Lesson 2-1: Polling the students' knowledge
~20 minutes

Student Version	Teacher Discussion Notes	Materials
N/A	For your own knowledge, poll the class with this pre-quiz to gauge student understanding of ocean acidification. ● You may find that many of them don't have a comprehensive grasp of ocean acidification and may carry with them misconceptions. Don't worry. In the engagement step, students will have the opportunity to gain more background knowledge and to have their misconceptions addressed. ● You may want to alter this quiz based on your knowledge of the class's experience with this topic and/or use this quiz again after the engagement step to assess their growth. This pre-quiz should not be counted as a grade now, but the post-quiz could be graded.	Student Poll

Name: _____

Ocean Acidification Poll

1. What causes ocean acidification?
    a. Acid rain that originates in highly polluted areas
    b. Carbon dioxide emissions
    c. Natural ocean processes
    d. Hydrogen dioxide emissions

2. What is the primary acid involved in this process?
    _____

3. What compound makes up shells and coral?
    a. Lithium sulfate, Li_2SO_4
    b. Magnesium nitrate, $MgNO_3$
    c. Calcium carbonate, $CaCO_3$
    d. Barium phosphate, $Ba_3(PO_4)_2$

4. What process causes ocean shells to dissolve?

5. What about the reactions involved in ocean acidification makes it such that shells cannot form?

Ocean Acidification Answer key:

1. What causes ocean acidification?
    a. Acid rain that originates in highly polluted areas
    b. Carbon dioxide emissions
    c. Natural ocean processes
    d. Hydrogen dioxide emissions
2. What is the primary acid involved in this process?
   Carbonic acid, H_2CO_3
3. What compound makes up shells and coral?
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4. What process causes ocean shells to dissolve?

    Since there are more hydrogen ions in solution, the equilibrium with bicarbonate ions, HCO_3^-, and carbonate, CO_3^{2-}, shifts towards the formation of bicarbonate, which cannot bind with calcium ions to make calcium carbonate, $CaCO_3$. Therefore, shells made with calcium carbonate begin to dissolve to increase the concentration of carbonate in the ocean as more reacts to make bicarbonate.

5. What about the reactions involved in ocean acidification makes it such that shells cannot form?

    As sea life tries to make shells, they use carbonate ions and calcium ions to create $CaCO_3$. When the ocean becomes more acidic, carbonate the equilibrium is shifted towards the creation of bicarbonate. This means it takes sea creatures much more energy to make shells since there is less carbonate available to use in their shells. The more energy shellfish have to use the more likely that they will be unable to survive the process.

    Reaction 1: $CO_2 + H_2O \rightarrow H_2CO_3$
    Reaction 2: $H_2CO_3 \rightarrow HCO_3^- + H^+$
    - Reactions 1 and 2 are directly related to CO_2 dissolving into the ocean. Reaction 1 explains how CO_2 reacts with water to form carbonic acid, and reaction 2 shows that carbonic acid quickly dissociates into bicarbonate and a H^+ ion.

    Reaction 3: $CO_3^{2-} + H^+ \rightarrow HCO_3^-$
    - Reaction 3 describes how carbonate ions in the ocean attempt to reverse this process. Carbonate ions that already exist in the ocean react with the H^+ ions to form bicarbonate. However, this means that there are fewer carbonate ions for shells and coral to use to make their calcium carbonate structures.

    Net reaction: $CO_2 + H_2O + CO_3^{2-} \rightarrow 2HCO_3^-$

- These reactions cause ocean acidification because reactions 1 and 2 happen at a much faster rate than reaction 3, so there are still H^+ ions being added to the ocean