The Inspiration:

For my research project, I wanted to use science to accomplish something big.

Climate change is primarily caused by an increase in Carbon Dioxide in the atmosphere. Carbon Dioxide is a greenhouse gas, meaning that it will trap radiation from the sun in the atmosphere. As a result, global warming happens.

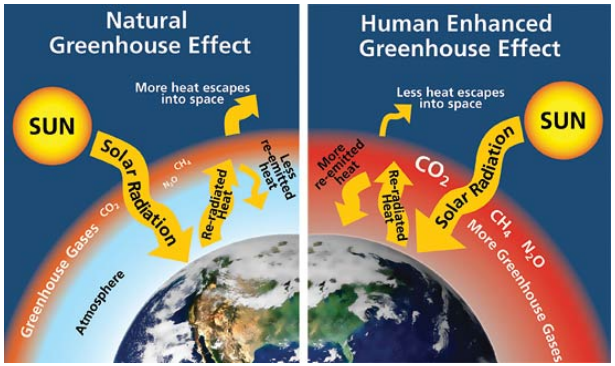


Image Source: National Parks Service (2015)

This heating is not good for the Earth. Global warming could cause the extinction of many animals, as well as an increase in extreme weather. As a result, I wanted to study existing chemical technologies which could slow down global warming.

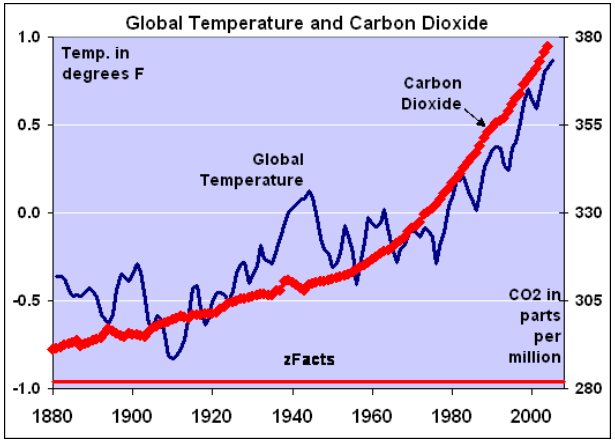
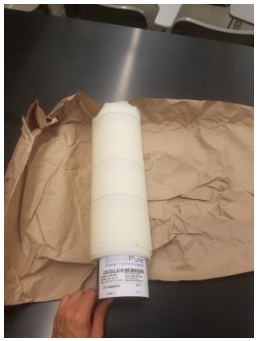


Image Source: zFacts (2006)

How to Capture Carbon Dioxide:

To capture the Carbon Dioxide, I used an ion-exchange resin called I-200 from Snowpure in San Clemente, CA. The resin was originally meant for purifying water, so it had to be chemically transformed to capture Carbon Dioxide.

The sheet came in a large 25 ft. roll, shown below. The sheet itself is made of polypropylene and in its original form has chlorine ions on it to remove positive ions from water.



After it's treated in a 90 ° C water bath and has its Chlorine ions replaced with Hydroxide ions, the exchange resin is ready to capture Carbon Dioxide. It can capture Carbon Dioxide in two hour cycles.

For one hour, when the sheet is dry, it will capture Carbon Dioxide, but once the sheet is dipped in water, the sheet will release Carbon Dioxide for another hour. The cycles can be repeated 1,000+ times.

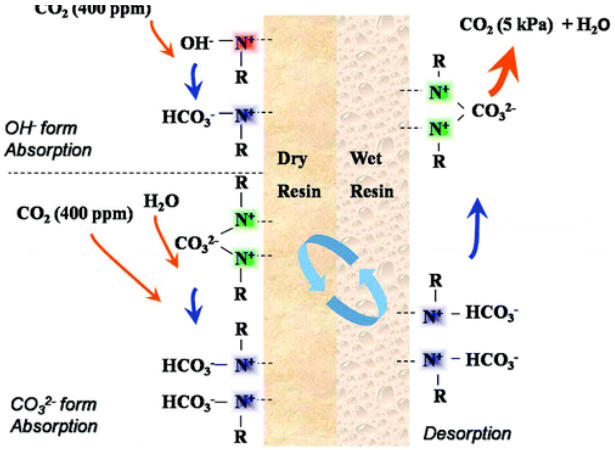
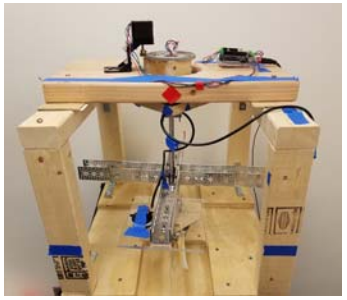


Image Source: Lackner et al (2011)

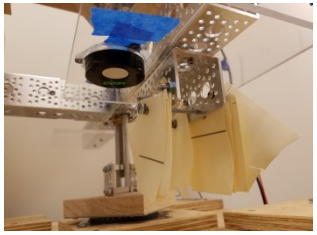
Building the Machine:

In order to capture the Carbon Dioxide, I had to build a machine that could repeat the wet/dry cycles of the resin. Further, since this machine needed to have practical future applications, it needed to be automated.



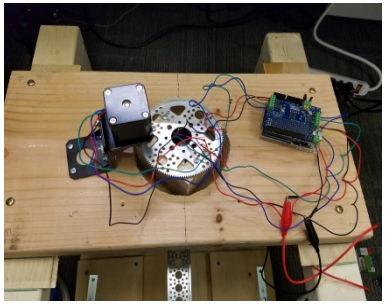
The machine has spaces for a box of water, and a release box. It rotates through these boxes and the open air to capture Carbon Dioxide.

One of the "arms" of the machine has small squares of the ion-exchange resin, shown right, as well as a COZIR Carbon Dioxide sensor.



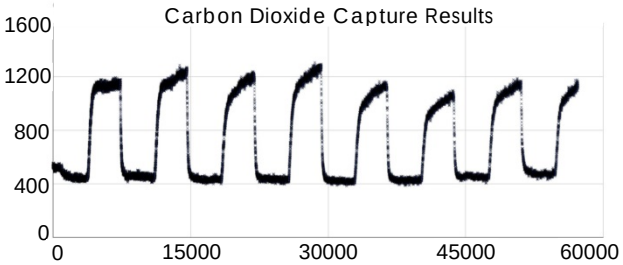
The leadscrew (the dark long screw in the middle), as well as the two guide-rails around it, move the arms of the machine up and down, in and out of the water and release boxes when powered by a motor.

The gear shown right moves the arms between the two boxes. I then used an Arduino micro-controller and an Adafruit v2 motor shield to automate the machine.



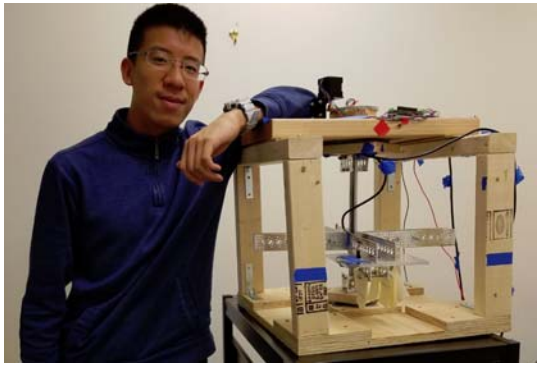
The Results:

The machine successfully captured Carbon Dioxide, as seen in the graph below.



In the graph, ppm of Carbon Dioxide is measured on the y-axis against seconds since the start of the trial on the x-axis. The graph shows roughly 8 wet/dry cycles of the resin. 400 ppm is roughly the atmospheric concentration of Carbon Dioxide, and 1200 ppm is triple that level.

In 8 cycles (16 hours), the machine captured 0.25 liters of Carbon Dioxide; however, the capture rate can be improved. Since the release chamber was never ventilated, the higher concentration in the release box made it harder for Carbon Dioxide to leave the resin sheet.



Looking Ahead:

In the future, the technology can be used in larger artificial "trees," like the ones shown below. It's estimated that 1 square mile of these "trees" could absorb 10 million tons of Carbon Dioxide from the atmosphere every year.

Further, the captured Carbon Dioxide can be put to good use. Since Carbon Dioxide is good for plants, it can be used to grow trees or algae, which can in turn be used to make fuel, or the gas can possibly be used to make carbonated soda water.

Image Source: Stonehaven Productions

Special Thanks:

I'd like to thank a number of people for helping me with my project: Prof. Klaus Lackner and Allen Wright from Arizona State University, for introducing me to the technology, as well as Peter Klebnikov, Steve Binkley, George Zachos, Dr. Jan Beyea, Scott Panning, John Brock, Prof. Katrina Kuh and Natalia Sharova, all for giving me research advice along the way, Robbie and Wendell from GCS and Calvin Liu from Cooper Union for helping me construct the machine, Mr. Reilly, my grade dean; Mr. Klebnikov, my school advisor; Mr. Benadiba, my project advisor and Mr. Zia for supporting me at school, and finally the GCS Science Department and Christ Church Riverdale for helping fund my project.

Carbon Dioxide Capture

using Direct Air Capture (DAC) to remove Carbon Dioxide from the air

To Sum it Up:

155 screws
62 Lines of Code
17 people consulted
6,006,945,000,000,000,000,000 molecules of Carbon Dioxide Captured

For More Info:

For more information on the machine, visit: https://goo.gl/UR2y9F

For a video of my machine in action, visit: https://goo.gl/w3kVVO

Cover Image Source: Patil et al (2012)

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