AQUARIUS

Education & Public Outreach

LIQUID RAINBOW

Unit: *Salinity Patterns & the Water Cycle* **| Grade Level:** *Elementary* **| Time Required:** *45 min. (in class) after solutions are prepared by the teacher* **| Content Standard:** *NSES Physical Science, properties of objects and materials* **| Ocean Literacy Principle 1e:** *Most of Earth's water (97%) is in the ocean. Seawater has unique properties: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic.*

Big Idea: *When solutions of two different densities meet, the lower density (less dense) solution will move on top of the higher density (more dense) solution, resulting in layering or stratification of the solutions. Density is an important feature of seawater since many physical and biological processes are affected by it, such as moving heat around the globe influencing climate and feeding and reproduction by marine organisms.*

Key Concepts:

- Different densities of water, or solutions, will stratify to form layers.
- Density of ocean water is affected by temperature and ***salinity.***
- Cold water with dissolved salts (higher salinity) is denser than warm water without dissolved salts (low or no salinity).
- In the oceans, the deep, bottom layer is colder and saltier than the surface layer.

Essential Questions:

- Why do some objects float or sink relative to other objects?
- How can knowing specific properties of solutions be useful in life?
- What properties of water make our daily life easier?
- How is salt water different from fresh water?
- Would the Earth be different if the oceans contained freshwater?

Knowledge and Skills:

- Hypothesize what will happen if 4 liquids, each a different color and density, are poured together.
- Plan and conduct a simple investigation.
- Demonstrate changes in density through experimentation.
- Compare and contrast results of experimentation with hypotheses.
- Describe how salt affects the density of water.

Prior Knowledge:

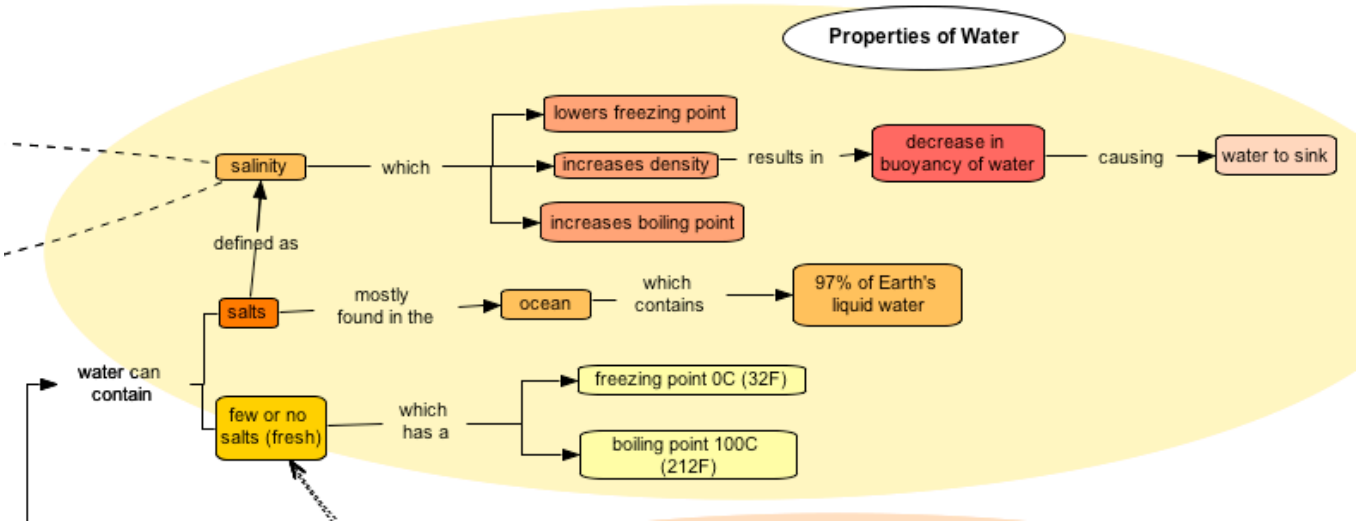
- Identify floating and sinking objects.
- Describe attributes of matter, which are qualitative, such as color, smell, size, and texture.
- Use simple measurement devices to make measurements in scientific investigations.

Common Preconceptions:

- Students may think that objects sink in water because they are “heavier” than water.
- An object floats because it has air in it.
- Students often confuse density and thickness, assuming that thick liquid is denser than thinner, less viscous liquids.
- An object floats because it is “lighter” than water.
- All liquids mix.

Concept Map- This map is best used for the teacher’s benefit to understand how salinity affects the properties of water. A concept map could be constructed with the students using the essential question

- *How can knowing specific properties of solutions be useful in life?* – as a precursor to the activity.



Background

Density is a property of matter that can be introduced at the elementary level by thinking of it in terms of the relationship between weight and volume. How can two objects that are the same size have different weights? The answer has to do with their density. An object's density is determined by comparing its mass to its volume. If you compare a rock and a cork that are the same size (they have equal volume), which is heavier? The rock is, because it has more mass. Thus the rock is denser than the cork because it has more mass in the same volume.

Liquids have density too. Unlike the densities of solids, which remain relatively constant, the densities of many fluids can be easily changed. Do objects float the same way in fresh water as they do in salt water? If you have the same amount of each, saltwater weighs more than fresh water. Salt water is described as being more dense than fresh water. In the case of ocean water, heating, cooling, and salinity all influence density. Circulation in the ocean depends in part on differences in density of the water. Water with more salt is denser (heavier) and sinks while fresh water is less dense and "floats" on the surface. These buoyancy differences can result in the separation of water into layers (stratification) within an estuary or ocean. Stratification can be disrupted by tidal mixing, heating and cooling of surface waters, and / or by wind generated water movement, such as waves and currents.This action results in vertical mixing. Density driven currents are an important feature in coastal waters, affecting the physical, chemical, and biological dynamics in the ocean. Many marine organisms use density currents for migration, reproduction, and feeding.

Materials:

4 large containers (e.g., pitchers or milk jugs), food coloring (4 colors), transparent drinking straws, pickling salt (preferred), 5 vials or test tubes per student group (4 for solutions and 1 for waste)

Preparation:

Before the students arrive, the teacher will prepare 4 solutions, each with a different density, as follows:

- Container #1: 1 gallon water + 0 cups of salt + bottle of yellow food coloring
- Container #2: 1 gallon water + 1/2 cup of salt + bottle of green food coloring
- Container #3: 1 gallon water + 1 cup of salt + bottle of red food coloring
- Container #4: 1 gallon water + 2 cups of salt + bottle of blue food coloring

Mix the solutions thoroughly, until all salt is dissolved. The solutions must be distinctly colored. Use the entire contents of one of the small bottles usually sold in sets of four at the grocery store. Pickling salt is preferred for this activity because it does not have any additives and will not make cloudy solutions.

Clear or translucent drinking straws must be used so that the colors of the different solutions can be observed when in the straw.

Activity –

- For best results, do not reveal how much salt is in the solutions while the students are crafting hypotheses. Also, do not arrange the solutions in their containers in any manner that may divulge the relative density of the solutions.
- Distribute a sub-sample of each of the four solutions to students. Demonstrate and then instruct them to practice picking up solution in their straw by placing a finger over the end of a straw, using their finger like a valve. **Lab Safety Reminder** - Mouth pipetting is a hazard and should not be allowed.
- Direct students to select two of the solutions at random. While holding the solution in the straw, lower the end of the straw into the second liquid. Draw a sample of the second solution into the straw. If the first solution floats on the second, the first is less dense. If the first mixes or falls through the second; the first is more dense.
- By making systematic comparisons of all four liquids and recording each trial (i.e., noting which colors float above others in the straw), students will establish an order of density for the four liquids.
- As an extension, challenge students to get all four solutions layered in the straw.

Assessment Questions –

- Ask students if they can define density. If not, ask them to name a pair of things that are approximately the same size (i.e., volume) but one floats in water while the other sinks (e.g., ping pong ball and a small rock; a paper boat and a brick; a cork and large pebble; a Cheerio and a dime). Ask the students how these paired items differ from one another. (Although they have the approximately the same size or volume, their masses are different; thus they have different densities.) Explain that "density" is "mass per volume."
- Ask students if the solutions they "stacked" in their straws had different volumes. (No, the straw itself constrained the volume of the solutions.) Which color of solution was the least dense? (Yellow.) Which color of solution was the most dense? (Blue.) Ask students to hypothesize about what made the density (or mass) of each solution different – was it the color? (No.) Ask the students to hypothesize about what might have been added to the solutions to increase their densities. Ask "What experiments might you conduct to discover the 'secret ingredient' used to increase the density of your solutions?" **Lab Safety Reminder** - Tasting the blue solution would be effective but should not be encouraged.
- After the students have discovered that salinity – or salt content – affected the density of their solutions, ask which color had the highest salinity (Blue.) and which had the lowest salinity (Yellow.). Explain that as the salinity of water increases, so does its density, making it heavier and more likely to sink. Ask the students to name examples of high salinity water (Oceans.) and low-to-no salinity water (Lakes, rainwater, tap water). Ask "What happens when rain falls on the ocean?" (It would float on the ocean water until it was mixed by wind or waves.)

Tip: This activity is indirectly adapted (through McREL) from the activity "*Layering Liquids*" featured in the Great Explorations in Math and Science (GEMS) curriculum, "*Discovering Density.*" Find data sheets to supplement and guide this activity in this publication.
http://www.lawrencehallofscience.org/gems/GEM300.html

Vocabulary

- **analytical:** Able to reason validly; logical; rational.
- **density:** Mass per given unit of volume.
- **mass:** The property of a body that causes it to have weight in a gravitational field.
- **salinity:** Saltiness or dissolved salt content of a body of water.
- **stratification:** Physical layering of the water column resulting from density differences caused by salinity or temperature variation.

Original source: *Adapted from Mid-continent for Research and Education (McREL)*
***Aquarius* Education & Public Outreach URL:** *http://aquarius.nasa.gov/*

Lab Safety Reminders

1. Students should never taste any chemical.
2. Presenting the liquids as different colors eliminates the potential for students to pour the chemicals back into the wrong dispensing container and thereby contaminate a large quantity. Tell them that all of the liquids are actually colorless, that you have added the color for safety and that the color has no effect on the results of the lab.
3. Remind students to never mouth pipet.