Seawater – Physical Properties – Light, Viscosity, and Pressure

Another important characteristic of water is how it transmits light. Most water lets at least some light through it, but this light is bent. We see that clearly when we put an object halfway into water and we see that the outside lines don't match up. This bending of light is also visible when we see a rainbow. In this case, the sunlight – white light that's composed of all colors of the spectrum – red, orange, yellow, green, blue, violet – bends as it travels through water droplets in the cloud. Each color of light has a different wavelength, so each color bends at a different angle. The water droplets actually split the light into all its colors, and a rainbow results.

This image shows how light interacts with colored objects. In this case, we take white light, which contains all colors of light, and we shine it on a blue-pigmented object, such as a blue binder. The pigment makes the object opaque to blue light – so the blue cannot be absorbed. Every other color is absorbed (and bends or refracts at different amounts depending on the refractive index of the material), but the blue reflects off the surface and returns to our eye. What we see is only the blue light, and the object looks blue.

Pause now.

This image shows a cross-section across the continental margin. You can clearly see the shelf, slope, and in this case also a trench. The **photic (or euphotic)** zone is the area of the ocean's surface where at least 1% of visible light penetrates.

Depths below which 0% of visible light penetrates is known as the **aphotic** zone. Between these two zones (0-1% visible light penetration) lies the **disphotic** zone.

In the open ocean, with mostly clear water, white light descends through the photic zone, with increasing absorption with depth by water molecules and the dissolved ions within it. As you can see from this absorption spectrum, red light is absorbed first. Blue remains the longest. Hence, when we look down into clear deep ocean, the color we see is blue.

In the nearshore, coastal ocean, water is typically filled with varying amounts of suspended sediment and microscopic plankton. As you can see from this absorption spectrum, blue light is absorbed first, followed by red, and then yellow. Green remains the longest. Hence, when we look down into these waters, the color we see is green.

You can also see from this graph that the percentage of solar energy that makes it to various depths decreases when we enter the turbid coastal area with lots of suspended material. **Attenuation** is the term we use to describe an increasing % of absorption and thus less of the original light left as we descend. Turbid waters have a higher attenuation than clear waters.

The combination of all these factors lead to the different colors and transparencies of waters around the world's oceans. In Cancun, Mexico, there is a lack of suspended materials or living plankton. Big Sur has a lot of plankton in the water. San Francisco has both plankton and suspended sands and muds.

Pause now.

This image shows a copepod and two dinoflagellates – all planktonic organisms that live at the ocean's surface. For them, an important part of water's physical properties is its **viscosity** – or **resistance** to flow. To us, water might seem to have no resistance to flow – thus have a very LOW viscosity. From our vantage point, water certainly appears to flow regularly and easily down hills and over tabletops. But how does it feel to a microscopic planktonic organism that is 2 millimeters wide or less? To them, the viscosity of water can feel like honey or molasses or syrup. These organisms depend on water's viscosity to resist their sinking and keep them afloat. However, just like syrup, the viscosity of water can change.

What happens to syrup when we heat it up? It flows faster. Its viscosity drops. What about high-sugar maple syrup versus maple syrup with low-sugar? High-sugar content (or high amount of dissolved ions) makes it more viscous. The same is true for seawater. The highest viscosity seawater is cold and salty – the lowest is warm and fresher.

If you're a planktonic organism in the world's oceans and you need to stay afloat, which kind of water would you prefer? And what would happen when the conditions changed on you? It could become either easier or harder to move. Which would you prefer? If you can't swim well, you probably need high-viscosity water to buoy you up. And if that water heated up, you'd lose that buoyancy, and you'd fall to the bottom of the seafloor with all the other things at the ocean's surface that are too heavy to withstand the force of gravity.

What happens to these organisms as they descend into the depths of the oceans? It gets colder, and also becomes higher in pressure. Organisms that live in the deep ocean have to deal with the high pressures from the weight of overlying water.

Pause now.

On land, air pressure comes from the weight of the air above us. In the oceans it comes from the weight of the air and the water. And the weight of the water has a much greater impact. At sea level, the air pressure is 14 pounds per square inch or 1 atmosphere (abbreviated as atm). For every 10 meters you descend in the oceans, the pressure increases by 1 atmosphere. At 10 meters, it's 2 atmospheres, at 20 meters, it's 3. At 1000 meters, or 1 km, it's 101 atmospheres. What's the pressure at 3 km in the center of the mid-ocean ridge rift valleys? 301 atmospheres! That's 300 times the surface pressure. What happens to objects that descend that deep? They get compressed. Really compressed. These styrofoam cups were sent 3 kilometers down in the oceans in a submersible, where they were exposed to the pressures of the seawater by a robotic arm on the submersible. The air in the styrofoam compressed under that pressure, and the cups shrank as you can see here.

Pause now.

For more information and more detail, continue on to the next video in this series.

[End credits]
<u>Seawater Physical Properties Series:</u>
Part I: Water Molecule Shape
Part II: Water Phases
Part III: Water Density
Part IV: Heats of Water
Part V: Light, Viscosity, & Pressure
Part VI: Heat Transfer

Light, Viscosity, & Pressure
Geoscience Video Tutorial
Produced by Katryn Wiese
City College of San Francisco

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