Using Evidence and Reasoning, and Tracking Carbon

Session 7

Session Goals

- **Climate Science Ideas**: Most organisms get energy and matter from molecules that contain carbon, and release CO2 as the molecules are broken down. Carbon flows from one carbon reservoir to another in the carbon cycle.
- **Using Data**: Use a model as well as professionally-collected and graphed data sources to interpret patterns in atmospheric CO_2 concentrations. Practice orientation, interpretation, and synthesis skills. Explore why we use proxies in science and how to observe the overall pattern in the data through the variability.
- **Teaching & Learning**: Engage in effective strategies designed to explore multiple ideas and encourage discussion.
- **Framework/ NGSS**: Engage in arguing from evidence as described in the Framework for K–12 Science Education.

Session 2.2

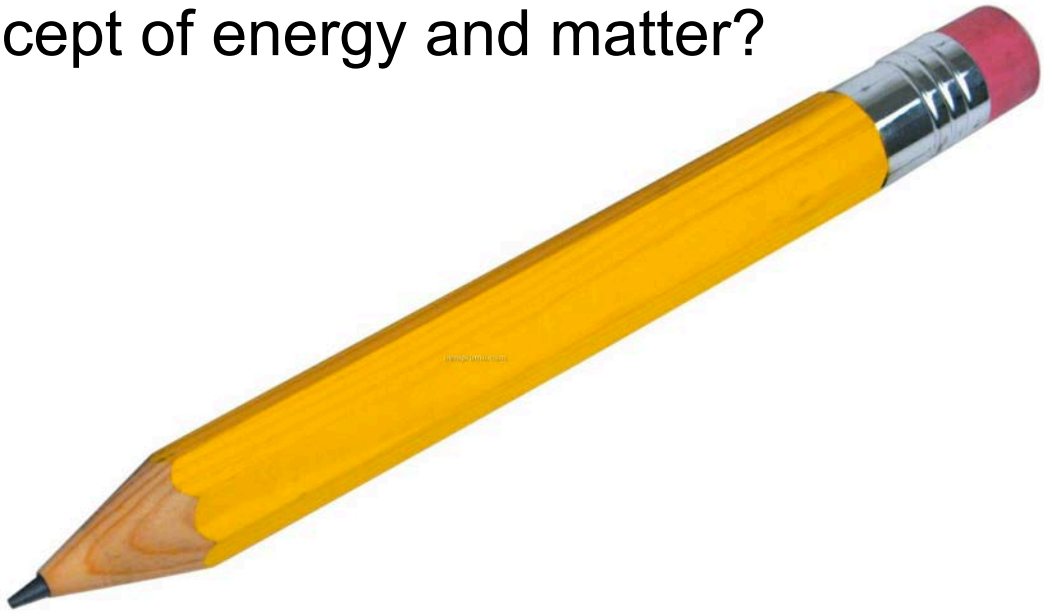
Tracking Carbon... through Respiration

Turn and Talk

- What are other processes involved in atmospheric CO_2 cycling besides fossil fuel combustion?
- What does carbon and the carbon cycle have to do with climate change?
- How might you relate what we have learned so far about the ocean-atmosphere connection to this new focus on the carbon cycle?

Quick Write

- What do you already know about respiration and photosynthesis?
- How might you explain these two processes in terms of the crosscutting concept of energy and matter?



It's All About Carbon

- Carbon reservoirs - definition
- Carbon cards - exploration

- Carbon video
  - As you watch the video, jot down questions or ideas
  - After the video, do a Turn & Talk

Where is the carbon in the Sydney Harbor ecosystem?

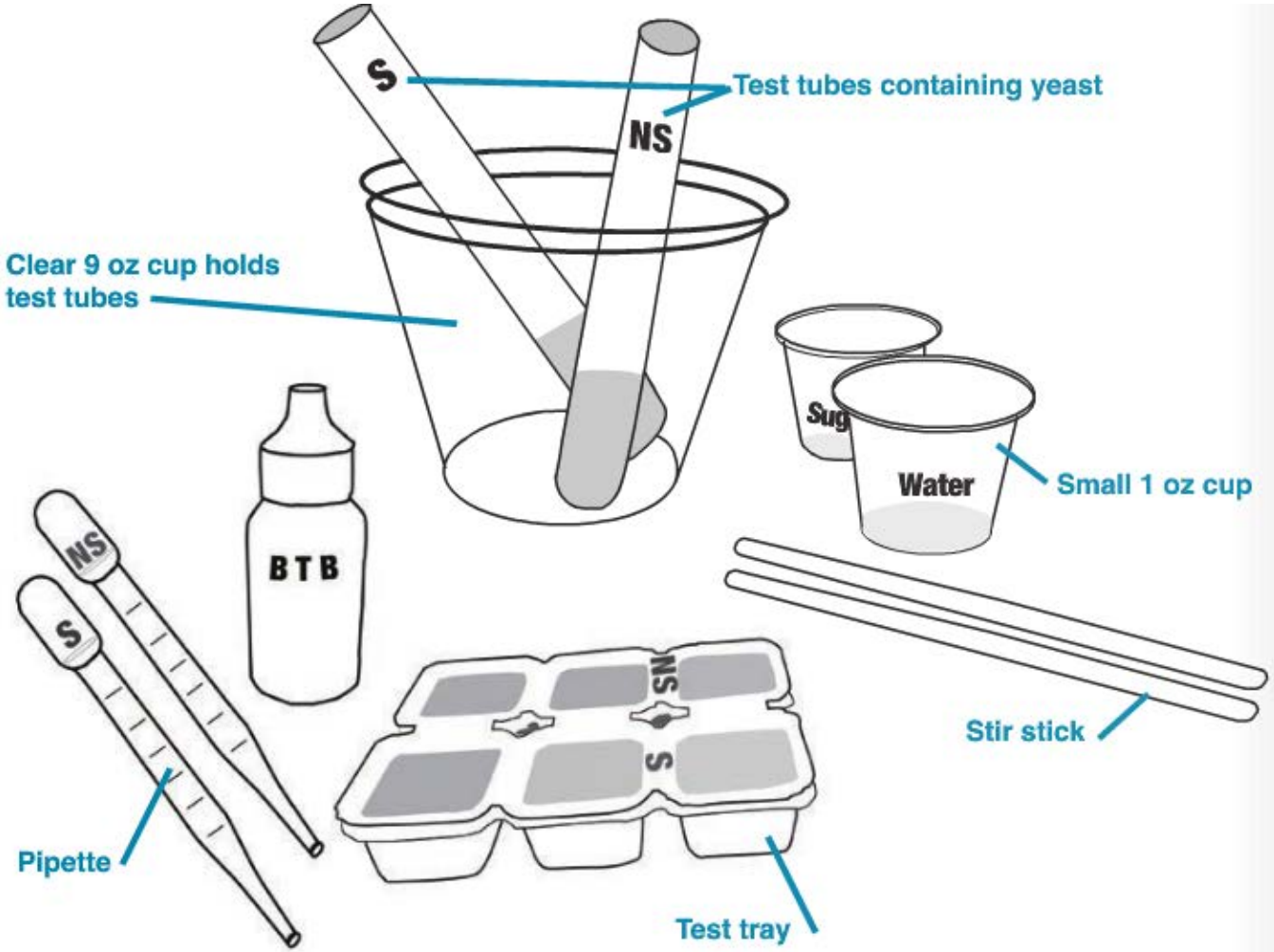
1. Draw a quick sketch of what you see.
2. Label carbon reservoirs & carbon flows.
3. Record questions.

Guiding Question:

How do organisms use carbon?

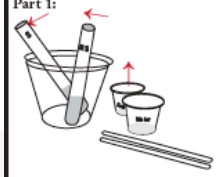
Yeast Investigations

What does eating have to do with producing carbon dioxide?



Yeast Investigation

Part 1:



1. Get a tray that holds materials for two pairs. Share the materials.
2. Carefully add the sugar water to the yeast in the "S" test tube. Stir with one stir stick, and place the test tube back into the cup.
3. Carefully add the plain water to the yeast in the "NS" test tube. Stir with the other stir stick, and place the test tube back into the cup.
4. Observe the test tubes for the next 10 minutes and record your observations.

A. Describe how each test tube looks at the beginning.

B. What is the first change you notice?

C. What is the next change? Draw what you see.

D. Describe what you notice when the 10 minutes is almost up.

Yeast Investigation (continued)

Part 2:

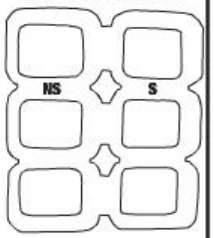
1. Notice that the test tray has three cups for sugar and three for no sugar.
2. Fill the "S" pipette from the "S" test tube. Deposit the sugar-yeast mixture into one of the cups on the "S" side of the test tray. Repeat twice to put yeast into the other two "S" cups.
3. Fill the "NS" pipette from the "NS" test tube. Deposit the yeast mixture into one of the cups on the "NS" side of the test tray. Repeat twice.
4. Squeeze 8 drops of BTB into each test-tray cup.
5. Observe any color changes; match to color key.

Color Key: Testing for Carbon Dioxide with BTB:

Blue = no carbon dioxide	Green = some carbon dioxide	Yellow = lots of carbon dioxide

Describe your results.

Draw and label your results.



What evidence did you gather to help answer the question, What does eating have to do with producing CO_2?

Yeast Investigation, Part 1

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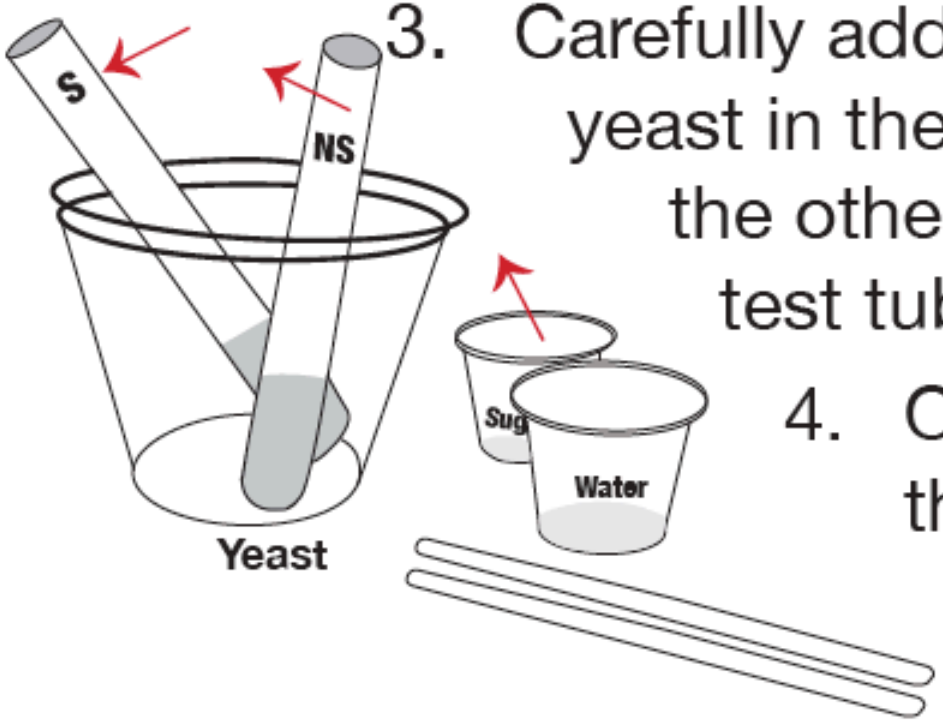
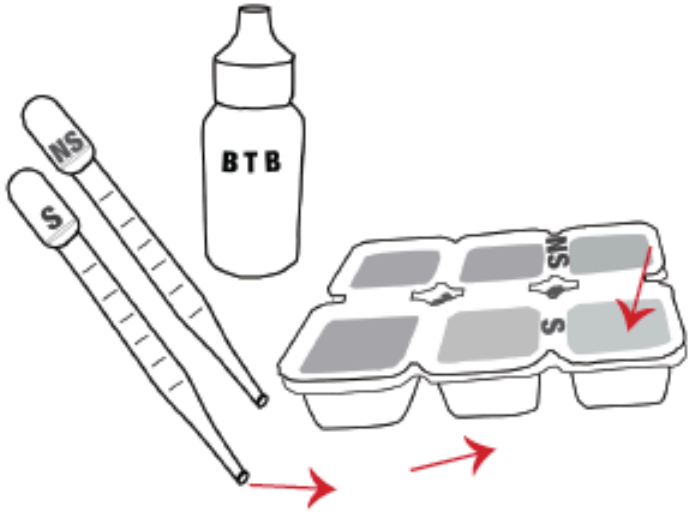


Yeast Investigation, Part 2



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4. Squeeze 8 drops of BTB into each test-tray cup.
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A few things before starting the investigation…

- What is BTB?
  - Bromothymol blue, a chemical that turns green or yellow when it's mixed with an acid. In water, CO_2 makes an acid called carbonic acid, so if the BTB turns color, that is evidence there may be CO_2 present.
- Why do we need to use a **proxy**?
  - a measured parameter used to estimate or predict another parameter that cannot be measured or quantified directly
  - We can't accurately measure the *amount* of CO_2 in the water, but BTB can be used as a proxy to indicate the presence or absence of CO_2.

A few more things before starting the investigation

- What about a control?
  - How does BTB react in *plain water without yeast*? (control)
  - How does BTB react in *sugar water without yeast*? (control)
  - How does BTB react in *water WITH yeast?* (treatment)
  - the controls will help us observe the effect of increasing the amount of carbonic acid in the water, due to CO_2 being released by the yeast.
  - Comparing the difference in BTB reactions (color) between the treatment and controls shows what happens when yeast is added.

Yeast Investigation, Part 1

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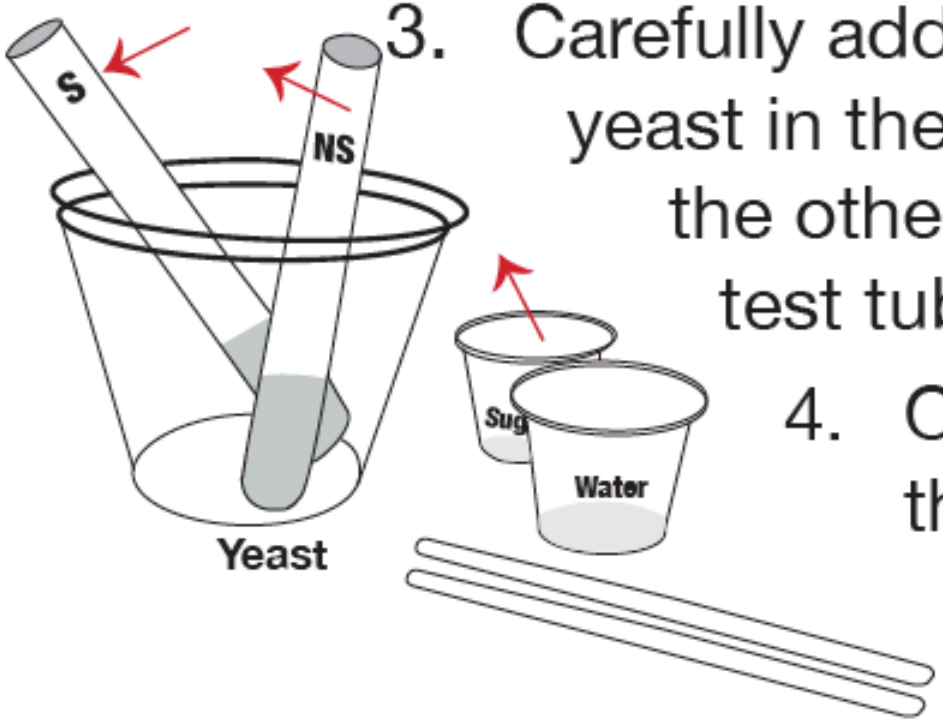

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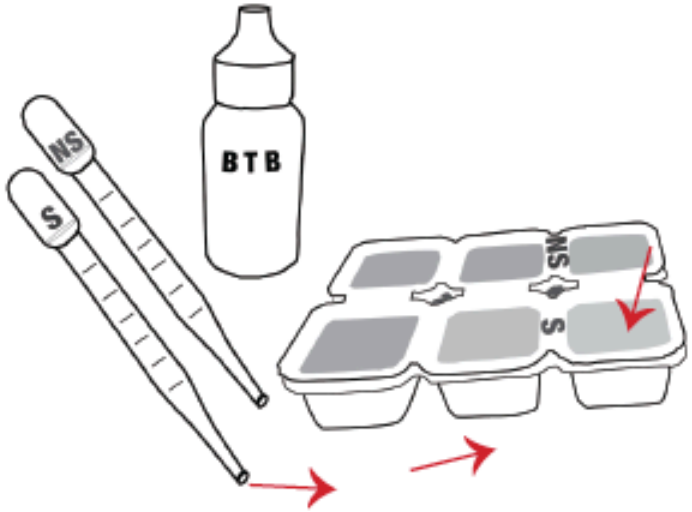

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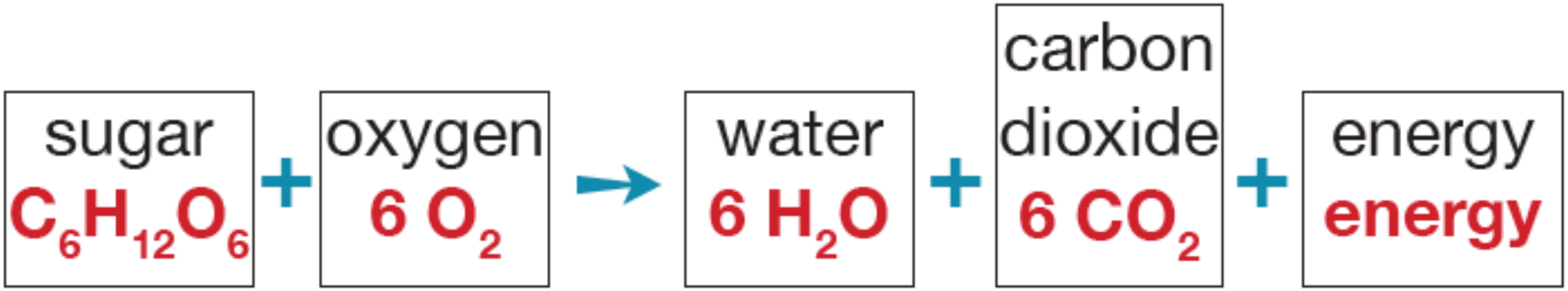
Making sense of yeast investigations

- Sharing observations
- What is your evidence that the tube with sugar was producing CO_2?
- Did you find similar results each time you tested the yeast?
- Where do you think the CO_2 came from? Why do you think that?

What does eating have to do with producing (breathing out) CO_2?

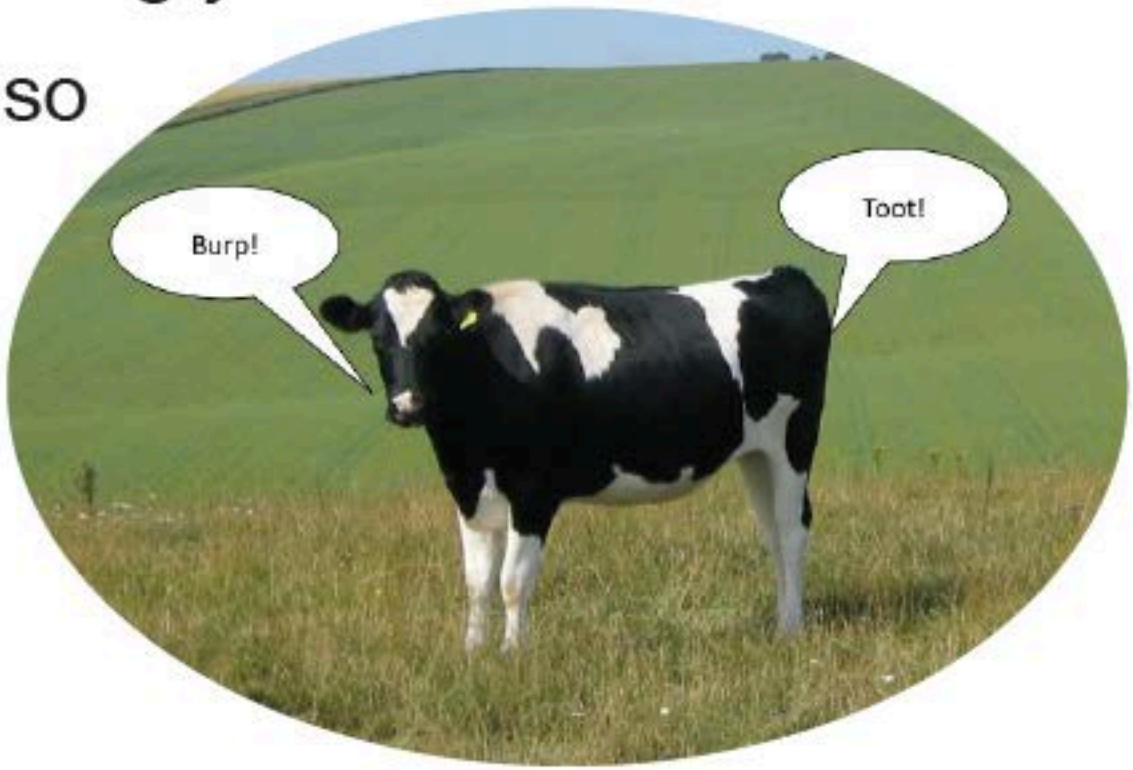
Respiration: the whole process of organisms breaking down carbon containing molecules, such as sugar, for energy and for building bodies, and releasing some of the carbon as CO_2 by breathing it out into the atmosphere.

Carbon In/Carbon Out for **Respiration**



Releasing Carbon Dioxide and Methane Gas

- The carbon in the carbon dioxide gas you are breathing out comes from solid carbon, which is found in everything you eat.
- Some animals also release carbon as methane gas (CH_4). Some release a lot more CH_4 than others.



Key Concept

2.2

Most organisms get energy and materials to build their bodies from molecules that contain carbon. They break down these molecules and release carbon dioxide gas. This is respiration.

In water, carbon dioxide makes an acid called carbonic acid, so if the BTB (an acid indicator) turns green or yellow, that is evidence that the water is becoming more acidic and that there may be carbon dioxide present.

Climate Science Ideas Chart – Turn & Talk

- What do the key concepts have to do with climate change?

Session 2.3

Tracking Carbon through Photosynthesis, Part 1

BTB Changes

water + BTB

water + BTB + CO_2

water + BTB + CO_2 + plant + sunlight

1. *Why do you think the BTB changed back to blue after the plant and sunlight were added?*
2. *What have you heard about photosynthesis?*

Plants and other photosynthetic organisms take in CO_2 and give off O_2 during photosynthesis.

Scientific Evidence

- Evidence can come from our own investigations.
- Evidence can come from other people's investigations.
- Why the evidence supports the claim needs to be made clear with reasoning.
- Scientific explanations are based on evidence and reasoning to answer a question.

Where does most of the matter in plants come from?

Three Common Answers

Most of the matter in plants comes from

- ⊗ a. the soil.
- ⊗ b. the water.
- ⊗ c. the air.

Where does most of the mass (new plant material) of a new plant come from?

Carlos

Its mass comes from the soil.

Its mass comes from the air.

Michael

Its mass comes from the water it takes in through the roots.

Its mass comes from the sunlight.

Susie

Keshawn

Questions to discuss:

1) What would you say to each of these kids about their solution to the problem?
2) Do you agree with any of the kids? If so, who? Why?
3) What question would you ask each student about their answer? Why?

Using Plant Evidence to make explanations supported by evidence and reasoning

1. Work in a group of 3 to read 3 investigations in envelope; each person will read one investigation aloud.
2. The group will discuss how the investigation's results supports or does not support each of the three common answers.
3. The group needs to come to agreement before individuals fill in the table on their copy of *Evaluate the Evidence: The Source of Most Matter in Plant Structures.*
   - write "yes" in the column if the evidence supports that answer, "no" if it does not support the answer, and "maybe" if the group is not sure
   - Discuss each answer using 'If__, then____, because_____.'

4. Start with Investigation B and go in order.

Investigation A:
An example & class discussion

"In the 1600's, Jan Baptista van Helmont grew a tree in a pot for five years. He measured the weight of the plant and the weight of the dry soil at the beginning and the end of the five-year period. He kept the soil covered so nothing else could get in. He watered the soil regularly. He found that the tree gained 74 kilograms (164 pounds), but the dry soil weighed only .05 kg (2 ounces or 1/8 of a pound) less at the end."

If most of the matter came from soil, then the amount of soil should be much reduced. However, soil decreased only slightly, so the evidence doesn't support that most matter comes from soil. Also since water was added throughout the experiment while the plant was exposed to the atmosphere, we can't tell whether the matter came from the water or the atmosphere. Therefore, maybe the matter came from both the water and the atmosphere.

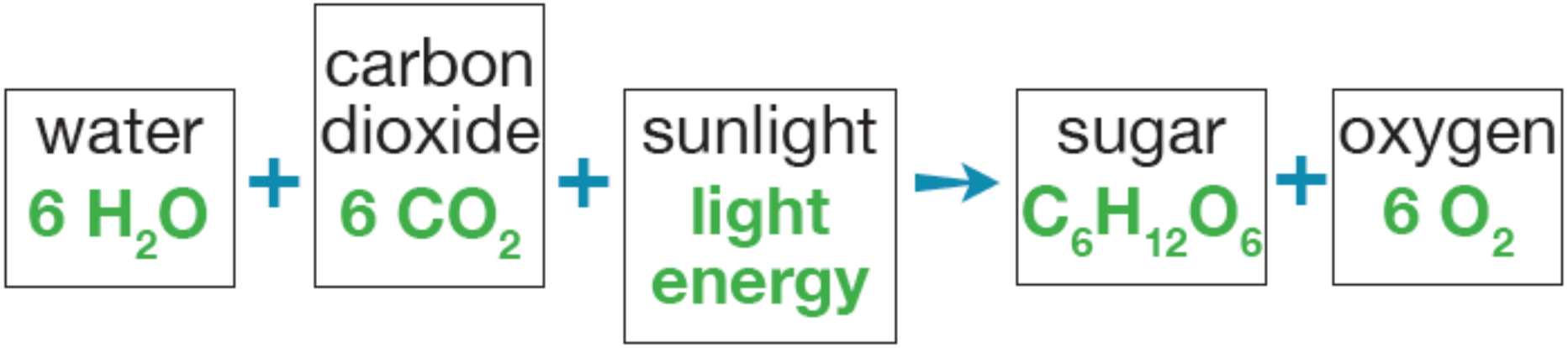
Using Plant Evidence to make explanations supported by evidence and reasoning

1. Work in a group of 3 to read 3 investigations in envelope; each person will read one investigation aloud
2. The group will discuss how the investigation's results supports or does not support each of the three common answers.
3. The group needs to come to agreement before individuals fill in the table on their own, *Evaluate the Evidence: The Source of Most Matter in Plant Structures*
   - write "yes" in the column if the evidence supports that answer, "no" if it does not support the answer, and "maybe" if the group is not sure
   - Discuss each answer using 'If__, then____, because_____.'
4. Start with Investigation B and go in order.

Discuss answers, evidence & reasoning with whole group

- **Answer 1: “Most of the matter in plants comes from the soil.”**
- **Answer 2: “Most of the matter in plants comes from the water.”**
- **Answer 3: “Most of the matter in plants comes from the air.”**

Carbon In/Carbon Out for Photosynthesis



Gathering more evidence

- Use the active reading strategy as you read *Researching Photosynthesis*.
- After reading, pair up with someone and discuss your questions and the following two prompts focusing in on the equation for photosynthesis as shown in the reading.

  - Where could the oxygen (O) in the sugar have come from?
  - Where could the carbon (C) in the sugar could have come from?
  - Is there enough evidence to support one of the answers (water or air) over another? If yes, explain. If no, what more information would you need in order to have enough evidence to support one of the answers?

Gathering even more evidence

- Sit with a partner to read and discuss:
  - "*Following the Water in Photosynthesis*"

- What new evidence did you gather?

Claim, evidence, reasoning

- Discuss your claim, evidence and reasoning with a partner using
  - If___, then_____, because_____
- Be ready to share your explanation with the whole group.

Example:

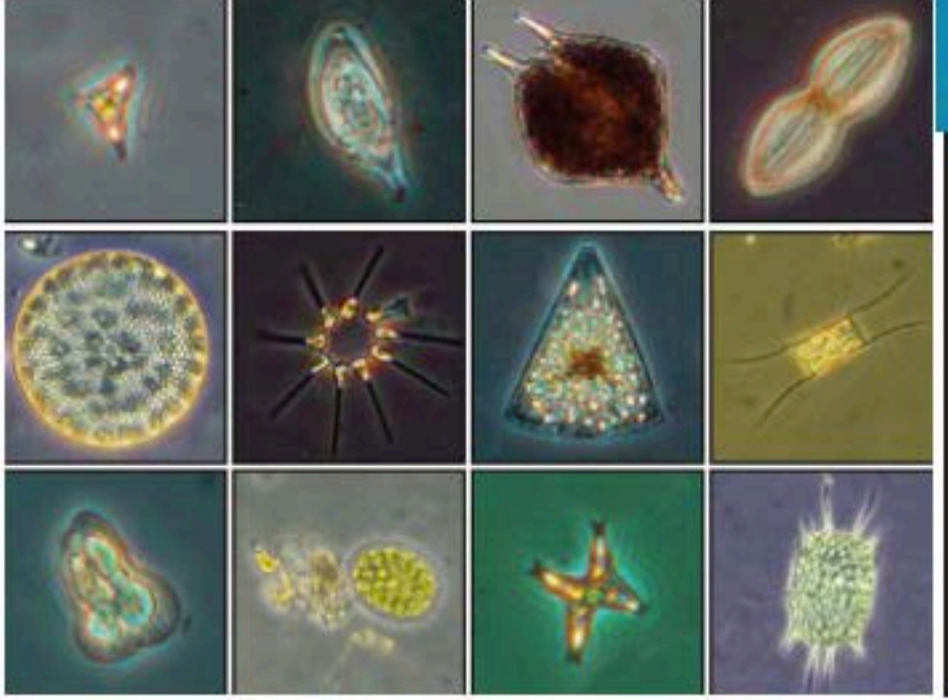
If most of the mass of a plant comes from CO_2 in the air, then sugar molecules which make up the mass of the plant structures would be made from C and O from CO_2 molecules, because according to the equation for photosynthesis, only CO_2 and H_2O plus sunlight are needed to make sugar molecules. Evidence to support this claim came from reading multiple scientific investigations.

Think Pair Share

- Thinking back on the Concept Cartoon strategy:
  - Did you find the strategy to be effective in helping to make sense of the concepts? If yes, in what ways was it effective? If no, why not?

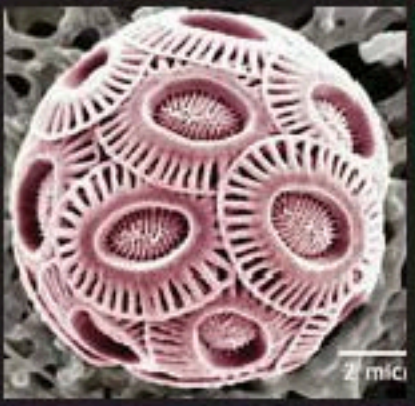
- Resources for strategies
  - Strategies to explore multiple ideas handout
  - Argumentation Toolkit http://www.argumentationtoolkit.org/index.html.

Photosynthetic Ocean Organisms



2.5

Ocean Organisms with Shells



Opposite Processes

Respiration (digestion, growing, moving):

Photosynthesis:

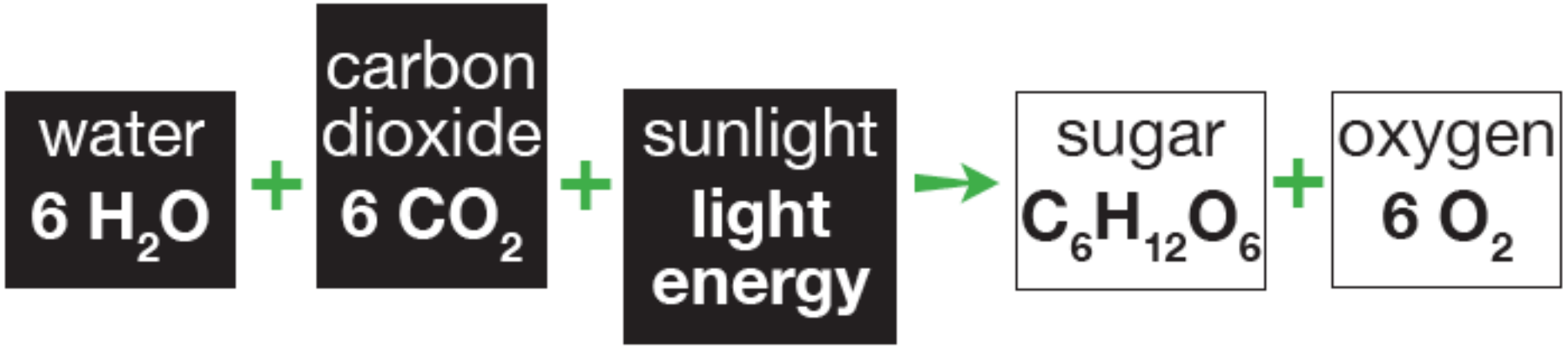
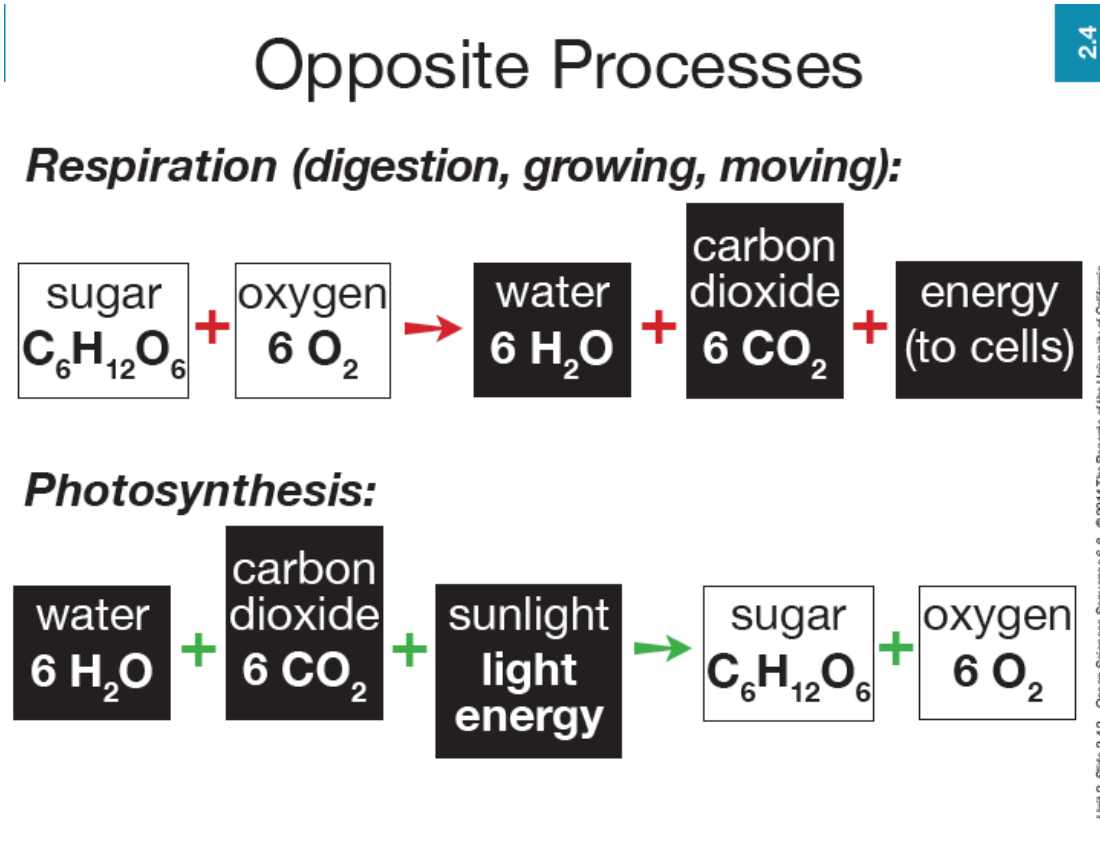
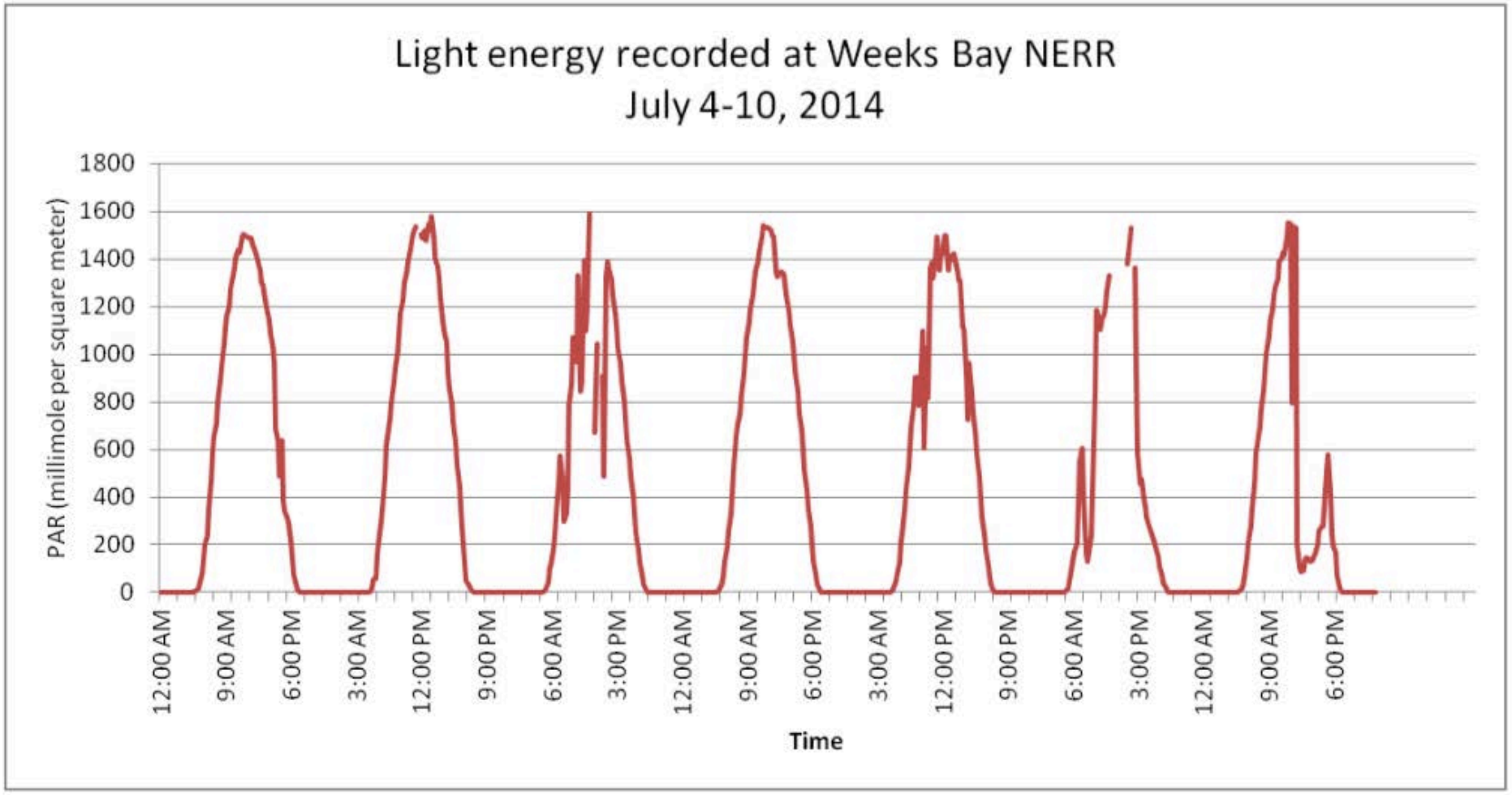


Table group discussion

1. What do you think will happen to oxygen concentrations when plants or phytoplankton are exposed to light energy?
2. Therefore, what do you think will happen to carbon dioxide concentrations when plants or phytoplankton are exposed to light energy?
3. At nighttime and in the absence of light, which of the following is the most dominant process – respiration or photosynthesis?
4. What happens to oxygen and carbon dioxide concentrations if the amount of respiration in a system is greater than the amount of photosynthesis?




Light energy recorded at Weeks Bay NERR
July 4-10, 2014
PAR (millimole per square meter)
1800
1600
1400
1200
1000
800
600
400
200
0
12:00 AM
9:00 AM
6:00 PM
3:00 AM
12:00 PM
9:00 PM
6:00 AM
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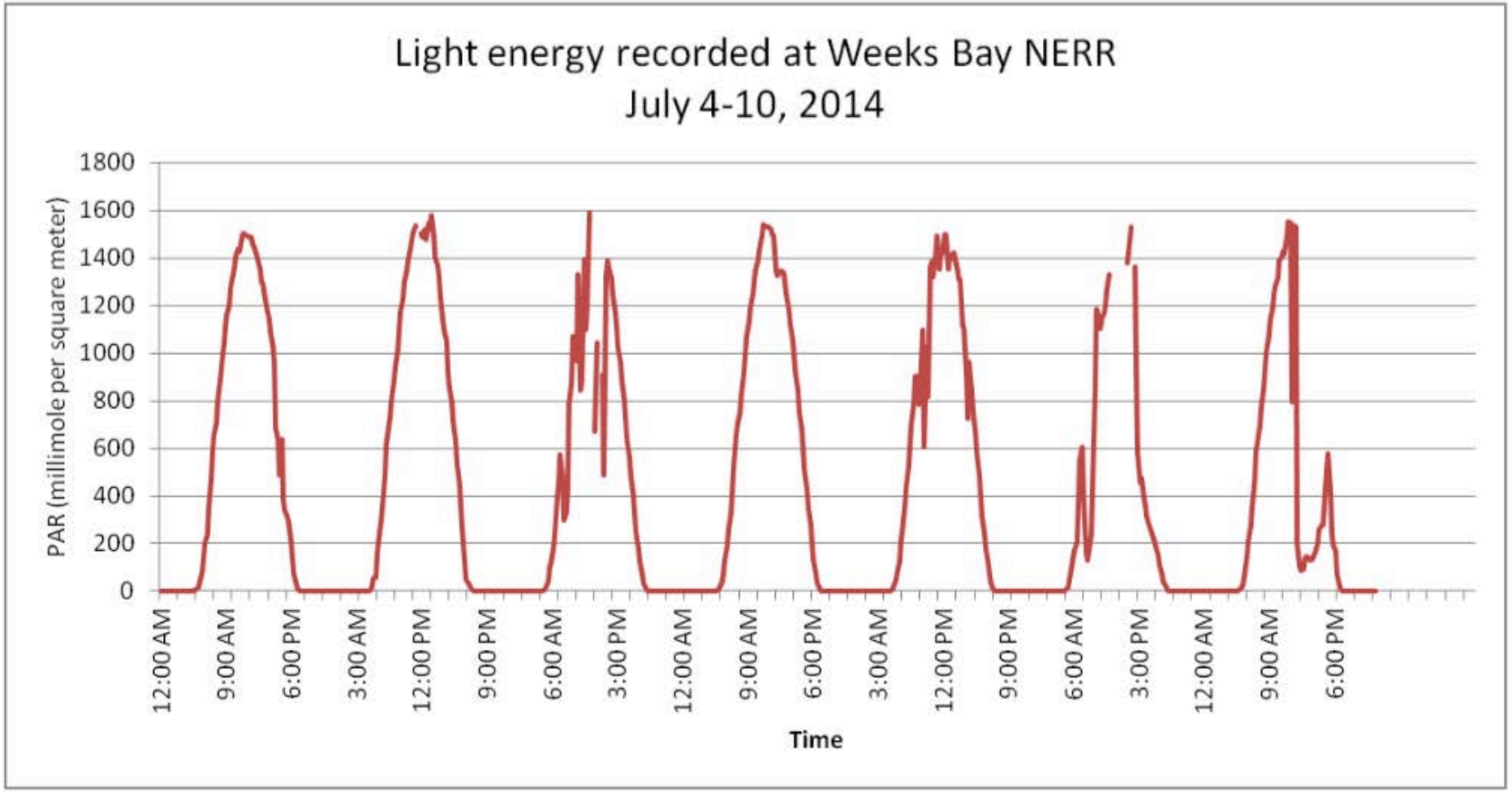
Time



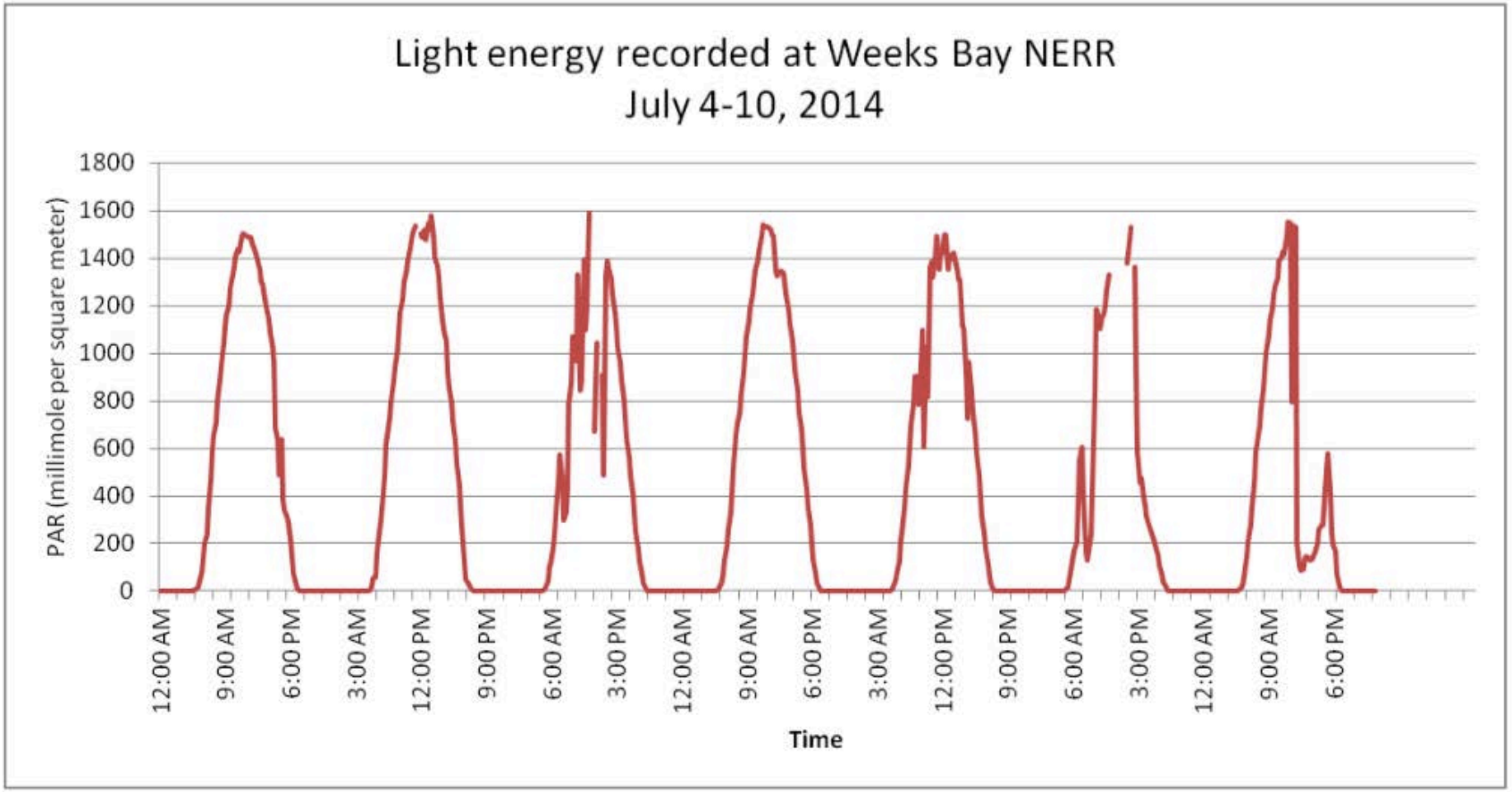
1. How many days do these data cover?
2. What time of day do you see the highest light intensity? The lowest?
3. How do you think the weather might have been different on Day 1 vs day 3? What is your evidence for this?
4. What do you notice about the data for Day 6? What do you think happened?

How much photosynthesis & respiration is taking place?

- Difficult to measure the cellular processes of respiration and photosynthesis directly – especially in the field
- Changes in the concentration of oxygen is often used as a proxy for photosynthesis and respiration.
  - Proxy - “A measured parameter used to estimate or predict another parameter that cannot be measured or quantified directly.”

To keep in mind as you make predictions about respiration and photosynthesis

- when the rate of photosynthesis is greater than the rate of respiration, the dissolved oxygen concentration in the water will increase;
- in the absence of light, the rate of respiration will exceed the rate of photosynthesis and dissolved oxygen concentrations will decrease.

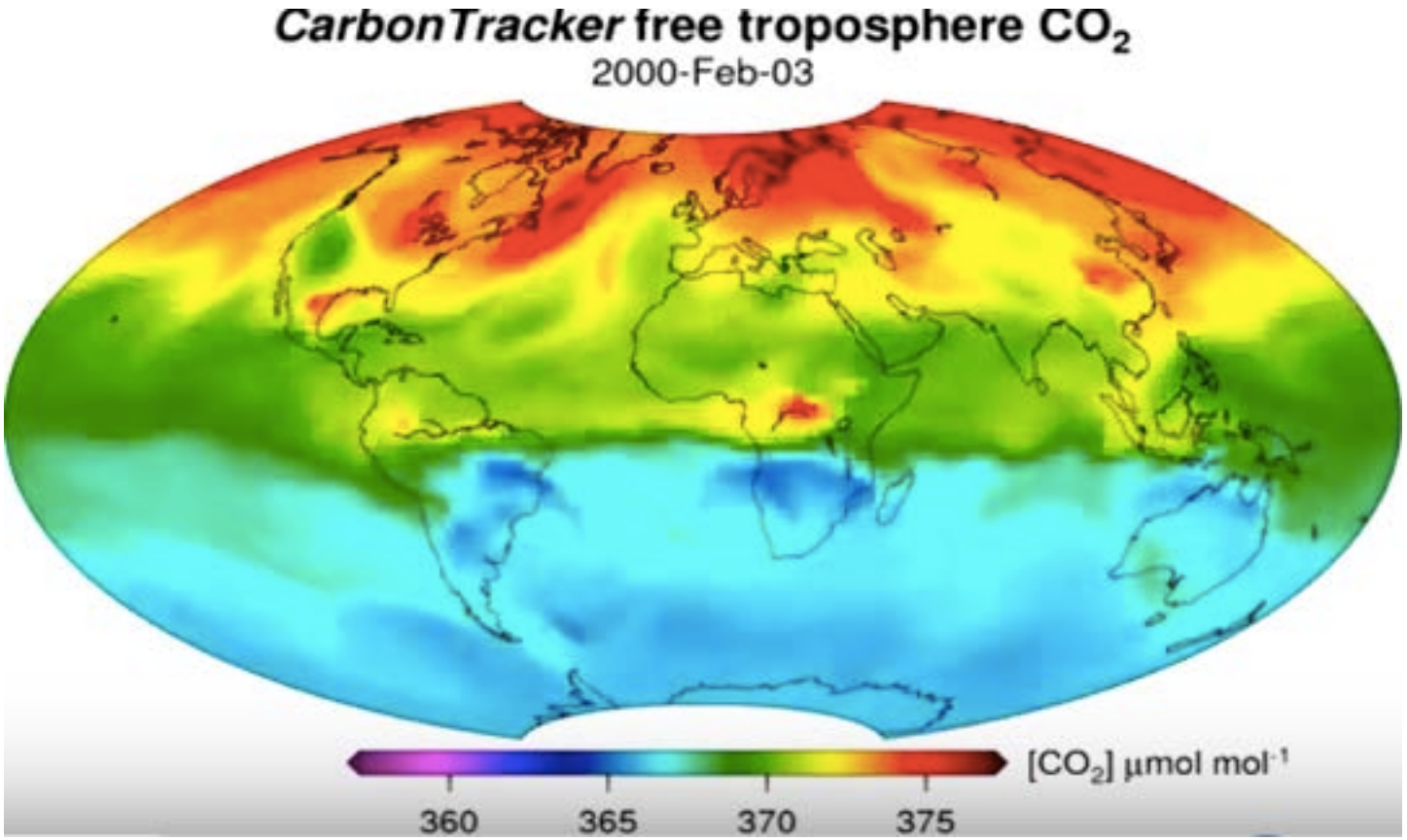


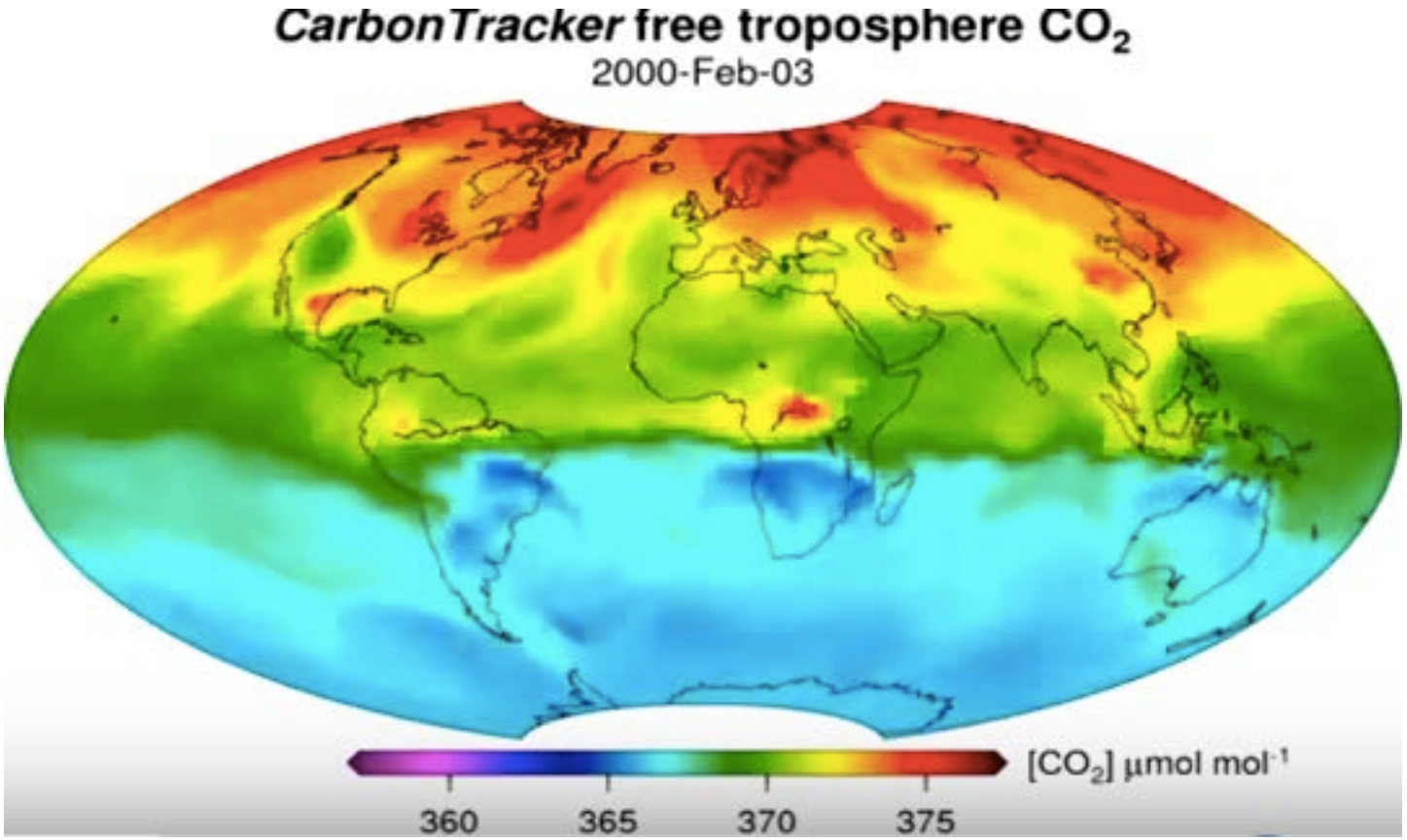
1. Thinking about the relationship between light energy, photosynthesis & phytoplankton in the water, what do you predict would happen to dissolved oxygen concentrations as light intensity increases?
2. Assuming plankton respiration is relatively constant throughout a 24 hour period, what would you predict would happen to dissolved oxygen concentrations at night in the water column?
3. What do you predict will happen to CO_2 concentrations between high light (day) and low light (night) periods?

Group discussion

- Given the changes in CO_2 you predicted between high light (day) and low light (night) periods, how would you expect atmospheric CO_2 concentrations to vary throughout the year? What makes you think that?
- If only natural processes were involved, what season would you expect to find the highest concentrations of CO_2 in the atmosphere? What is your evidence for that?
- What season would you find the lowest concentrations of CO_2 in the atmosphere? Why?

VISUALIZING GLOBAL SCALE CHANGES IN ATMOSPHERIC CO_2


CarbonTracker free troposphere CO2
2000-Feb-03
[CO2] µmol mol-1
360
365
370
375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360
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370
375

Synthesizing data– Explaining the patterns

- Use evidence or scientific concepts discussed in this session to explain the patterns shown on the carbon tracker.
  - Why do you think the amount of CO_2 in the atmosphere might change during a year?
  - What is different about summer and winter that could affect CO_2 in the atmosphere?

Spring and Summer

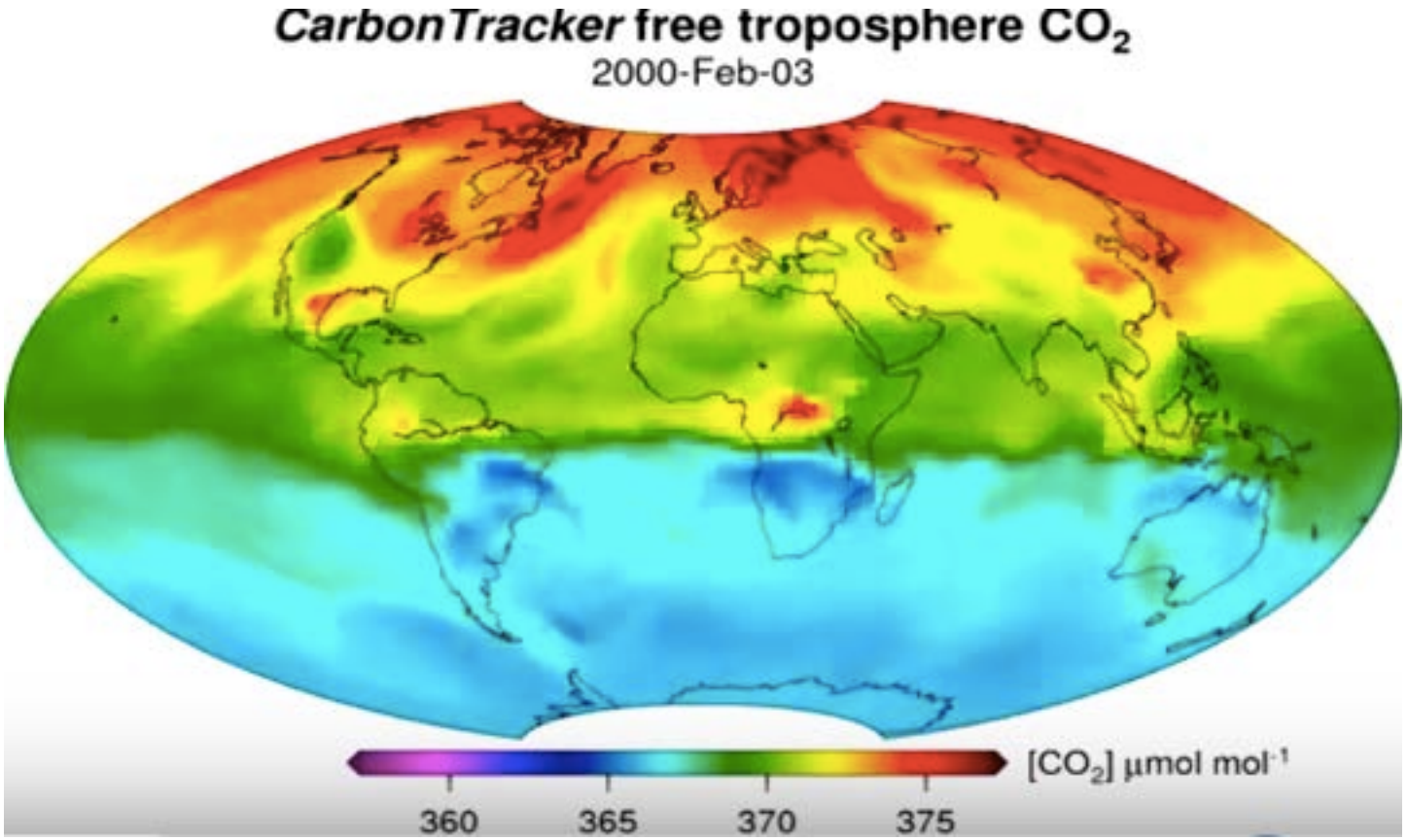
- ✔ a lot of sunlight
- ✔ plants have a lot of leaves
- ✔ a lot of photosynthesis is happening
- ✔ huge amounts of CO_2 from the atmosphere get absorbed
- ✔ CO_2 levels in the atmosphere go down

Fall and Winter

- ✔ less sunlight
- ✔ many plants are without leaves
- ✔ not as much photosynthesis is happening
- ✔ much less CO_2 from the atmosphere gets absorbed
- ✔ CO_2 levels in the atmosphere go up

Key Concept

During the growing season each year, plants take in huge amounts of CO_2 from Earth's atmosphere.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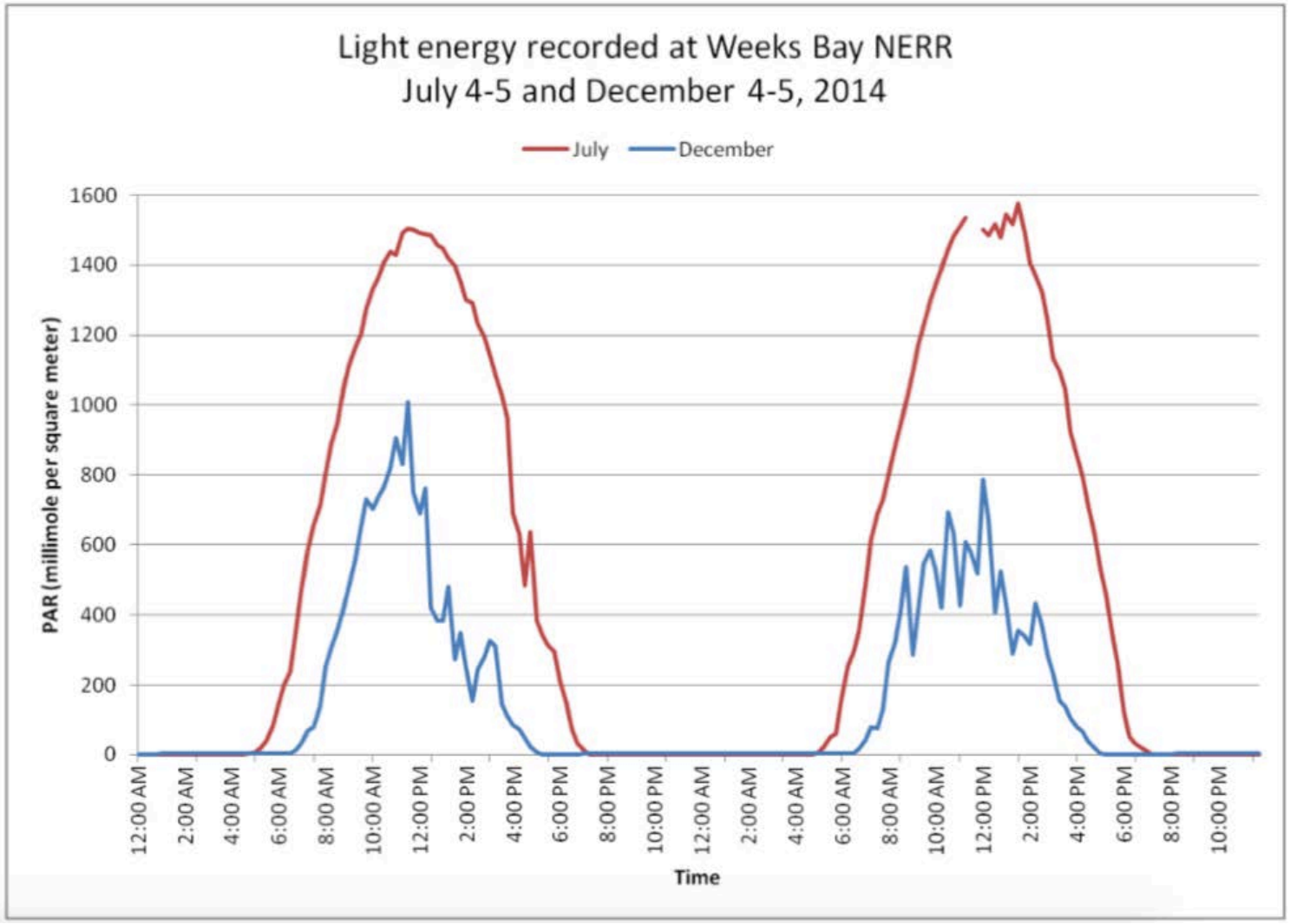
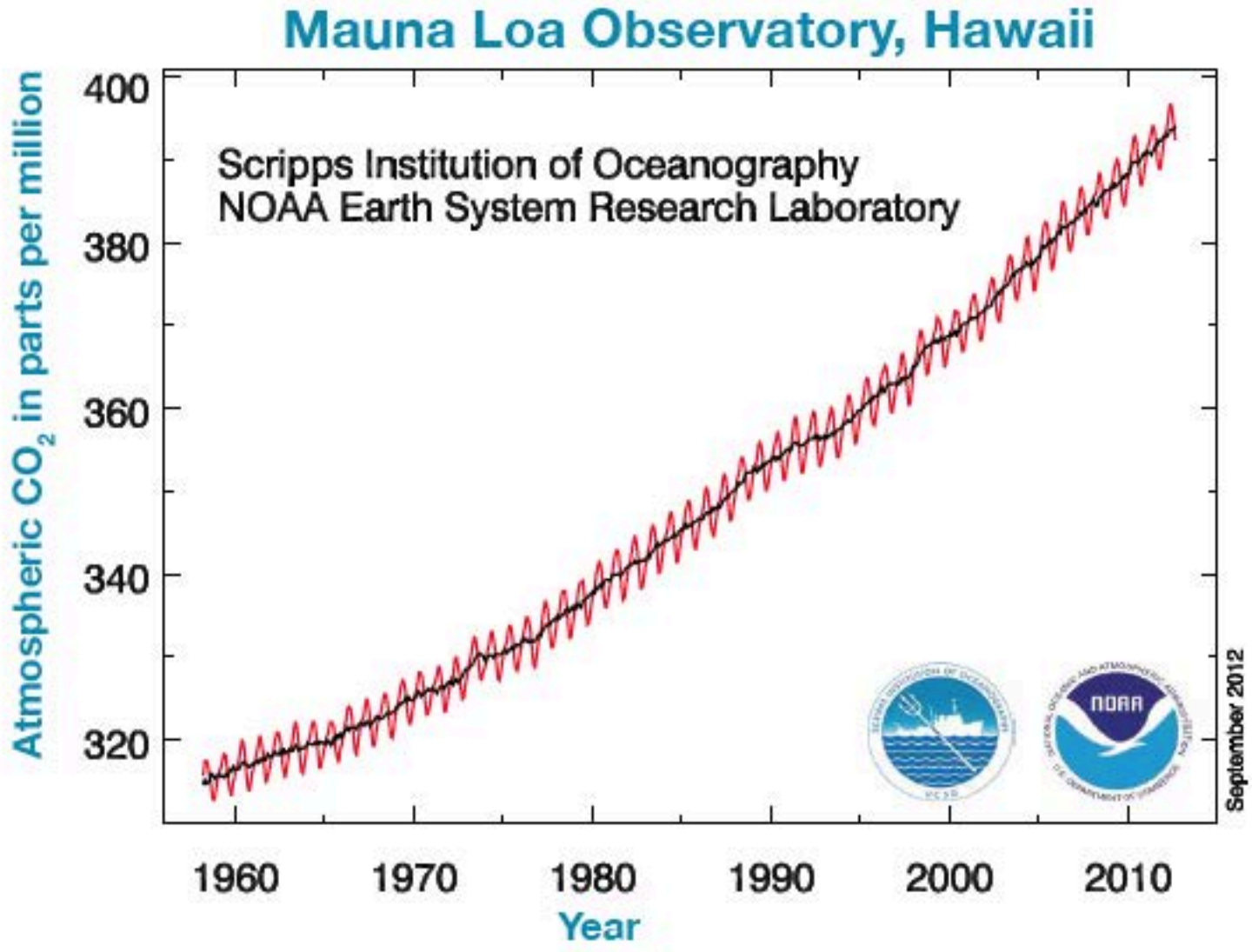


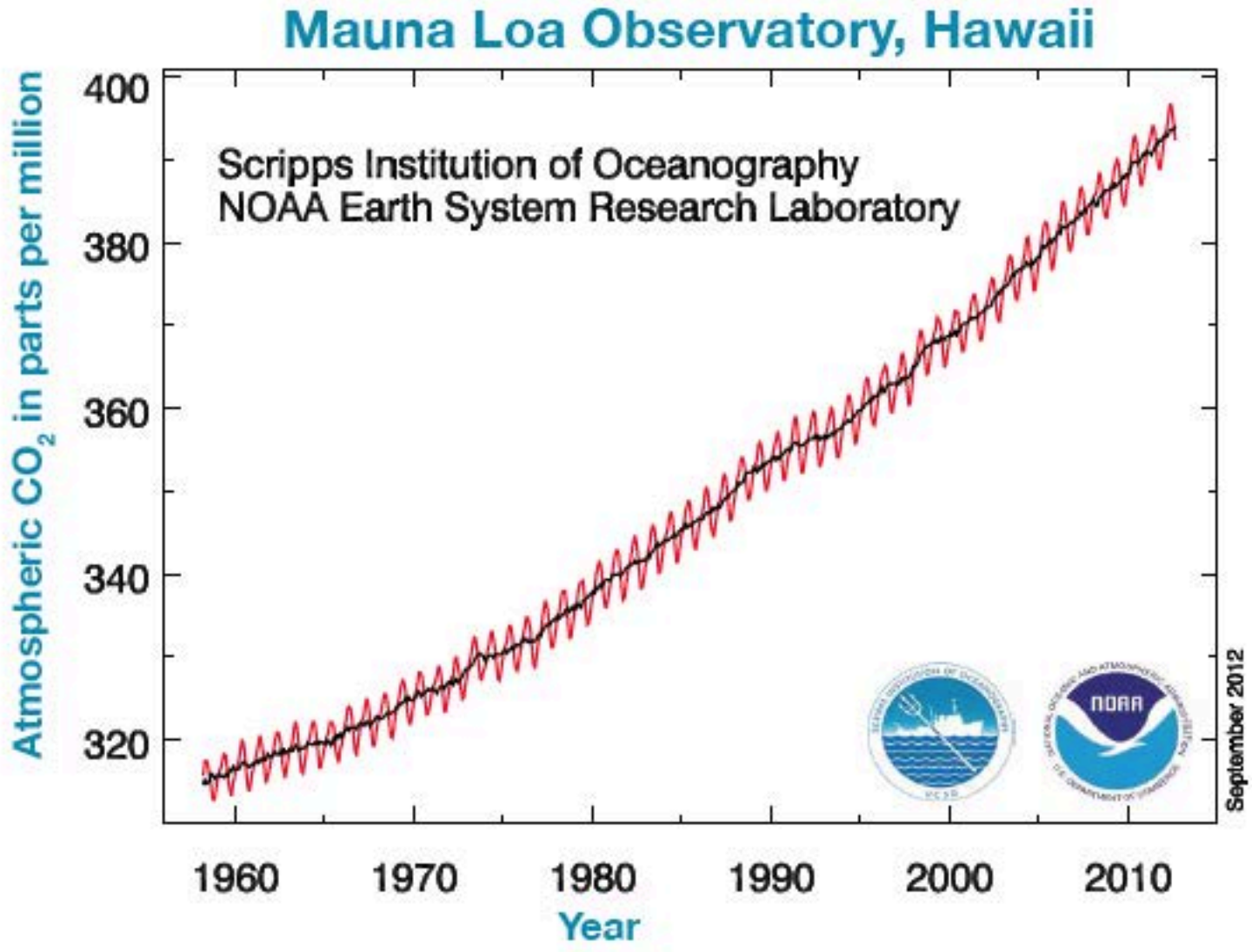
1. What do you notice about the difference in PAR?
2. How do you think the decrease in light availability will affect the rate of photosynthesis?
3. If rates of respiration remain relatively constant while the rate of photosynthesis decreases, what do you predict will happen to CO_2 concentrations?
4. During what season would you expect to see the highest concentrations of CO_2 in the water or atmosphere?
5. When would carbon dioxide be the lowest?

INTERPRETING DATA: CARBON LEVELS OVER MANY YEARS

Keeling Curve: CO_2 Levels in the Atmosphere



Keeling Curve: CO_2 Levels in the Atmosphere



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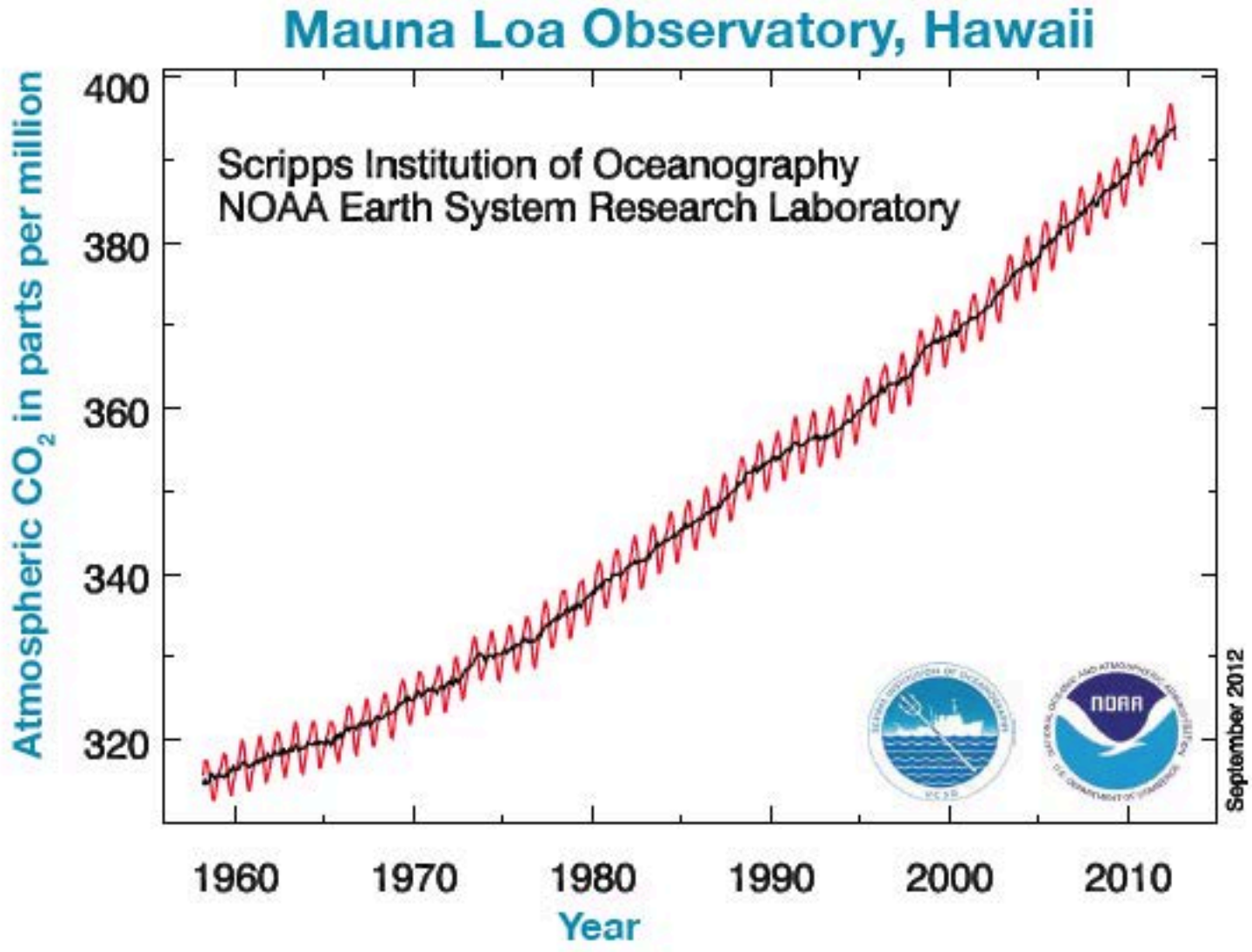
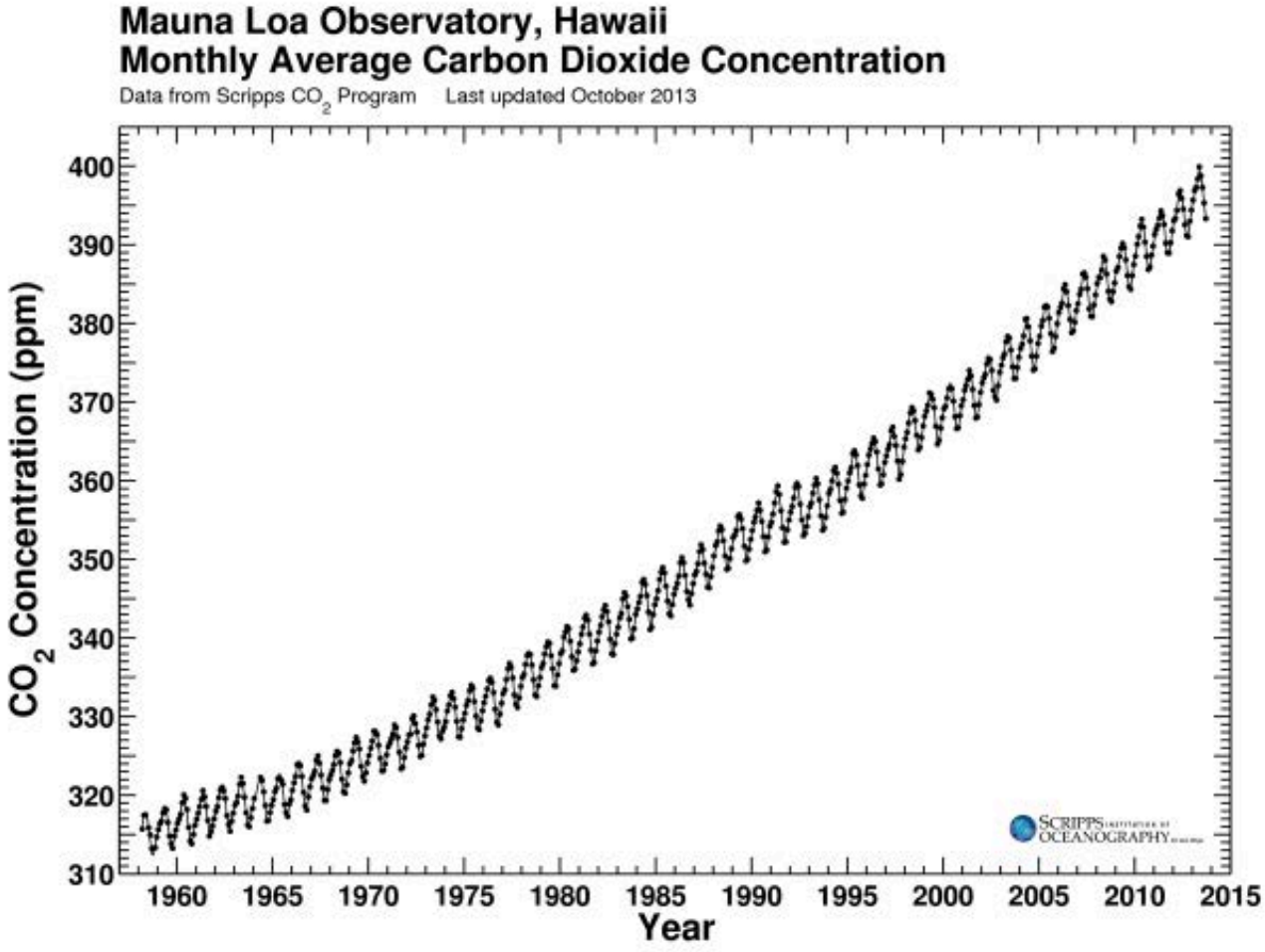
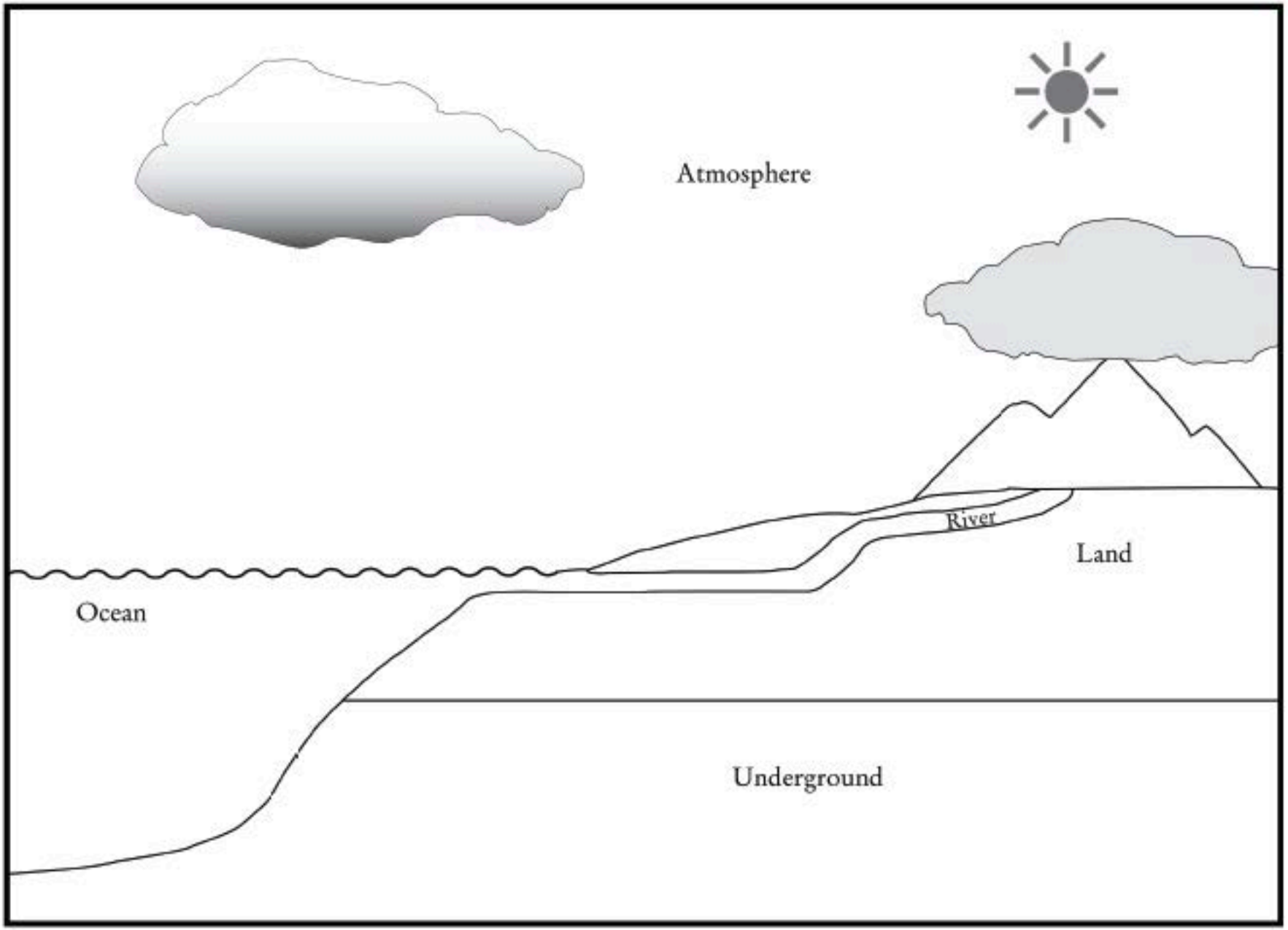



Mauna Loa Observatory, Hawaii
Monthly Average Carbon Dioxide Concentration
Data from Scripps CO2 Program Last updated October 2013
CO2 Concentration (ppm)
400
390
380
370
360
350
340
330
320
310
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
SCRIPPS INSTITUTION OF OCEANOGRAPHY

Carbon Cycle Diagram



Turn & Talk

- Choose one arrow on your diagram that goes from a plant to an animal. Explain how the carbon (matter) moves between these two reservoirs.
- Follow arrows on your diagram that show how carbon could move from an animal, to the atmosphere, and then to a plant. Explain how the carbon (matter) moves between these three reservoirs.
- Show how carbon could flow from the reservoir of a land plant into the reservoir of the ocean.

Reflection Quick Write

- What are other processes involved in atmospheric CO_2 cycling besides fossil fuel combustion?
- What do you already know about respiration and photosynthesis?
- How might you explain these two processes in terms of the crosscutting concept of energy and matter?

- Draw a line of learning under your original response and add new info and details under the line:
  - explaining these concepts in terms of the crosscutting concepts of energy and matter.
  - including which of their questions were they able to answer about carbon, carbon flows and reservoirs, what questions they still have, and how they might find the answers to their questions.

Revisit Big Charts of SEPs

- Constructing explanations:
  - what did the instructor do, say or ask to support the construction of explanations?
  - how did they engage as learners with constructing explanations?

- Arguing from evidence:
  - what did the instructor do, say or ask to support arguing from evidence?
  - how did they engage as learners in arguing from evidence?

- Analyzing and interpreting data:
  - what did the instructor do, say or ask to support analyzing and interpreting data?
  - how did they engage as learners with the analyzing and interpreting data?

Homework

- **Write out answers to Reflection Prompts:**
  - Explain how carbon might move from the atmosphere and eventually end up in you.
  - How might cutting down forests affect CO_2 levels in the atmosphere? Describe the carbon cycle processes that are involved in your answer.
  - What do you think might happen to a plant grown where there is less CO_2 in the air? Explain your answer.

- **Watch a couple of videos about fossil fuel formation**, such as the following:
  - https://www.youtube.com/watch?v=_8VqWKZIPrM or
  - https://www.youtube.com/watch?v=zaXBVYr9Ij0 or
  - https://www.youtube.com/watch?v=jjfs_7kwRks
- **Then after the video, answer the following prompts:**
  - Explain how carbon might move from an organism that dies and eventually ends up in the atmosphere.
  - How does human activity affect the flow of carbon between reservoirs?
  - Considering how fossil fuels form, why are some people worried about running out of fossil fuels? What do you think about this?

- **Watch *Tools of Science videos*** *(http://toolsofscience.org/lessons.html):*
  - *Practice 1: Asking Testable Questions*
  - *Practice 3: Proxies in Scientific Investigations*