Cause and Effect & Ocean Acidification

Session 10

Partner share: *Reflecting on Homework*

1. Photosynthesis, Respiration and Oxygen
2. Daily Rains
3. Land vs Sea Breezes
4. Upwelling/Density
5. Temperatures around the Planet
6. El Nino, Rainfall and Temperature
7. Heat, Air, Currents
8. Variability in Chlorophyll Concentrations

In your partner groups of 4…

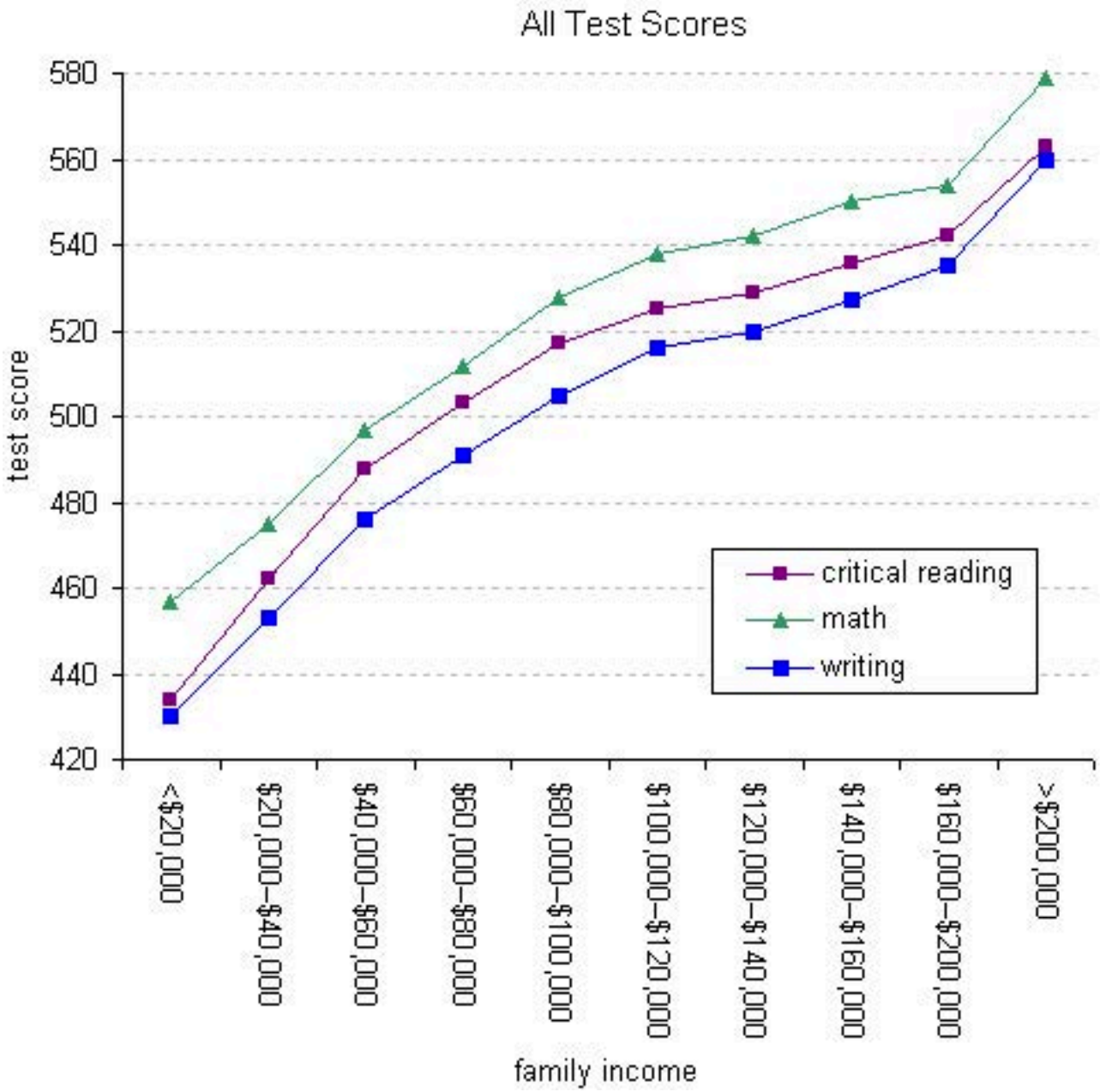
Make sure each pair has an opportunity to share and receive feedback on each of the following:

a. Which data did you explore related to the topic area?
b. What were your two *More Focused Questions*?
c. What did the data suggest that you found interesting and wanted to create a question around?
d. How could you revise your *More Focused Questions* more to make them even more specific of a relationship, time period, and location in which you will investigate (e.g., a testable question)?

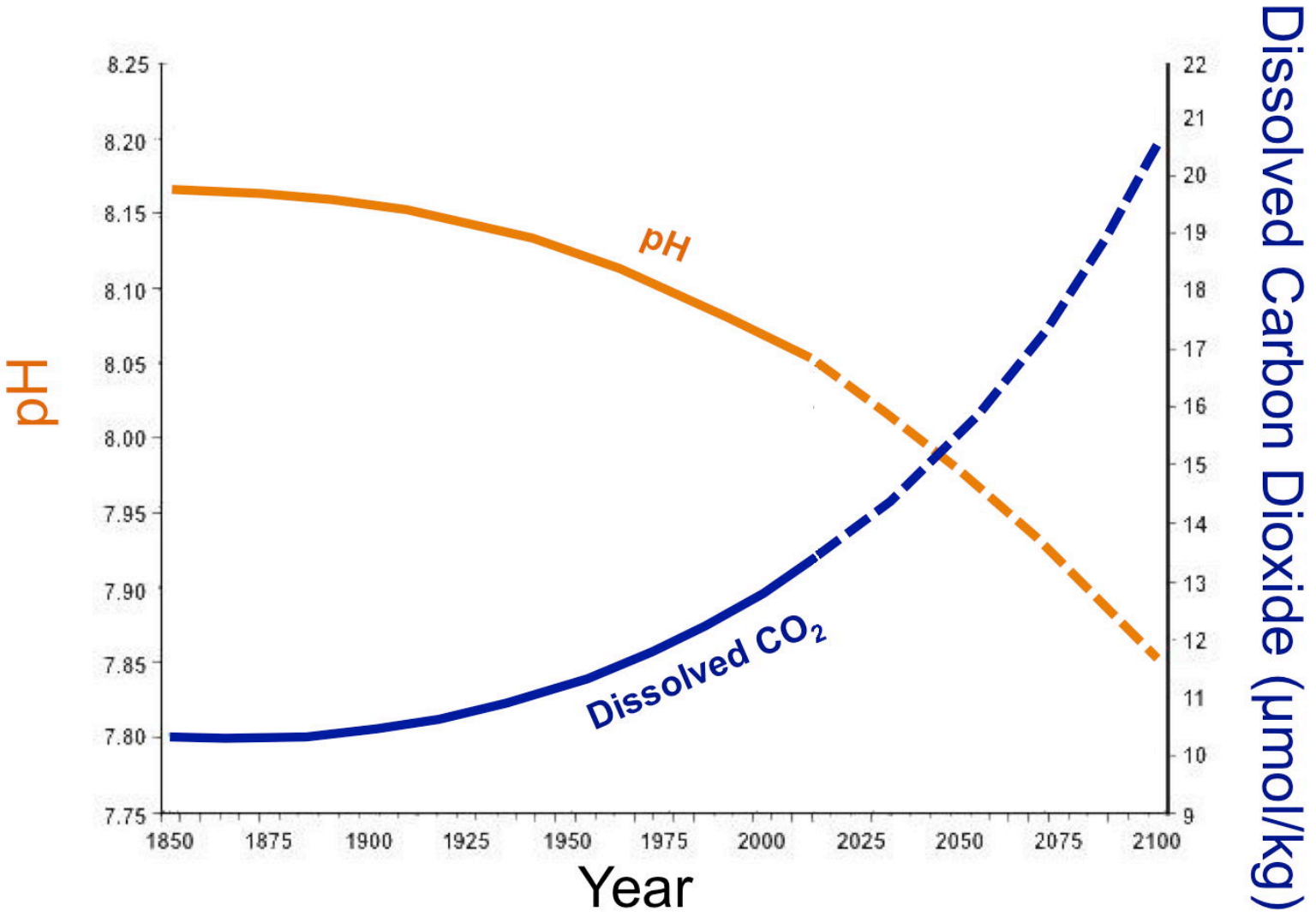
Session Goals

- **Climate science ideas:** Gain an understanding of the cause and effects of ocean acidification (OA) by engaging in an activity and applying this knowledge to propose solutions to real-life problems resulting from OA.
- **Using data:** Gain skills necessary to create and interpret data visualizations and explore the difference between correlation and causation.
- **Learning and teaching:** Discuss the value of using local ecological knowledge and issues to promote student engagement and learning.
- **Framework/NGSS:** Read the cause and effect crosscutting concept and reflect on how it might be applied to deepen student understanding of science content.

SAT Scores vs. Family Income

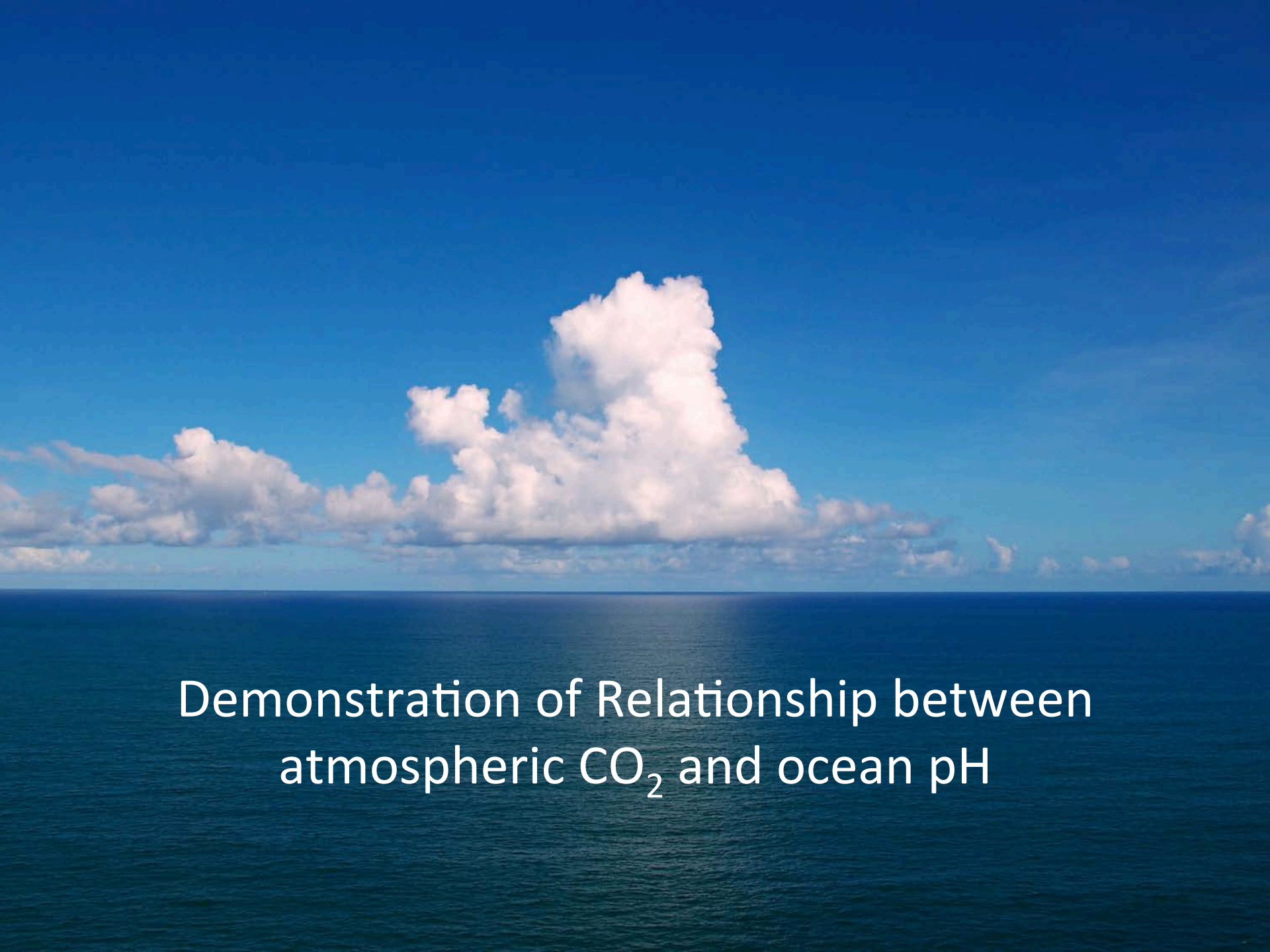


Atmospheric CO_2 vs. Ocean pH



How to Do Active Reading

- As you read…
  - Underline things you think are interesting or important.
  - Circle things you think are confusing, and write your questions in the margin.
- After reading…
  - Turn to your partner, and help each other as you try to answer your questions.


Demonstration of Relationship between atmospheric CO_2 and ocean pH

pH portion of demonstration

- Square 250 mL bottle has room temperature water with one end of the rubber tubing submerged in the water.
- A pH probe is also submerged in the water.
- A round 500 mL bottle is empty and ready for the yeast, sugar, and water to be added.
- Once added, the end of the rubber tubing with the small, black stopper will seal the round 500 mL bottle.

CO_2 portion of demonstration

- The square BioChamber has the CO_2 probe horizontally inside.
- One end of the rubber tubing seals the BioChamber.
- A round 500 mL bottle is empty and ready for the yeast, sugar, and water to be added.
- Once added, the end of the rubber tubing with the small, black stopper will seal the round 500 mL bottle.

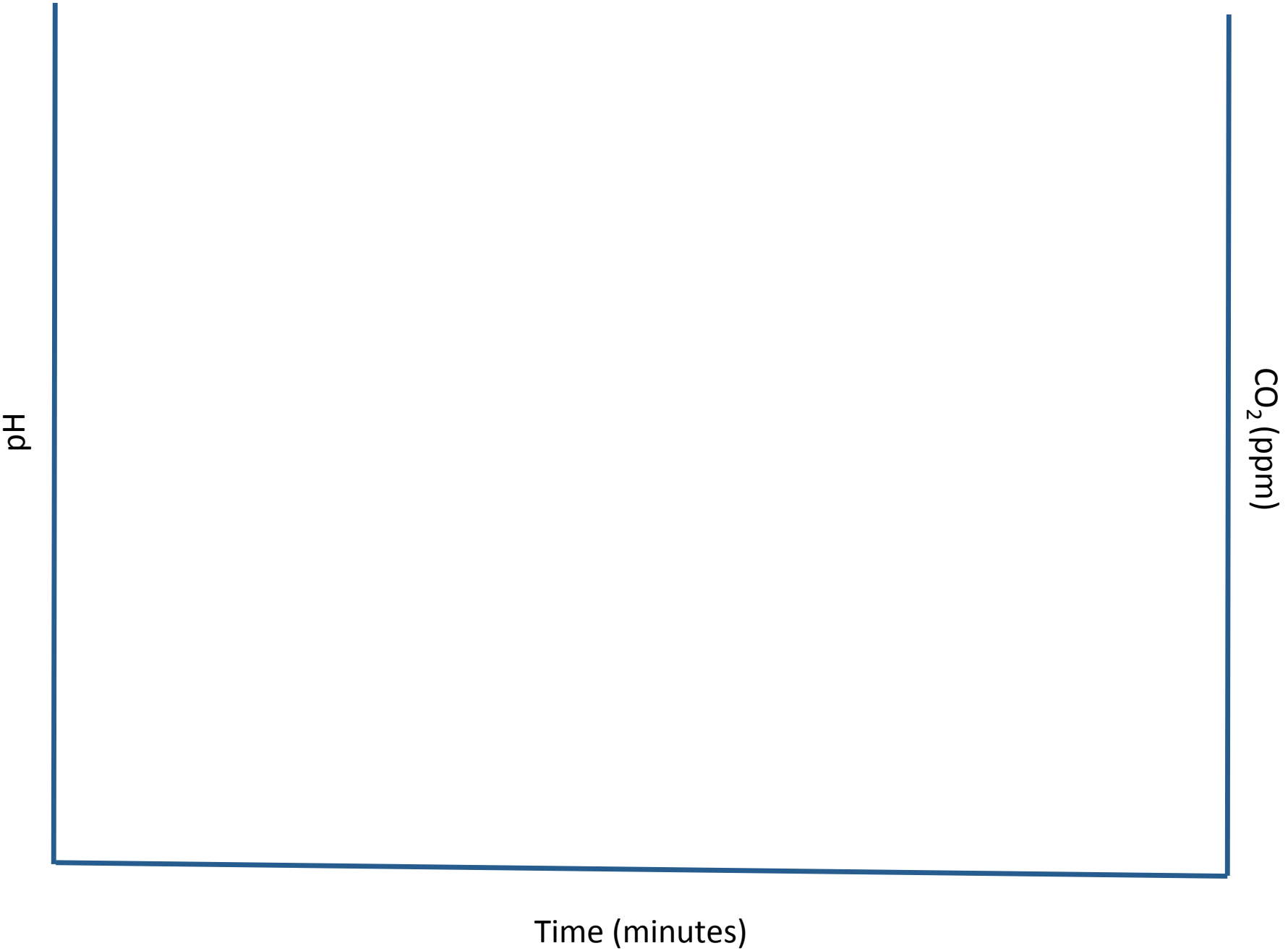
pH & CO_2 Demonstration Set-up

Transferring Data from Tables into Visualizations to Interpret

Time (s)	pH	CO2 Concentration (ppm)	Time (s)	Time (min)	
0		7	357	0	0
30		7	421	30	0.5
60		7	426	60	1
90		7	427	90	1.5
120		7	413	120	2
150		7	435	150	2.5
180		7	486	180	3
210		7	598	210	3.5
240		7	771	240	4
270		7	1015	270	4.5
300		7	1341	300	5
330		7	1749	330	5.5
360		7	2163	360	6
390		7	2603	390	6.5
420		7	3112	420	7
450		7	3995	450	7.5
480		7	5104	480	8
510		7	6523	510	8.5
540		7	8456	540	9
570		7	10637	570	9.5
600		7	13138	600	10
630		6.9	15925	630	10.5
660		6.9	18821	660	11
690		6.9	22040	690	11.5
720		6.9	25194	720	12
750		6.9	28529	750	12.5
780		6.9	31398	780	13
810		6.9	34393	810	13.5
840		6.9	37432	840	14
870		6.8	40305	870	14.5
900		6.8	42932	900	15
930		6.8	45354	930	15.5

Graphing the data

- What kind of data do we have?
- What do we want to show with the data?
- What kind of graph should we use to display the pH and CO_2 data?
- How many lines do you expect to include on your line chart?


pH
CO_2 (ppm)
Time (minutes)

Now that you have the graph...

Orient your partner to your graph as if they were a student.

Work together on interpreting and synthesizing the results.

Causal or Correlational?

- Did the CO_2 concentration increase or decrease over time?
- Did the pH increase or decrease over time?
- What is the relationship between CO_2 and pH?
- Was this a causal relationship?

Mental Model Builder (optional)

1. An **increase in atmospheric CO2** results in what?

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2. An **increase in the concentration of CO_2 molecules in the air** results in what changes in the air that is incorporated into surrounding water?

Mental Model Builder (optional)

1. An increase in atmospheric CO_2 results in what?

2. An increase in the concentration of CO_2 molecules in the air results in what changes in the air that is incorporated into surrounding water?

3. As the **amount of CO_2 molecules incorporated into the water increases**, what product is produced at an increased amount?

Mental Model Builder (optional)

1. An increase in atmospheric CO_2 results in what?

2. An increase in the concentration of CO_2 molecules in the air results in what changes in the air that is incorporated into surrounding water?

3. As the amount of CO_2 molecules incorporated into the water increases, what product is produced at an increased amount?

4. As **more carbonic acid** is formed what results in the level of pH of the water?

Section D. Ocean Acidification: Effects on Organisms

Minute Paper

- What is ocean acidification? Explain as best you can.
- Which concept(s) on the Climate Science Ideas chart may have to do with ocean acidification?
- Which organisms do you think might be affected by ocean acidification, and how?

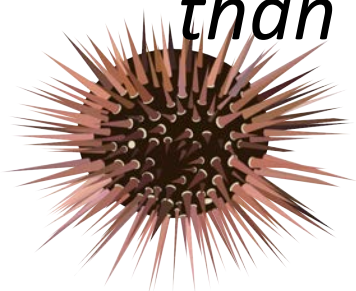
Ocean Acidification

- Since the start of the Industrial Revolution, the ocean has gotten 25% more acidic.
- Caused by excess CO_2 entering the atmosphere and then being absorbed by the ocean
- Extra CO_2 comes from the burning of fossil fuels
- Atmospheric CO_2 levels have been steadily increasing since the Industrial Revolution.

Exploration Question

What happens to some ocean organisms if the ocean absorbs more CO_2 than they are adapted for?

- *Which organisms' parts might break down in water with a lower pH than they are adapted for?*
- *Can shells form if ocean water has a lower pH than they are adapted for?"*



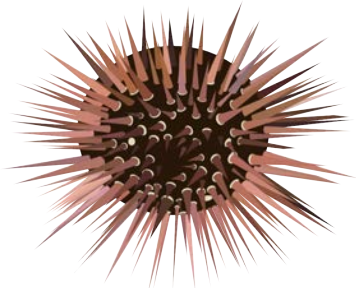
“Break Down” Investigation

1. Spoon a small amount of each of the appropriate materials in each of the labeled spots on the petri dish (seaweed, jellies, shells/corals).
2. Predict what will happen when “lower pH water” is dropped on each of these materials.
3. Using the eyedropper, add a few drops of “lower pH water” to each material on your plate.
4. Note what happens to each material.

5. Discuss these questions:
   - *Which materials seem to be most affected by lower pH water?*
   - *Are any of the materials unaffected by the lower pH water? If so, which ones?*

Discussing Results

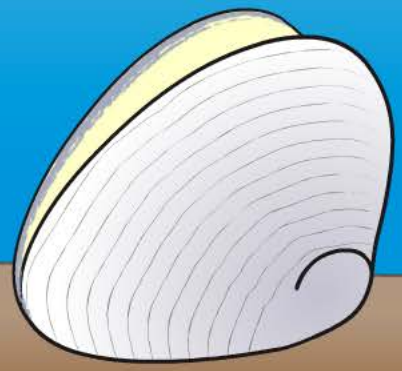
- *What types of organisms might be affected by ocean acidification based on your evidence so far?*
- *Which organisms might fare well in a more acidic (lower pH) ocean?*



Carbon dioxide, shell building, and ocean acidification

Seawater is a soup of dissolved substances, chemicals, and ions. To build shells and skeletons, marine organisms , such as this hypothetical clam, extract calcium ions (Ca_2^+) and carbonate ions (CO_3^{2-}) from seawater, combining them into solid crystals of calcium carbonate ($CaCO_3$) that are laid down to make shells.

START



Turn and Talk

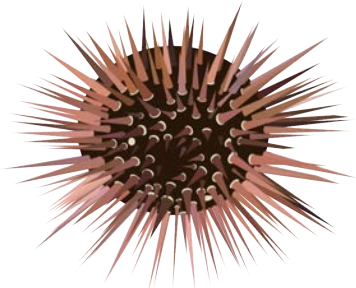
- Based on what you know about shell formation, how do you think falling ocean pH may impact organisms' abilities to make shells?

"Build Up" Investigation

1. Note three cups on the sheet of paper labeled, 1, 2 and 3 and a line reading higher pH at one end and lower pH at the other end. Each cup contains limewater. Line the cups up from 1 to 3, with #1 closest to the higher pH end of the line, cup #2 in the middle of the line, and cup #3 at the lower pH end of the line.
2. Drop 10 drops of vinegar into cup #2.
3. Drop 20 drops of vinegar into cup #3.
4. Using litmus paper, measure the pH in each cup to confirm placement on the pH line.
5. Cover each of the cups with a lid.
6. When CO_2 mixes with Calcium in water, sometimes calcium carbonate is formed. ***Predict what will happen*** when you add CO_2 to each cup by breathing into them through a straw. This will mimic CO_2 naturally being absorbed by ocean water. You will be able to tell if calcium carbonate forms in the cups because the cup will become cloudy from the white calcium carbonate.
7. Unwrap the straws; insert one straw through the lids into each of the three cups of limewater. Do not drink the water. Give each of the cups to different people.
8. At the same time, have each person holding a cup use their straw to blow air into the solution in the cup. Air bubbles should be apparent in the solution. Have each person blow for the same amount of time—about 30-45 seconds.
9. Record observations of each of the cups and answer the wrap-up question: *Which of the cups of water seems to have more calcium carbonate available for organisms to use to build shells? What is your evidence?*

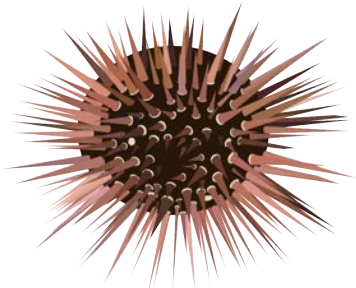
Discussing Results

- Which water was the cloudiest? Least cloudy?
- Which of the waters appears to have more calcium carbonate available for building shells? How do you know?
- How is shell building connected to atmospheric CO_2 concentrations?



Models in science

- In what ways were the ocean acidification models we just used accurate?
- In what ways were they inaccurate?



Flying Birds

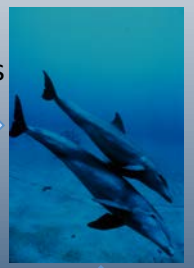
Shore Birds

Baleen Whales

Krill

Sharks

Dolphins



Turtles

Small Fish

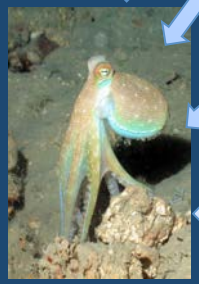
Based on the available evidence, what can you say about direct and indirect effects of ocean acidification on organisms?

Zooplankton and Phytoplankton

Small Fish

Shrimp

Jelly Fish



Octopus

Shell Fish (Oysters and Clams)

Corals

Squid

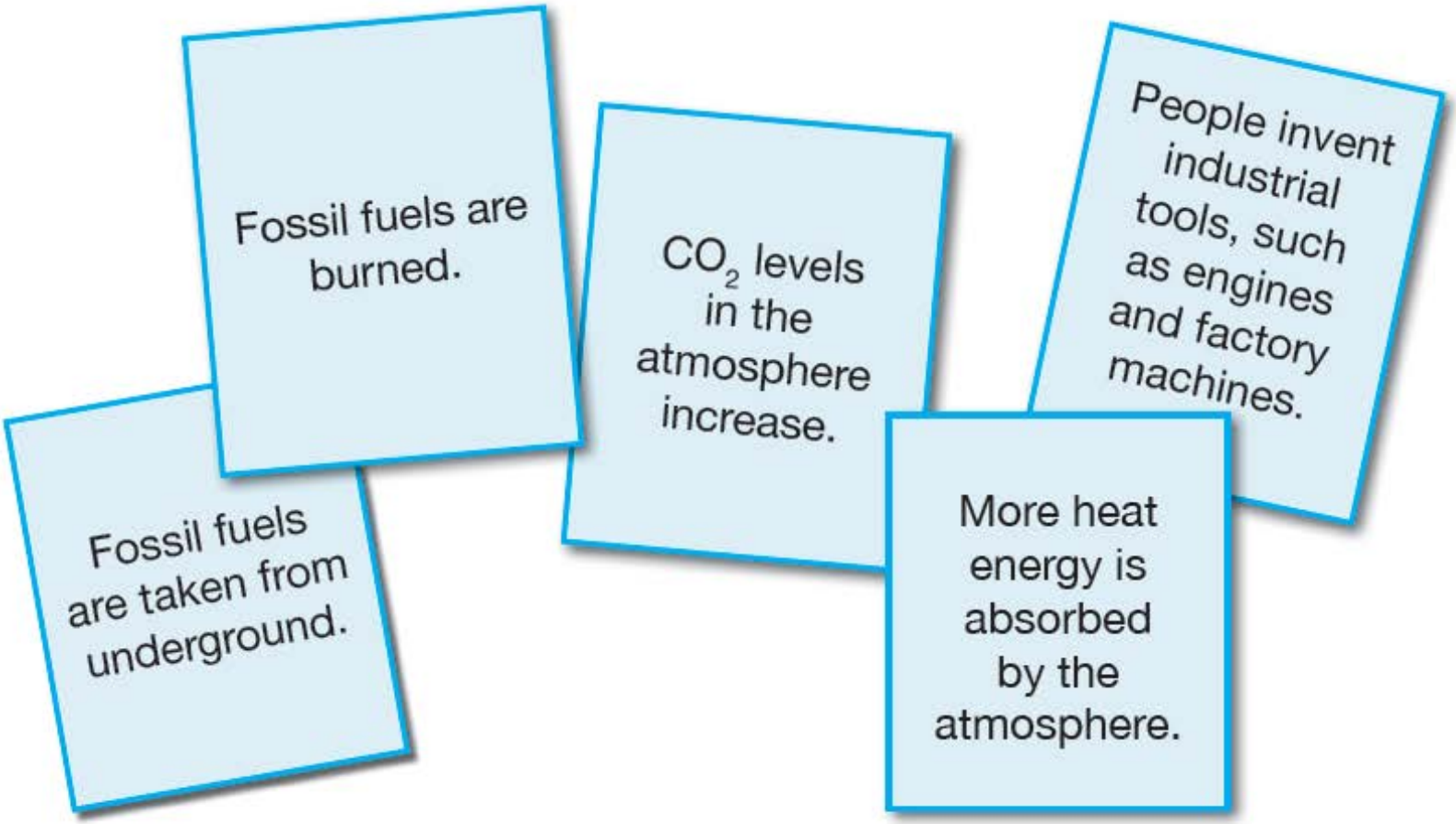
Minute Paper Revisited

- What is ocean acidification? Explain as best you can.
- Which concept(s) on the Climate Science Ideas chart may have to do with ocean acidification?
- Which organisms do you think might be affected by ocean acidification, and how?

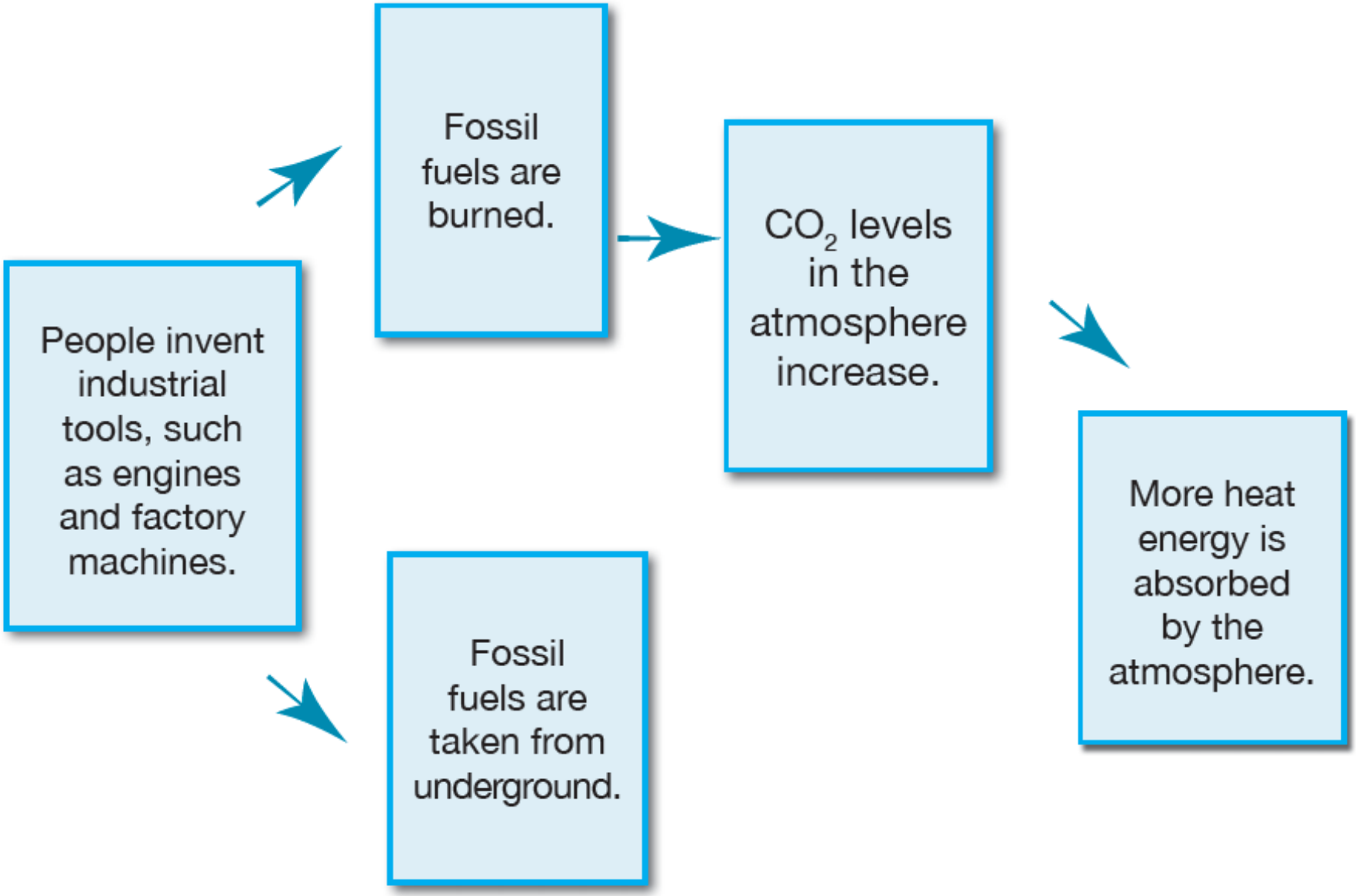
Section E. Ocean Acidification: Cause and Effect Flow Chart

Make a Flow Chart

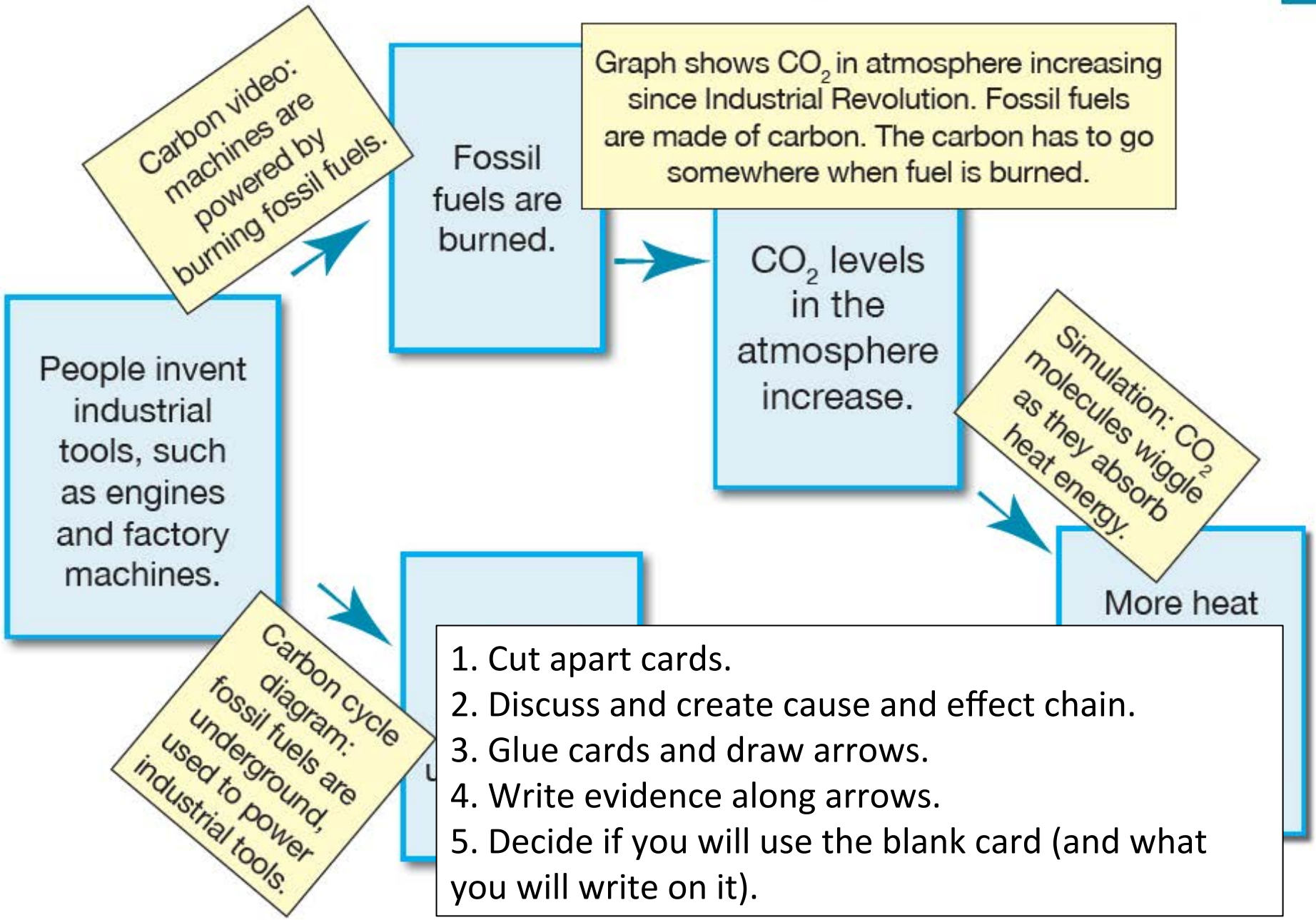
How could you make a cause and effect flow chart with these cards?



Flow Chart Example



Flow Chart with Evidence



1. Cut apart cards.
2. Discuss and create cause and effect chain.
3. Glue cards and draw arrows.
4. Write evidence along arrows.
5. Decide if you will use the blank card (and what you will write on it).

Key concepts

- Ocean acidification is caused by _____.
- The effects of ocean acidification include _____.

Section F. Solving Local Environmental Challenges: Ocean Acidification

Background: Effects of Ocean Acidification and Oysters

- Read:
  - Background section of handout
  - First page of "Like Putting Headlights on a Car"
- Create a written list of the challenges faced by the shellfish industry

Ocean Acidification's Impact on Oysters and Other Shellfish

Supplement Your OA Flowchart

- Using content from the video, reading and any prior content from the course, add to your "Cause and Effect" flowchart.

  What are the downstream effects of elevated CO_2 on:

  - ocean pH?
  - oyster larvae?
  - adult oysters?
  - the people who rely on the oyster industry for income and livelihood?

Designing a solution to the problem facing oyster growers…

Imagine you are an oyster grower in the Pacific Northwest, with many families, employees, restaurants and seafood distributors that depend on you for oysters and livelihood. In order to maintain production of healthy oyster larvae, you need to pump fresh ocean water into your hatchery daily until they reach a size when they are less vulnerable to changing environmental conditions (approximately 2 weeks). However, if you pump ocean water into your hatchery that is too low in pH, millions of oyster larvae might die and shellfish growers will be left without oyster seed."

Making it locally relevant…

- What are some of the local, ocean-based industries in your area? If you don't have any local ones, what are some ocean-based industries overall?

- Which of these might be impacted by ocean acidification?

- If not ocean acidification, are there other changes in the oceans related to pH, water quality or climate that would have an impact on these industries?

Comparing Solutions

1. What are some of the solutions that oyster growers implemented to deal with low pH waters in the Pacific Northwest? Were these similar to the solutions your group proposed?

2. What ocean observing technologies were used to assist in the solution described in the NOAA article?

3. This exercise has focused on oysters in the Pacific Northwest. Based on your own ideas and the PBS video, what other coastal industries are potentially affected by ocean acidification?

Reflecting on practice and learning

- How can learning be improved by students thinking about solutions to local problems?
- What are the advantages and/or challenges of using examples that are potentially geographically distant from the learners (e.g. oysters in the Pacific Northwest)?
- What are the advantages and/or challenges of using more local examples?

Section G. Pair-Share: Big chart of crosscutting concepts

Partner Share: Cause and Effect

- How did the instructor(s) use the crosscutting concept of Cause and Effect to support your understanding of ocean acidification?
- How did you, as learners, use the crosscutting concept?

Homework

- **Read Analyzing and Interpreting Data** in *NGSS Appendix F (p. 9)* and in *A Framework for K-12 Science Education (pp. 51 & 61-63).*
- **Work on completing the data components of the Final Project.**
  - Complete Part 4 of the "Data Components of Final Project" worksheet.
  - Print out a version of the data visualization that students will use in the activity and bring it to the next class session.
- **Develop first draft of Final Project.**
  - Work with your partner to develop your draft Final Project.
  - Your draft should include each section of the write-up: Introduction, Science Content Overview, Data Components, and Learning Cycle. Bring the draft to the next class session and be prepared to share and receive feedback from instructor and peers.