

# Week 14 Lecture 1

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## 1 Administrative drivel

- Clicker serial number assignment on Canvas
- No clicker qs today – no base
- final on the 16th at 4:30 in the usual classroom
- Review sheet should be posted tonight
  - The exam will be 45-50 questions
  - 2 hours to complete

## 2 Climate change – continued

- We'll finish climate change today – hopefully
- Temperature change
  - Warmer in the last few decades, almost certainly human caused
  - fossil fuels release carbon that's been tied up in rocks for thousands of years into the atmosphere
  - the amount of carbon the atmosphere is relatively constant, at least for the last 10s of millions of years
  - burning fossil fuels has changed this
  - since the 80's we've seen a steady rise in temp which is associated with increase in  $CO_2$
- Some evidence and patterns
  - There is a tight relationship between temperature and  $CO_2$  concentration
    - \* How do they know the  $CO_2$  concentration 160k years ago?
      - Looking at ice cores!
  - Historic
    - \* Steady  $CO_2$  till the mid 1980's when exponential growth began
  - More recent
    - \*  $CO_2$  has been exponentially increasing by industry output, and has stopped during 3 periods in the 20th century
    - \* The use of electricity is accelerating, increasing  $CO_2$  production
  - very recent
    - \*  $CO_2$  production Accelerating over the last 50 years
  - $C$  14 short half life, not present in fossil fuels, so we can measure its concentration to see how much is from fossil fuels

- The  $C^{14}$  concentration in the atmosphere has decreased with the burning of fossil fuels depleted in  $C^{14}$
- Coal – major contributor of  $CO_2$ 
  - In volume of  $CO_2$  concentration, coal is one of the largest contributor
  - Used for most electricity
  - natural gas makes about 1/3 the  $CO_2$  that coal makes
  - it costs a lot to make power plants that are clean, so we have a lot coal generators still
  - Now, coal is substantially more expensive than other sources, as of fairly recently
- It's not only  $CO_2$ 
  - Methane ( $CH_4$ ), Chlorofluorocarbons (CFCs), Nitrous oxide ( $N_2O$ )
    - \* Methane is about 20 times more potent as a greenhouse gas than  $CO_2$  by weight
    - \* CFCs are rare – used in refrigerants – made the hole in the ozone, so it's outlawed as of 30 ish years ago
- Greenhouse effect: how it works
  - most of what happens is
    - \* Sun emits energy through the atmosphere (some visible, most invisible)
    - \* Some bounces off and goes into space
    - \* some comes through and is
      - absorbed by atoms in the atmosphere or
      - absorbed by atoms on the land
      - absorption transforms the energy into heat – thermal energy
      - absorption heats the earth
      - some bounces back out into space
    - \* Some of the heat is let out as radiation cooling the earth
    - \* If the amount of radiation coming in is the same as going out, the earth's temperature will be at equilibrium (constant)
    - \* greenhouse gasses absorb some of the radiation on it's way out of the atmosphere, turning it back into heat, so energy gets trapped, breaking the equilibrium, heating the earth's atmosphere
- We're in an interglacial period, so the the temp/ $CO_2$  levels are high just from normal changes in temp/ $CO_2$ , but now we're well above the norm and at a much faster rate of increase than has ever been seen
- things to do: drive less (walk, bike, take the bus), avoid air travel when possible (airplanes dump a lot of  $CO_2$ )
- Things goverments can do: finance power grids, tax carbon, regulate greenhouse gas emition
- half life of  $CO_2$  is long – 120 years – so it takes a long time to get out
- Most of the warming is at the far north, and over land
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