KWLA Question: Why is Lake Nyos "layered" or stratified?

Inquiry: Have students brainstorm reasons for density differences and devise an experiment to test their hypothesis.

Potential Investigations and alternate methods:

### 1A - *How does the temperature of the water affect the layering of the Lake?*

Notes:

1. A thermometer may be used to measure temperature if you do not have access to the Vernier technology.
2. If you do not have access to a density box, you can use 2 bottles instead. The bottles must have the same size opening. Fill one completely full of one solution colored red and the other completely full of the other solution colored blue. Place an index card on top of one bottle and invert it so that the card "sticks" to the bottle and the water doesn't fall out. Place one bottle over the other bottle carefully lining up the edges. Holding both bottles firmly, cautiously slide the index card out so that the bottles do not move. Observe the solutions as the denser solution moves to (or remains in) the lower bottle.

Sample Results for Temperature investigation:

Solution 1   Solution 2
Measurement   Measurement
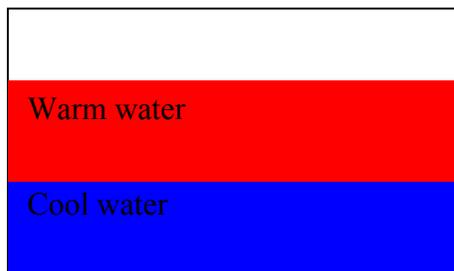
Warm water   Cool water
80°C   10°C

Sketch and color the observations from your experiment with the density box.

Which layers settled to the bottom? *Cool water*
Why? *Cold water is more dense than warm water and settles to the bottom of the container. A lower temperature means that the particles have less kinetic energy indicating that the molecules are not moving as quickly. The particles tend to be packed more closely together so that in a given volume, the mass is greater.*

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Draw what happened from a molecular perspective…
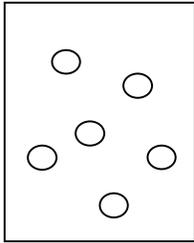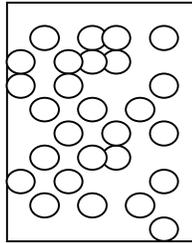
Warm water   **Cool water**

### 1B - *How does the concentration of dissolved gases affect the layering of the Lake?*

 Notes:
1. Students may use seltzer water on one side of the density box colored red and distilled water on the other side colored blue. The red seltzer water will sink to the bottom of the box when the divider is removed.
2. The 2-bottle method described above may be used instead of a density box.
3. A conductivity probe may be used to test for dissolved CO_2. Some of the CO_2 reacts with water to form hydronium ions and bicarbonate ions resulting in an increase in electrical conductivity.
4. A handheld conductivity tester may be used instead of the Vernier technology.

 Sample Results for Conductivity investigation:

Solution 1
Measurement

Seltzer Water
160 mg/L

Distilled water
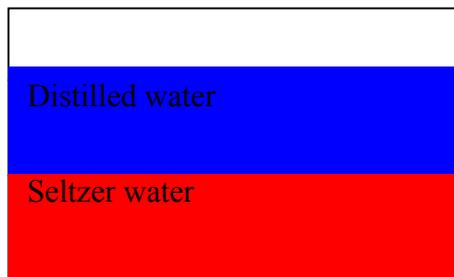
Seltzer water

Solution 2
Measurement

Distilled
Water
30 mg/L

Sketch and color the observations from your experiment with the density box.

Which layer settled to the bottom? *Seltzer water*
Why (describe or draw an explanation)? *Seltzer water is simply carbonated water. Any given volume of seltzer water has a higher mass due to the dissolved CO_2 than distilled water. As a result the seltzer water has a higher density.*

Based on your data and the profiles for Lake Nyos, what might cause the density differences that lead to stratification? ? (See Handout III of *A Killer Lake* Case Study[1] or Temperature and Conductivity Profiles from US-OFDA Report[3].)

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Although many lakes are stratified based on temperature differences, lake Nyos is not. The magma chamber below it exudes "warm gas-rich fluids near the lake bottom"[3] causing the bottom layer of water to be warmer than the others. In the vertical temperature profile of Lake Nyos, the temperature of the bottom layer is almost as warm as the upper layer. The conductivity profile of Lake Nyos reveals that the lower layer has a higher conductivity, thus the dissolved salts or gases must be the cause of the density differences.

1C - *How does the concentration of dissolved salts affect the layering of the Lake?*

Notes:
1. Students may also hypothesize that salt concentration may be the cause of the density differences. Although it is a freshwater lake, some minerals may dissolve in the water to form ions that increase the conductivity. They may choose to use salt water vs. distilled water. The salt water, being denser, will settle to the bottom.
2. The 2-bottle method described above may be used instead of a density box.
3. A handheld conductivity tester may be used instead of the Vernier technology.

Sample Results for Conductivity investigation:

Solution 1
Measurement

Solution 2
Measurement

Salt Water
200 mg/L
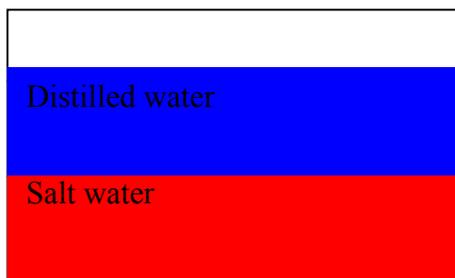
Distilled water

Salt water

Distilled
Water
30 mg/L

Sketch and color the observations from your experiment with the density box.

Which layer settled to the bottom? *Salt water*
Why (describe or draw an explanation)? *The additional salts in a given volume of water results in a higher density*

Based on your data and the profiles for Lake Nyos, what might cause the density differences that lead to stratification? ? (See Handout III of *A Killer Lake* Case Study[1] or Temperature and Conductivity Profiles from US-OFDA Report[3].)
Although many lakes are stratified based on temperature differences, lake Nyos is not. The magma chamber below it exudes "warm gas-rich fluids near the lake bottom"[3] causing the bottom layer of water to be warmer than the others. In the vertical temperature profile of Lake Nyos, the temperature of the bottom layer is almost as warm as the upper layer. The conductivity profile of Lake Nyos reveals that the lower layer has a higher conductivity, thus the dissolved salts or gases must be the cause of the density differences.