



Master Timeline (1 of 4)

Most of the events listed in the timeline below came from *The Discovery of Global Warming* by S. Weart (2010) and *The History of Climate Science* by J. Mason (2013). Events from additional references are cited in text. The carbon dioxide levels came from NOAA's Global Greenhouse Gas Reference Network (Tans & Keeling, 2014). Full citations can be found in the References Cited section of this activity.

Year	Event	Science or Policy	Reinforcing Prompt	Steps
1823	Carbon dioxide in the atmosphere was about 290 parts per million.	Interval Sign	While tools were not available at the time to measure atmospheric carbon dioxide levels, in the 1980s scientists learned how to measure air bubbles trapped in ice cores to determine atmospheric carbon dioxide levels from the past.	Walk 1 step
1824	Jean Baptiste Joseph Fourier (FOO-ree-ey), a French scientist, described Earth's atmosphere as an insulating blanket for the planet. He was the first to use the phrase the "greenhouse effect" to illustrate how the greenhouse gases keep the Earth a comfortable temperature despite our great distance from the sun.	Science		Walk 35 steps
1859	John Tyndall (TIN-dull), an Irish physicist, discovered that carbon dioxide is very good at trapping heat in the atmosphere. He worked with a variety of gases found in the atmosphere and found that carbon dioxide can block heat radiation.	Science		Walk 37 steps
1896	Svante Arrhenius (Suh-VAN-tay Are-REY-nee-oos), a Swedish scientist, was the first to say that increases in carbon dioxide in our atmosphere due to burning coal would cause a global warming effect.	Science	Coal replaced wood as the predominant energy source in the United States.	Walk 21 steps
1917	Alexander Graham Bell, a Scottish scientist and inventor of the telephone, wrote, "The unchecked burning of fossil fuels would have a sort of greenhouse effect" and "The net result is the greenhouse becomes a sort of hot-house."	Science	While Bell was most famous for the invention of the telephone, he worked in many fields of science. The 1917 paper was about natural resource depletion and demonstrated that many scientists were concerned about the impacts of greenhouse gases.	Walk 14 steps
1931	E.O. Hulburt, an American scientist, continued the work of Arrhenius (Are-REY-nee-oos), to include atmospheric water vapor and found that increases in carbon dioxide levels would increase global average temperatures by as much as approximately 4 degrees Celsius.	Science	This is equivalent to 7.2 degrees Fahrenheit.	Walk 7 steps



Master Timeline (2 of 4)

Year	Event	Science or Policy	Reinforcing Prompt	Steps
1938	Guy Callendar, an English engineer, looked at historical temperature records and carbon dioxide levels from around the world and concluded that levels had increased almost 10 percent since the 19th century and temperatures were warming globally.	Science		Walk 18 steps
1956	Gilbert Plass, an American physicist, published <i>The Carbon Dioxide Theory of Climate Change</i> , and said that more carbon dioxide in the atmosphere would increase global warming.	Science		Walk 1 step
1957	Roger Revelle (Ra-VELL), a scientist in California, said that there is a limit to how much carbon dioxide the ocean could absorb from the atmosphere and remain healthy.	Science	Previously, scientists thought the ocean could absorb unlimited amounts of carbon dioxide.	Walk 1 step
1958	Charles David Keeling (KEY-ling), a scientist from California, used new technology to measure levels of carbon dioxide in the atmosphere. Keeling measured atmospheric carbon dioxide levels to be 315 parts per million in 1958.	Science	The measurement stations that Keeling established in Antarctica and Mauna Loa, Hawaii, still function. They have allowed scientists to keep track of carbon dioxide levels and establish an increasing trend.	Walk 5 steps
1963	The annual average of carbon dioxide in the atmosphere was measured at 318 parts per million.	Interval Sign	Remember, the timeline started at 290 parts per million in 1823.	Walk 4 steps
1967	Syukuro Manabe (Shoo-KOO-roo Mah-NAH-bay), a meteorologist from Tokyo University, created the first computer model simulation of Earth's climate. This complex model included many variables and reaffirmed that the climate was changing, not only at Earth's surface but also throughout the atmosphere.	Science		Walk 6 steps
1973	The annual average of carbon dioxide in the atmosphere was measured at 330 parts per million.	Interval Sign		Walk 8 steps
1981	Climatologists Tom Wigley and Phil Jones wrote that "the effects of carbon dioxide may not be detectable until around the turn of the century. By this time, atmospheric carbon dioxide concentration will probably have become sufficiently high that a climatic change significantly larger than any which has occurred in the past century could be unavoidable."	Science		Walk 2 steps
1983	The annual average of carbon dioxide in the atmosphere was measured at 343 parts per million.	Interval Sign		Walk 2 steps
1985	A group of Russian scientists at the Vostok (VAH-stock) Station in Antarctica drilled an ice core about 2 kilometers (more than 1,980 meters or 6,500 feet!) deep. This ice core held approximately 150,000 years of climate history trapped in air bubbles.	Science	This is how we knew the carbon dioxide levels in 1823 when we started the timeline.	Walk 3 steps



Master Timeline (3 of 4)

Year	Event	Science or Policy	Reinforcing Prompt	Steps
1988	The Intergovernmental Panel on Climate Change (IPCC) was started. This international organization includes scientists and government officials from around the world who help synthesize climate science and make recommendations about how greenhouse gas emissions and climate change will impact the Earth and its inhabitants.	Policy		Walk 4 steps
1992	A significant number of the world's nations recognized that climate change needed to be addressed globally and formed the United Nations Framework Convention on Climate Change. Nearly every country, including the United States, signed the agreement.	Policy		Walk 1 step
1993	The annual average of carbon dioxide in the atmosphere was measured at 357 parts per million.	Interval Sign		No steps
1993	Ice cores from Greenland showed that in the past, drastic climate changes occurred in a span of only 10 years. This greatly changed impressions that a changing climate only happens on a slow, gradual basis.	Science		Walk 4 steps
1997	Negotiations at the United Nations' Conference on Climate Change in Kyoto, Japan, resulted in the Kyoto Protocol, an international agreement to reduce greenhouse gases.	Policy	The U.S. signed the Kyoto Protocol on November 12, 1998. However, the Protocol met opposition in the U.S. Congress and was never ratified.	Walk 6 steps
2003	The annual average of carbon dioxide in the atmosphere was measured at 376 parts per million.	Interval Sign		No steps
2003	Scientists reported that the increase in atmospheric carbon dioxide resulted in increased absorption of carbon dioxide in the oceans, causing a change in the pH of the oceans. The change in pH, which continues today, is larger than anything in the geological record for the last 300 million years (Caldeira & Wickett, 2003).	Science	Recall Roger Revelle from 1957, who thought the oceans can only absorb so much carbon and be healthy. This was proof that he was correct!	Walk 2 steps
2005	The European Union Emissions Trading System was launched to reduce greenhouse gas emissions through a "cap and trade" program.	Policy	A cap and trade program creates incentives for companies to reduce emissions and forces companies who pollute to pay for the privilege.	Walk 2 steps



Master Timeline (4 of 4)

Year	Event	Science or Policy	Reinforcing Prompt	Steps
2007	Scientists reported that the melting of Arctic sea ice has been faster than models originally predicted. They showed the rate of melting was accelerating (Stroeve et al., 2007).	Science		No steps
2007	The United Nations Framework Convention on Climate Change made important decisions on a climate change mitigation solution that seeks to reduce emissions from deforestation in developing countries. That initiative is called REDD+ (Red Plus).	Policy	This policy agreement is helping countries that still have forests to keep them.	Walk 1 step
2008	The U.S. Forest Service published a report called a "Strategic Framework for Responding to Climate Change," which outlined strategies that support adaptation to climate change in our national forests.	Policy		Walk 1 step
2009	The U.S. Interagency Climate Change Adaptation Task Force was created to develop recommendations for the U.S. president to prepare for and adapt to the effects of climate change at the national level.	Policy		Walk 4 steps
2013	The annual average of carbon dioxide in the atmosphere was measured at 396 parts per million.	Interval Sign	In May 2014, the daily average for atmospheric carbon dioxide exceeded 400 parts per million for the first time in recorded history. The level of carbon dioxide in the atmosphere varies by season, peaking in May just before many trees in the northern hemisphere get new leaves and begin to photosynthesize. The average annual level is not yet at 400 parts per million.	No steps
2013	Scientists measured the mean global temperature at 14.6 degrees Celsius, the warmest it has been in thousands of years.	Science	This average global temperature is equivalent to approximately 58 degrees Fahrenheit.	No steps
2013	The United States president, Barack Obama, signed an executive order that created the Council on Climate Preparedness and Resilience. The council works to help federal programs prepare for climate-related changes and provide information for the public.	Policy	This new Council replaced the Interagency Climate Change Adaptation Task Force.	Walk 1 step
2014	While much of the eastern United States experienced a colder than normal winter, it was warmer than normal in the Arctic (National Snow and Ice Data Center, 2014).	Science	It was so warm in the Arctic that the sea ice did not extend as it typically does. The winter of 2014 was the fourth lowest extent of Arctic sea ice ever recorded by satellites during February.	Done!



Timeline Cards (1 of 3)

1824

Jean Baptiste Joseph Fourier (FOO-ree-ey), a French scientist, described Earth's atmosphere as an insulating blanket for the planet. He was the first to use the phrase the "greenhouse effect" to illustrate how the greenhouse gases keep the Earth a comfortable temperature despite our great distance from the sun.

1859

John Tyndall (TIN-dull), an Irish physicist, discovered that carbon dioxide is very good at trapping heat in the atmosphere. He worked with a variety of gases found in the atmosphere and found that carbon dioxide can block heat radiation.

1896

Svante Arrhenius (Suh-VAN-tay Are-REY-nee-oos), a Swedish scientist, was the first to say that increases in carbon dioxide in our atmosphere due to burning coal would cause a global warming effect.

1917

Alexander Graham Bell, a Scottish scientist and inventor of the telephone, wrote, "The unchecked burning of fossil fuels would have a sort of greenhouse effect" and "The net result is the greenhouse becomes a sort of hot-house."

1931

E.O. Hulburt, an American scientist, continued the work of Arrhenius (Are-REY-nee-oos), to include atmospheric water vapor and found that increases in carbon dioxide levels would increase global average temperatures by as much as approximately 4 degrees Celsius.

1938

Guy Callendar, an English engineer, looked at historical temperature records and carbon dioxide levels from around the world and concluded that levels had increased almost 10 percent since the 19th century and temperatures were warming globally.

1956

Gilbert Plass, an American physicist, published *The Carbon Dioxide Theory of Climate Change*, and said that more carbon dioxide in the atmosphere would increase global warming.

1957

Roger Revelle (Ra-VELL), a scientist in California, said that there is a limit to how much carbon dioxide the ocean could absorb from the atmosphere and remain healthy.

1958

Charles David Keeling (KEY-ling), a scientist from California, used new technology to measure levels of carbon dioxide in the atmosphere. Keeling measured atmospheric carbon dioxide levels to be 315 parts per million in 1958.



Timeline Cards (2 of 3)

1967	<p>Syukuro Manabe (Shoo-KOO-roo Mah-NAH-bay), a meteorologist from Tokyo University, created the first computer model simulation of Earth's climate. This complex model included many variables and reaffirmed that the climate was changing, not only at Earth's surface but also throughout the atmosphere.</p>
1981	<p>Climatologists Tom Wigley and Phil Jones wrote that "the effects of carbon dioxide may not be detectable until around the turn of the century. By this time, atmospheric carbon dioxide concentration will probably have become sufficiently high that a climatic change significantly larger than any which has occurred in the past century could be unavoidable."</p>
1985	<p>A group of Russian scientists at the Vostok (VAH-stock) Station in Antarctica drilled an ice core about 2 kilometers (more than 1,980 meters or 6,500 feet!) deep. This ice core held approximately 150,000 years of climate history trapped in air bubbles.</p>
1988	<p>The Intergovernmental Panel on Climate Change (IPCC) was started. This international organization includes scientists and government officials from around the world who help synthesize climate science and make recommendations about how greenhouse gas emissions and climate change will impact the Earth and its inhabitants.</p>
1992	<p>A significant number of the world's nations recognized that climate change needed to be addressed globally and formed the United Nations Framework Convention on Climate Change. Nearly every country, including the United States, signed the agreement.</p>
1993	<p>Ice cores from Greenland showed that in the past, drastic climate changes occurred in a span of only 10 years. This greatly changed impressions that a changing climate only happens on a slow, gradual basis.</p>
1997	<p>Negotiations at the United Nations' Conference on Climate Change in Kyoto, Japan, resulted in the Kyoto Protocol, an international agreement to reduce greenhouse gases.</p>
2003	<p>Scientists reported that the increase in atmospheric carbon dioxide resulted in increased absorption of carbon dioxide in the oceans, causing a change in the pH of the oceans. The change in pH, which continues today, is larger than anything in the geological record for the last 300 million years.</p>



Timeline Cards (3 of 3)

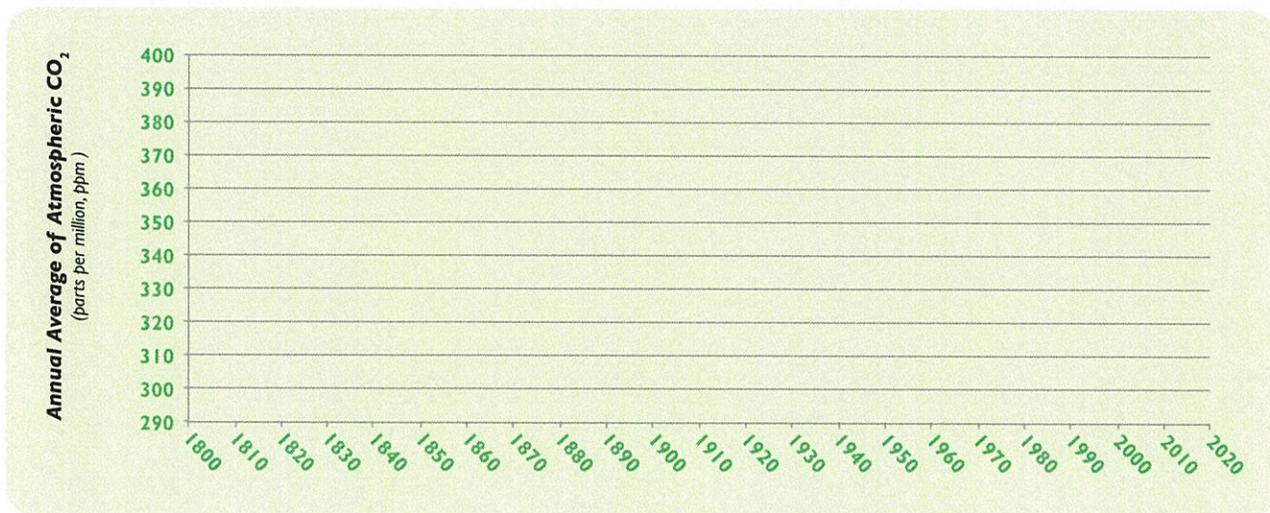
2005	The European Union Emissions Trading System was launched to reduce greenhouse gas emissions through a “cap and trade” program.
2007	Scientists reported that the melting of Arctic sea ice has been faster than models originally predicted. They showed the rate of melting was accelerating.
2007	The United Nations Framework Convention on Climate Change made important decisions on a climate change mitigation solution that seeks to reduce emissions from deforestation in developing countries. That initiative is called REDD+ (Red Plus).
2008	The U.S. Forest Service published a report called a “Strategic Framework for Responding to Climate Change,” which outlined strategies that support adaptation to climate change in our national forests.
2009	The U.S. Interagency Climate Change Adaptation Task Force was created to develop recommendations for the U.S. president to prepare for and adapt to the effects of climate change at the national level.
2013	Scientists measured the mean global temperature at 14.6 degrees Celsius, the warmest it has been in thousands of years.
2013	The United States president, Barack Obama, signed an executive order that created the Council on Climate Preparedness and Resilience. The council works to help federal programs prepare for climate-related changes and provide information for the public.
2014	While much of the eastern United States experienced a colder than normal winter, it was warmer than normal in the Arctic.

Climate Science Timeline (1 of 2)

NAME _____

DATE _____

- On the graph below, plot the measurements of atmospheric carbon dioxide (CO₂) as you step through the timeline of climate science. Once you make it through the entire timeline, connect the dots with straight lines to see how the amount of carbon dioxide in the atmosphere has changed over the past 200 years.



- Mark the climate history events on the two timelines below. The events are categorized as either science or policy. As you listen to the dates of these events, add an "X" at the appropriate place on the correct timeline to indicate when that event took place.

Science Events:



Policy Events:





Forest Service and Climate Change Video (1 of 2)

NAME _____

DATE _____

Read over the following questions. Then watch the 13-minute video to learn more about what the U.S. Forest Service is doing to help our forests as we deal with a changing climate. Answer the questions as you watch the video.

Video Questions

1. What is the environmentally friendly machine that helps to trap carbon dioxide (CO₂)? _____
2. What is the process by which trees remove CO₂ from the atmosphere?
3. Forests cover almost _____ of the world's total land area and account for _____% of the annual interchange of carbon between the atmosphere and the land.
4. Name the three main roles of the U.S. Forest Service with regard to climate change:
 - 1) _____
 - 2) _____
 - 3) _____

Video Break Discussion

5. What is mitigation? Describe one example of this strategy used by the U.S. Forest Service and explain how it mitigates against climate change.

Video Break Discussion

6. What is adaptation? Describe one example of this strategy and explain why it is an adaptation to future climate change.
7. Finish the quote: "It's not only about changing light bulbs, it's about changing _____ and _____."

