

Climate Change: Simple, Serious, Solvable



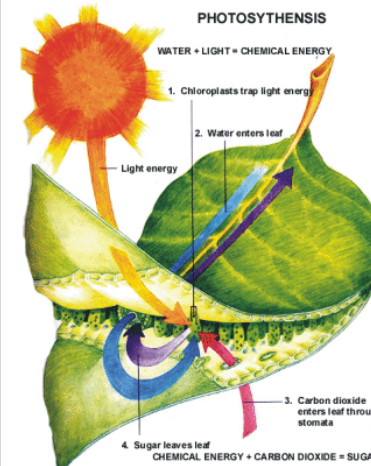
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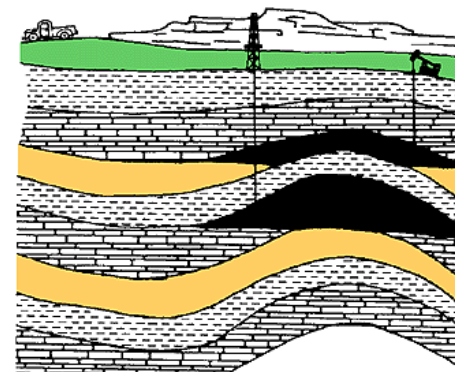
Carbon, Life, and Energy



- Photosynthesis uses energy from the sun to **convert inorganic air (CO₂) to living biomass!**
- Most of this energy is **released through respiration (back to CO₂)** when plants are eaten by animals, bacteria, people

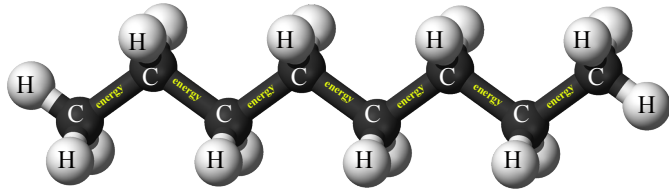


Fossil Fuels

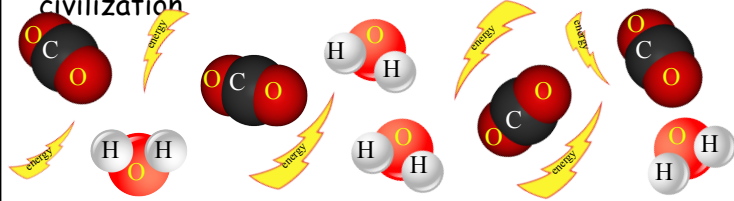


Some of the stored solar energy in biomass can be **preserved in fossilized remains**

Hydrocarbons, Energy, and CO₂

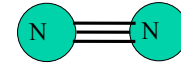
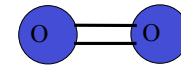


- We dig this stuff (“fossil fuels”) up and **burn it**, **harvesting the stored energy** to power civilization



Dancing Molecules and Heat Rays!

- Nearly all of the air is made of oxygen (O₂) and nitrogen (N₂) in which **two atoms of the same element** share electrons

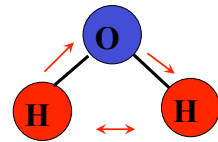
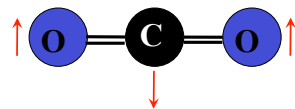


- Infrared (heat) **energy radiated up from the surface can be absorbed** by these molecules, but not very well

Diatomic molecules can vibrate back and forth like balls on a spring, but the ends are identical

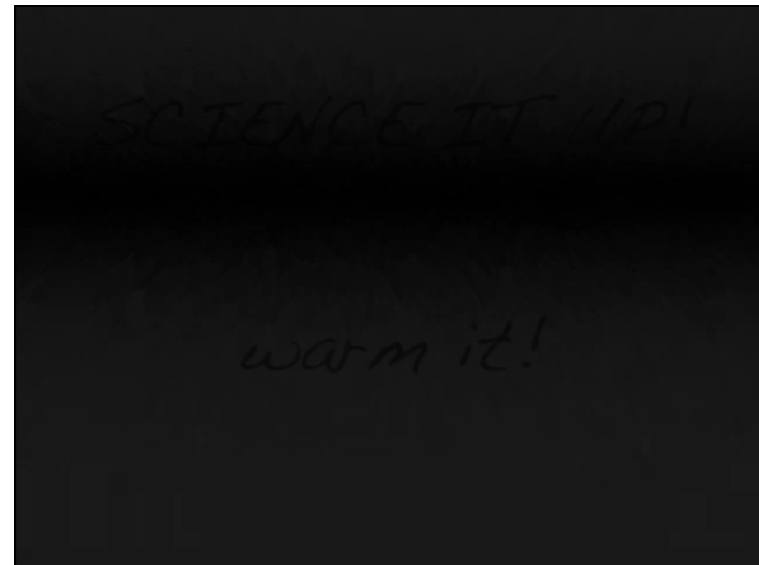
Dancing Molecules and Heat Rays!

- Carbon dioxide (CO₂) and water vapor (H₂O) are different!
- They have **many more ways to vibrate** and rotate, so they are very good at absorbing and emitting infrared (heat) radiation

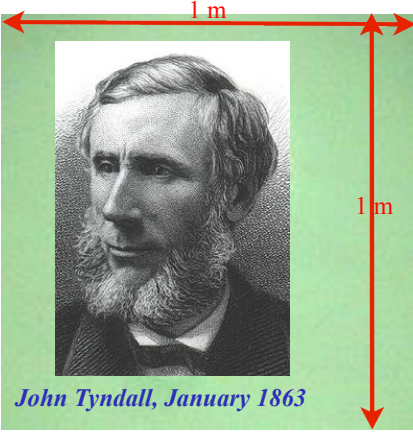


Molecules that have many ways to wiggle are called “Greenhouse” molecules

Absorption spectrum of CO₂ was measured by John Tyndall in 1863



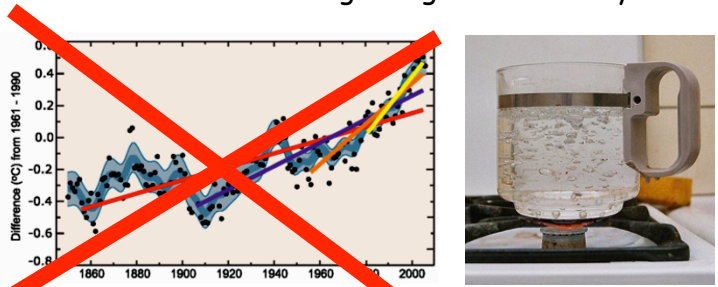
Common Sense



- Doubling CO₂ would add **4 watts to every square meter** of the surface of the Earth, **24/7**
- Doing that would make the surface **warmer**
- This was known before light bulbs were invented!

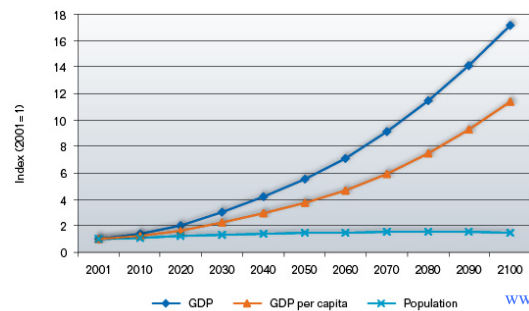
Common Myth #1

“People are worried about climate change because it’s been getting warmer lately”



WRONG! We’re concerned because we know that when we add energy to things, they warm up

Population is **not** the driver of future climate!



UN Reference Scenarios

www.garnautreview.org.au

- Population to grow by 40% in 100 years
- Global **economy to grow by 1600%** (assumes 2.8% annual GDP growth)



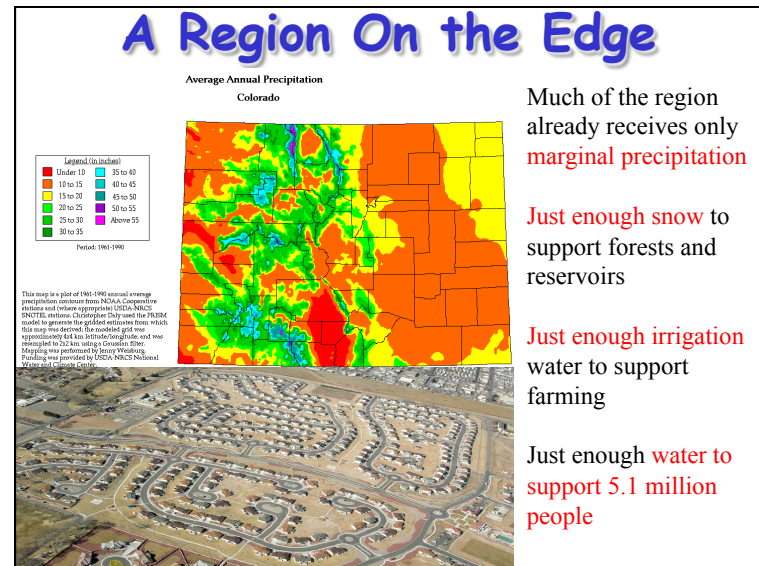
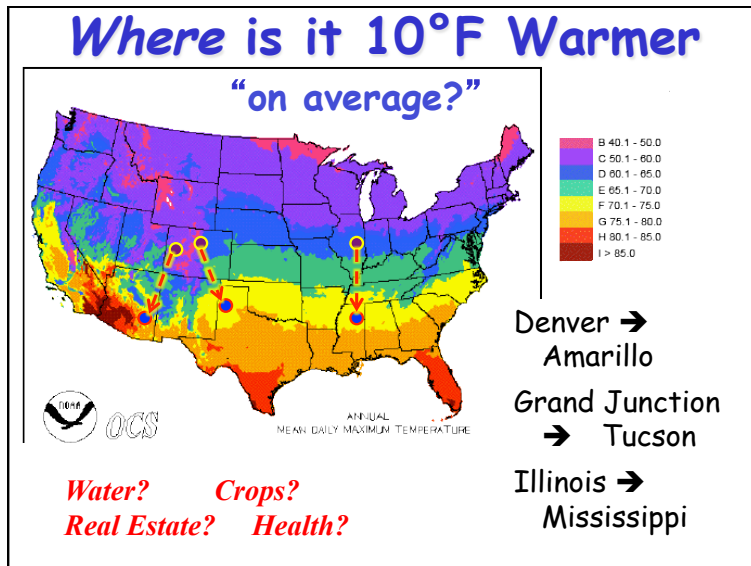


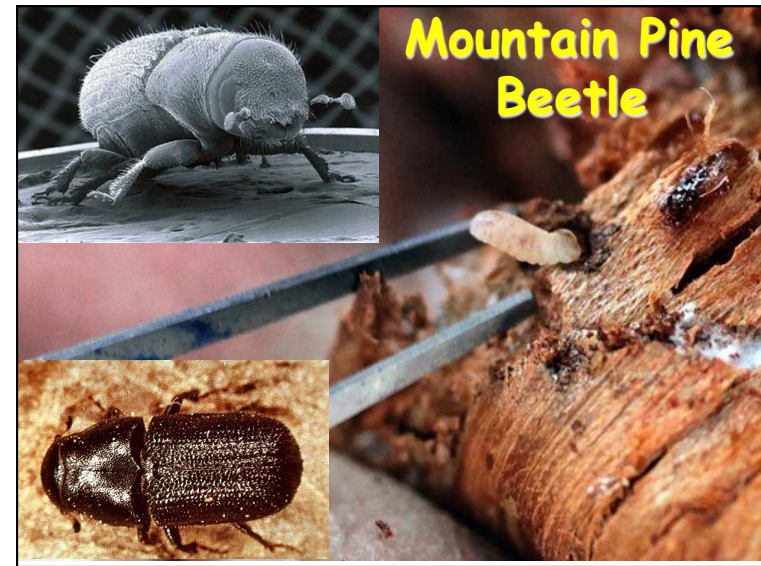
How much warmer?

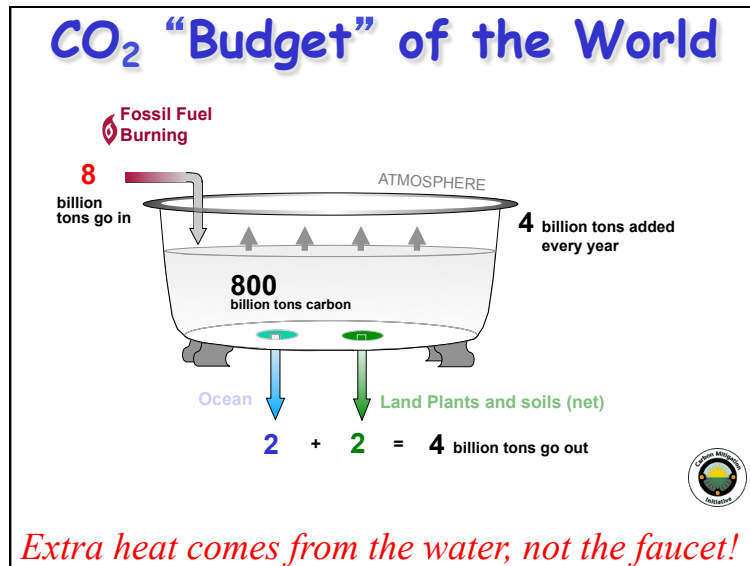
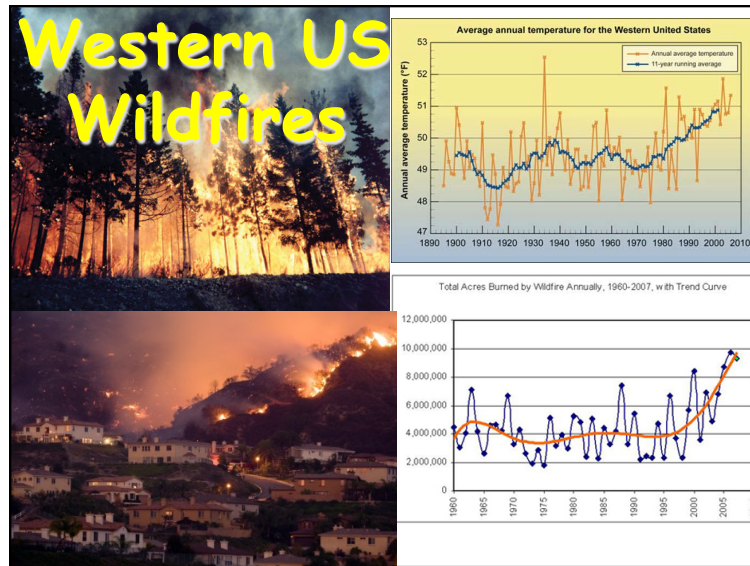
- Land vs ocean!
- North vs South
- Global mean warming of 2° to 5° C
- North American warming of 3° to 6° C
- = 5° to 11° F
- Arctic warming of 8° to 14° F

Low Emissions
Moderate Emissions
High Emissions

Rainfall? Agriculture?
Water supply? Ski industry?
Mass immigration?







Common Myth #2

"When we reduce or stop burning fossil fuel, CO₂ will go away and things will go back to normal"

- If China and India industrialize with coal ...
- CO₂ will rise to **5x preindustrial**
- Extra CO₂ will remain for **millennia after coal is gone**

CO₂ (ppm) and **Warming (Celsius)** vs **year**

Gt/yr vs **year**

you are here (at year 2000)

emissions (at year 2000)

Never mind Polar Bears ... what would that do to farmers?

We Know for Sure

- CO₂ **molecules absorb** & re-emit thermal radiation (John Tyndall, 1863)
- Doubling the number of CO₂ molecules would add **4 W m⁻²** to the Earth 24/7 (Svante Arrhenius, 1896)
- If China and India industrialize with coal, CO₂ will approach **400% preindustrial by 2100**
- Additional CO₂ will continue adding heat to Earth for **thousands of years**

What We're Not So Sure About

- **When and precisely how** the climate will change, especially locally
- The economic, political, and social **consequences** of these changes
- **What to do** about all of this

The Worst Myth of All

- Without the subsidy of cheap fossil energy, civilization will crumble
- People will freeze in the dark!
- **We'll starve!**

“The sky is falling!”

Be skeptical ... be very skeptical !

Solutions

- To provide a **decent standard of living** for billions of people on Earth ...
- ... we must generate huge amounts of **energy without releasing CO₂**.
- This is **definitely possible** (as an engineering task) ...
- ... but expensive and **politically difficult**.
- Can't do it by “tinkering around the edges.”
- Requires **profound changes to energy and economics**

Imagine it's 1800, and you're in charge ...

Somebody presents you with a grand idea for transforming the world economy:

- ✓ Dig 10 billion barrels of oil out of the ground every year
- ✓ Build a system of oil pipelines, oil tankers, railroads, highways, and airports to deliver it to every street in the world
- ✓ Build millions of power plants, and millions of miles of roads to get the oil to the power plants
- ✓ Generate and pipe enough electricity to every house to power lights & stereos & plasma TVs



... *"and here's the itemized bill ..."*

Choose Your Future

- Some people think:
 - "Our modern lifestyle is only possible because it is subsidized by cheap fossil fuel. If we ever stop burning coal we'll freeze in the dark!"
- I prefer:
 - "Our well-being depends on creativity, ingenuity, and hard work. Before we run out of oil, we'll invent energy technologies for the 21st Century.
 - **Our future is bright.**"