Ecosystems Unit – Week 2

Name: _____ Hour_____Date: _____

Date Packet is due:_____ Why late? _____Score: _____
Day of Week Date If your project was late, describe why

Driving Question: How do imbalances in matter and energy cause ecosystem disturbances?

Anchoring Phenomenon: This week we are investigating how imbalances in matter movement and energy transformations disrupt ecosystems. Specifically, we are considering how imbalances between molecular & cellular processes like photosynthesis, cell respiration, and combustion can alter ecosystems.

Deeper Questions

1. How do ecosystems enable matter movement and energy transformation?
2. How do imbalances in matter and energy occur?
3. What happens when matter and energy are unbalanced?
4. How does human activity relate to these kinds of disturbances?

Weekly Schedule

Part 1: Introduction
- Initial Ideas & Data Dives
- Discussion & Developing Explanations

Part 2: Core Ideas
- Core Ideas
- Revisions of Part 1 Explanations

Part 3: Investigation
- Part 3: Greenhouse Effect Simulation

Part 4: Review & Assessment
- Critiquing Ideas
- Assessment

Part 5: Life Connections
- Weekly Recap
- Life Connections – Mendota Ice Data

NGSS Standards: HS-ESS2-2 Earth's Systems. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
HS-ESS2-4 Earth's Systems. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
HS-ESS2-6 Earth's Systems. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
HS-ESS3-5 Earth and Human Activity. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
HS-ESS3-6 Earth and Human Activity. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Semester Schedule

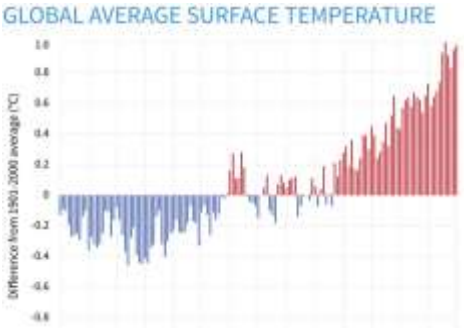
Matter & Energy
Week 1: What happens when something burns?
Week 2: What happens to molecules during burning?
Week 3: Unit Assessment

Animals
Week 1: What are animal cells and food made from?
Week 2: What happens to food when it is consumed?
Week 3: What happens inside animal cells?
Week 4: Unit Assessment

Plants
Week 1: What are plant cells made from?
Week 2: How do plants get their food?
Week 3: What happens inside plant cells?
Week 4: Unit Assessment

Ecosystems
Week 1: How do living organisms affect each other?
Week 2: Tracing Matter
Week 3: Global Biodiversity
Week 4: Humans & Biodiversity

Part 1: Introduction – Data Dive



Overview: In this activity, your group will consider claims and review data to identify patterns and trends that you will use to develop an explanatory model. You will then conclude by comparing your observations and explanations to those of other groups to check your accuracy and make revisions.

Initial Ideas: Over the past decades, scientists have observed that average surface temperatures on the planet are continuing to warm (see data →).

1. **Do you agree or disagree with each student's claim about why these changes are occurring**?
   a. Mike: "The earth is simply going through a natural cycle like it always has." Agree/ Disagree
   b. Lucia: "I think that human activity is primarily responsible for this warming." Agree / Disagree
   c. Oscar: "I think that these changes are due to a variety of factors like sunspots, volcanic activity, natural cycles, and maybe human activity too." Agree / Disagree

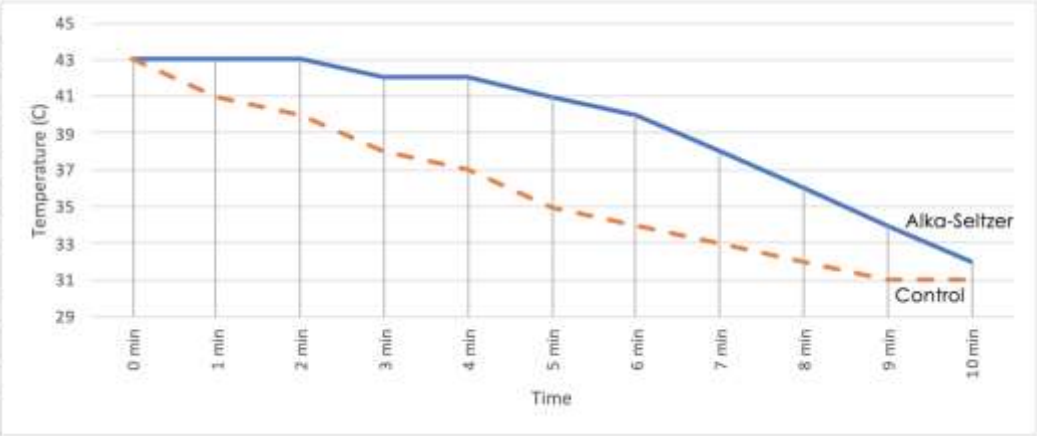
2. **Work in your small groups to discuss your ideas.** Try to identify how your ideas are similar or different. Then work as a team to decide as a group whether each statement is correct or incorrect (and why). Be prepared to present your ideas to the class.

Data Dive 1: Below, you see data showing how carbon dioxide molecules interact with heat energy. Students increased the concentration of carbon dioxide inside a sealed beaker of water using Alka-Seltzer (*which forms CO_2 as it interacts with water*). They compared this to an untreated beaker with the same amount of water. They then heated both beakers to 43° C and then turned off the heaters. They recorded the temperature in each bioreactor every minute. Their data is shown below.

1. **Based on this data, what is one conclusion that would be supported by this data?**
   a. How is this conclusion supported by this data?
   b. What specifically suggests that your claim is accurate?

2. **Based on this data, what is a second conclusion that would be supported by this data?**
   a. How is this conclusion supported by this data?
   b. What specifically suggests that your claim is accurate?

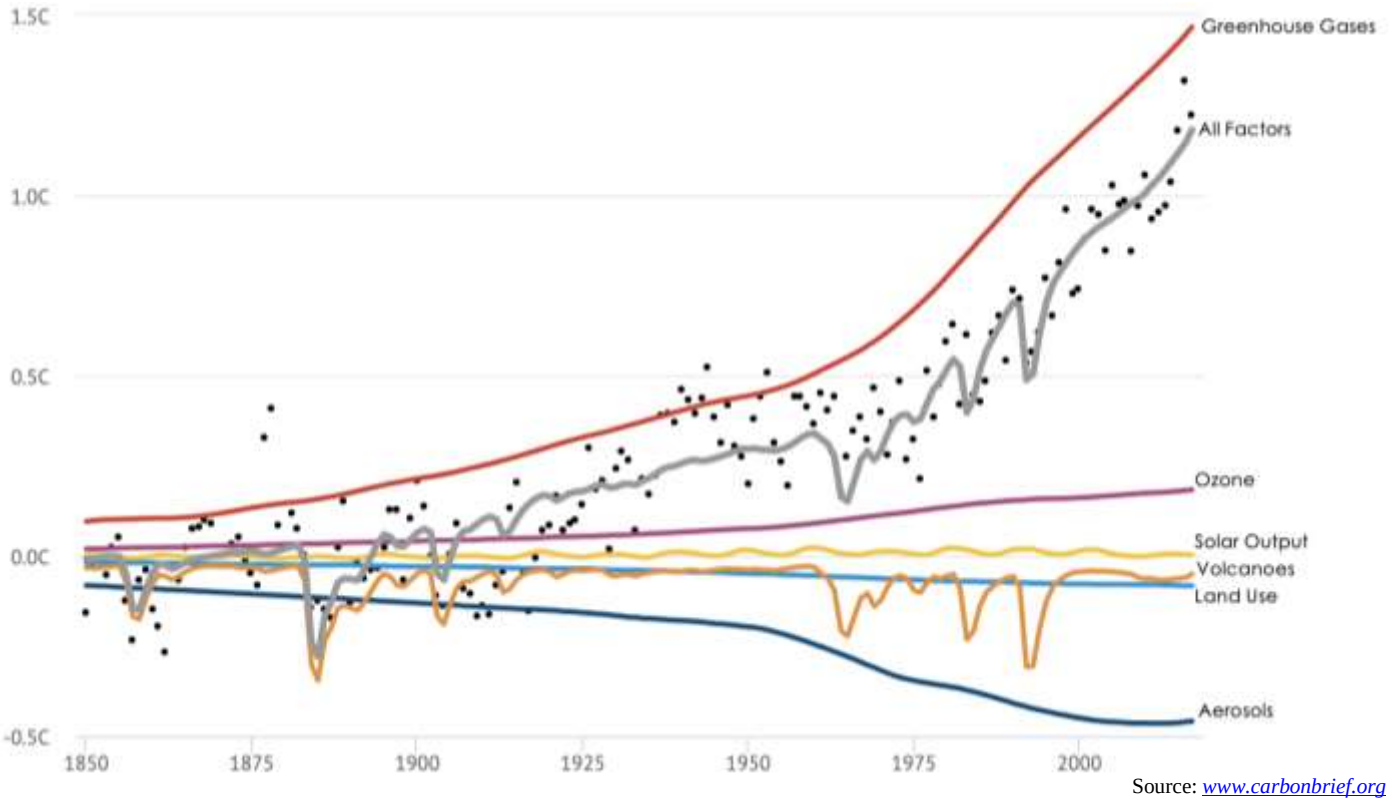
Time	Alka-Seltzer	Control
0 min	43	43
1 min	43	41
2 min	43	40
3 min	42	38
4 min	42	37
5 min	41	35
6 min	40	34
7 min	38	33
8 min	36	32
9 min	34	31
10 min	32	31



Data Dive 2: The mean (average) surface temperatures of the planet is shown in the graph below as a series of dots. Scientists compared six possible changes in temperature: 1) changes to land use (e.g., deforestation), 2) changes to atmospheric ozone, 3) changes in atmospheric greenhouse gases, 4) shifts in solar energy output, 5) prevalence of aerosols, and 6) volcanic activity. They then calculated how changes to these factors would influence the earth's temperature over time. They show this on the graph below.

3. **Based on this data, what is one conclusion that would be supported by this data?** How does this data indicate that your claim is accurate?

4. **Based on this data, what is a second conclusion that would be supported by this data?** How does this data indicate that your claim is accurate?



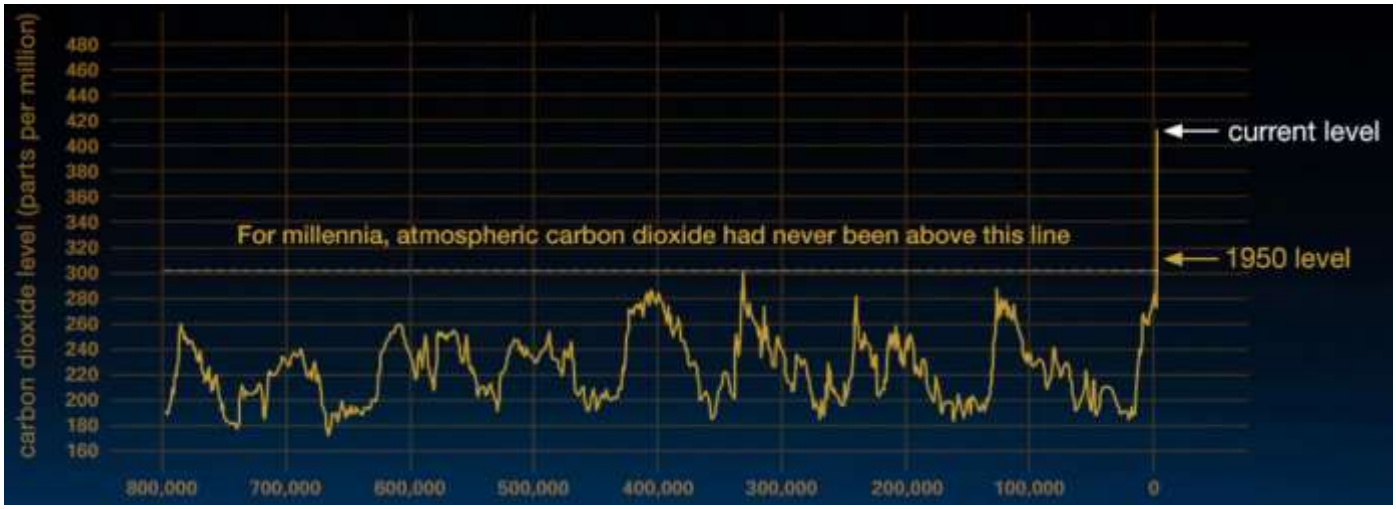
Source: www.carbonbrief.org

Data Dive 3: Air trapped in polar ice sheets can provide a record of the atmospheric conditions over hundreds of thousands of years. This graph from NASA (next page) shows fluctuations in the earth's average atmospheric carbon dioxide levels over the previous 800,000 years based on this data.

5. **What was the maximum CO_2 level prior to the Industrial Revolution 150 years ago?** _____ ppm

6. **What is the current level of atmospheric CO_2?** _____ ppm

7. **What might be one possible explanation for why CO_2 is so much higher now? Why is CO_2 being released at a faster rate than it is being absorbed?**



Source: https://climate.nasa.gov/evidence/

8. **Based on the data on the previous two graphs, create a hypothesis that summarizes the relationship between temperature and greenhouse gases like carbon dioxide**.

   I hypothesize that _____

   _____

Discussion & Developing Ideas

9. As a class, discuss your ideas about why average global temperatures are warming. What are ideas that most students agreed with? Where did your ideas differ as a class? Based on your instructor's directions, use the space below or another option (e.g., whiteboard, online document, etc.) to record your ideas.

We all agree that…	We disagreed about…

10. **Why do you think that the earth is warming**? Write down your initial explanation in the space below. Don't worry if you aren't completely sure about your answer! You will come back and revise this explanation as you gain more information during this unit.

    I think that the surface temperatures of the planet are increasing because… _____

    _____

    _____

Part 2: Core Ideas

Overview: In this activity, you will begin with a short slideshow presentation. This will provide you with core ideas that will help you clarify your initial ideas. Your instructor will decide on how to implement this portion depending on your previous experience and capabilities with this content.

You will then work in small teams to answer the questions listed below. You should take notes in a notebook, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. *Note: your instructor may assign specific questions to your group if time is limited.*

Core Ideas Presentation: https://bit.ly/WUHS-Bio-EcosystemsW2

Driving Questions:

1. How did an asteroid strike 65 million years ago disrupt matter movement and energy transformation in ecosystems? How did this result in the extinction of the dinosaurs? In your explanation, address factors at the molecular, cellular, organismal, and ecosystem levels.
2. True or false: increasing rates of cell respiration, decomposition, or combustion will not result in ecosystem disturbances as long as rates of photosynthesis stay constant. Explain.
3. How do current rates of CO_2 emissions compare to rates of CO_2 absorption? Why is this occurring?
4. Why does the moon have more widely fluctuating temperatures compared to the earth given both are roughly the same distance from the sun?
5. True or false: CO_2 is only a small percentage of the earth's atmosphere; therefore, changes to CO_2 concentrations are unlikely to have a major impact on temperature. Explain.
6. What is a greenhouse gas? What determines if a molecule can act as a greenhouse gas?
7. What is the greenhouse effect? What is infrared radiation? How do both light and infrared radiation relate to the greenhouse effect?
8. Could changes in global temperatures be part of a natural cycle? Use the term *Milankovitch Cycles* in your response.
9. What is climate change? How does it relate to changes in CO_2 concentrations?
10. How do changing CO_2 levels affect ecological factors such as vegetation, habitat loss, precipitation patterns, and ocean acidification?
11. True or false: while rising CO_2 levels are affecting ecosystems, human activity is largely unaffected by climate change. Explain.
12. Summarize other imbalances in matter movement that are resulting in ecological disturbances.
13. **Revising Explanations**: Return to your original explanation that you created at the end of Part 1. Based on this new information, how would you now respond to this question?

I think that the surface temperatures of the planet are increasing because… _____

_____

_____

Part 3 Investigation: GH Effect Simulations

See the directions in *The Greenhouse Effect Simulation Directions* (*see website*) to complete this worksheet.

A. Investigating how different gases in the atmosphere interact with light:

1. Observe how the infrared and visible light photons respond when they encounter CO_2 and N_2 molecule. Then circle the descriptor that best describes the movement of each kind of photon when it strikes each kind of gas molecule below:

When a visible light photon hits CO_2, the photon's movement is…	**Unchanged**	**Scattered**
When an infrared photon hits CO_2, the photon's movement is…	**Unchanged**	**Scattered**
When a visible light photon hits N_2, the photon's movement is…	**Unchanged**	**Scattered**
When an infrared photon hits N_2, the photon's movement is…	**Unchanged**	**Scattered**

2. How did the interactions of CO_2 and infrared photons differ from the interactions of N_2 and infrared photons?

3. How can the different molecular properties of CO_2 and of N_2 help to explain these differences? (Revisit the Core Ideas from this week if needed).

4. How do these molecular properties determine whether an atmospheric molecule can be a greenhouse gas? (Revisit the Core Ideas from this week if needed).

5. How do your observations in this exercise relate to the Greenhouse Effect? (Revisit the Core Ideas from this week if needed).

B. Investigating how different gases in the atmosphere affect the Earth's temperature:

6. Complete the table below to record your observations from this activity:

	Impact on Yellow Light Photons	Impact on Red Infrared Photons	Temperature Range
Low GHG's			
High GHG's			

7. In what ways (if any) did the movement of the yellow visible light photons change as the greenhouse gas concentrations were increased?

8. In what ways (if any) did the movement of the red infrared photons change as the greenhouse gas concentrations were increased?

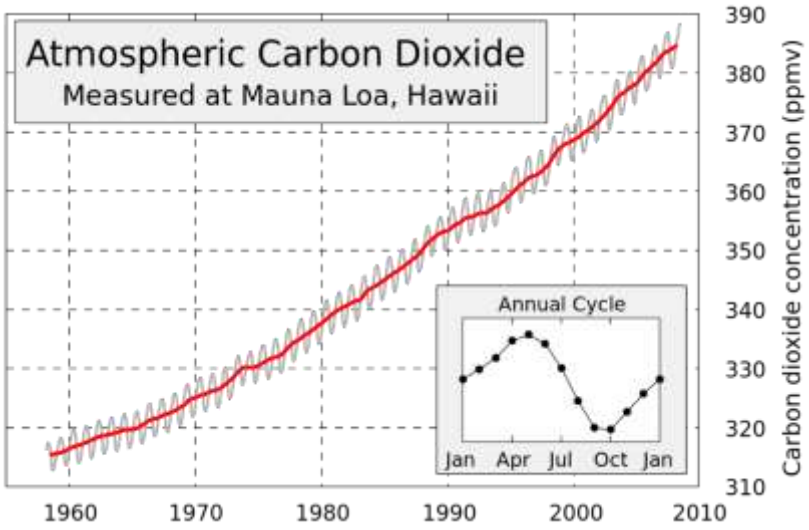
9. How do your observations in this exercise relate to the Greenhouse Effect?

10. What happened to the temperature as the concentrations of greenhouse gases were increased?

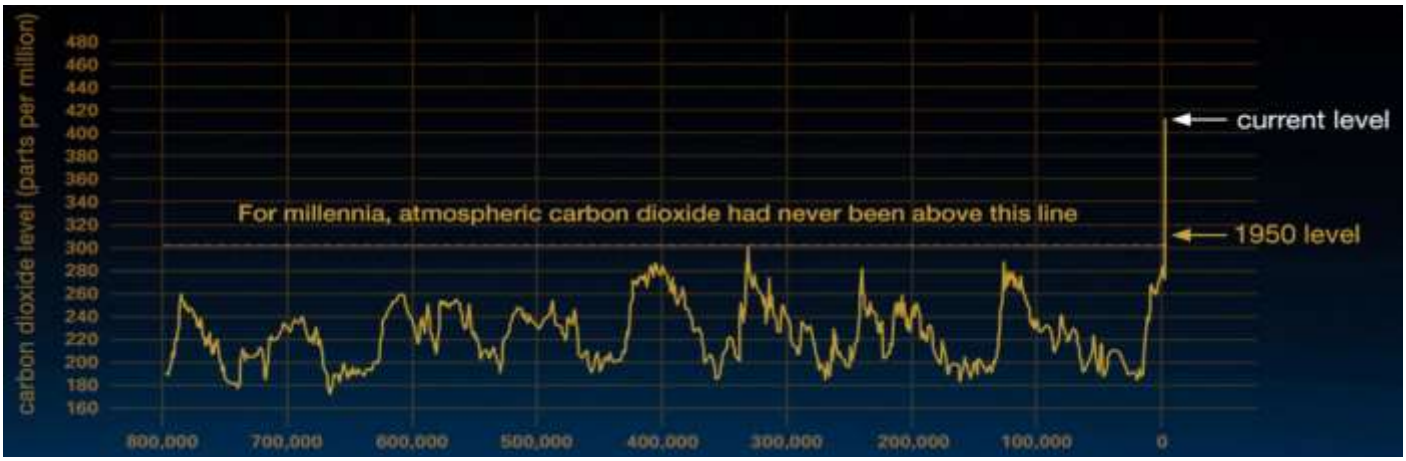
11. What is the relationship between the concentration of greenhouse gases in the atmosphere and the temperature of the earth's surface?

C. Investigating Why the Keeling Curve is Important: The Keeling Curve shows the levels of atmospheric CO_2 since the mid-1900s. It indicates that while CO_2 levels fluctuate over the course of the year (due to increases in global rates of photosynthesis from April to October), the amount of CO_2 in the atmosphere increases each year. This shows that the release of CO_2 exceeds the rate of absorption.

12. How do the patterns and relationships that you observed throughout this activity relate to the Keeling Curve (below)?



13. Given what you have observed throughout this activity regarding the relationship between CO_2, infrared radiation, and temperature, respond to the NASA graph below showing the changes to CO_2 concentrations over the past 800,000 years. What implications could these trends have for the future of the planet given the current trajectory of CO_2 concentrations?



Part 4: Review & Assessment

Overview: For each objective, rank it as a 1 (*completely unsure*), 2 (*somewhat unsure*), or 3 (*completely sure*) based on your comfort with that objective. Then work in teams to review each item and prepare a response. You will conclude by completing a formative assessment.

Driving Questions

1. How did an asteroid strike 65 million years ago disrupt matter movement and energy transformation in ecosystems? How did this result in the extinction of the dinosaurs? In your explanation, address factors at the molecular, cellular, organismal, and ecosystem levels.
2. True or false: increasing rates of cell respiration, decomposition, or combustion will not result in ecosystem disturbances as long as rates of photosynthesis stay constant. Explain.
3. How do current rates of CO_2 emissions compare to rates of CO_2 absorption? Why is this occurring?
4. Why does the moon have more widely fluctuating temperatures compared to the earth given both are roughly the same distance from the sun?
5. True or false: CO_2 is only a small percentage of the earth's atmosphere; therefore, changes to CO_2 concentrations are unlikely to have a major impact on temperature. Explain.
6. What is a greenhouse gas? What determines if a molecule can act as a greenhouse gas?
7. What is the greenhouse effect? What is infrared radiation? How do both light and infrared radiation relate to the greenhouse effect?
8. Could changes in global temperatures be part of a natural cycle? Use the term *Milankovitch Cycles* in your response.
9. What is climate change? How does it relate to changes in CO_2 concentrations?
10. How do changing CO_2 levels affect ecological factors such as vegetation, habitat loss, precipitation patterns, and ocean acidification?
11. True or false: while rising CO_2 levels are affecting ecosystems, human activity is largely unaffected by climate change. Explain.
12. Summarize other imbalances in matter movement that are resulting in ecological disturbances.
13. **Revising Explanations**: Return to your original explanation that you created at the end of Part 1. Based on this new information, how would you now respond to this question?

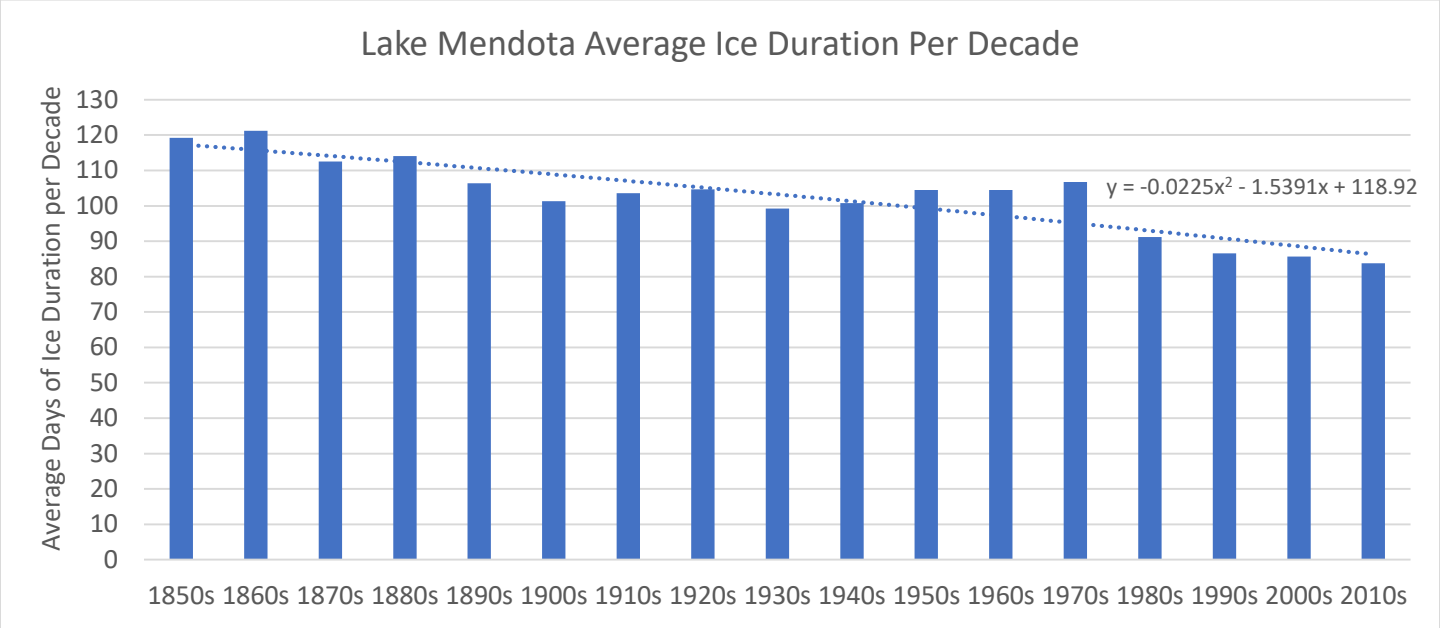
I think that the surface temperatures of the planet are increasing because… _____

_____

_____

Part 5: Life Connections – Mendota Ice Graph

Overview: Lake Mendota in Madison, WI is one of the most studied lakes in the world. Scientists have been collecting data on this lake since the mid-1800s. One of the types of data they have collected is *ice duration*, or the number of days during which the lake was completely frozen over. The average annual days of ice duration per decade is shown in the graph below. Interpret this graph to identify patterns and trends. Then answer the questions below.



1. **Based on this data, what is one conclusion that would be supported by this data?**
    a. How is this conclusion supported by this data?
    b. What specifically suggests that your claim is accurate?

2. **Based on this data, what is a second conclusion that would be supported by this data?**
    a. How is this conclusion supported by this data?
    b. What specifically suggests that your claim is accurate?

3. **A dotted trendline has been added to this graph. A trendline indicates the general pattern or trend on a graph based on the average values of the data.**
    a. What does this trendline suggest?
    b. How does this relate to the topics from this week?

This trendline is a polynomial trendline, which is useful for analyzing gains or losses in a data set. This trendline provides a quadratic formula that can be used to predict the number of years remaining before a specific outcome. Let's assume that a minimum of 30 days of ice is needed to reliably go ice fishing (two weeks for ice to form and two weeks to melt). If we determine that y = 30, then x (the number of years until this outcome) is about 37; i.e., this data suggests that within your lifetime, ice fishing may not be feasible.

4. **How does this impact your views about climate change?**

Be prepared to discuss your ideas in small groups and as a class.

Data source: https://www.aos.wisc.edu/~sco/lakes/Mendota-ice.html

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Ecosystems Unit, Week 1 Assessment

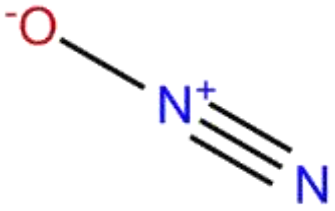
Name: _____ Hour_____ Date:_____ Score:_____ /_____

Directions: A 3x5 notecard with handwritten notes can be used to guide your answers. Your instructor may allow you to work in assigned groups. If so, have a different person write each response while others assist.

1. **Briefly summarize how and why imbalances in matter movement and the flow of energy from an asteroid strike caused the dinosaurs to go extinct. Explain how and why these changes occurred at the ecosystem, organismal, cellular, and molecular-atomic levels.**

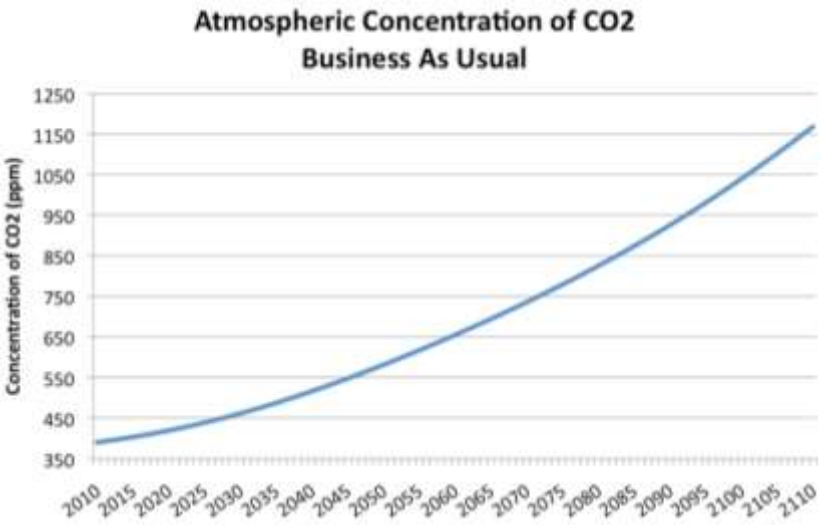
Writer's Name:

2. This is Nitrous Oxide (N_2O). It consists of multiple elements (oxygen and nitrogen) and has three atoms. **A) If atmospheric levels of N_2O increase on Planet X by 50%, how would this affect the movement of light and infrared radiation? B) How would this change conditions on the surface of the planet? Explain & justify w/ evidence. Include the following:** *greenhouse gas; molecular properties; greenhouse effect; infrared radiation***.**



Writer's Name:

3. The graph on the right shows how CO_2 levels will change over the next 100 years under a "business as usual" scenario (*i.e., no changes to the current trends related to our CO_2 emissions*).



What are some outcomes that we would expect if CO_2 levels were to continue to increase at this rate? In your response, explain a) the relationship between CO_2 and temperature, and b) how changing levels of CO_2 result in different kinds of ecosystem disturbances.

Writer's Name:

4. **Are the changes that are now happening in climate due to natural cycles, or due to other natural factors like volcanoes or sunspots? Explain using evidence and reasoning.**

Writer's Name:

5. The map below shows the locations of aquatic dead zones that are caused by eutrophication. **A) Begin by defining the terms *dead zones* and *eutrophication*. B) Then explain how imbalances in matter movement from human activity result in these outcomes.**

Writer's Name:

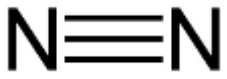
Ecosystems Unit - Week 2 Investigation Mastery Check

Name: _____ Hour_____ Date:_____ Score:_____ /12

1. **CO_2 is a greenhouse gas. Greenhouse gases…**
   a. Comprise a majority of the earth's atmosphere.
   b. Are harmful to ecosystems at any concentration.
   c. Slow the loss of infrared radiation (what we feel as heat).
   d. Shield the earth from harmful UV rays.

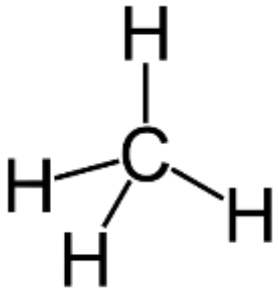
2. **Which of the following best summarizes the greenhouse effect?**
   a. When CO_2 decomposes, it releases heat.
   b. CO_2 creates friction, releasing heat energy.
   c. Plants release large amounts of heat energy; the more plants, the warmer the planet.
   d. Substances like glass and CO_2 allow light to pass but slow the loss of heat.

3. For a molecule to act as a greenhouse gas, it must a) have more than two atoms and b) contain at least two different elements. **Nitrogen gas (N_2) is shown at the right. It is by far the most abundant gas in the atmosphere. Is this a greenhouse gas?**
   a. Yes b. No



4. **If N_2 levels were to change in the atmosphere, would it affect the surface temperatures of the earth?**
   a. Yes b. No

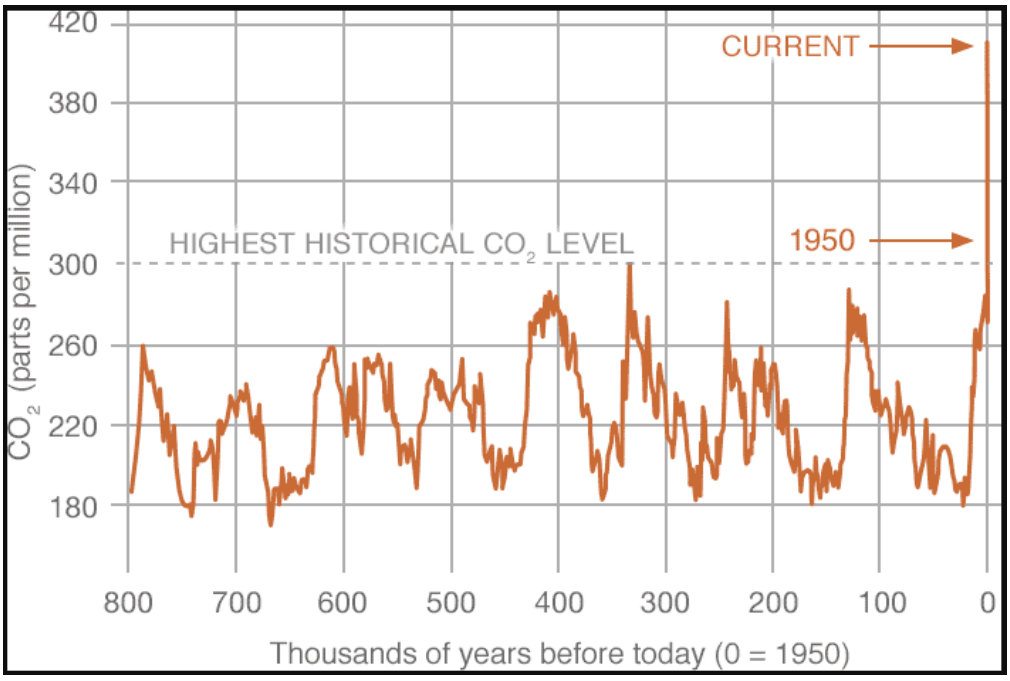
5. **Methane gas (CH_4) is shown at the right. It comprises 0.00017% of the atmosphere. Is this a greenhouse gas?**
   a. Yes b. No

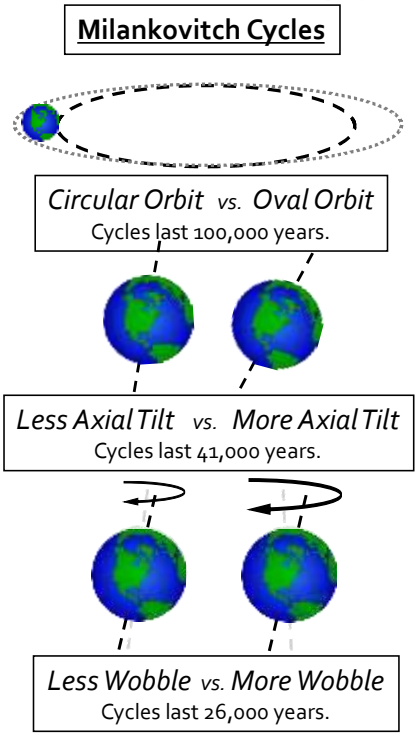


6. **If methane levels were to change in the atmosphere, would it affect the surface temperatures of the earth?**
   a. Yes b. No

7. The map at the right shows dead zones that are caused by eutrophication. **Eutrophication can be defined as…**
   a. When substances (such as glass or gases like CO_2) allow light to pass but slow the loss of heat.
   b. Reductions in dissolved oxygen in aquatic ecosystems due to excess nutrient levels.
   c. An imbalance in the transformation of matter into energy.

8. **Which of the following is most likely to cause eutrophication & dead zones in aquatic ecosystems?**
   a. Carbon Dioxide b. Methane c. Phosphorus d. Oxygen





Use the images shown here to assist you in answering the question below.
(Image credit: NASA)

9. **Modern humans have existed for roughly 200,000 years. Prior to the Industrial Revolution, what was the maximum carbon dioxide levels based on the data above?**
   a. 180 ppm b. 300 ppm c. 420 ppm d. 480 ppm

10. Recent changes in global temperatures have occurred within a period of less than 200 years. **Based on the timespan for each of the natural cycles of warming and cooling (i.e., the Milankovitch Cycles), which is primarily responsible for these changes?**
    a. Changes in circular orbit vs. oval orbit (100,000 year cycles).
    b. Changes in axial tilt (41,000 year cycles).
    c. Changes in the "wobble" of the earth's orbit (26,000 year cycles).
    d. None of the above. This change is occurring too rapidly for these cycles to be responsible.

11. **Which most accurately describes the effects of a warmer atmosphere on precipitation?**
    a. Droughts become more common - a warmer atmosphere holds moisture for longer periods.
    b. Flooding becomes more common - a warmer atmosphere results in more intense precipitation.
    c. Both flooding ***and*** droughts are likely to be more common in a warmer atmosphere.
    d. Rates of flooding and droughts are both unaffected by changes in temperature.

12. **Which of the following is FALSE?**
    a. Higher levels of atmospheric CO_2 harm marine ecosystems by creating more acidic water.
    b. A warming climate changes vegetation, displacing the species that depend on that vegetation.
    c. Warming conditions reduce the oxygen in aquatic ecosystems, threatening aquatic species.
    d. Agricultural yields will mostly improve from a warming climate.