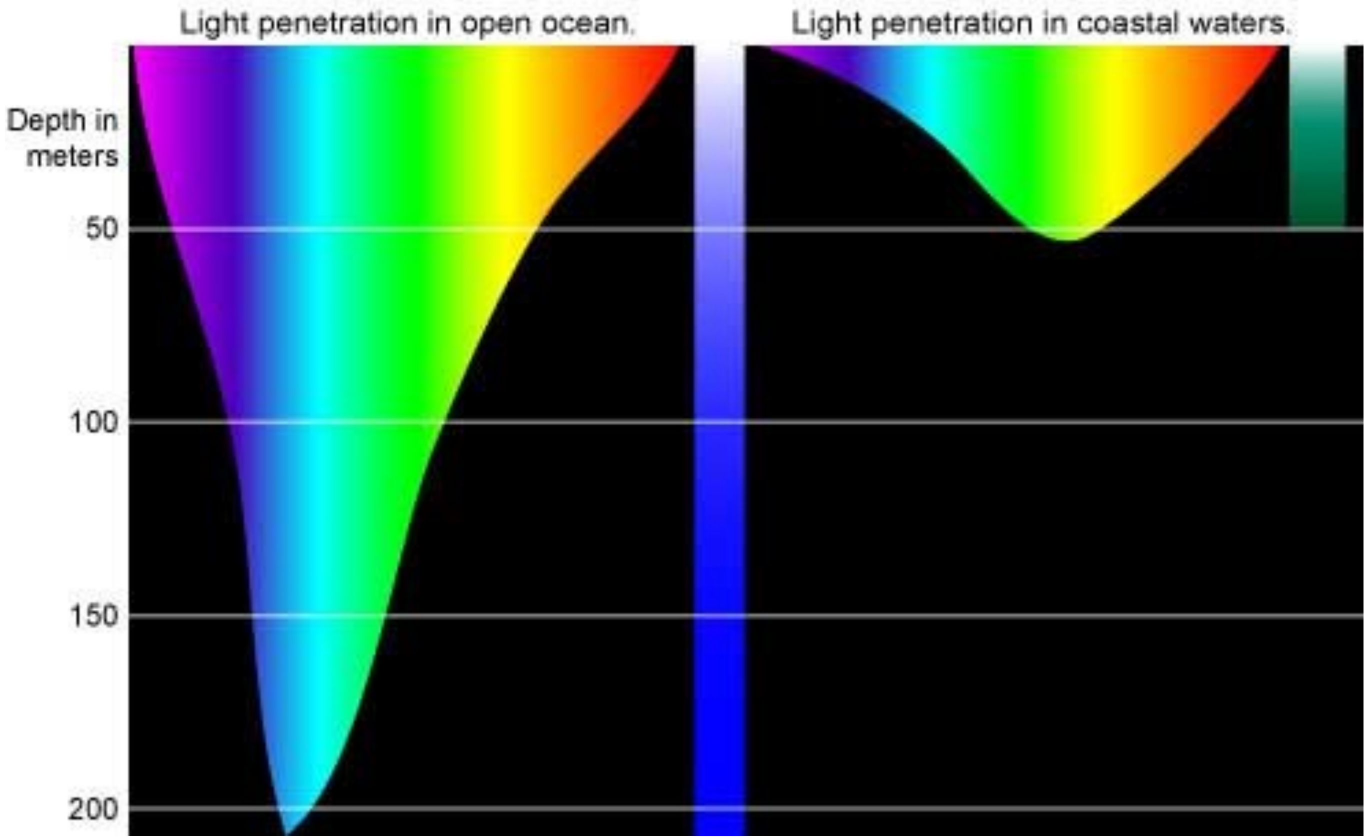



*Image courtesy of Kyle Carothers, NOAA-OE*

Vampire Squid
*Vampyroteuthis infernalis*


Johnson's sea cucumber
*Parastichopus johnsoni*


Flapjack octopus
*Opisthoteuthis californiana*


Comb Jelly (ctenophore)
*Aulacoctena*

Pacific Blackdragon
*Idiocanthus anstrotomus*

Fanfin Anglerfish
*Caulophryne polynema*


Siphonophore
*Praya Species Unknown*


Colobonema
*Colobonema Species Unknown*