CLIMATE CHANGE

Scientific Consensus: A Tsunami of Evidence

Lesson Set 1 of 6

NCSE National Center for Science Education

Teacher Prep

Age Levels: 6th - 12th grade
Note: Middle School modifications referenced in student directions

Time Commitment: 4-6 days
(if all activities completed)

Key Vocabulary/Concepts: data, evidence, scientific consensus, outliers, peer review, verifiable, falsifiable, weather, precipitation, cloud formation, atmosphere, climate, climate change, climate normal, anthropogenic, greenhouse gases (GHGs), positive and negative feedback loops, science denial, FLICC, fake experts, logical fallacies (red herring, misrepresentation, oversimplification, false analogy), impossible expectations, cherry picking, conspiracy theories

Materials:

- Internet access
- Dark chocolate bar (at least 70% cacao)
- GISTEMP Global Temperature Anomaly Data (1880–2021)
* Consensus vs. Expertise Graph
* Temperature Data Predictons
  - Upper vs. lower atmosphere
  - Summer vs. winter
  - Daytime vs. nighttime

Introduction

This lesson set provides the foundation for the entire NCSE climate change curriculum.

Five climate change core principles, borrowed from the oft-quoted Edward Maibach, weave throughout this lesson set: It's Real, It's Us, It's Bad, Experts Agree, and There's Hope. Additionally, the lesson set addresses what climate scientists repeatedly warn are the biggest misconceptions in their field; if you're short on time, this lesson set could be taught as a stand-alone apart from the rest of the curriculum.

Teacher Goals

1) Create a safe environment for students to express their current understanding about climate change, ask questions, have productive discussions, and examine the evidence without feeling judged or pressured
2) Provide students with an understanding of how scientists achieve consensus
3) Guide students through analysis of real-world climate data to provide an understanding of how climate scientists arrive at conclusions
4) Use questioning strategies rather than providing easy answers
   Note: This is especially important when dealing with students who are resistant to the scientific consensus on climate change.

Student Learning Goals

1) Evaluate independent lines of evidence to acquire an understanding of the scientific community's process for developing consensus

Climate Change Lesson Set Series

https://ncse.ngo/supporting-teachers/classroom-resources

CLIMATE CHANGE

Teacher Prep (continued)

Apps and Software:

- Google Jamboard or Google Drawings
- Graphing software (Excel, Google Sheets, Vernier LoggerPro, or Vernier Graphical Analysis)

Student Learning Goals (continued)

2) Analyze the factors that have resulted in the scientific conclusion that the climate is changing as a result of anthropogenic (i.e., human-caused) activity
3) Assess the role of feedback loops in climate systems
4) Understand why the climate change crisis is urgent but not unsolvable

Background

Teacher Knowledge

Nature of Science

It's recommended that students work through the NCSE Nature of Science lesson sets at some point during the year. However, if this is not possible, be sure to introduce students to FLICC, a framework for understanding science denial, prior to presenting this lesson set. *Part E: The Characteristics of Science Denial* in Nature of Science Lesson Set 1: Science is a Way of Knowing is especially valuable. It takes students through several examples of FLICC in action while dismantling common misconceptions about the COVID-19 pandemic. Learn more about FLICC.

Scientific Concepts:

This lesson set focuses on the plethora of scientific evidence available that supports the idea that the climate is changing. Furthermore, students are provided with numerous examples that reinforce the idea that modern-day climate change directly results from human influence (i.e., it's anthropogenic). To complete this lesson set, a basic knowledge of climate science is needed. If a refresher on climate change is necessary, consider checking out the Paleontological Research Institute's Teacher-Friendly Guide to Climate Change or Jeffrey Bennett's online Global Warming Primer before introducing this curriculum to your students.

Discussion Points

a) How do we know what's scientifically credible?
b) Why is consensus critical in science?
c) Why do most climate scientists think that anthropogenic climate change is occurring?
d) What motivates people to spread misinformation about the climate science consensus?

Prerequisite Student Knowledge

Before starting the activities below, provide students with an opportunity to share their concerns about climate change and its effect on our planet's biodiversity. Consider reviewing the **major types of energy** (solar, thermal, chemical, etc.) and the **major earth cycles** (water, carbon, and nitrogen). Also, an understanding of the **layers and composition of the atmosphere** is recommended.

Core Misconceptions

✘ **MISCONCEPTION:** ***The scientific consensus on climate change is not genuine but rather the product of error, undue alarm, or hoax***

✔ **FACT: Climate change is supported by multiple lines of overwhelming evidence**

✔ **FACT: Scientists are more likely to underestimate climate impacts than exaggerate them**

✘ **MISCONCEPTION:** ***There is no scientific consensus or agreement on anthropogenic climate change***

✔ **FACT: Based on independent lines of evidence, a scientific consensus has emerged that human influence is the single most significant cause of modern-day climate change**

✘ **MISCONCEPTION:** ***Climate change impacts will not be that harmful; some might even be beneficial***

✔ **FACT: When looking at the full range of climate change effects, the negative impacts on the environment and society far outweigh any possible benefits**

Student Directions

Anchor: A Chocolate a Day is the Healthy Way

The Con:

- At the beginning of class (while taking attendance or doing other normal routine activities), open a dark chocolate bar (>70% cacao). Eat one or two small sections of the chocolate.
- Once students have noticed (and begged you for some), apologize for eating in front of them and explain that you have started a new diet. Be sure to express the desire to get in shape, lose weight, and be more healthy.

Anchor: A Chocolate a Day is the Healthy Way (continued)

The Con: (continued)

- For general classes, show the video from Australia, Chocolate Diet: Lose Weight and Feel Better (3:05), recorded around the time the original study was published. Add that you found information about the diet while searching on YouTube and that there were many videos announcing the benefits of dark chocolate.
- If you prefer an American news source or an additional video for students, show the CBS New York video, New Diet Pushes Eating Chocolate Every Day (2:29). Please note that this video is tied to a different fad diet—not the journal article (students will probably not realize this).
- For more advanced courses, provide students with the original study that you claim supports the diet, "Chocolate with high cocoa content as a weight-loss accelerator." If you decide not to share the actual journal article, be sure to emphasize to students that, being both diligent and skeptical, you looked for scientifically legitimate studies that have tested this diet before committing to it yourself and found an excellent example. *Note: You could display a portion of it on the screen or read with them to modify for a general course or differentiated instruction.*
- If students are familiar with **peer review** as a concept, it may help the conversation to bring it up. But if students are unfamiliar with peer review, introducing it in this context may have the unintended consequence of undermining students' acceptance of peer review as a useful process and should be avoided.

The Marks:

- At this point, demonstrate that after the original journal article was published, you found many examples of it being referenced in mainstream media (beyond just videos).
- Share with them any or all of the examples available in the Teacher Resources folder, but students would likely be most familiar with *Shape* and *Prevention*. To explain why the other articles are international, remind them that the diet was initially studied in Germany and became popular in Australia before catching on in the U.S.
- Students will probably ask questions, and you should guide the discussion toward considering what most diet experts and doctors might say about this study (see these resources for examples: Eat More Chocolate, Weigh Less? or Why Experts Aren't Sweet on Study Claiming Chocolate Might Help Burn Fat). In passing, mention to them that you could only find ***one*** scientific study supporting this diet and all the rest of your sources were mainstream media outlets.
- Questions to consider:
  - What do other experts say about the chocolate diet?
  - Are there any studies that contradict the chocolate diet?
  - Is a single scientific study enough support for the credibility of the chocolate diet?
  - Is all information reported on the news or in mainstream media reliable and verified rigorously? *Note: Avoid using the term "fake news," which lacks a clear meaning and can lead to even more misconceptions.*
  - How are scientific studies tested for credibility and verification?

Anchor: A Chocolate a Day is the Healthy Way (continued)

The Marks: (continued)

- These questions introduce the importance of **scientific consensus** and the fact that outliers/fringe experts sometimes publish work disagreeing with the majority or consensus view. We would need robust evidence from rigorous testing to accept the **outlier** over the majority.
- When discussing scientific consensus, it's advisable to introduce **peer review** to students unfamiliar with the concept. Explain the processes that science journals and publishers have in place to ensure the scientific credibility of their published studies.

The Reveal

- After discussing peer review, scientific consensus, and the nature of science with students, it is time to reveal the truth. The journal article provided at the beginning of the discussion was an excellent example of **misleading science** (i.e., the results are false or the methodology was conducted incorrectly).
- Emphasize to students that this scientific journal article was intentionally written to mislead. In fact, it was meant to show that the current publication system is not perfect and could benefit from improvements to the peer-review process.
- Additionally, the study's authors wanted to show how easily media outlets can be convinced to run with a "shocking" science story. Even the most reputable magazines and news sources can be deceived if a study appears legitimate at first glance. Point out that media outlets could also benefit from a more rigorous fact-checking process or a better understanding of the nature of science.
- It is important to note that while this study was intended to mislead, similar claims are offered on behalf of similar diets. This fact further illustrates the problem posed by fringe "experts" as cited in "I Lost Weight on the Chocolate Diet" from *Elle* magazine or in this *Wall Street Journal* video Will Chocolate Diet Help You Lose Weight? (3:45) that features Will Clower, the author of *Eat Chocolate, Lose Weight*.
- See the Extension section for more on how scientific studies can be misleading when misunderstood.

Driving Questions Board: The Core Principles of Climate Change

- Once students have worked through *The Chocolate Diet* scenario, direct them to open the Google Jamboard driving questions board for this unit.
  Note: Please make a copy of the DQB template provided before beginning the activity.
- Google Jamboard is a free whiteboard platform for brainstorming group ideas.
- On each Jamboard slide, students will find one climate change **core principle** that will be studied throughout this lesson set.
- Ask students to write down any questions they have about each core principle and/or possible **misleading science** headlines they have read (or heard) about each principle.

Anchor: A Chocolate a Day is the Healthy Way (continued)

Driving Questions Board: The Core Principles of Climate Change (continued)

- Remind students that just like *The Chocolate Diet*, many information sources can sound legitimate and appear to be appropriately sourced, but are actually taken out of context in the media. The purpose of this lesson set is to help them break down major misconceptions about climate change.
- Have students generate as many Jamboard sticky notes as they can about each area, focusing on questions or topics they want to learn more about throughout this unit.

Activities and Handouts

Part A: It's Real

- Visualizing Data—Global Temperature Anomalies
  - To begin this activity, provide students with the GISTEMP Temperature Anomaly Data (1880–2021), which is an estimate of global surface temperature change, along with a description of how scientists collected the data. The dataset provided was generated using Combined Land-Surface Air and Sea-Surface Water Temperature Anomalies, also known as the Land-Ocean Temperature Index (L-OTI).
  - Be sure to introduce the idea of a climate normal at this time. Traditionally, a **climate normal** is a three-decade (30-year) average of a climatological variable, such as temperature or precipitation.
  - Ask students to construct a graph using data from the 19th to the 21st century. These data will be compared to the **1951–1980 climate normal** used by the Goddard Institute for Space Studies when collecting global surface temperature changes from land and ocean stations.
    Note: As climate changes, the climate normal will change, too. Eventually, a new standard will be set, and data will need to be updated to reflect these changes. This point can make for an interesting conversation with students about how we continue to learn more about the climate every year, but all trends support the idea that temperatures are increasing. A new climate normal will most likely show an even higher correlation for this fact.
  - Students should work in small groups to construct an electronic or hand-drawn graph of these data. Encourage them to discuss any trends they see as a group.
  - For students who have more difficulty with graphing or time constraints, show or distribute GISTEMP premade graphs and discuss them as a class. We provide three variations.
  - Alternatively, students can generate their own graphs using the National Oceanic and Atmospheric Administration's Climate at a Glance Time Series resource. However, the climate normal used is from **1981–2010**, so students will have to alter the end date from 1995 to 2021 in all ending fields.

Activities and Handouts (continued)

Part A: It's Real (continued)

- Interpreting Data—Global Temperature Anomalies
  - After students have completed their graphs, bring the class back together for a group discussion. Ask for volunteers to explain the trends they found in the overall global temperature data over time. The unambiguous conclusion is that temperatures have increased throughout the 20th century (and into the 21st). The question, then, is not whether warming is happening but *what* is causing it.
  - Consider using a BSCS Science Learning I^2 (Identify and Interpret) Strategy as a sense-making tool for interpreting figures and graphs. See Teacher Resources for both student and teacher I^2 strategy documents.
- Convergence of Data—Other Factors/Data Trends
  - Either introduce other factors/data trends consistent with the conclusion that Earth is warming or assign students to research and present them. Students can explore additional factors and data at NASA's Global Climate Change: Vital Signs of the Planet. Possible factors include:
    - Melting of ice caps/sheets
    - Glacial retreat
    - Decreased snow cover
    - Sea level rise
    - Ocean warming
    - Declining Arctic sea ice
    - Ocean acidification
    - Increase in extreme weather events
  - After exploring these factors, students should see the plethora (tsunami even) of evidence from different sources and fields that provide scientists with the data and confidence that anthropogenic causes of rapid climate change are the current reality.
    Note: If time is a factor, this activity could be made optional or homework.
- Anchor to Activity—Tying It All Together
  - To wrap up this activity, guide the discussion back to the opening activity, *A Chocolate A Day is the Healthy Way*. Briefly mention that many people believe that climate change is like the chocolate diet—a fad or hoax. To dismantle this misconception, have them compare the chocolate diet to climate consensus by asking the following questions and using the information provided:
    - What would it take to create a climate change hoax?
      - The chocolate diet involved ***one*** paper submitted to a handful of disreputable journals, only ***one*** of which was fooled into publishing it.
      - If climate change were a hoax, it would mean that thousands of researchers have published fraudulent papers in numerous respectable journals despite their peer-review process.
      - Each paper would also be filled with millions of bits of unsubstantiated data from the past two centuries. Additionally, since the data was generated by organizations like NOAA, NASA, and EPA, these respected sources would have to be a part of the conspiracy, too.

Activities and Handouts (continued)

Part A: It's Real (continued)

- Who would have to be in on the hoax?
  - The chocolate diet involved two documentarians, a molecular biologist who had run a similar sting in the past, a doctor, a statistician, and a public relations person, working together for about six months.
  - If climate change were a hoax, it would involve thousands of researchers from all over the world, and the lie would have to have been perpetuated repeatedly since before the 1970s—without a single whistle-blower.
  - The chocolate diet would have been exposed if even one reporter had contacted outside researchers or looked into the organization. Conversely, researchers ***have*** looked into the scientific consensus multiple times and have consistently found … ***see Part B***.

- Have students return to the *Climate Change Core Principles Jamboard* you made a copy of at the beginning of the unit.
  - Ask them to look at all the questions generated for the **first** core principle.
  - If the *Part A: It's Real* activity either answered their questions or debunked the misconceptions tied to the principle, have them draw an X through their sticky notes.
  - Have them group any left-over questions/misconceptions to one side of the slide. (Ideally, there will be few sticky notes left after completing this activity; if not, the notes were not completely on topic.)
  - Do they have any new questions or concerns they want to add?

Part B: It's Us

- Effects on Climate Jamboard
  - Depending on the classroom setup, this activity can be conducted as a whole group, small group, or digital breakout session.
  - Feel free to use the provided template or make your own. If using the template, please **make a copy** for classroom use.
  - Begin this activity by engaging students in a conversation about the factors that can influence global climate.
  - Add student responses to the left side of the Jamboard. Be sure to list the **effect** (blue sticky note) and what one would expect to **see** (pink sticky note) if this effect impacts climate.
  - Place a sticky note of the effect on the provided image as the discussion continues so that students have a reference point.
  - Possible responses include deforestation, urbanization, continental drift, albedo, etc., but students should definitely include the sun and **greenhouse gases** (GHGs) on the list. If not, guide them to do so as it is important for the next activity.

Activities and Handouts (continued)

Part B: It's Us (continued)

- Also, let the students know that they will be returning to this model again during *Climate Change Lesson Set Two: Understanding Climate Modeling*
- The model used for this activity was adapted from a project developed by the University of California Museum of Paleontology called Understanding Global Change.

- Temperature Data Predictions Jigsaw
  - Provide students with data focused on two aspects of climate effects discussed during the Jamboard activity: solar-forced vs. greenhouse-gas-based warming
  - Temperature Data Predictions:
    - Upper vs. lower atmosphere
    - Summer vs. winter
    - Daytime vs. nighttime
  - Have students break into groups to generate graphs of the three data sets, analyze data, and draw conclusions based on the key expectations above.
  - If time allows, consider using the BSCS Science Learning I^2 Strategy, introduced earlier in *Part A: It's Real*, to analyze the graphs generated from the data.
  - Possible probing questions to ask students during activity:
    - How can the sun affect Earth's average global temperature?
    - How can GHGs affect Earth's average global temperature?
    - Why is the troposphere warmer than the stratosphere?
    - Are the troposphere and stratosphere composed of the same gases? Are there the same amounts of each gas in each layer?
    - Why does each layer cool at night?
    - Why are summer days and nights warmer than winter days and nights? Do you think the stratosphere has seasonal variations, too?
    - What happens when the troposphere and stratosphere meet? Why are the layers so distinct?

Activities and Handouts (continued)

Part B: It's Us (continued)

- Key expectations needed from the Effects on Climate Jamboard discussion for the next activity:

Sun-Caused Warming	Human-generated GHGs Warming
The upper atmosphere should warm more than the lower atmosphere because the sun heats the atmosphere from the outside to the inside	The lower atmosphere should warm more than the upper atmosphere because GHGs trap energy re-radiated the surface
One should see greater warming in the summer months than in the winter because there is more direct sunlight.	In winter, Earth cools by radiating energy back into space. If human-generated GHGs are causing warming, this process will slow, and one would expect to see a significant warming in the winter
Solar forcing should cause more extreme daytime warming than nighttime	GHGs take time to heat up and thus would show more extreme warming at night
One would expect to see warming on other planets in the solar system if the sun is causing warming	One should expect to see warming only on Earth if human-generated GHGs are the cause of warming

- Post-Activity Discussion/Whiteboarding
  - Come back together to share findings as a large group or allow a gallery walk to examine different groups' results.
  - Which climate-effect factor (solar-forced or greenhouse-gas-based warming) best fits the results of the graphs generated from the data?
  - Now that we have finally reached a consensus on the primary cause of climate change, it's time to consider just how bad it might be … ***see Part C***.
  - Have students return to the *Climate Change Core Principles Jamboard* you made a copy of at the beginning of the unit.
    - Ask them to look at all the questions generated for the **second** core principle.
    - If the *Part B: It's Us* activity either answered their questions or debunked the misconceptions tied to the principle, have them draw an X through their sticky notes.
    - Have them group any left-over questions/misconceptions to one side of the slide
    - Do they have any new questions or concerns they want to add?

Activities and Handouts (continued)

Part C: It's Bad

- Climate Feedback Loops
  - First, introduce the topic of feedback loops, reviewing both **negative** and **positive feedback loops** in general before providing any climate examples.
  - If you need a refresher or want to provide a reference for students during the classroom discussion, consider using Science Education Research Center's Starting Point for feedback loop summary models.
- PhET Greenhouse Effect Simulation
  - Go to the following interactive: The Greenhouse Effect.
    - The interactive should autoload. Currently, this program runs via a Java provider, but PhET is upgrading all its apps to HTML5 as funding allows.
    - **Teacher Tip:** This activity can be downloaded and played offline. Additionally, there are apps available for iPads and Chromebooks. For technical support, PhET has a variety of troubleshooting tips, whether your students are in-class or remote.
  - Students may do this activity individually, in small groups, or as part of a whole-class demonstration.
  - Provide students with the handout entitled *Climate Feedback Loops*.
  - Begin by instructing students to set the simulation to 1750, prior to the Industrial Revolution. The students should observe and describe what is happening in the simulation.
    - Example Explanation: Sunlight and infrared photons are being absorbed by the atmosphere and surface, causing the release of infrared photons. The temperature is also increasing to a point.
  - Guide students to observe what happens when they make certain changes:

Variable Change	Effect of Change
Increase Greenhouse Gases	Temperature Goes Up
Decrease Greenhouse Gases	Temperature Goes Down
Increase Cloud Cover	Temperature Goes Down

  - Instruct students to click the "Photon Absorption" tab and explore which substances absorb and re-radiate light, acting as GHGs.
  - After the students have explored this simulation, lead a discussion and ask them to share what they learned.
  - Some essential questions to consider during the discussion:
    - Keeping in mind previous activities, where did the data for this interactive originate? Does the data seem credible and supported by scientific consensus?

Activities and Handouts (continued)

Part C: It's Bad (continued)

- As higher temperatures cause more people to use air conditioning run by electric companies and power plants that release CO_2, what would happen?
- What would happen if increased temperatures caused the release of methane trapped in the ice caps?
- How would increasing temperatures affect water evaporation? What makes this a complicated process?
  - Be sure students notice that clouds cool, but H_2O in the form of water vapor is a GHG; therefore, clouds in this simulation re-radiate infrared energy.

- Be sure students identify the following feedback loops:
  - Warming → melting ice caps → lower albedo → more warming
  - Warming → melting of methane-rich ice → more warming
  - Warming → more evaporation → more clouds → higher albedo → cooling
  - Warming → more evaporation → more water vapor in atmosphere → more warming
- It is also important to note that, unlike the chocolate diet, experts agree … ***see Part D***.

- Have students return to the *Climate Change Core Principles Jamboard* you made a copy of at the beginning of the unit.
  - Ask them to look at all the questions generated for the **third** core principle.
  - If the *Part C: It's Bad* activity either answered their questions or debunked the misconceptions tied to the principle, have them draw an X through their sticky notes.
  - Have them group any left-over questions/misconceptions to one side of the slide
  - Do they have any new questions or concerns they want to add?

Part D: Experts Agree

- At this point, the students have examined different data sets and should have reached a consensus about several causes of climate change. Now is the appropriate point to return to the discussion of **scientific consensus**. The activities completed thus far are excellent examples of how science works, particularly how climate scientists have arrived at their conclusions over the last 50 years: by testing hypotheses through data collection and analysis. Current peer-reviewed scientific data continues to provide evidence supporting the claim that changes in rising global temperatures and the climate are due to human activities that have increased the amount of GHGs in the atmosphere, leading to a warming trend.
- **Anthropogenic climate change** is one of the largest factors driving current climate change.
- To help debunk the misconception that there is no consensus among climate scientists or that the matter of anthropogenic climate change is still up for debate, conduct the *Spot the Fallacy* activity at this time.

Activities and Handouts (continued)

Part D: Experts Agree (continued)

- **Spot the Fallacy**
  - One impactful way to draw together the first four core principles, is by completing this two-part activity.
  - This activity can be completed as homework, as an in-class assignment, or as a guided discussion.
  - This activity is also broken into two parts and could easily be split into two assignments.
  - By spotting the fallacies at the heart of climate change denial—especially well-organized efforts—students can begin to inoculate themselves against future encounters with climate change misinformation.
  - The first activity explores research conducted on the degree of consensus among climate scientists regarding the anthropogenic nature of climate change.
  - The second activity focuses on the "Global Warming Petition Project," which was started in 1998 by *climate change deniers* to counter the idea that climate scientists generally agree on the subject of climate change. Students examine information about the petition and use their previous research to conclude its credibility.
- You may wish to bring in statements disputing the scientific consensus made by public figures in the news or on social media throughout this activity. You may also introduce videos, shows, or news articles in which the climate-science perspective and the climate-denialist perspective are incorrectly given equal weight.
- In reality, the consensus for climate change has been studied repeatedly in different ways, revealing that upward of 97% of climate scientists and published papers on climate change agree that human activity is the cause of the observed changes in Earth's climate.
- Denial primarily comes from **fake experts** and the **magnified minority**
  Note: This is FLICC terminology—see Nature of Science Lesson Set One, Part E. The Characteristics of Science Denial for more detail.
- There will always be **outliers** or people on the fringes (e.g., the 3% of scientists and their papers in the consensus studies, comparable to the people and articles actually promoting the Chocolate Diet) and people speaking outside their areas of expertise (e.g., John Bohannon of the Chocolate Diet Hoax) on an issue.
- The teacher may wish to display the scientific agreement graph illustrating that consensus is strongest among scientists with the most relevant expertise on climate.
- With each of NCSE's climate change lesson sets, it is important to end with hope to lessen students' climate anxiety … ***see Part E***.
- Have students return to the *Climate Change Core Principles Jamboard* you made a copy of at the beginning of the unit.
  - Ask them to look at all the questions generated for the **fourth** core principle.

Activities and Handouts (continued)

Part D: Experts Agree (continued)

- If the *Part D: Experts Agree* activity either answered their questions or debunked the misconceptions tied to the principle, have them draw an X through their sticky notes.
- Have them group any left-over questions/misconceptions to one side of the slide
- Do they have any new questions or concerns they want to add?

Part E: There's Hope

- Building on previous activities, ask students to speculate what might result from increasing temperatures and feedback loops over time. Students probably will suggest various negative outcomes and few positive ones.
- Note that some students will view this information and believe that nothing we do will help or it's too late to do anything about the problem. But these are also misconceptions and ultimately have the same effect as denying the problem exists.
- In reality, the more we do sooner, the better off we'll be:
  - Substantially reducing GHGs released can affect rising temperatures
  - Interrupting the positive feedback loops prevent them from becoming runaway problems
  - Taking advantage of negative feedback loops can slow problems and keep them from progressing
- Wrap up the lesson by bringing the topic back to the Chocolate Diet as an analogy.
- Discuss three scenarios: stopping the chocolate diet today, stopping it after a month, and stopping it after a year.
  - In every situation, stopping this diet is going to lead to improved health
  - Be sure to emphasize the essential point: *The longer we wait, the more work we'd have to do to achieve our health goals and the more chance that we'd do long-term damage in the process*
- The same point is valid for climate change. There's no such thing as "too late"—the question is, how hard will it be to fix the damage, and how much damage will occur before we start?
- We'll address specific impacts in Lesson Set Four and solutions in Lesson Set Five, so it's unnecessary to get into deep detail here. The point is that students should not leave this lesson thinking that the problems presented by climate change are insurmountable.
- Have students return to the *Climate Change Core Principles Jamboard* one final time.
  - Ask them to look at all the questions generated for the **fifth** core principle
  - Were any of their questions or concerns addressed throughout the previous parts or *Part E: There's Hope?*
  - If not, explain that over the next few weeks, each lesson set covered will help them strategize possible climate solutions for the future
  - Have them group any left-over questions/misconceptions to one side of the slide
  - Do they have any new questions or concerns they want to add?
  - Let the students know they will return to this driving question board at the very end of this curriculum

Extension Activities

Deeper Dive

- The Dark Truth About Chocolate is an excellent source for students to dive deeper into how some scientific studies can be misleading when used by brand marketing to sell products.
- The Surgisphere Scandal: What Went Wrong? explores how scientific misconduct can damage public healthcare and why students need to examine evidence thoroughly. This article also provides evidence of the self-correcting nature of science. An infographic was developed to accompany this article.
- Buying Face Cream? Grab a Glossary provides an example of how marketers exploit the vocabulary of science to sell beauty products.

Formative Assessment

- Cranky Uncle game — provides students a way to assess their ability to identify the components of the FLICC model of science denial. It is also an excellent source to dismantle misconceptions about climate science. Be sure to check out climate communicator and researcher John Cook's site that also features research and background information for the game — including a teacher's guide.

Online Resources

The Con

» Chocolate diet research article: "Chocolate with High Cocoa Content as Weight Accelerator"

» *Today* (Australia): The Chocolate Diet: Lose Weight and Feel Better (3:05)

» CBS New York video: New Diet Pushes Eating Chocolate Every Day (2:29)

The Mark

» *Daily Star* chocolate diet article: "Eating Chocolate Can Help You Lose Weight, Shock Study Discovers"

Note: Other downloaded examples in the Teacher Resources folder

The Reveal

» *Gizmodo* chocolate diet article: "I Fooled Millions into Thinking Chocolate Helps Weight Loss. Here's How."

» CBSN Video: All About the Chocolate Diet Hoax (4:52)

» *Elle* magazine "I Lost Weight on the Chocolate Diet"

» *Wall Street Journal* video: Will a Chocolate Diet Help You Lose Weight? (3:45)

» SERC Geoscience Feedback Loops

» PhET The Greenhouse Effect simulation

» *Spot the Fallacy* Summative Activity: Global Warming Petition Project

Primary Literature/Works Cited

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