The WAR for Carbonate Ions in Ocean Acidification

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Summary

This short activity allows students to visualize the negative impacts on ocean organisms as the pH of the ocean drops (ocean acidification or OA). It focuses on how the changes in ocean chemistry, as more CO2 dissolves in the water, affects life in the ocean. Student groups play four rounds of a modified card game *War* with the changes in the rules as the pH of the ocean drops. This activity will help uncover student misconceptions that in order for OA to hurt organisms, the pH must reach acidic levels. This lesson is part of a broader unit on pH which would be applicable to both chemistry courses and the biochemistry unit in biology as well as ecological impacts of a changing environment.

TAGS: Ocean Acidification, pH

Key Concepts

Lowering of the pH of the ocean (increasing acidity) will have a negative impact on marine organisms

Objectives

Include clear, measurable statements of what students will be able to do, such as:

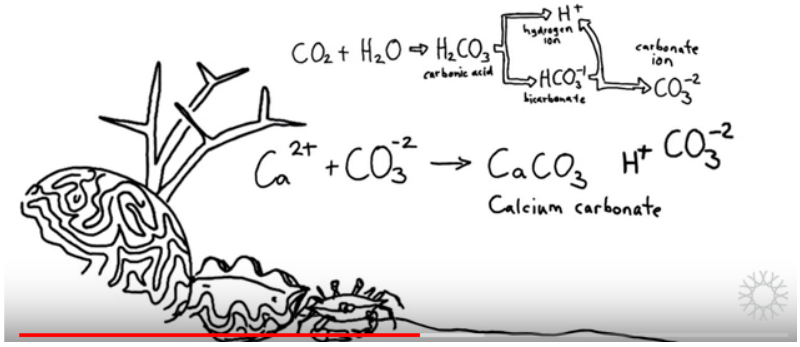
- Ask questions and construct explanations
- Define problems and design solutions
- Develop and use models
- Plan and carry out investigations
- Analyze and interpret data
- Use mathematics and computational thinking
- Engage in argument from evidence
- Obtain, evaluate, and communicate information

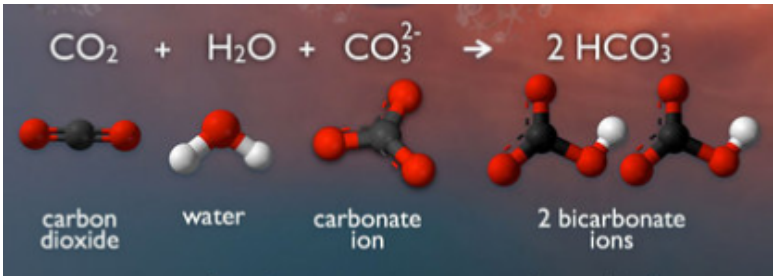
Materials

- Teacher materials
    - Link to Background Information (will be coming…really)
    - Internet access to show video
    - Possible answers to Student trends for Student Data, Observation and Trend Sheet
- Student materials
    - Deck of cards (deck of cards per 2 students)
    - Student Data, Observation and Trend sheet

Procedure

1. Watch this video, remember the more CO_2 dissolved in the water, the more carbonic acid produced. Carbonic acid can lose a H+ to bicarbonate ions and carbonate ions that are produced which increases the acidity of the water (lowers the pH). H+ grab the carbonate ions in the ocean water.





2. Get in groups of four students and take a deck of cards.

3. Each person in the group will choose her/his role for the game. One person will be the OCEAN. The rest of the individuals will pick and organism (possible choices: coral, pteropod, sea urchin, Dungeness crab, coccolithophore, oyster, or fish (like a clownfish, salmon). Links to more about the organisms are at the end of this handout (which is also on Canvas). Record both their name *and* your role in **Data Table 1** on the next page.

4. Basically, you will be playing a modified version of the child's card game WAR (https://www.bicyclecards.com/how-to-play/war/). Students flip over their top card at the same time. The highest card wins all the rest of the cards from that play (the Ace is the highest card, then K, Q, J, 10 all the way down to 2 being the lowest card). If two (or more) students flip over the same high card at the same time, there is a "war". They will then place one card face down and another face up. The high card will win all the cards from that play.

5. The set up for each pH level is as follows below:
   pH of 8.2: shuffle the deck of cards and randomly deal the cards so that each player (including the Ocean) has the same number of cards (with four players that will be 13 cards per person).
   pH of 8.1, For this pH level, first take out and give to the ocean: 2 Aces, 2 Kings,

2 Queens and 1 Jack. Shuffle the remaining cards and then randomly deal 7 cards to the remaining players. Finally, randomly deal the remaining cards so that each player has the same number.
pH of 8.0, For this pH level, first take out and give to the ocean: 2 As, 2Ks, 2Qs and 3 Js. Shuffle the remaining cards and then randomly deal 9 cards to the remaining players. Finally, randomly deal the remaining cards so that each player has the same number.
pH of 7.9, For this pH level, first take out and give to the ocean: 4 As, 3 K, 3 Q s and 3 Js (if you are playing with four players this will be all the cards the Ocean is dealt). Shuffle the remaining cards and then randomly deal 13 cards to the remaining players. Finally, if playing with fewer than four players randomly deal the remaining cards so that each player has the same number.

6. **Student Data: Effect of lowering pH on ocean organisms on cards "won" in WAR (6 pts)** Play two "rounds" for each pH level and then record your results (count your cards AFTER the 2nd round) on **Data Table 1**. For instance, if four players each start with 13 cards, you will flip the 13 cards in your deck for Round 1. Keep your "winnings" from that round separate. Then take those "winning" cards, shuffle for yourself and play Round 2 of the 8.2 pH. Have each player record in **Data Table 1 below**, their total card count after ***both*** rounds of the 8.2 pH. (pH 8.1, pH 8.0 and pH of 7.9)

Table 1: Number of cards after two rounds of a pH level AND Functions used with the cards

Record your name and your organism/role	Player 1 OCEAN (ocean is the role)	Player 2	Player 3	Player 4
pH of ocean	No matter how many players are in the game, all players should have the same number of cards (give or take a card or two)			
8.2 (current pH of ocean)	Randomly deal all the cards evenly between the players. If there are four players, each player will get 13 cards			
	Number of cards after both rounds _____	Number of cards after both rounds _____	Number of cards after both rounds _____	Number of cards after both rounds _____
Ocean 8.1 (26% change from 8.2 *)	For this pH level, first take out and give to the ocean: 2 Aces, 2 Kings, 2 Queens and 1 Jack . Then randomly deal 7 cards to the remaining players. Finally randomly deal the remaining cards so that each player has the same number.			
	Number of cards after both rounds _____	Number of cards after both rounds _____	Number of cards after both rounds _____	Number of cards after both rounds _____
Ocean pH 8.0 (32%*) 58%	For this pH level, first take out and give to the ocean: 2 As, 2Ks, 2Qs and 3 Js Then randomly deal 9 cards to the remaining players. Finally randomly deal the remaining cards so that each player has the same number.			
	Number of cards after both rounds _____	Number of cards after both rounds _____	Number of cards after both rounds _____	Number of cards after both rounds _____
Ocean pH 7.9 (42%*)	For this pH level, first take out and give to the ocean: 4 As, 3 K, 3 Q s and 3 Js (if you are playing with four players this will be all the cards the Ocean is dealt). Then randomly deal 13 cards to the remaining players. Finally, if playing with fewer than four players, randomly deal the remaining cards so that each player has the same number.			
	Number of cards after both rounds _____	Number of cards after both rounds _____	Number of cards after both rounds _____	Number of cards after both rounds _____

*based on data from https://pmel.noaa.gov/co2/file/Percent+change+in+acidity

7. Now using the information from Table 2 below, go back to Data Table 1 and for all organisms (so the ocean does not do this), record the metabolic functions that the organisms could perform at each pH level with their winning cards. For example, if a player has 12 cards, she would stay alive and have avoided being eaten by a predator. If a

player had 23 cards, he would have stayed alive, avoided predators, been able to grow/molt/lay down a shell, reproduced and still have some left-over energy.

Table 2: Translating Number of Cards won into metabolic functions

	# of cards needed to perform the function (does not matter what the cards number is, an ace and a 2, both would count as 1 card)
Activity	**# of cards need to perform this activity**
Stay alive (includes cellular respiration) for the day	3 cards
Avoid a predator to stay alive for the future	5 cards (would need a total of 8 cards to reach this level)
Grow (molting, laying down shell, etc)	5 cards (would need a total of 13 cards to reach this level)
Reproduce (Produce gametes like eggs/sperm)	5 cards (would need a total of 18 cards to reach this level)
	Extra cards mean that the critter has some extra energy for other activities (don't need to use the energy to maintain homeostasis, etc)

ANALYSIS

1. Record the roles that you chose. For each role, include a picture and a sentence or two about the role of your organism in the ecosystem (and or for humans). Include the ocean as well although it is not an organism (reputable links are provided at the end of this handout) 6 pts
   Ocean: _____
   Person: _____
   Person 2: _____
   Person 3: _____
2. Graph your data. Use a bar graph with pH on the X-axis, number of cards on the Y-axis, a legend to show the different organisms at each pH and a descriptive title). Attach your graph (5 pts). ***You will NOT graph "the ocean" data.***
3. What trends do you see after the two rounds of pH 8.2
   (did each organism successfully perform all its metabolic functions, etc.)? 2pts
4. What trends do you see after the two rounds of pH 8.1
   (did each organism successfully perform all its metabolic functions, etc.)? 2 pts
5. What trend do you see after the two rounds of pH 8.0
   (did each organism successfully perform all its metabolic functions, etc.)? 2pts
6. What trend do you see after the two rounds of pH 7.9
   (did each organism successfully perform all its metabolic functions, etc.)? 2 pts
7. Looking at all four pH levels, explain with your data, whether there is a negative or positive result for the majority of organisms (2 pts)
8. Compare your results with at least two other groups and discuss the comparison (4 pts).
9. What did you learn from this game? 3 pts

Assessment

- **Formative assessments**—class discussion (develop class questions)
- **Summative assessments**—provide student groups or individuals, a written prompt that includes a scenario for one organism in the ocean and how it would react to a change in the ocean's pH (develop three sample prompts and provide rubric for answers)

Additional Resources

Pteropods https://www.youtube.com/watch?v=MzpmUHdwLr0 and/or https://www.nationalgeographic.org/media/one-species-time-sea-butterfly/family/

Sea Urchins https://www.whoi.edu/science/B/people/kamaral/SeaUrchins.html and/or https://www.sciencedirect.com/science/article/pii/S002209811630274X

Coccolithophores https://earthobservatory.nasa.gov/Features/Coccolithophores/coccolith_1.php and/or https://www.forbes.com/sites/samlemonick/2016/12/13/how-rising-ocean-acidity-could-send-us-into-a-downward-spiral/#32f460c16146 and/or **https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6054640/**

Dungeness Crabs https://animaldiversity.org/accounts/Cancer_magister/ and/or https://oceanconservancy.org/blog/2016/05/18/will-ocean-acidification-affect-dungeness-crabs/

Oysters https://www.nationalgeographic.com/animals/invertebrates/group/oysters/

Clownfish https://www.livescience.com/55399-clownfish.html and/or http://tolweb.org/treehouses/?treehouse_id=3390

Salmon https://www.wildsalmoncenter.org/why-protect-salmon/ and/or https://animaldiversity.org/accounts/Salmonidae/

Coral https://www.noaa.gov/education/resource-collections/marine-life/coral-reef-ecosystems#:~:text=Coral%20reefs%20protect%20coastlines%20from,food%2C%20income%2C%20and%20protection.

The Ocean https://oceanservice.noaa.gov/facts/why-care-about-ocean.html

Extensions or adaptations

1. Students can calculate the percentage change from each 0.1 decrease on the pH scale.

2. Students can calculate the number of cards that need to be added to the Ocean Deck with each change in pH.

3. Students can research their chosen organism and make a slide, flyer, short video, etc to teach the rest of the class on how lowering the pH may affect the organism (algae and seagrasses could also be added as choices). Students may present their findings to the rest of the class or hang

them on the wall for other classes to enjoy.