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Hands-on: Part 1 - The 1856 Gas-in-Jars Experiments

Every chance we get, we should see if some straightforward experiment or observation can bring home what we are learning.

In **CSSG-2.1**, we saw some snapshots of some clouds. This one may be an example of superheated moist air billowing upwards so forcefully into the cold altitudes that rain was falling on to the **top** of the usual thunderhead! More intense rain is to be expected with global warming because of such rising quickly into colder altitudes.

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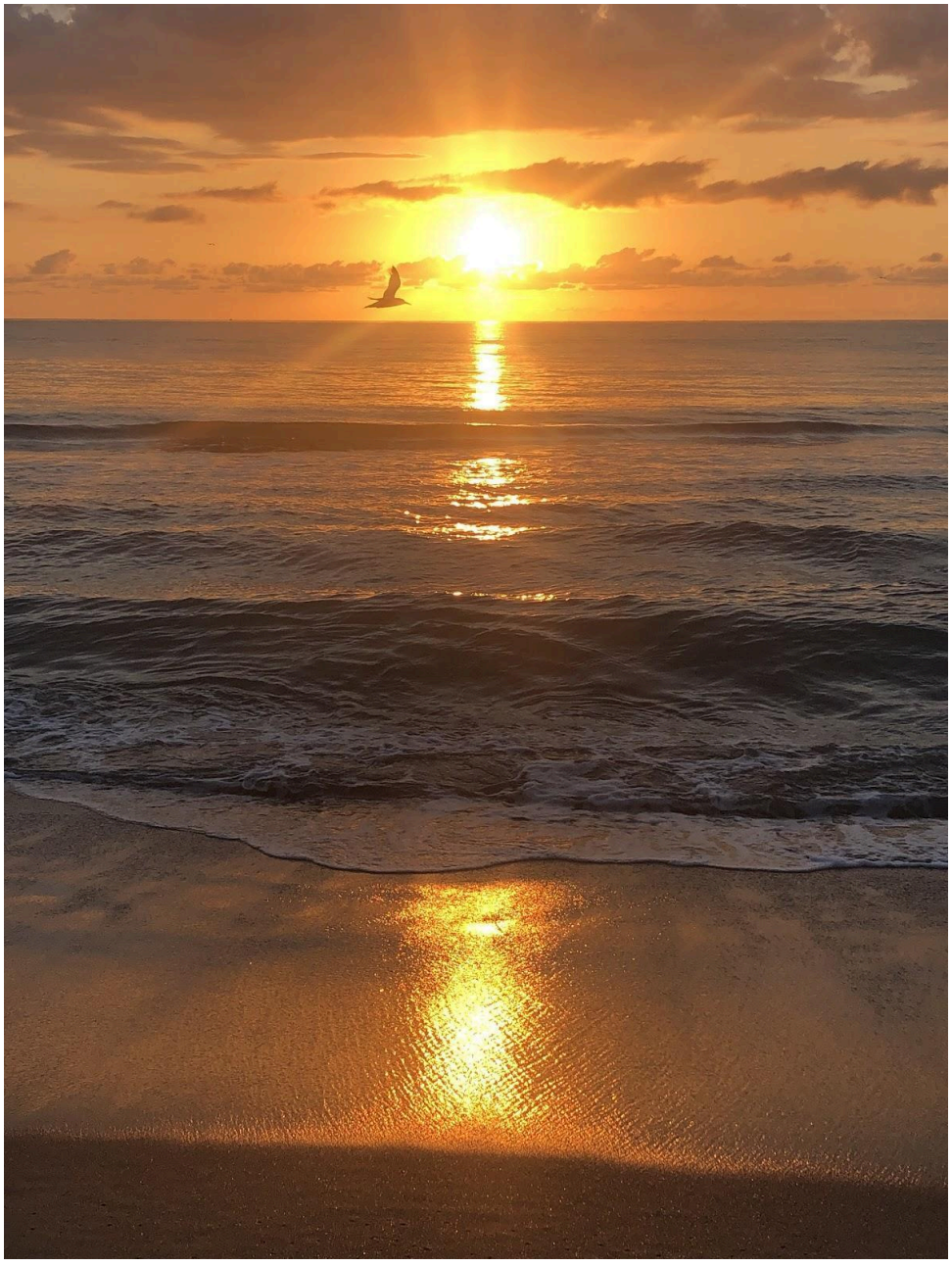
Likewise, we looked at this picture to notice the sun's (energy) rays were absorbed sometimes, reflected back to space sometimes, hitting the tops of clouds sometimes, the bottoms of clouds sometimes, etc.



The point is, what we are studying is tangible - not esoteric (From the Greek "within" - Esoteric knowledge is private, obscure, and exclusive and might be related to subjects such as mysticism or the arcane.)

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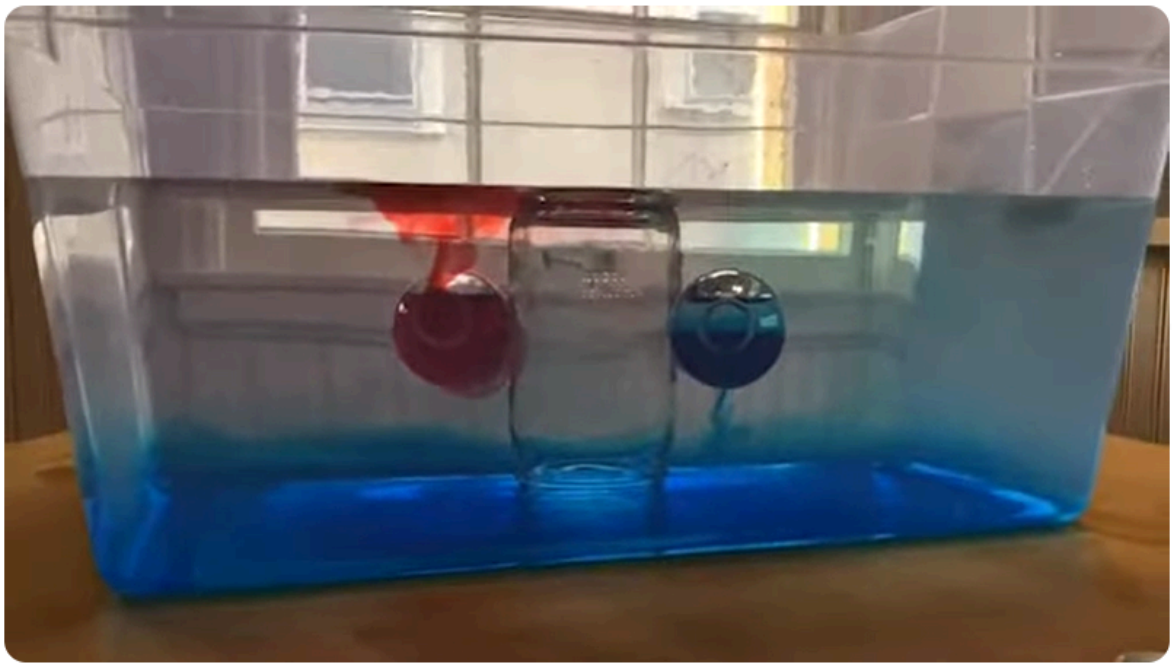
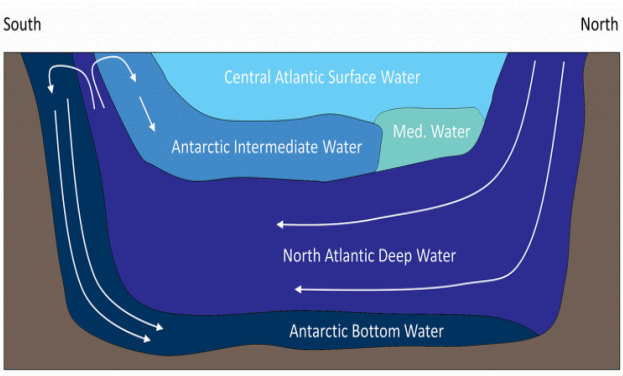
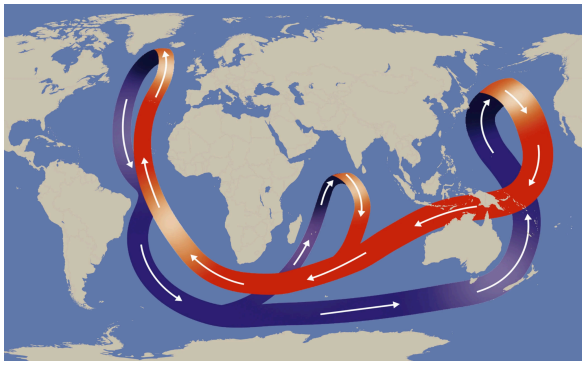
The type of Experiments we will work with along the way should be clear, to the point, and unforgettable! Here's a great example. It couldn't be a more rudimentary set-up, but the **BLUE water is SALTY;** the **RED water is fresh, room temperature water**. The **tub is filled with VERY COLD water.** Click on the link and think of the CSSG-2.7 discussion of the layering of various ocean masses and how the THERMOHALINE effects move the Great Conveyor.

The demonstration link —->>> Thermohaline Circulation Demonstration







https://rwu.pressbooks.pub/webboceanography/chapter/9-8-thermohaline-circulation/

Thermohaline Circulation !

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Now, for something NEW (and 167 years OLD)!

PLEASE enjoy this article - we're going to try to duplicate some of her experiments.

NOVEMBER 9, 2023 | 23 MIN READ

The Woman Who Demonstrated the Greenhouse Effect

Eunice Newton Foote showed that carbon dioxide traps the heat of the sun in 1856, beating the so-called father of the greenhouse effect by at least three years. Why was she forgotten?

BY KATIE HAFNER, THE LOST WOMEN OF SCIENCE INITIATIVE, ELAH FEDER & ZOE KURLAND

Credit: Paula Mangin

The article —->>>> https://apple.news/AyqDLaZ9STg-bylez-jYtHQ

Her research was noted in Scientific American shortly after it was presented, but the more detailed description was in Annual of Scientific Discovery, Year-Book of Facts in Science and Art, 1857, Gould and Lincoln, Boston, 1857. Write-up of the 1856 talk at AAAS, where a man named Joseph Henry read Eunice's paper for her.

It is pretty short, so I've copied it here - the part about CO_2 is near the bottom:

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Prof. Henry then read a paper by Mrs. Eunice Foote, prefacing it with a few words, to the effect that science was of no country and of no sex. The sphere of woman embraces not only the beautiful and the useful, but the true. Mrs. Foote had determined, first, that the action of the rays increases with the density of the air. She has taken two glass cylinders of the same size, containing thermometers. Into one the air was condensed, and from the other it was exhausted. When they were of the same temperature the cylinders were placed side by side in the sun, and the thermometers in the condensed air rose more than twenty degrees higher than those in the rarefied air. This effect of rarefaction must contribute to produce the feebleness of heating power in the sun's rays on the summits of lofty mountains. Secondly, the effect of the sun's rays is greater in moist than in dry air. In one cylinder the air was saturated with moisture, in the other dried with chloride of lime; both were placed in the sun, and a difference of about twelve degrees was observed. This high temperature of sunshine in moist air is frequently noticed; for instance, in the intervals between summer showers. The isothermal lines on the earth's surface are doubtless affected by the moisture of the air giving power to the sun, as well as by the temperature of the ocean yielding the moisture. Thirdly, a high effect of the sun's rays is produced in carbonic acid gas. One receiver being filled with carbonic acid, the other with common air, the temperature of the gas in the sun was raised twenty degrees above that of the air. The receiver containing the gas became very sensibly hotter than the other, and was much longer in cooling. An atmosphere of that gas would give to our earth a much higher temperature; and if there once was, as some suppose, a larger proportion of that gas in the air, an increased temperature must have accompanied it, both from the nature of

the gas and the increased density of the atmosphere. Mrs. Foote had also tried the heating effect of the sun's rays on hydrogen and oxygen, and found the former to be less, the latter more, susceptible to the heating action of sunlight.

To me, this looks like FUN! Maybe some of you would like to join me (even from afar) in the coming weeks separately from the Wednesday group and try these out. I've already started, but there is a lot more to try!

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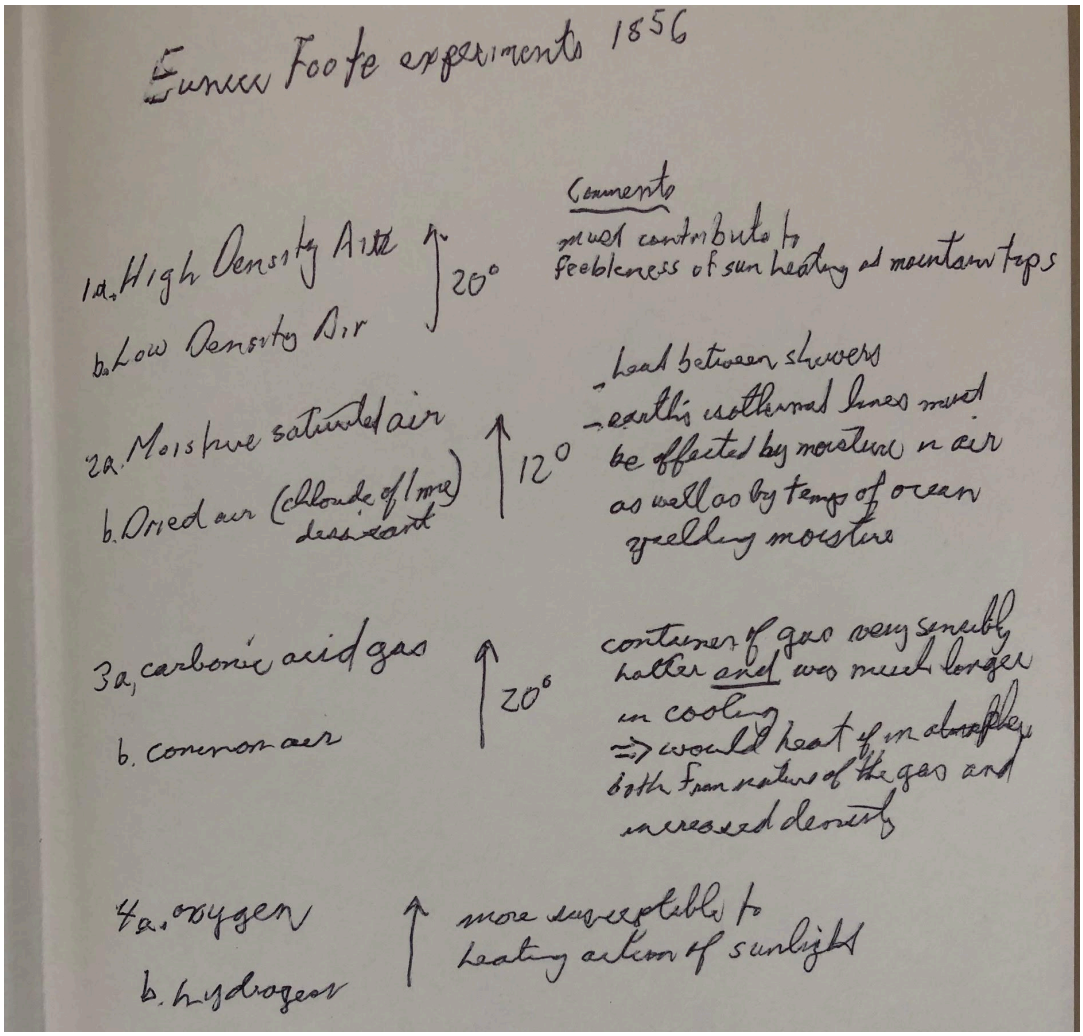
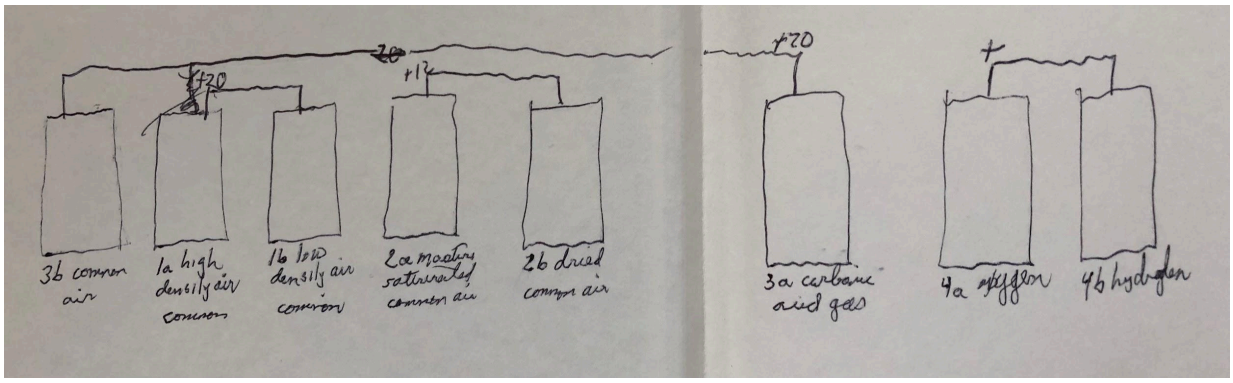
I first read the above account on the plane and sketched out some details (using my 1856 handwriting):



This is another way I tried to understand what was described:



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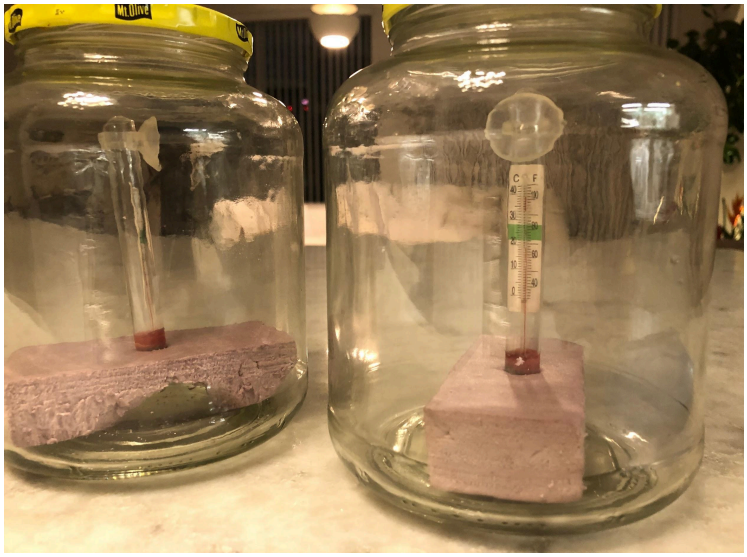
Clearly the first instruction was finding two jars. Pickles come to mind (although I think I've now had my yearly allotment)!



- I had two regular aquarium thermometers from earlier experiments which fit.
- Thinking that cold, refrigerator air would have at least some moisture squeezed out, I put the open "dry air" jar in there for a while and then closed it up.
- I had some bottled CO_2 from earlier experiments so I didn't need to use alka-seltzer tablets or other baking soda and vinegar, etc. so I filled the second jar with that.
- Before putting them in the sun, I made sure they were both at the same temperature in the shade
- Excited as I could be, I put them in the sun!

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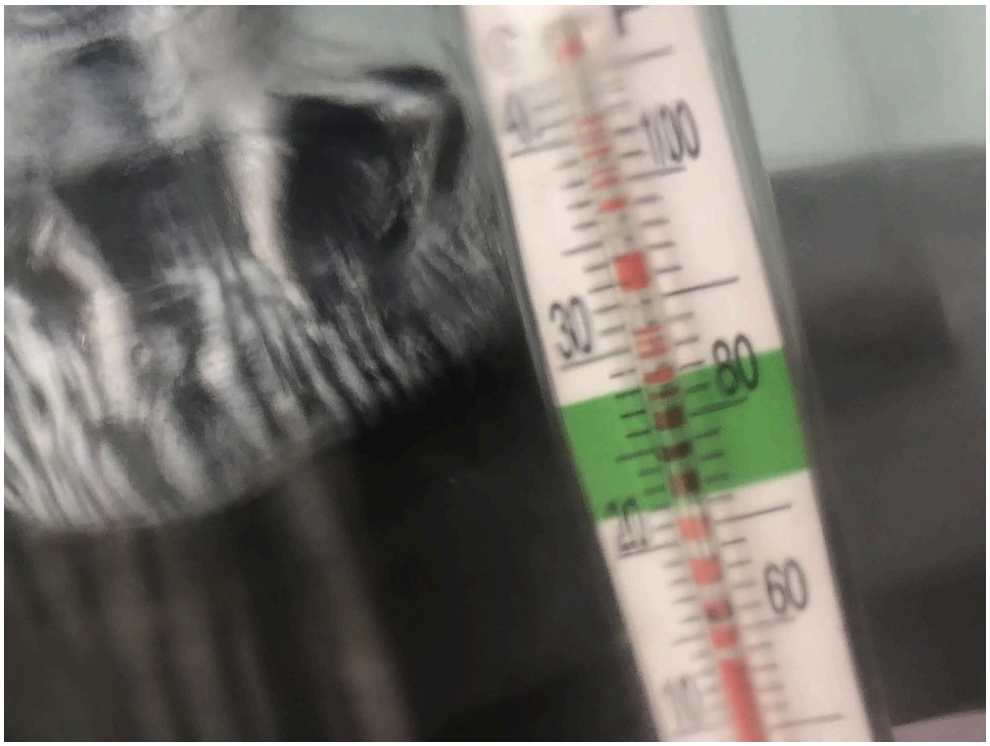
Unfortunately, when the jars heated up in the sun, they got so hot inside that the thermometers boiled and are now useless!



SO, PLAN B:

I just happened to have a couple of **digital** aquarium thermometers on hand (don't you?). Maybe they would do the trick:

- Same introduction of dry air and CO_2
- Let both jars come to shade temperature

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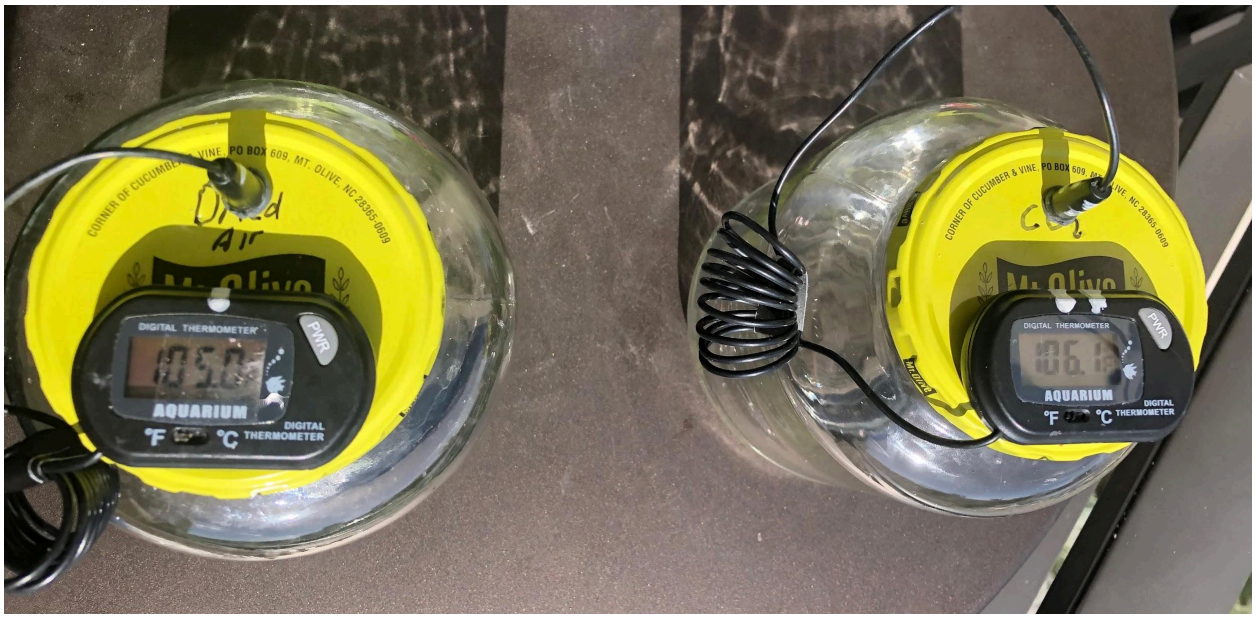
The maximum temperature difference I noted was about 1 ^{0}F. (The watch is missing from this shot because it had gotten so hot that it shut down).



Hoping against hope that I could get a larger temperature rise, I went to a **PLAN C,** a 250 Watt shop lamp on my desk. Here I'm waiting for the temperatures to come to room temperature**:**

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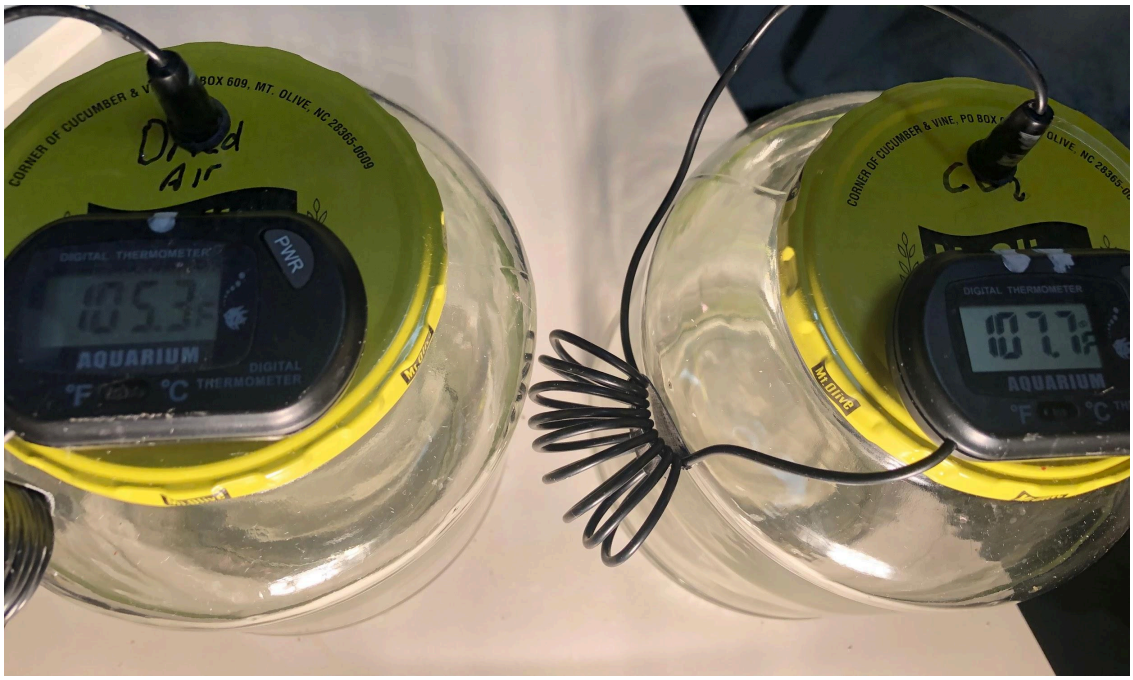
This time, with the lamp close up, I got **about 2.8 ^{0}F** difference, with the CO2 jar on the left.

I carefully switched their places in case the lamp was unevenly heating, and this time the difference was **about 2.4 ^{0}F.**



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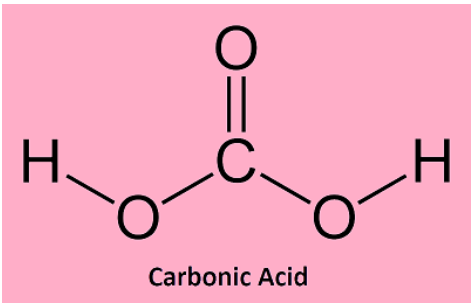
And, a final step after a few hours to be assured that the thermometers are giving about the same readings in my closed (clothes) closet:

Since they landed about 0.5 ^{0}F apart, it is reasonable to say that this demonstration recorded a **CO_2 effect of about 2 ^{0}F.**

Going back up to the writeup of Foote's findings and my notes, she claimed a temperature difference of **up to 20 ^{0}F**.

But, she never said CO_2!!! She said "carbonic acid gas (whatever that is - I had been supposing it was CO_2). So here's what it is: What is Carbonic Acid? Carbonic acid is a carbon-containing compound which has the chemical formula H_2CO_3.



But the molecule rapidly **converts to water and carbon dioxide** in the presence of water. Whew! We were looking at the right stuff - CO_2.

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So, two takeaways from this material:

1. Experiments are the best way I know to learn more deeply. Please let me know if you want to do some of these with me. I've ordered some more thermometers and desiccants to make "dry air". I'll bet we can find the reason for the **2 ^{0}F vs the 20 ^{0}F** also.
2. Experiments NEVER work the first time!

"Science is not about what we know. It's about what we don't know". That's why it's FUN!

Next time let's get our heads around what makes CO_2 of so much interest these days. It turns out that a little complexity is precisely what makes a gas become a "greenhouse gas".