Tim Davis summary - The Science Behind Climate Change

In his exploration of the science behind climate change, Tim asked asked himself several questions. The first was, **is the earth warming?**

People have been taking measurements of the temperature around the globe for centuries. To compare temperatures around the globe, scientists take the difference between measured temperature at different spots on the earth and its long-term average. This is the **temperature anomaly**. This has been roughly constant until 1910, after which it begins to rise. Average global temperature has now risen by almost 1.4 degrees Celsius in the past century, as has global sea surface temperature.

Satellites also measure changes in temperature – **observations of ice decreasing** is visible in Antarctica and Greenland, and glaciers are in decline. The Franz Josef glacier in New Zealand has retreated by 2 km in last 100 years, and its rate of melting has doubled in the past ten years. The resulting **global sea level rises from melting ice and warming oceans could be as much as several metres by the end of the century**, on the current trajectory of warming.

These changes indicate that **the Earth is warming** based on experimental measurement.

Tim went on to explain how **Earth's temperature is regulated**. The Earth is heated by the sun through **electromagnetic radiation** (chiefly sunlight), and cooled by **thermal radiation** (heat radiated into space). It remains in thermal equilibrium when these two processes are balanced. Since the Earth's temperature is warming, we need to find the cause of the imbalance.

This leads to a further question: **Are changes to the sun causing the warming, or is there too little radiative cooling?**

Variation in sun's temperature due to solar activity is relatively constant across periods of time, apart from the regular cycle of 11 years caused by sunspots, with **no correlation to earth's global average temperatures**. Therefore there is no evidence that solar activity is causing global heating. We are left with conclusion that the earth is not cooling fast enough, and something is inhibiting it's cooling.

To explain why, we need to look at the atmosphere. Cooling occurs by **thermal radiation**. Sunlight is reflected back into space by clouds, the atmosphere, and a smaller proportion from the ground. The rest of the light from the sun is absorbed and re-radiated as heat. The proportion of the heat (10%) that is radiated from the ground is radiated into space through what is called the **atmospheric window**, where the atmosphere is transparent to heat radiation. **Changes to the atmospheric window have reduced the rate of cooling**. Carbon dioxide, like water vapour, has a major impact on the transmission of radiation through the atmosphere, in spite of carbon dioxide's small concentration (0.04% of the atmosphere, or around 400 parts per million). Both water vapour and carbon dioxide control how quickly the earth can cool.

An increase in either of these gases will increase the absorption of thermal energy and reduce the rate of cooling. Measurements show that **carbon dioxide has increased by 12% since 1900, and is now exceeding 420 ppm**. The rise in global temperature over the past one hundred years is strongly correlated with this rise in carbon dioxide. The conclusion is clear - **carbon dioxide inhibits thermal radiation from leaving the earth, reducing the rate of cooling and increasing global temperatures.**

The scientific evidence is thus very clear that **excess carbon dioxide is causing global warming**. The increase in global temperature has resulted in more water vapour in the air that also impacts global warming. **There are no other explanations (e.g. emissions from volcanoes, warming Earth core, warming sun) that are consistent with the scientific evidence.**

Where does the carbon dioxide come from? 5% comes from deforestation, the rest from burning fossil fuels and industrial processes such as the manufacture of concrete.

Where does it go? 25 per cent is absorbed into oceans, another quarter is taken up by land use, and half goes into the atmosphere.

The amount of CO_2 absorbed by the oceans is a major concern as **oceans are responsible for keeping the earth as stable as it is**. As the oceans warm, this leads to instability in the atmosphere, with an increase in extreme weather events such as cyclones. In Australia, the existing weather patterns get disrupted – rainfall gets pushed further south away from land into the Southern Ocean, causing drought, and the tropics get wetter. The increase in the number of severe heat days is strongly correlated with the rise in carbon dioxide, as well as the increased likelihood of bushfires, and sea level rise associated with the melting of polar ice. Tim demonstrated the impact of rising sea levels and **resulting inundation on Melbourne** with a graphic simulation of a five metre high wave racing up the Yarra as far as Princes Bridge and beyond.

With increasing absorption of CO_2 into the oceans comes **ocean acidification**, created by mixing increased carbon dioxide with water. This produces carbonic acid and increases pH (acidity). The result of this is that marine creatures can't create shells. As these creatures form the basis of the ocean food chain, this has a **cascading and catastrophic effect on all who depend on the ocean for food and their livelihood.**

Tim finished with some suggestions for what can be done, heading the list with the need to **stop a net outflow of CO_2**, and **stop burning fossil fuels**. Other points included:

- Reduce cattle farming
- Proactive reforestation to act as carbon sinks
- Develop methods for food production in water-scarce environment
- Develop methods for producing potable water (e.g. desalination)