Keeling Curve-arama!

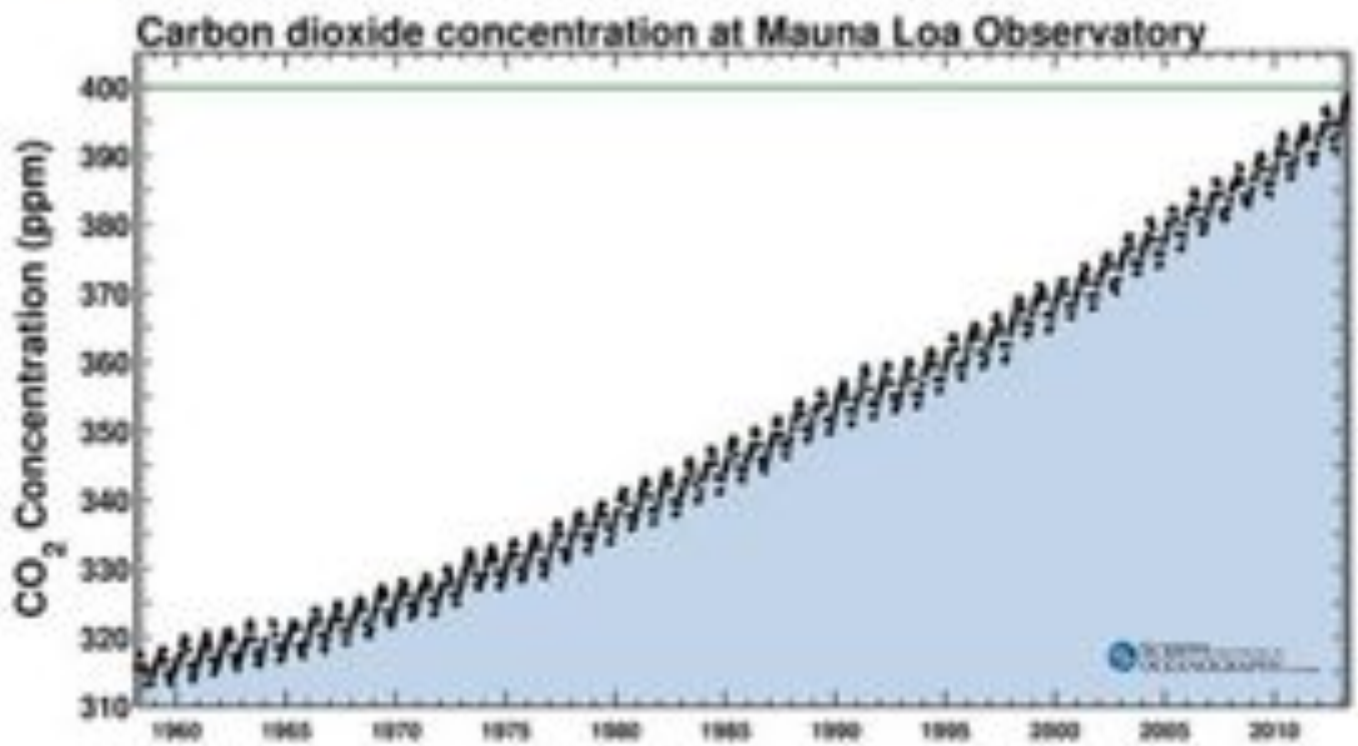
understanding what is local versus generalizable about atmospheric carbon dioxide concentrations

With Jenny Dauer & Andy Anderson

Climate Change's Psychological Milestone

Turning 400 is a lot worse than turning 40.

By Catherine Brahic | Posted Sunday, June 2, 2013, at 8:15 AM



Why Hawaii?

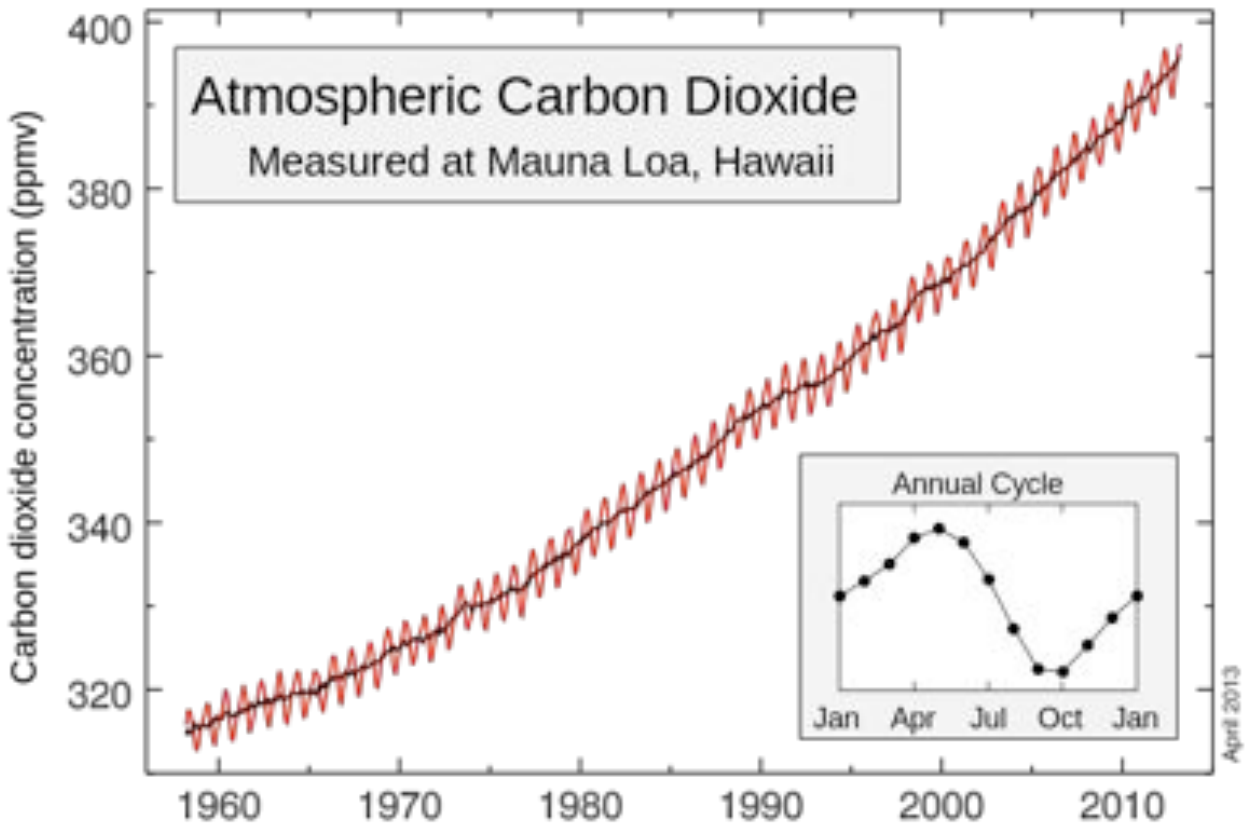
Was it the piña coladas?

Photo credit: NYT article, Jonathan Kingston/Aurora Select

PEOE Inquiry Sequence

Predict-Explain, Observe, Explain

Does the Keeling Curve tell us anything about Michigan?



Predict/Explain: What is the CO_2 concentration in the air in locations around KBS?

1. Split into 4 groups.
2. Pick at least two locations to measure CO_2 (Ideas: in classroom, in parking lot, by lake, near the grass.)
3. **Predict** the CO_2 concentration, and a range in which you might be 95% confident. For example: "325 ppm ± 20 ppm" for each location.
4. **Explain** why you made that prediction.

Observe: Take your measurements

Tools for the observation: CO_2 Vernier Probes

Take CO_2 measurements in two locations.

Please return in 15 minutes.

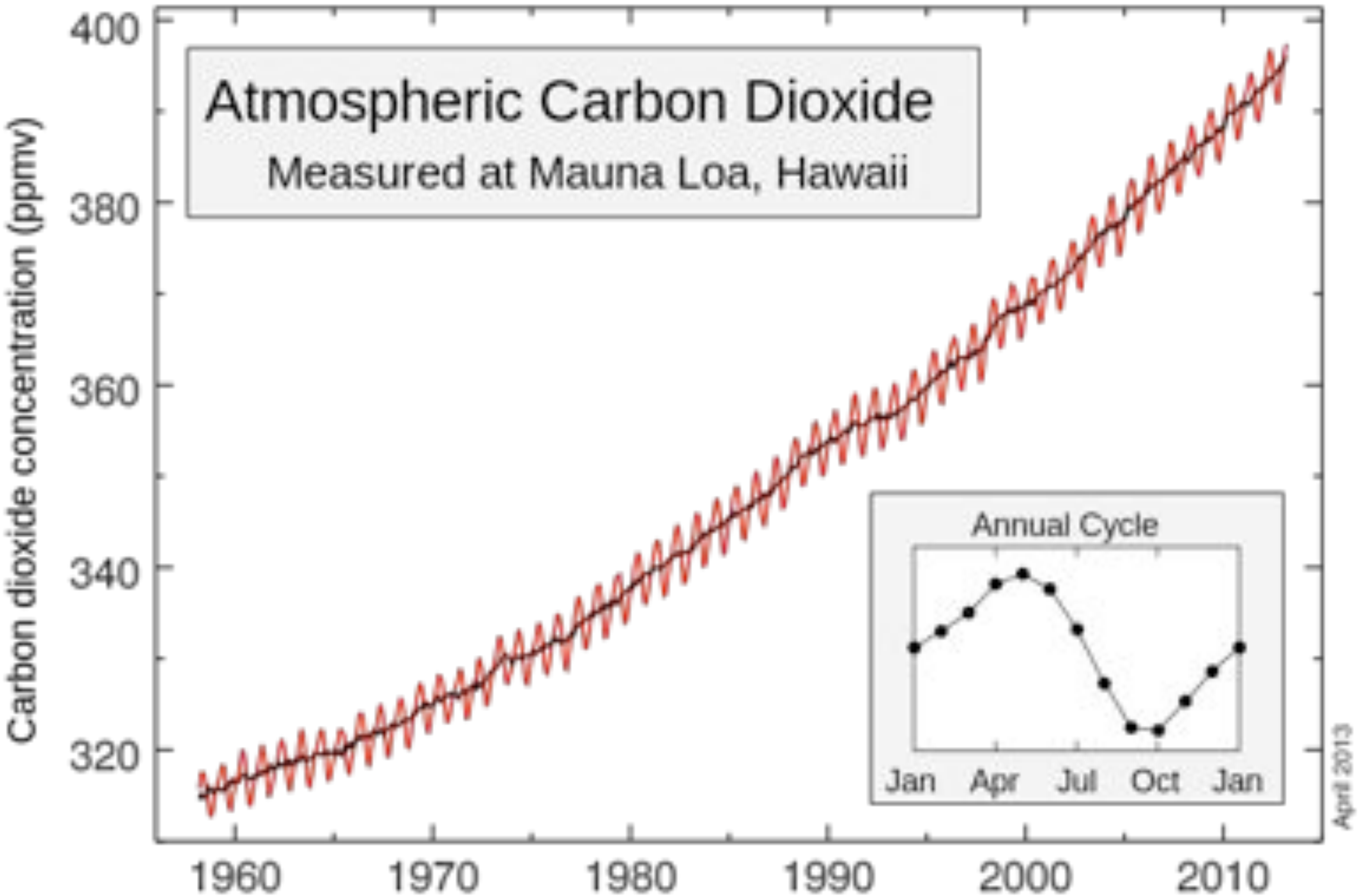
Compare class results and look for patterns

- Record your results on the chalkboard
- What patterns do you see in the data?

Discussion

Questions for discussion:

1. Did your predictions match the observations?
2. List the factors that might play a role in CO_2 concentration (on what spatial and temporal scale do these play role?)
3. What do you think the CO_2 concentration would be in these locations in the winter?

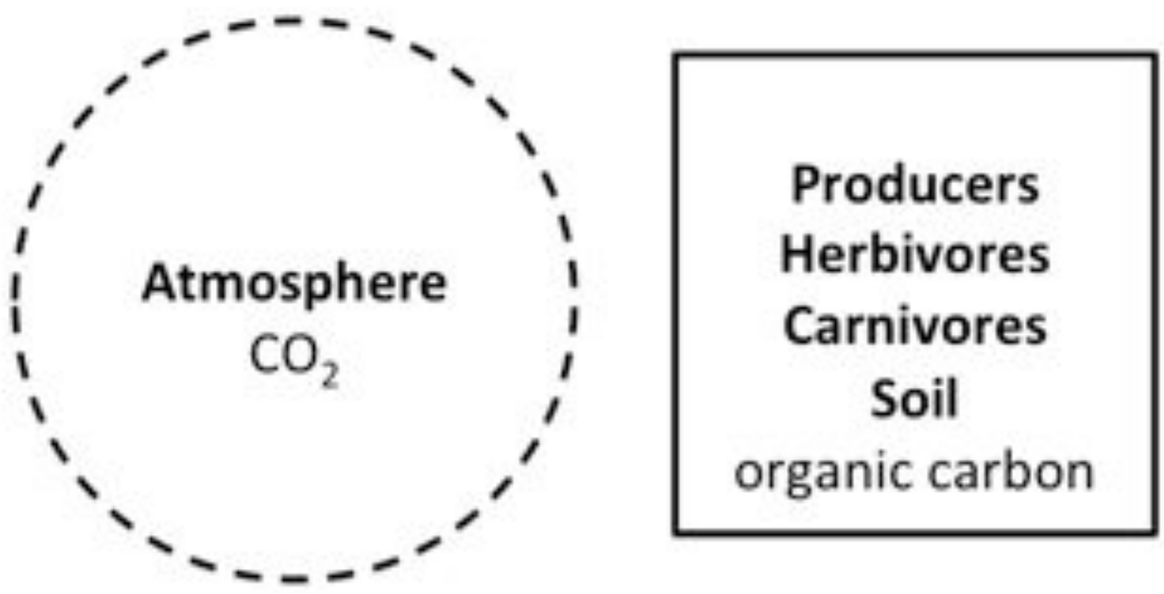

Atmospheric Carbon Dioxide
Measured at Mauna Loa, Hawaii
Carbon dioxide concentration (ppmv)
400
380
360
340
320
1960
1970
1980
1990
2000
2010
Annual Cycle
Jan
Apr
Jul
Oct
Jan
April 2013

Inorganic vs organic

These two pools represent:

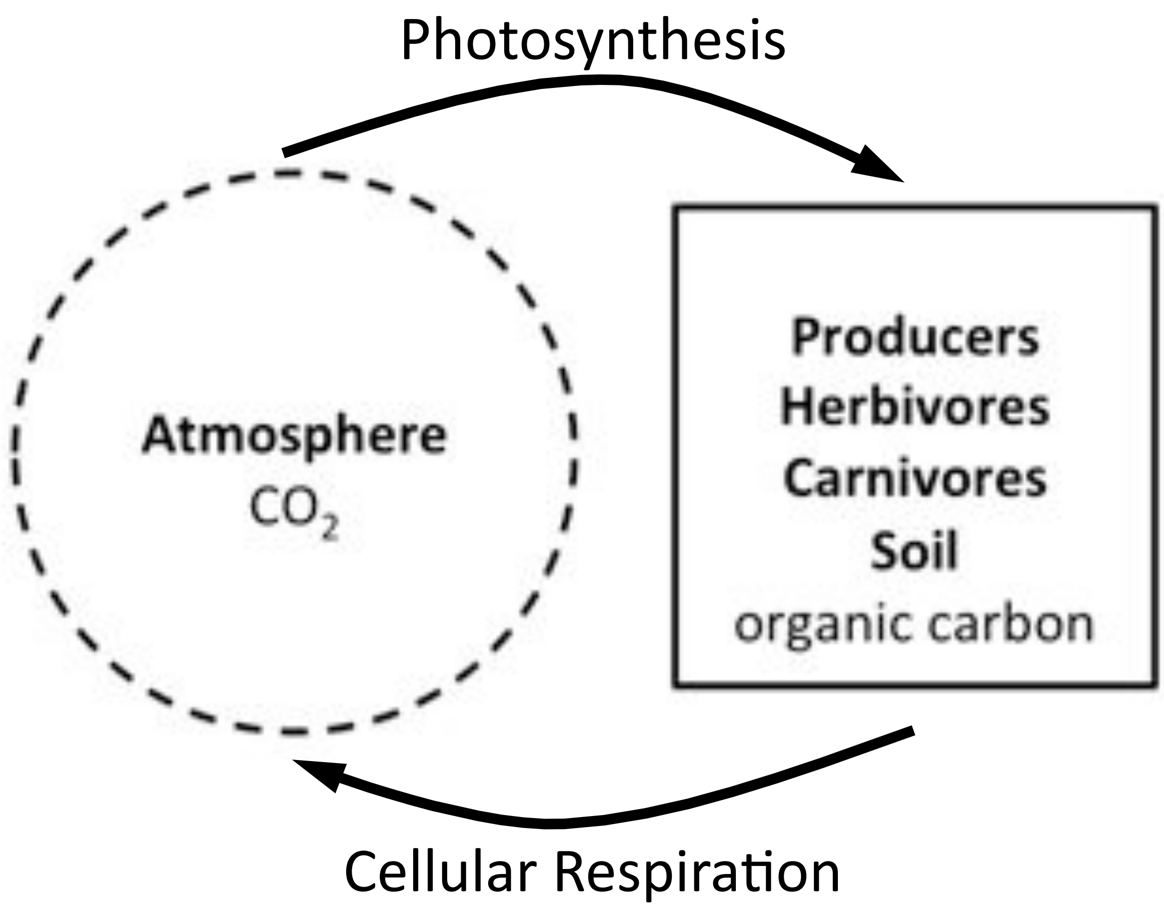
Inorganic carbon that is in the atmosphere in the form of CO_2

Organic biomass that is stored in the producers, herbivores, carnivores, soil, and other living parts of the ecosystem



Inorganic vs organic

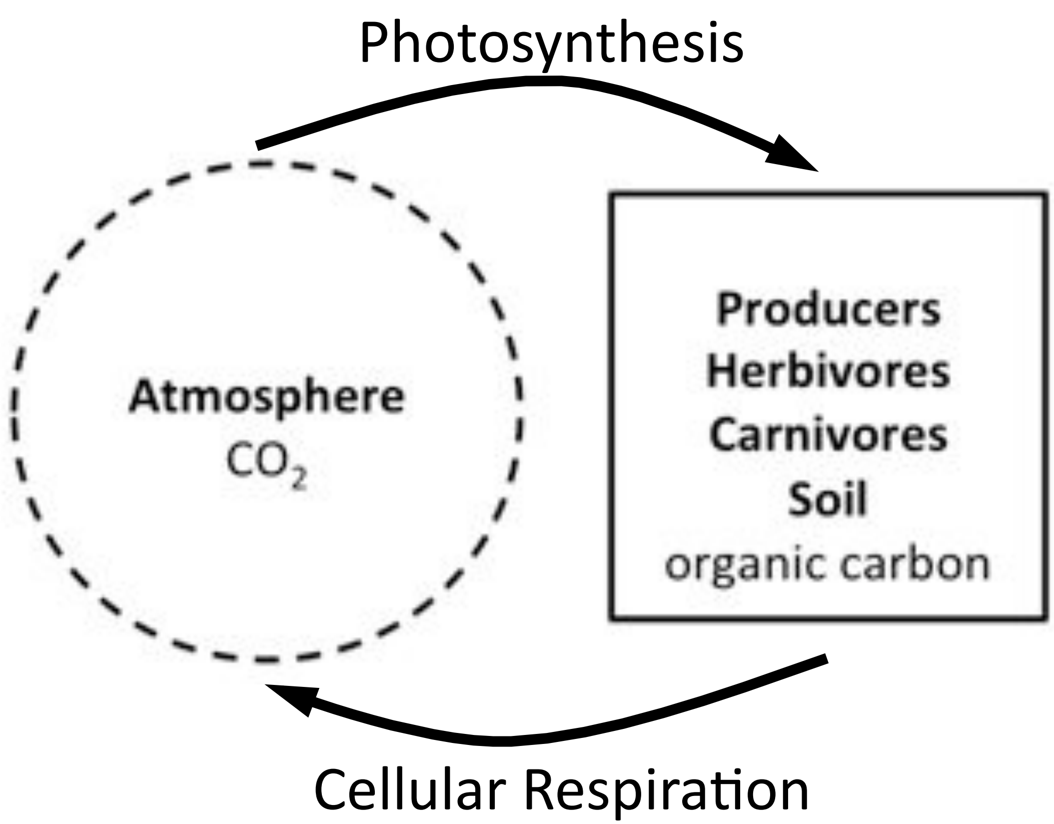
You will track carbon atoms moving back and forth between the inorganic pool of carbon in the atmosphere, and the organic pool of carbon in the biomass.



Fluxes

The amount of carbon that moves per unit of time is called a "flux". We will examine one year of time that passes.

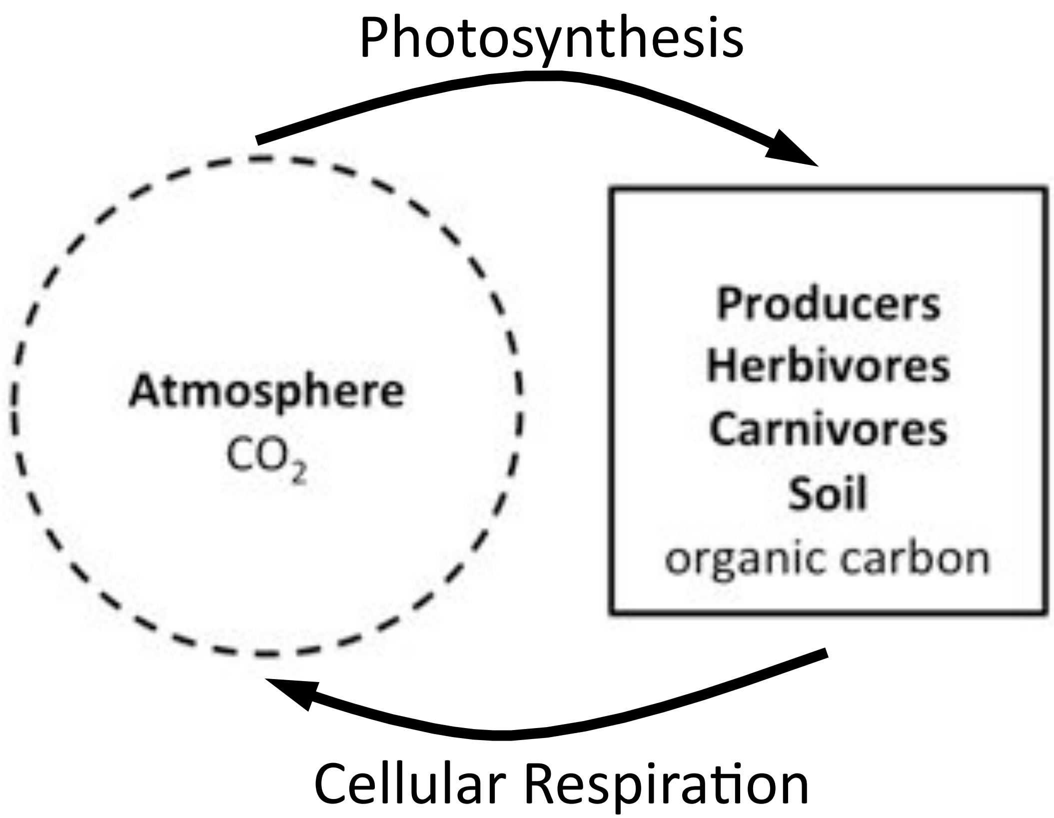
So you will record the number of carbon atoms that move between pools per year



Carbon Pools Change Size Over Time

If the organic pool has more carbon atoms, that means there are more living things in the ecosystem!

(More biomass and soil organic carbon exists, so more plants & animals)

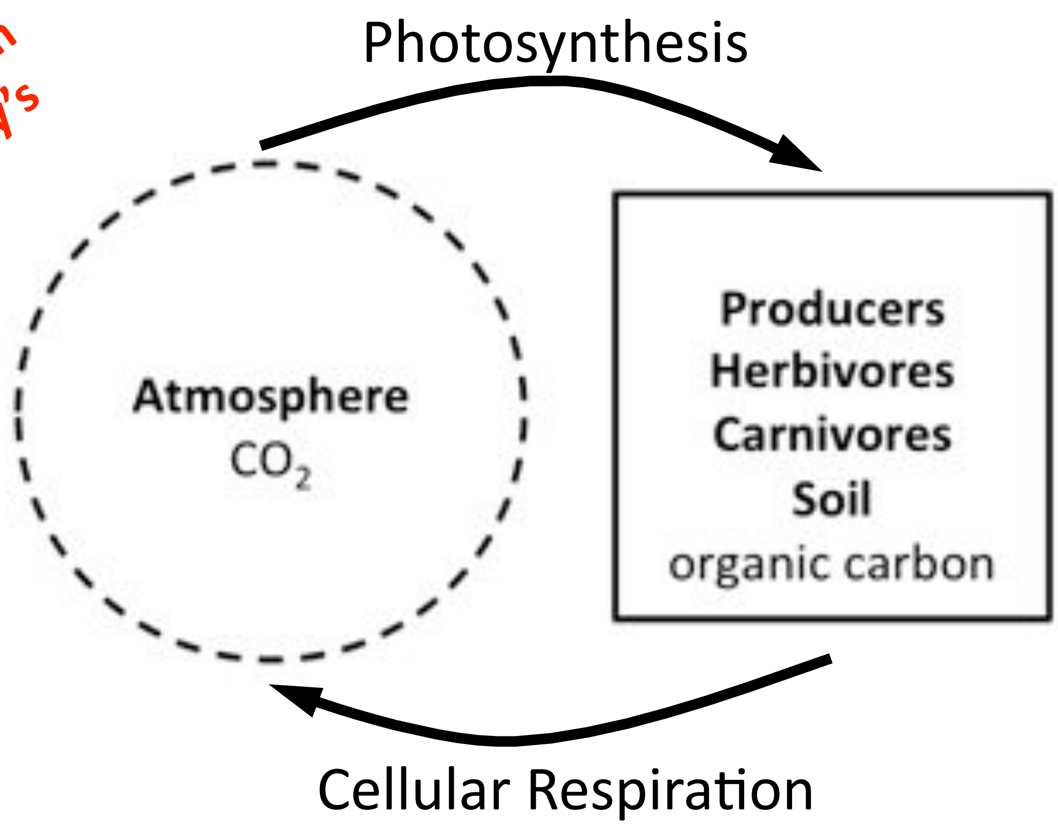


Round 2

Some trees were planted in an abandoned cornfield!

So photosynthesis happens at a faster rate than respiration. The result is trees growing and getting bigger. Soon there will be a forest!

Just one round as an example for today's workshop



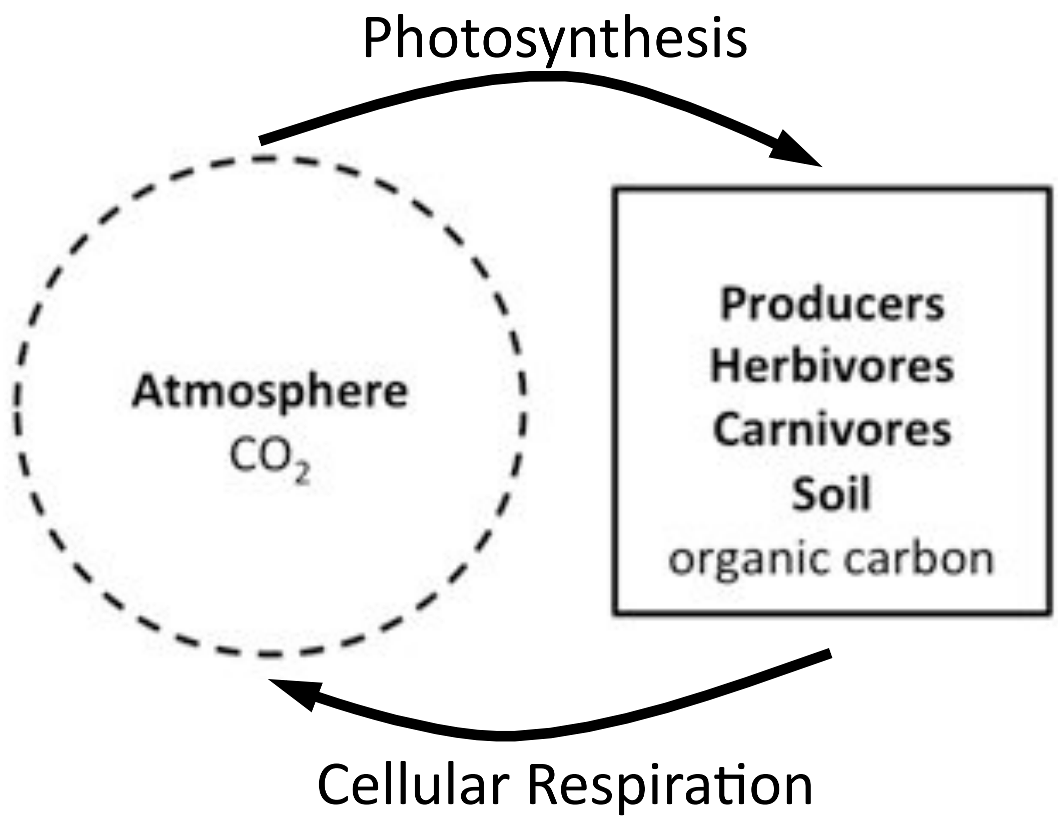
Round 2: Trees planted

Place 400 carbon atoms in the organic carbon pool.

Place 800 carbon atoms in the atmosphere pool.

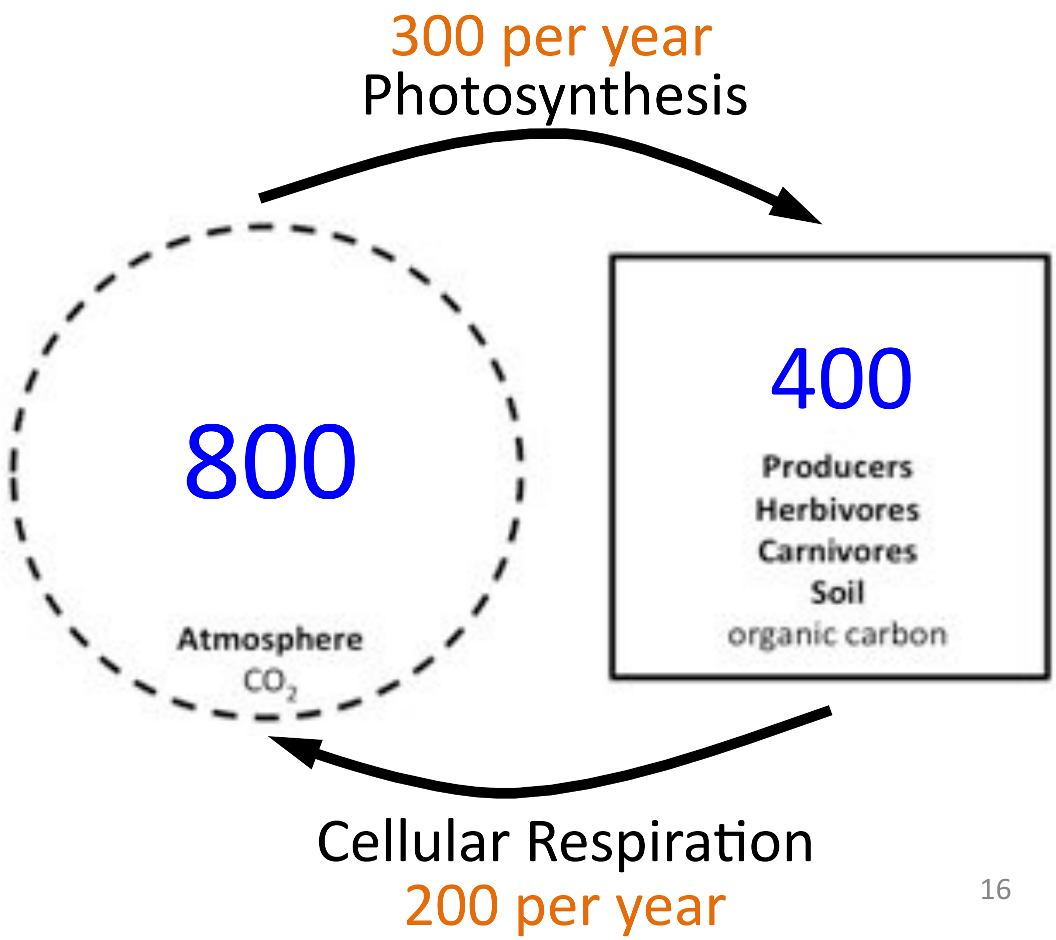
Every year 300 carbon atoms are photosynthesized.

Every year 200 carbon atoms are respired.



Round 2: Trees planted

Predict how pool sizes will change after a few years



Round 2: Trees are planted

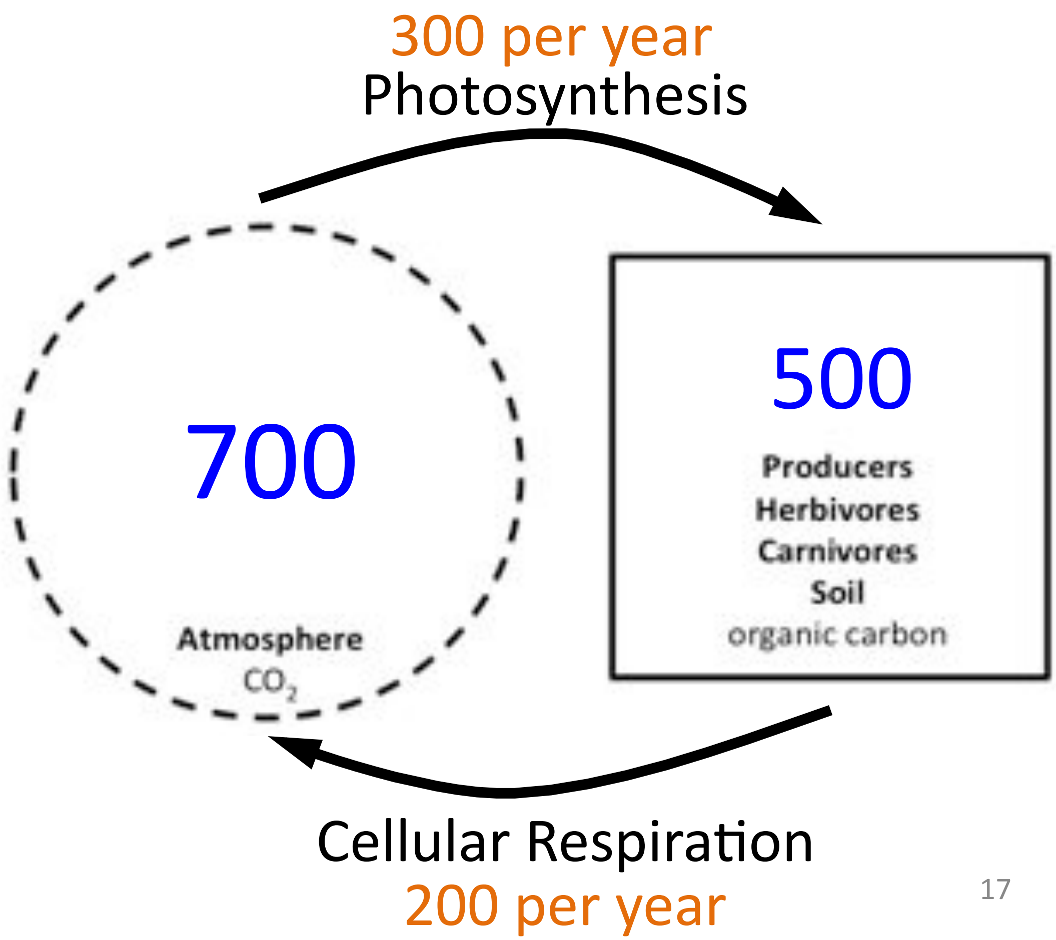
End of year 1:

Inorganic pool

800 – 300 + 200 = 700

Organic pool

400 – 200 + 300 = 500



Round 2: Trees are planted

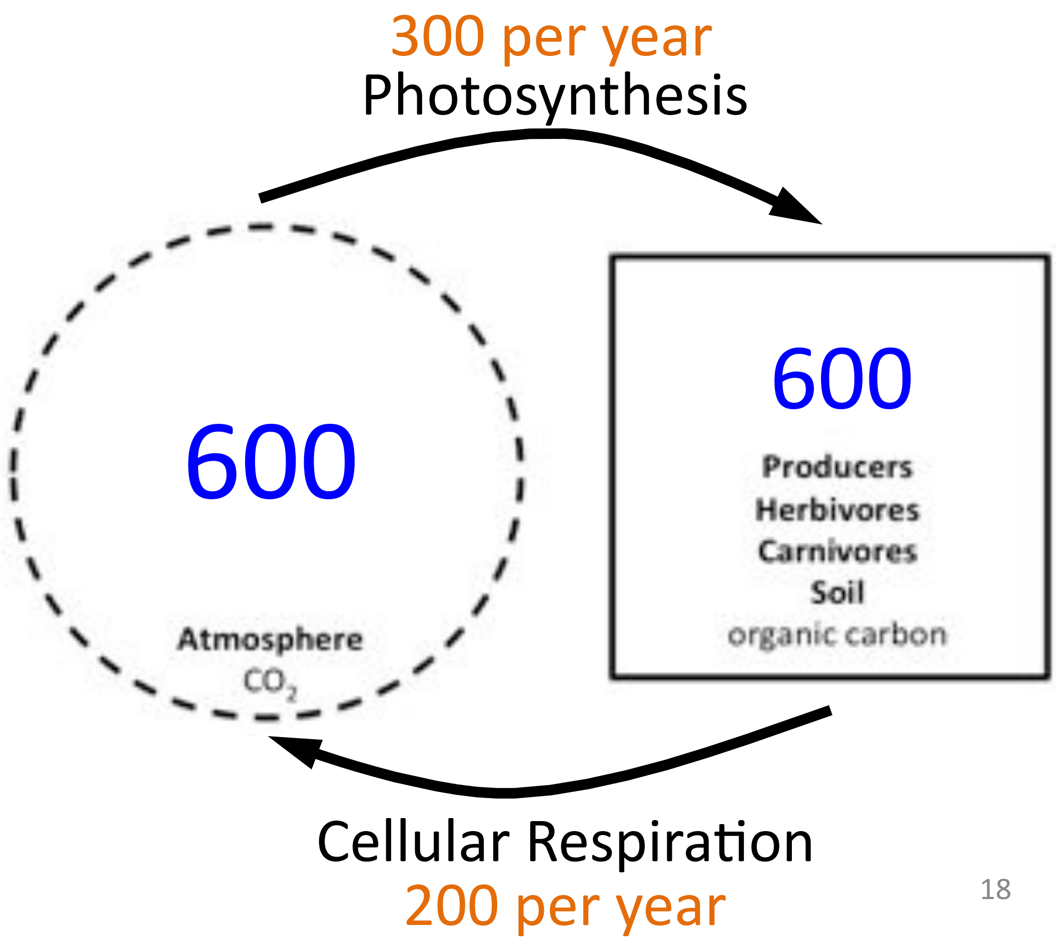
End of year 2:

Inorganic pool

700 – 300 + 200 = 600

Organic pool

500 – 200 + 300 = 600



Round 2: Trees are planted

The flux of photosynthesis is more than the flux of respiration in the ecosystem.

Where is most of the carbon in this round: In the organic pool or the inorganic pool?

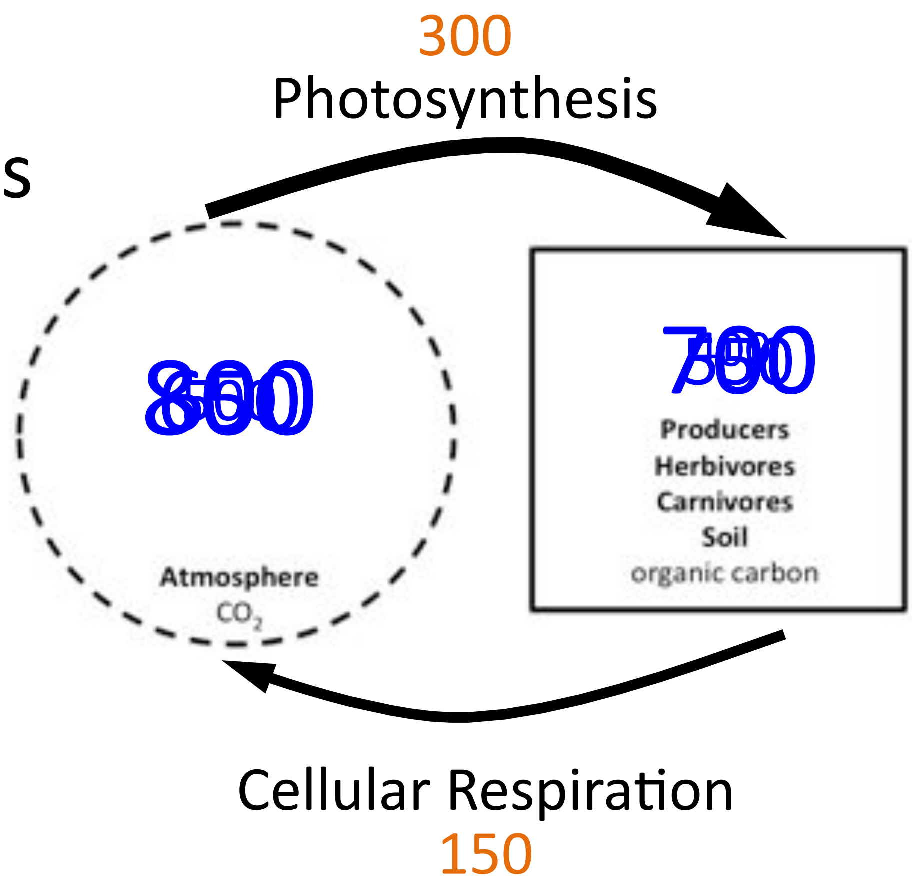
How did the organic and inorganic pools change over time?

At the end of the year, did the ecosystem get bigger (more plants and animals)?

Fluxes of carbon change during seasons

SUMMER:

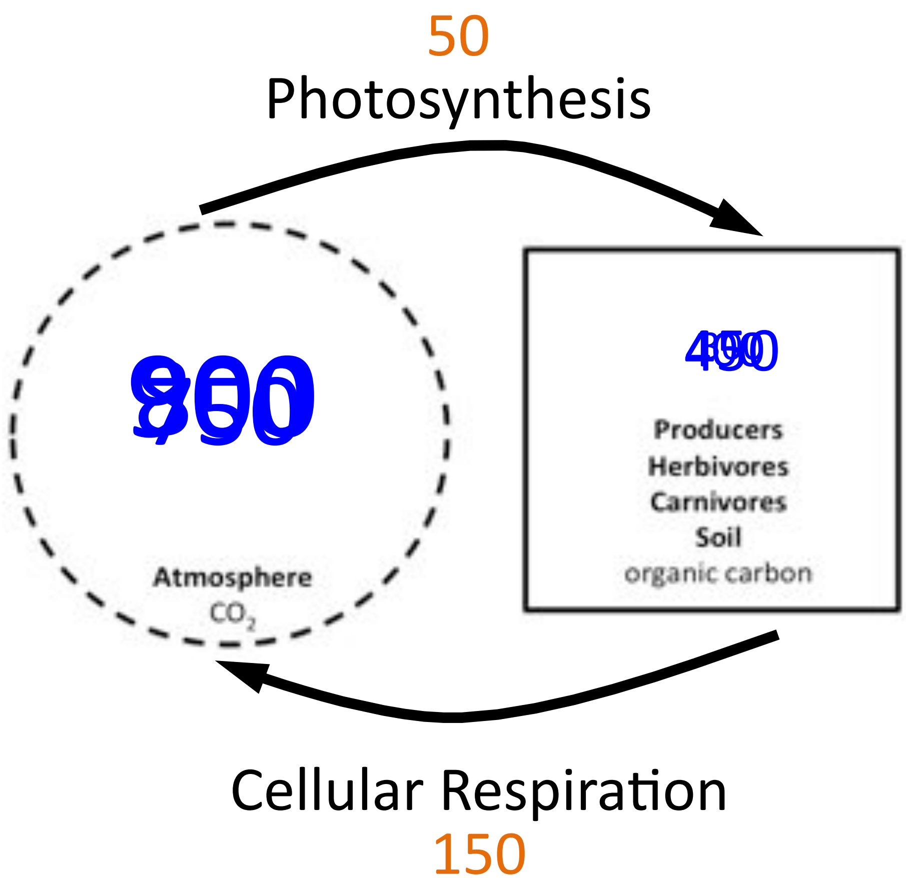
- Plants are growing
- Lots of photosynthesis



Fluxes of carbon change during seasons

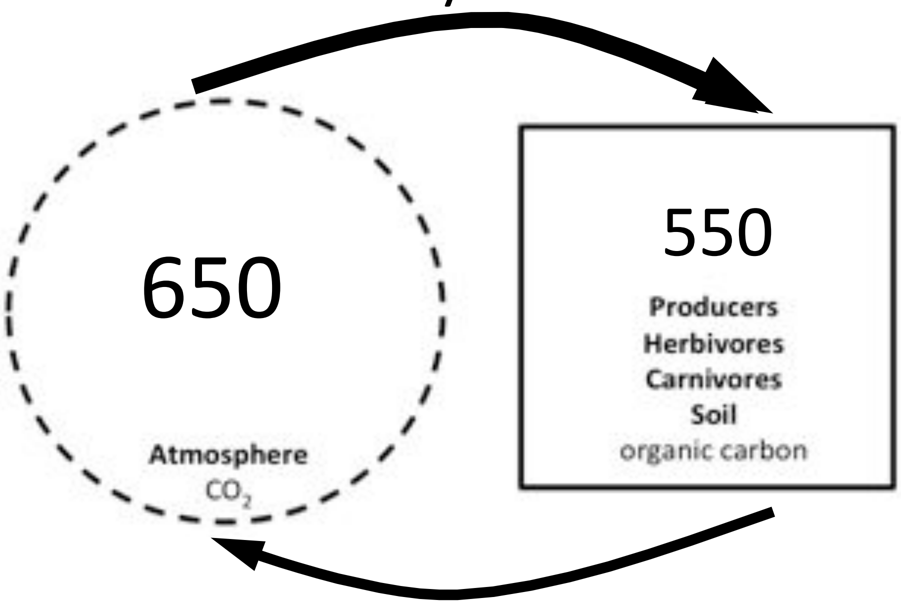
WINTER:

- Plants stop growing
- Less photosynthesis



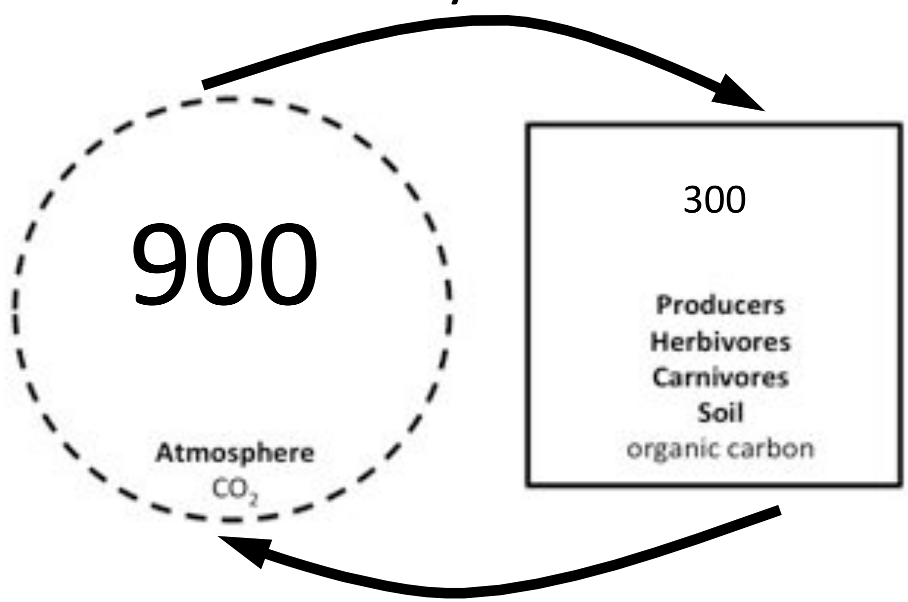
So carbon pools change size. Even throughout the seasons of one year!

Photosynthesis



Cellular Respiration

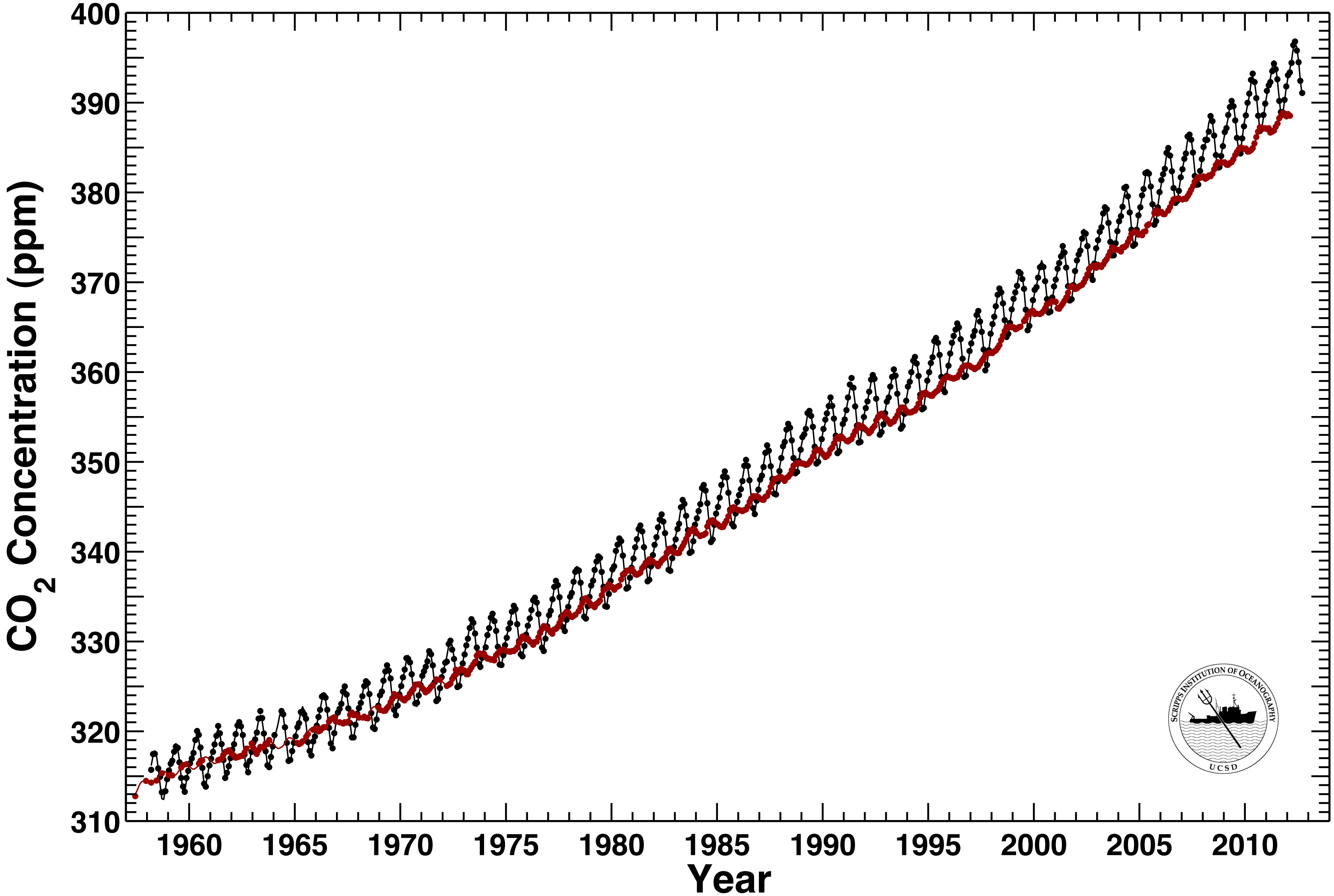
Photosynthesis



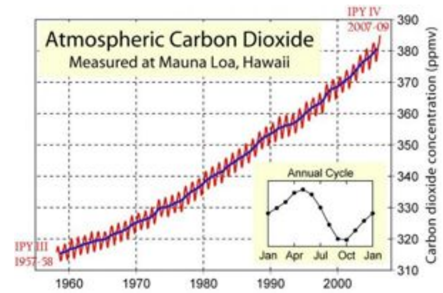
Cellular Respiration

Mauna Loa Observatory, Hawaii and South Pole, Antarctica
Monthly Average Carbon Dioxide Concentration

Data from Scripps CO_2 Program   Last updated October 2012



What do students think?



1) Do you have any idea why Charles Keeling went to Hawaii to collect these data?

2) Do you think we could use these data to estimate CO_2 concentrations in Michigan during this period? Why or why not?

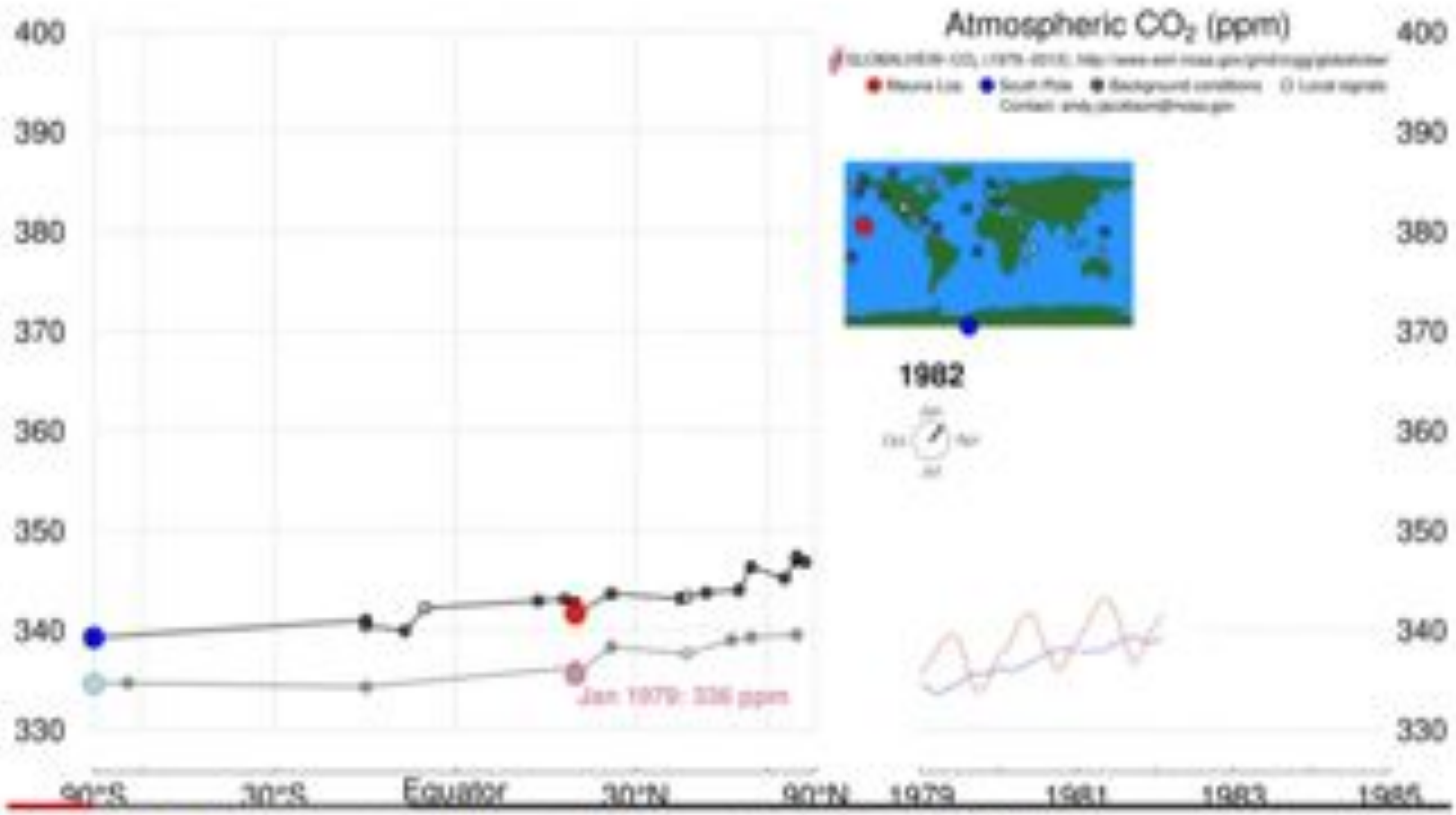
3) Do you see a pattern? If so, what pattern do you see?

4) What do you think could be the cause of this pattern of the line in blue?

5) What do you think could be the cause of this pattern of the line in red?

6) Could we use this graph to make predictions about carbon dioxide concentrations at Mauna Loa in 2015? What predictions could you make?

Time history of atmospheric carbon dioxide from 800,000 years ago until January, 2012.



Think-Pair-Share

- Would these materials be helpful in instruction? Why or why not? How might you use them?
- How do you think your students would respond to the
    - CO_2 PEOE activity
    - the Keeling Curve articles
    - the History of CO_2 video?

Thank you!
Don’t forget to sign in!

Photo credit: NYT article, Jonathan Kingston/Aurora Select

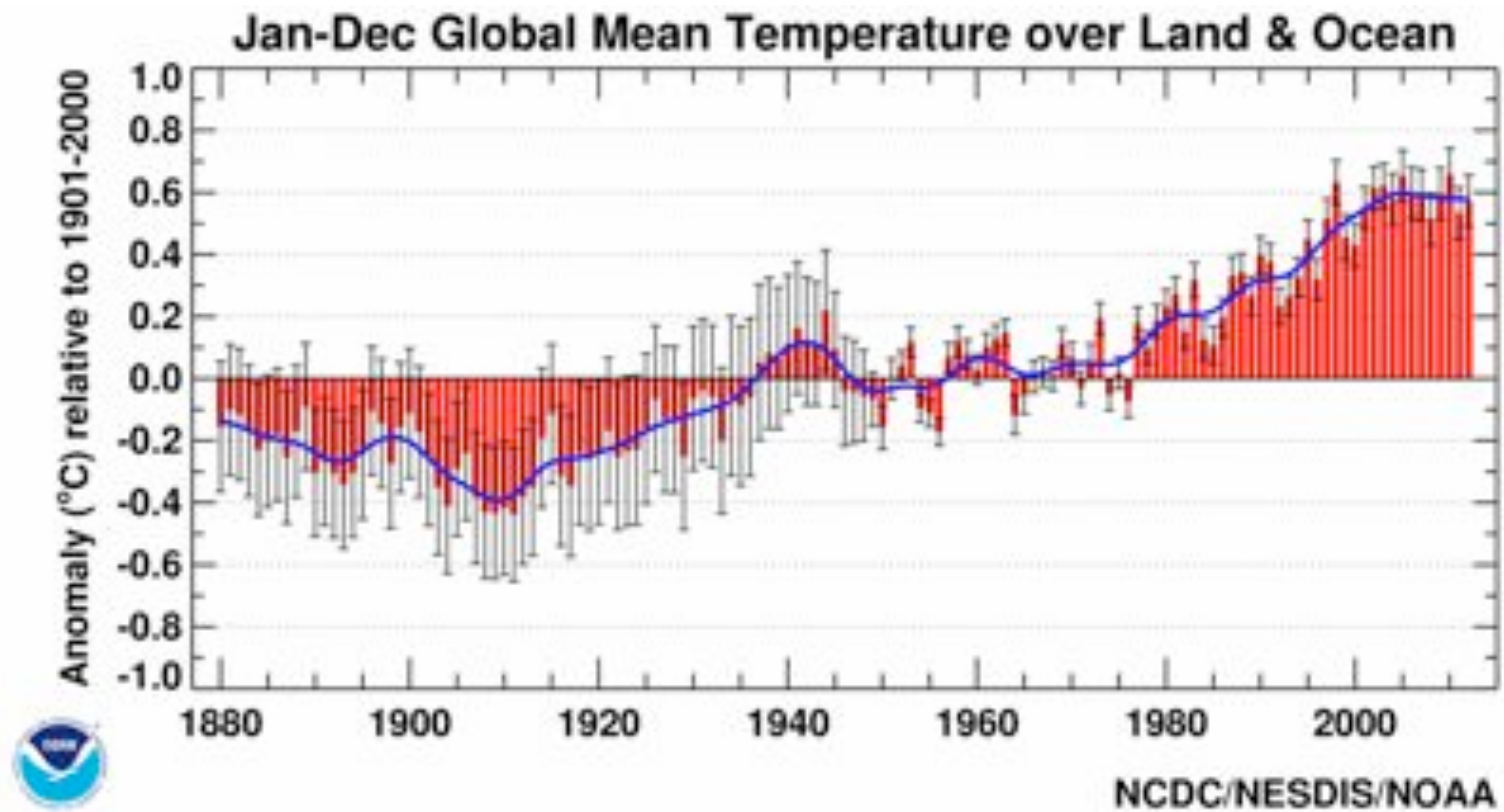
Extra pictures and graphs

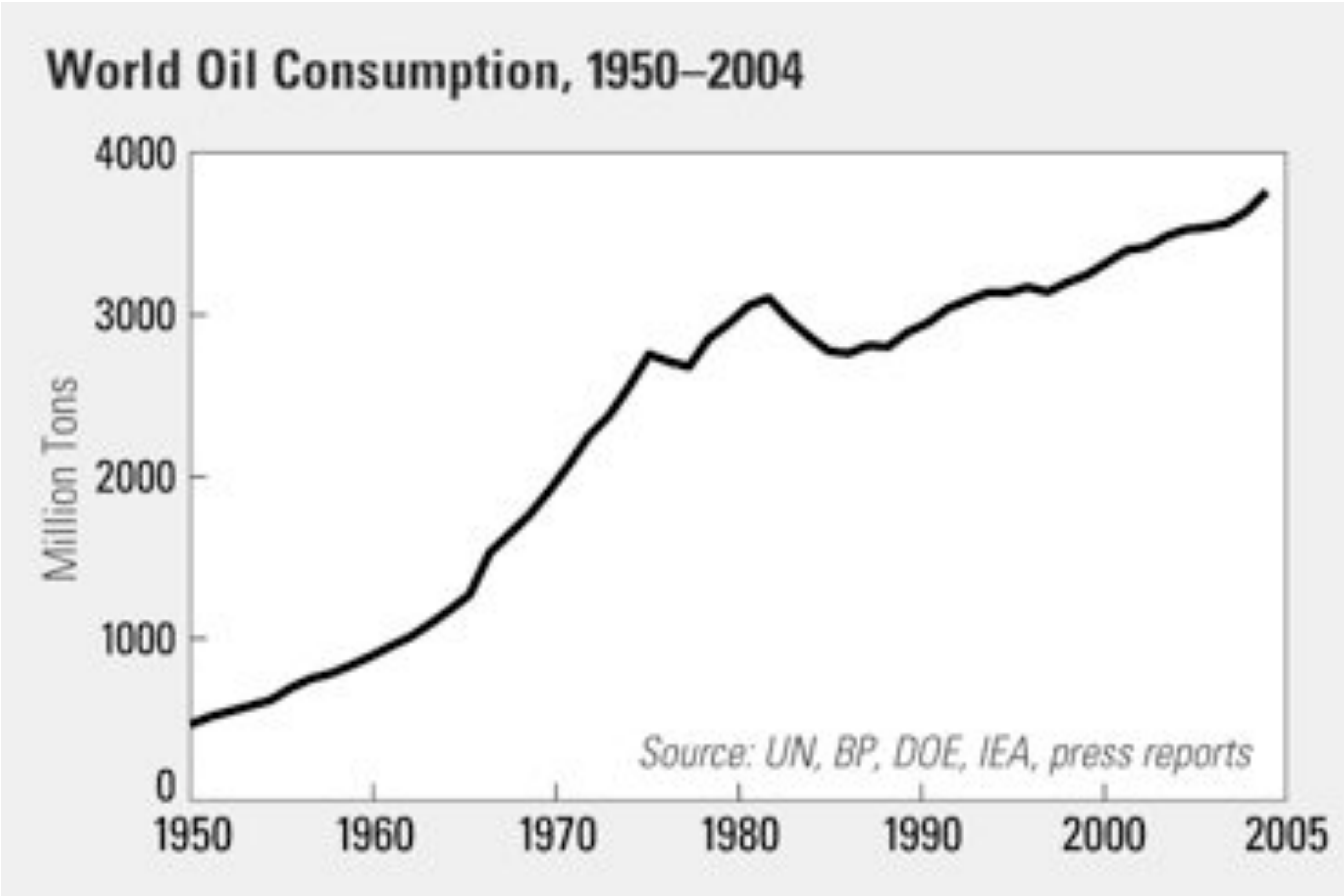
This is the original machine, operating with vacuum tubes, that was used to measure carbon dioxide at Mauna Loa Observatory starting in 1958. It is no longer in use.

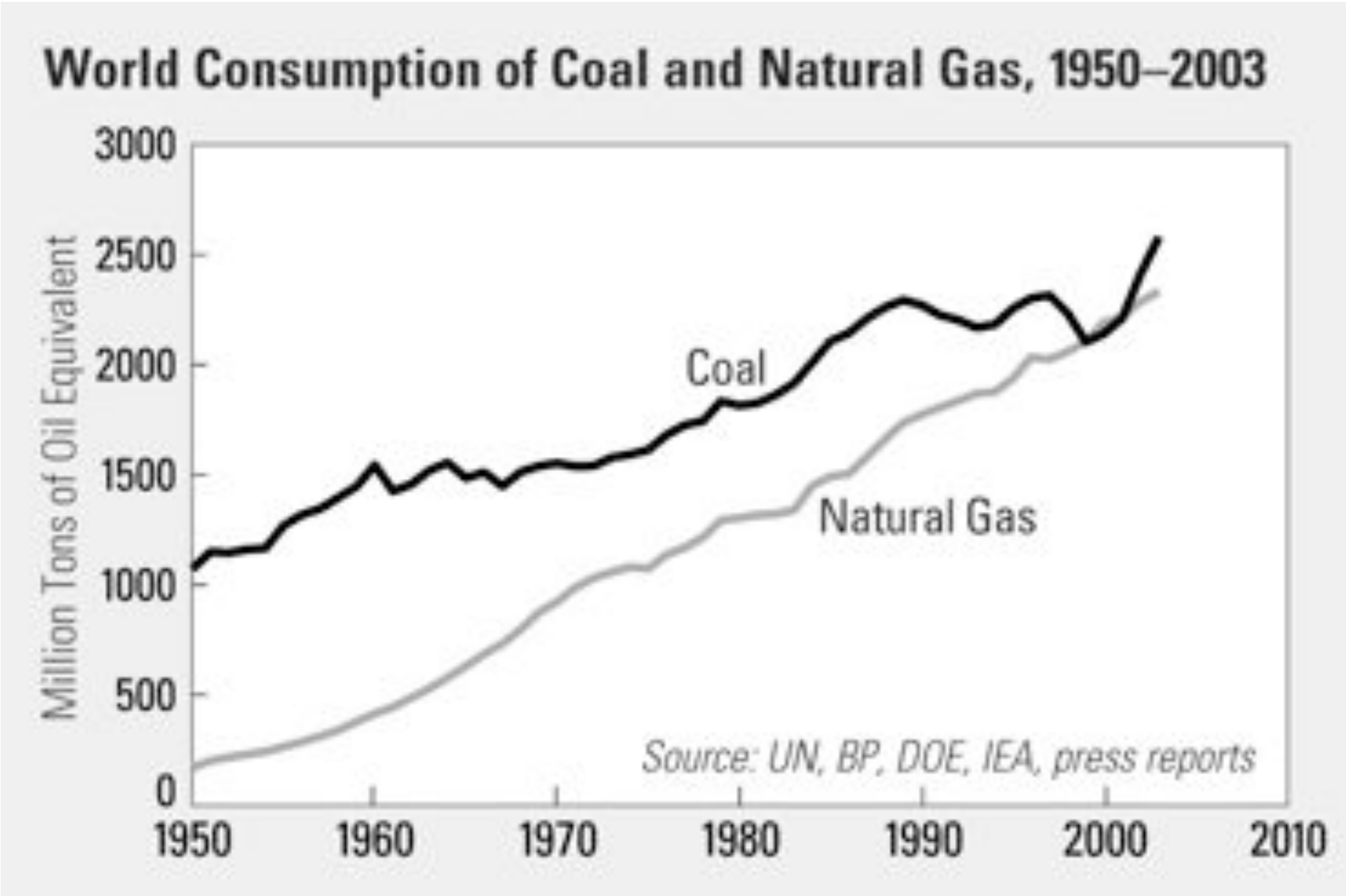
Photo credit: NYT article, Jonathan Kingston/Aurora Select

Ralph Keeling, an atmospheric scientist and son of Charles David Keeling, at work in his laboratory at the Scripps Institution of Oceanography in La Jolla, Calif. He has taken over his father's carbon dioxide program, and also runs his own making fine measurements of the oxygen in the atmosphere.

Credit: Sandy Huffaker for The New York Times


Jan-Dec Global Mean Temperature over Land & Ocean
Anomaly (°C) relative to 1901-2000
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1880
1900
1920
1940
1960
1980
2000
NCDC/NESDIS/NOAA


World Oil Consumption, 1950–2004
Million Tons
4000
3000
2000
1000
0
1950
1960
1970
1980
1990
2000
2005
Source: UN, BP, DOE, IEA, press reports


World Consumption of Coal and Natural Gas, 1950–2003
Million Tons of Oil Equivalent
3000
2500
2000
1500
1000
500
0
1950
1960
1970
1980
1990
2000
2010
Coal
Natural Gas
Source: UN, BP, DOE, IEA, press reports