

## **GE510 Physical Principles of the Eenvt**

### **Greenhouse gases and global warming: History of an Idea and observations**

#### **Jean Baptiste Fourier 1768-1830**

- Pioneered Planetary energy balance studies.
- Infrared radiation = “dark heat” balances incoming solar radiation.
- Without considering atmosphere, thinks earth should be much colder than it is.
- Concludes earth acts as a ‘glass house’, trapping heat. Not sure what in the atmosphere causes the glasshouse effect.



## John Tyndall 1820-1893

Connected specific gases to the greenhouse effect

“perfectly colorless and invisible gases and vapors” absorb/emit radiant heat

Earth "held fast in the iron grip of frost" if not for greenhouse gases.

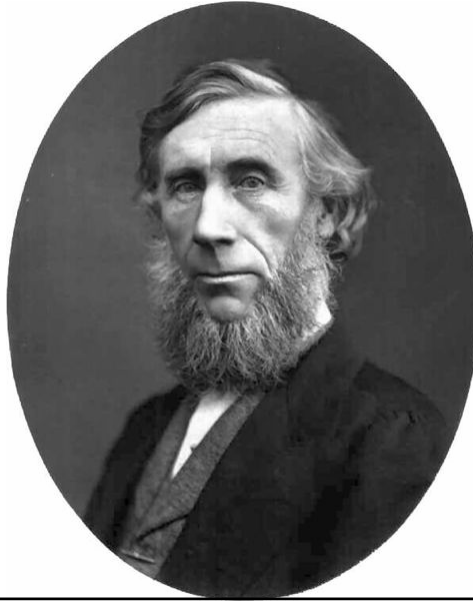
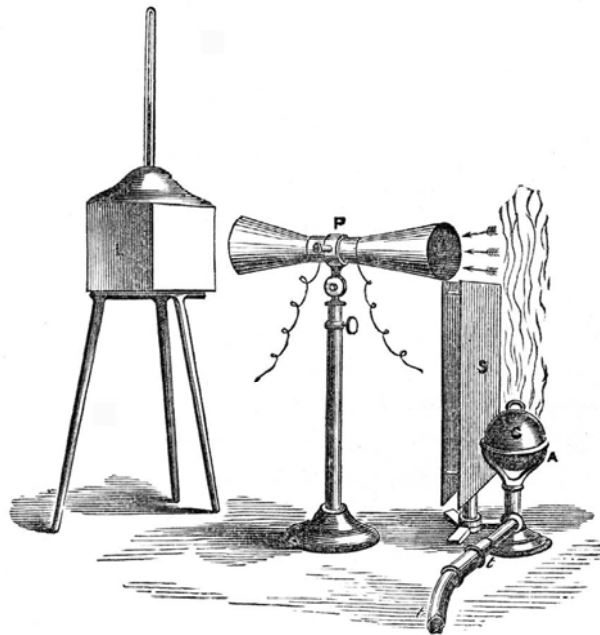
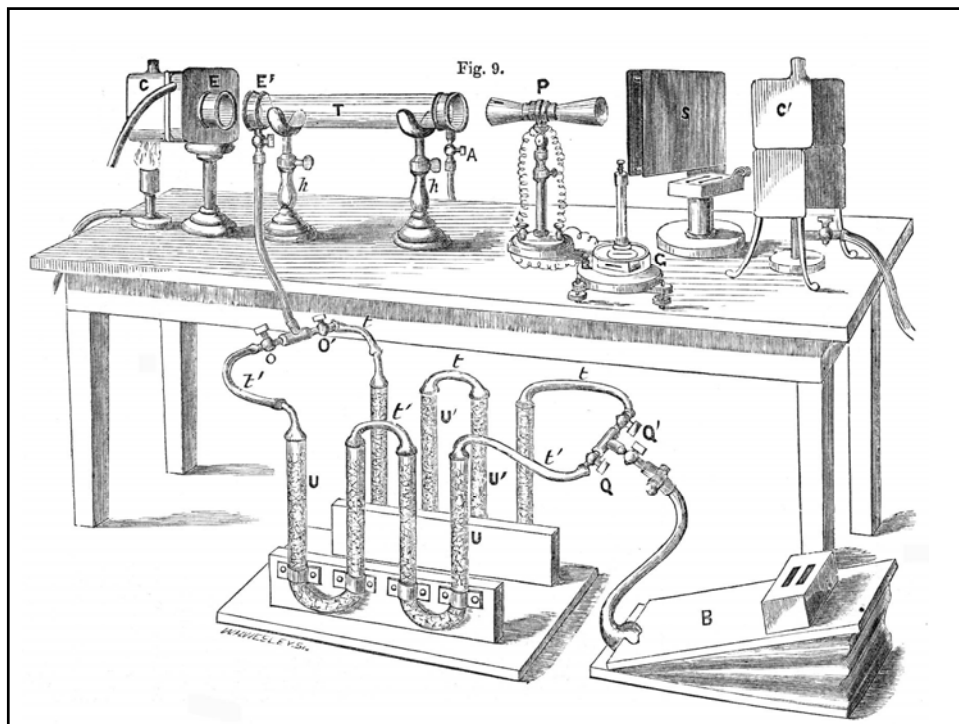


Fig. 1.





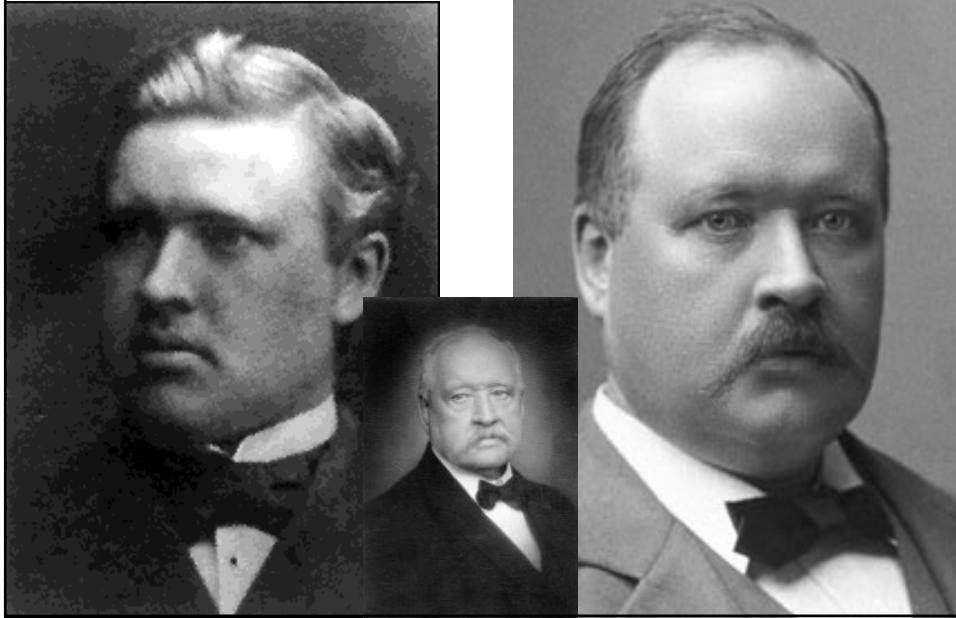
Tyndall:

The atmosphere admits of the entrance of the solar heat, but checks its exit; and the result is a tendency to accumulate heat at the surface of the planet.

The aqueous vapour constitutes a local dam, by which the temperature at the earth's surface is deepened; the dam, however, finally overflows, and we give to space all that we receive from the sun.

Changes in the amount of any of the radiatively active constituents of the atmosphere—water vapor, carbon dioxide, ozone, or hydrocarbons—could have produced *“all the mutations of climate which the researches of geologists reveal . . .*

## **Svante Arrhenius: 1859-1927**



## **Svante Arrhenius 1859-1927**

- Made first estimate of temperature sensitivity to atmospheric CO<sub>2</sub> doubling, based on work of Tyndall and others.
- Initially not motivated by human-caused CO<sub>2</sub> rise, but rather trying to explain ice ages (scandinavian!)
- By 1904, became aware of large human CO<sub>2</sub> emissions.

**“the slight percentage of carbonic acid in the atmosphere may, by the advances of industry, be changed to a noticeable degree in the course of a few centuries.”**

- But he thought this could be good for plant life and climate!

**“By the influence of the increasing percentage of carbonic acid in the atmosphere, we may hope to enjoy ages with more equable and better climates, especially as regards the colder regions of the earth, ages when the earth will bring forth much more abundant crops than at present, for the benefit of rapidly propagating mankind.”**

**— Svante Arrhenius (1908)**

### **Guy Stewart Callendar 1898-1964**

**Correlates temperature records to co2 records and claims a causal link**

Callendar, G.S. (1938). "The Artificial Production of Carbon Dioxide and Its Influence on Climate." *Quarterly J. Royal Meteorological Society* 64: 223-40.

Callendar, G.S. (1939). "The Composition of the Atmosphere through the Ages." *Meteorological Magazine* 74: 33-39.

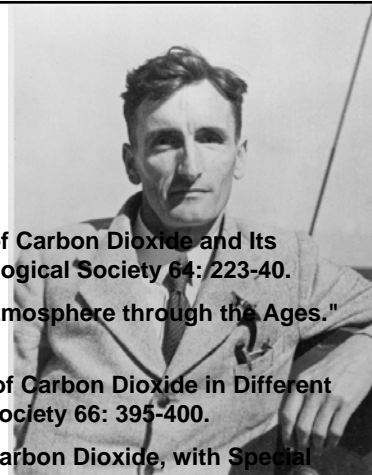
Callendar, G.S. (1940). "Variations in the Amount of Carbon Dioxide in Different Air Currents." *Quarterly J. Royal Meteorological Society* 66: 395-400.

Callendar, G.S. (1941). "Infra-Red Absorption by Carbon Dioxide, with Special Reference to Atmospheric Radiation." *Quarterly J. Royal Meteorological Society* 67: 263-75.

Callendar, G.S. (1949). "Can Carbon Dioxide Influence Climate?" *Weather* 4:310-14

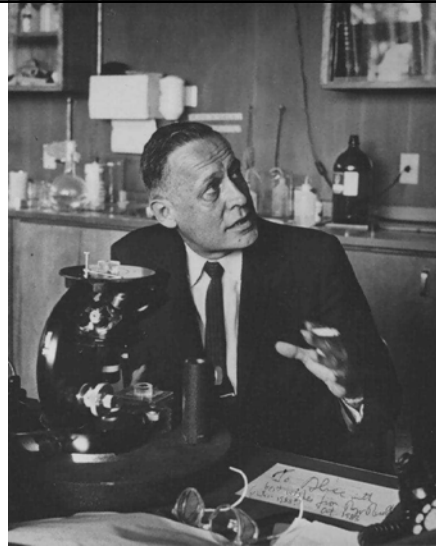
Callendar, G.S. (1958). "On the Amount of Carbon Dioxide in the Atmosphere." *Tellus* 10: 243-48.

Callendar, G.S. (1961). "Temperature Fluctuations and Trends over the Earth." *Quarterly J. Royal Meteorological Society* 87: 1-12.



## **Roger Revelle 1909-91**

- **Director, scripps Inst. oceanography 1950-64**
- **Oceans likely unable to absorb anthro. Emissions of  $\text{CO}_2$ .**
- **Hired C.D. Keeling**



Revelle, R., and H. Suess, "Carbon dioxide exchange between atmosphere and ocean and the question of an increase of atmospheric  $\text{CO}_2$  during the past decades." *Tellus* 9, 18-27 (1957).

- "the water from one layer doesn't exchange with the water from another layer."

- – Revelle, after nuclear bomb tests.

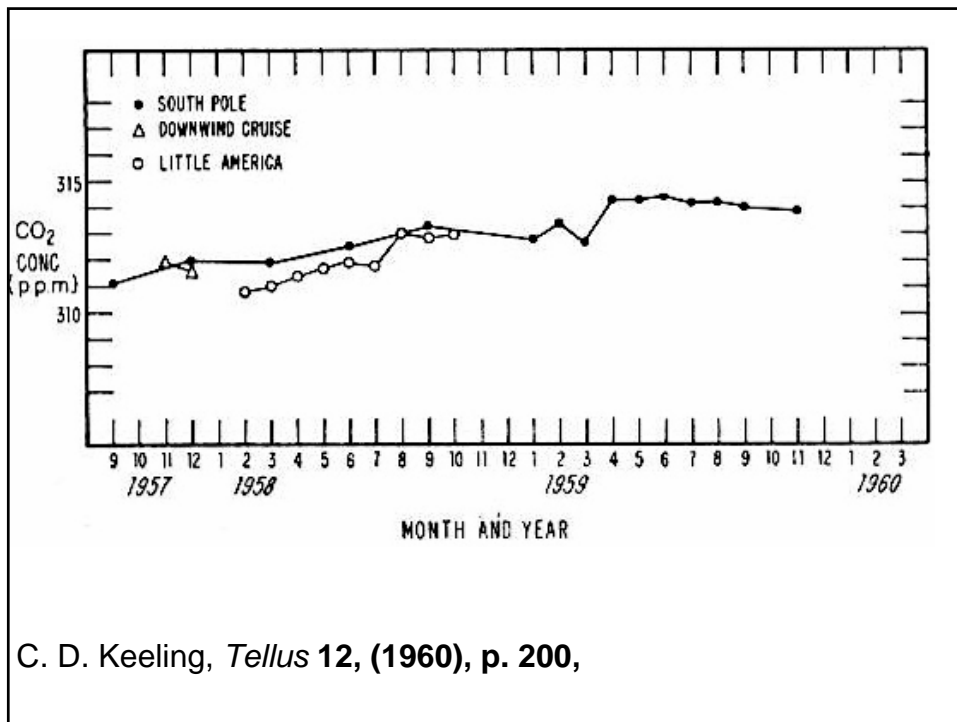
"radioactive residues had spread out in remarkably thin sheets, stretching a hundred square kilometers but only a meter thick" – Spencer Weart

- **"Human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future." — Revelle and Suess 1957**

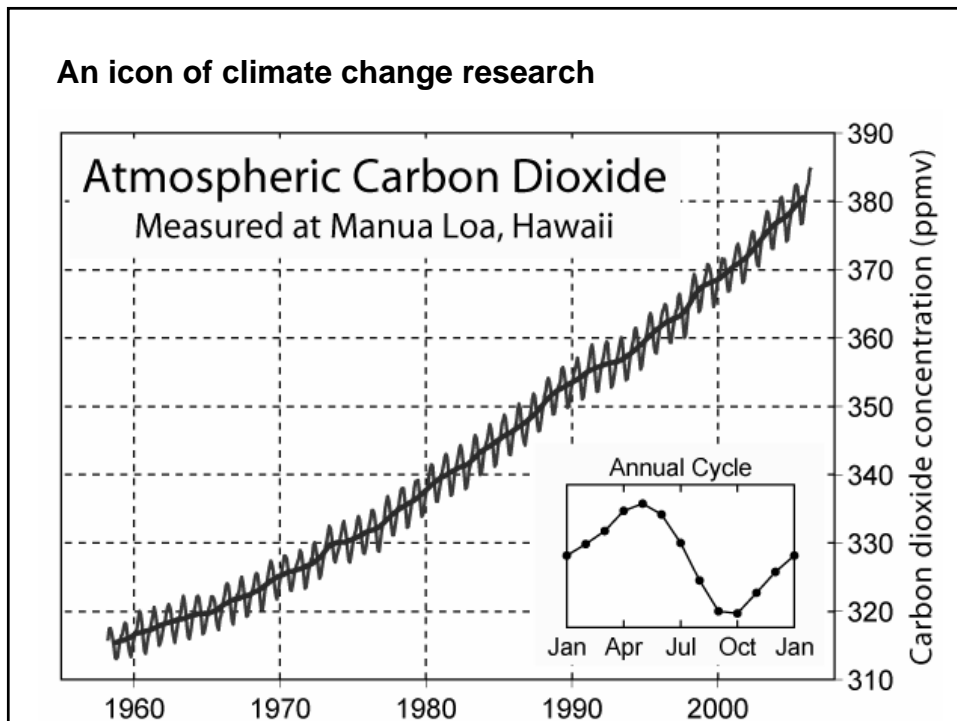
**Charles David Keeling 1928-2005**  
**Scripps Institute of Oceanography**

- **First person to confirm 'breathing of the biosphere'**
- **First to confirm rise in atmospheric CO<sub>2</sub>**





C. D. Keeling, *Tellus* 12, (1960), p. 200,





### **How Keeling's work was funded:**

- **Split among many residual pools: shoestringed**
- **Beauracratic infighting**
- **Standard cycle of funding still persists presently**
- **“worthless” monitoring of the envt.**

### **Conclusion:**

**Theory of global warming is not the product of scientific crackpots or alarmists, as some climate skeptics would claim. Other climate skeptics might embrace Arrhenius, though.**

**Arrhenius – Nobel Prize in Chemistry**

**Fourier – World class mathematician**

**Tyndall – Physics giant, polymath**

**Revelle – National Medal of Science (1990, GHWB), president AAAS**

**Keeling – National Medal of Science (2002, GWB)**