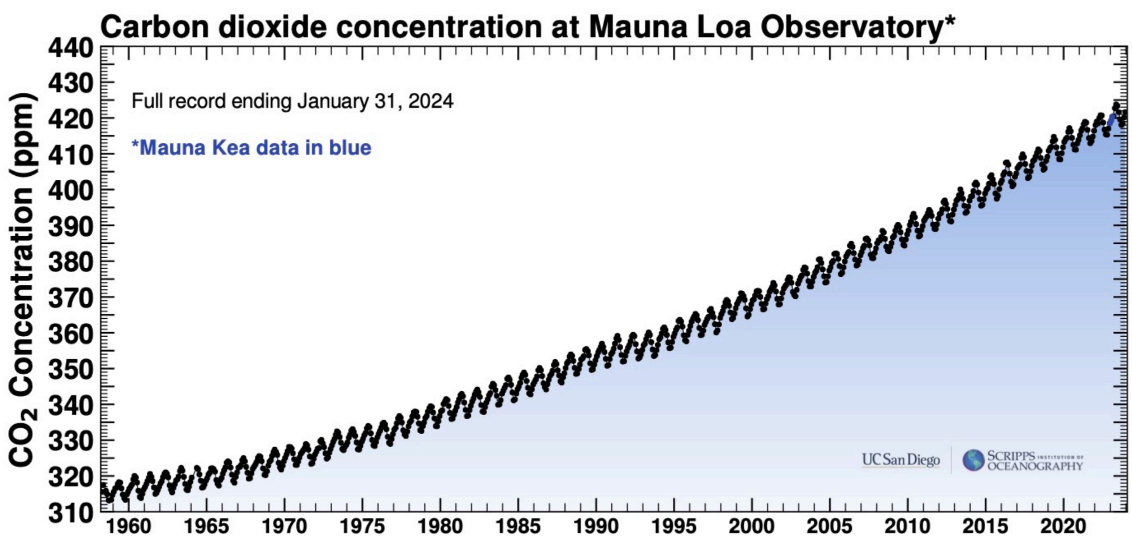
Read this excerpt from Chapter 4 of *Climate Change: The Science of Global Warming and Our Energy Future (2nd Edition)*, p.101:

> The growing amount of carbon dioxide (CO_2) in the atmosphere is the primary cause for global warming. It is therefore important to understand the factors that naturally control how carbon distributes itself among the various components of the Earth system. Atmospheric CO_2 levels have been measured continuously since 1958. That year, Charles Keeling (1928-2005), who had just joined the faculty at the Scripps Institution of Oceanography, began to measure CO_2 at the newly established observatory on the top of Mauna Loa Volcano in Hawai'i. The change in CO_2 content with time, widely referred to as the Keeling curve, shows two interesting features. First, every year CO_2 concentration reaches a maximum in May, then decreases until October, and finally begins to rise again. The reason is that plants in the Northern Hemisphere (the hemisphere with the largest plant biomass) begin to grow rapidly during the boreal late spring, which draws down CO_2 in the atmosphere. In the fall, these plants become dormant or die and decay, thus returning CO_2 to the atmosphere.



The Keeling curve (source)

> The second feature of the Keeling curve is equally obvious. The CO_2 content of the atmosphere has been rising at a rapid rate since Keeling started to measure it. In 1958, the annual average CO_2 content of the atmosphere was 315 ppm (parts per million), which was already about 12.5 percent higher than the preindustrial level of 280 ppm, as measured in ice cores. The year 2015 was the first in human history that the annual average CO_2 content of the atmosphere, as measured at Mauna Loa, exceeded 400 ppm. The last time CO_2 reached 400 ppm was probably more than 4 million years ago, during the mid-Pliocene. Moreover, the current rate of CO_2 increase, which has been about 2 ppm a year, is far greater than any common natural phenomenon could produce and is likely unprecedented in the climate record. Emissions of CO_2 and other

greenhouse gases from human activities – mainly fossil-fuel burning, cement production (which involves the heating of calcium carbonate [$CaCO_3$] to produce calcium oxide [or lime] and CO_2), and land-use change, together commonly referred to as anthropogenic emissions – account for this rise.

Despite the rising levels of CO_2 in the atmosphere, there is another curious relationship between the total carbon that is emitted by human activities and the amount that accumulates in the atmosphere: less than half of the carbon emitted since 1750 is now in the atmosphere. Where has the rest gone? The answer is that it has been removed by and is now stored in the ocean and terrestrial (land-based) ecosystems. This brings us to the subject of this chapter, the so-called *carbon cycle*, which refers to the flow of carbon among the various global "reservoirs" that store carbon. The chapter explores how the ocean and terrestrial reservoirs control the CO_2 content of the atmosphere, and how the ocean is affected by the increase in atmospheric CO_2.

This week, we're going to explore the carbon cycle, including where carbon is stored on our planet and the impacts it has when it moves. You'll break into three expert groups of 2-3 students each and investigate these topics to share with the rest of the class. You can use ***scientifically sound*** websites, pictures, diagrams, videos, etc. to help answer the guiding questions below, but remember to make your information *useful to the other students in the class*.

Group 1: Long-term carbon cycle & fossil fuels - Ryker & Kaysia & Ollie

- where is most carbon on Earth located? how much is stored there?
- what is the "long-term" carbon cycle? what materials does it involve? how is carbon stored in these materials? why is there so much more carbon in the long-term carbon cycle than in the short-term?
- what are fossil-fuels? how do they connect the long-term and short-term carbon cycles?

Group 2: Short-term carbon cycle & the ocean - Eli & Mayara & Gia

- what is the short-term carbon cycle? what are the surface reservoirs of carbon, and how much is stored in each?
- how does CO_2 dissolve in ocean water? how is solubility affected by temperature? how does dissolving CO_2 affect the ocean's pH?
- what is the ocean's "biological carbon pump" and how does it remove carbon from the atmosphere? where is this carbon eventually stored?

Group 3: Impacts of carbon emissions - Katherine & Anabelle & David

- how much carbon are humans putting in the atmosphere now? how does this compare to geological records? how does the rate of our carbon emissions compare to the rate of carbon uptake by the surface reservoirs?
- what is ocean acidification? what are some of its current and projected impacts? how could this affect marine life and people around the world?

- how are global biogeochemical processes predicted to operate with more carbon in the atmosphere? what impacts could this have on plant growth? soil formation? ocean CO_2 uptake?

Remember, these are guiding questions to help you assemble information about your topic. You aren't expected to answer every single question, but if you do, you'll have a deeper understanding of your topic, and you'll be better able to explain it to the rest of us. Make sure you keep track of your sources so you can share them with us!