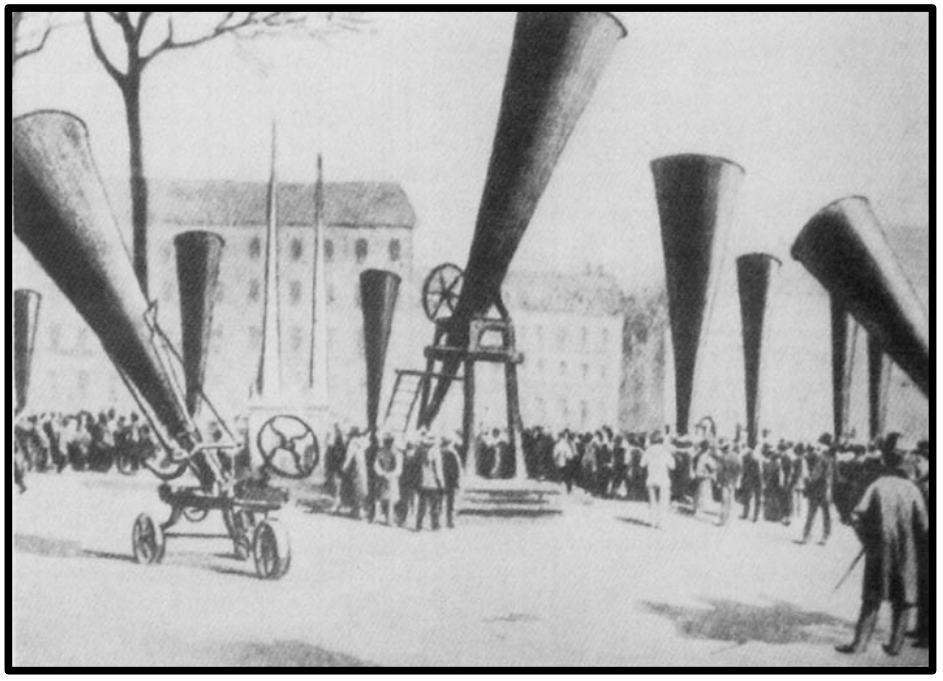
Early History of Weather Modification

- Many early attempts at modification of the weather.
- Generally, no scientific basis until 1940's.
- Work done at General Electric Research Labs in New York.



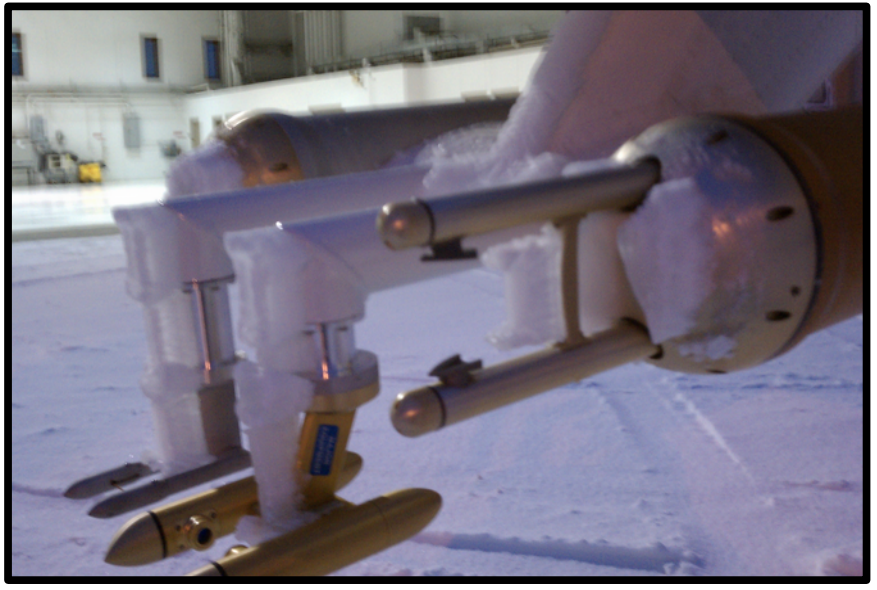
Hail cannons at an international congress on hail shooting held in 1901.

General Electric Research

- Experiments during World War II were conducted dealing with aircraft icing.
- Aircraft icing experiments directed by Irving Langmuir.
- Additional group involved Vincent Schaefer and Bernard Vonnegut.

Wilson Hunter, the Head of the Icing Research Section is shown demonstrating the dangerous icing of the propellers of a P-39 after a wind tunnel test. General Arnold (left) and George Lewis (far left).

Aircraft Icing: Still a Research Topic



Icing of Cloud Probes on the Citation Research Aircraft after November 24, 2010 flight.

Rosemount Icing Detector probes on the fuselage and on hot-wire boom under the left wing of P-3 aircraft for NASA IMPACTS 2023 field project.

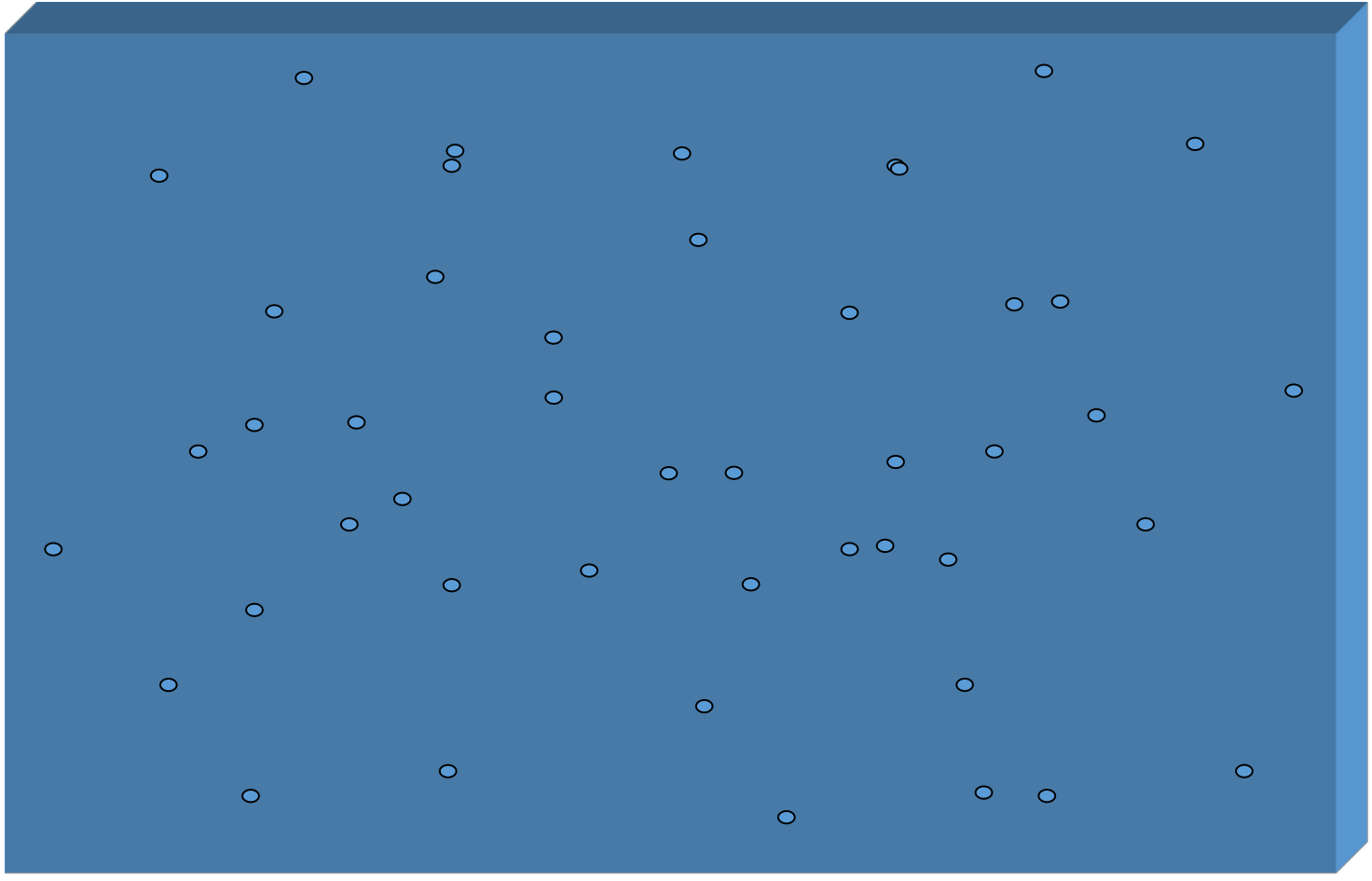
Important Early Results for Weather Modification

- Concept of Supercooled Liquid Water (important as for aircraft icing)
- Cold Box Experiments

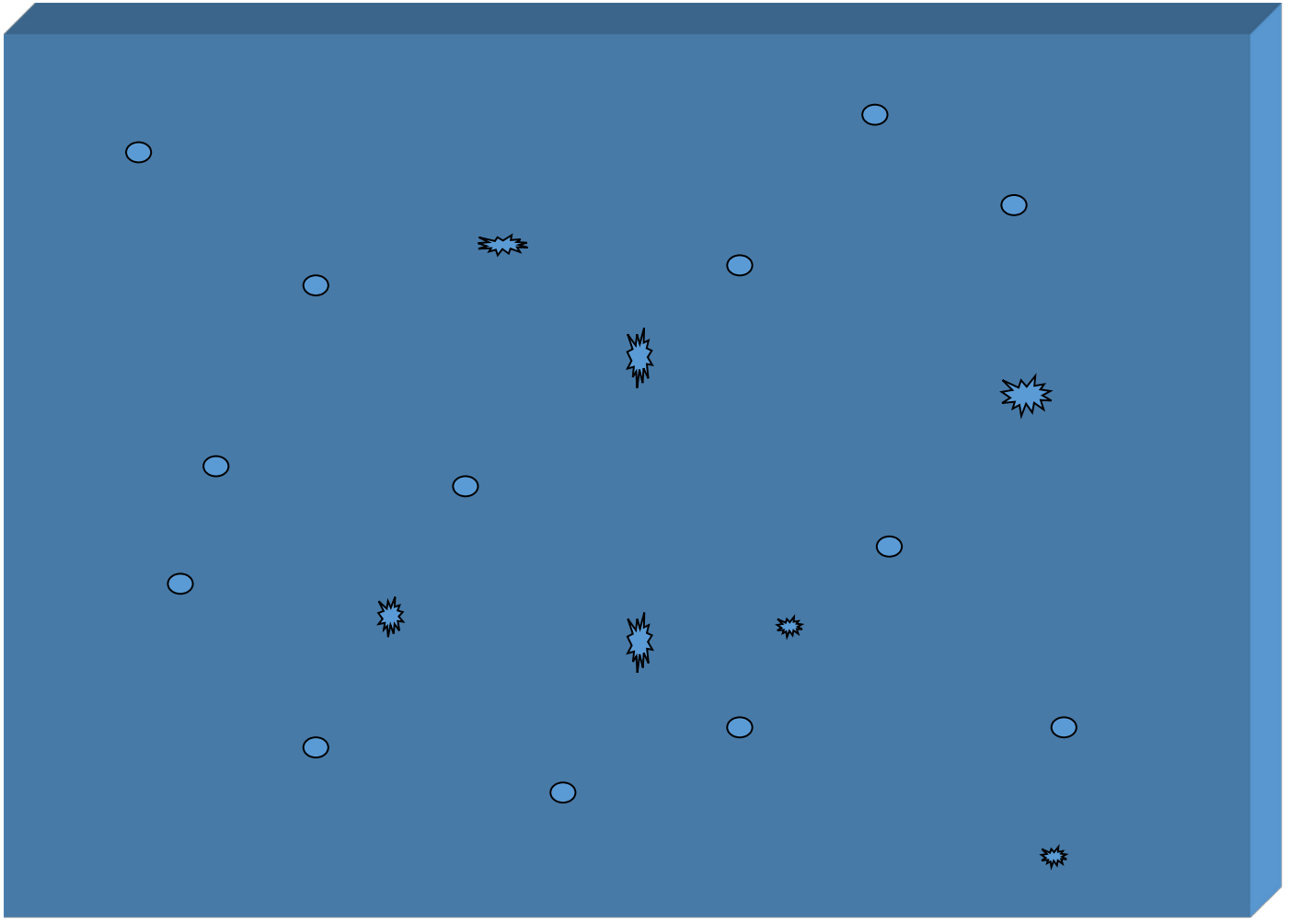
How cold can supercooled liquid droplets be in the atmosphere?

Photo of a hole punch cloud and the associated fall streaks, taken on the east side of Madison, WI, at 11:20 AM CST on Sunday, November 7th. By Tim Wagner

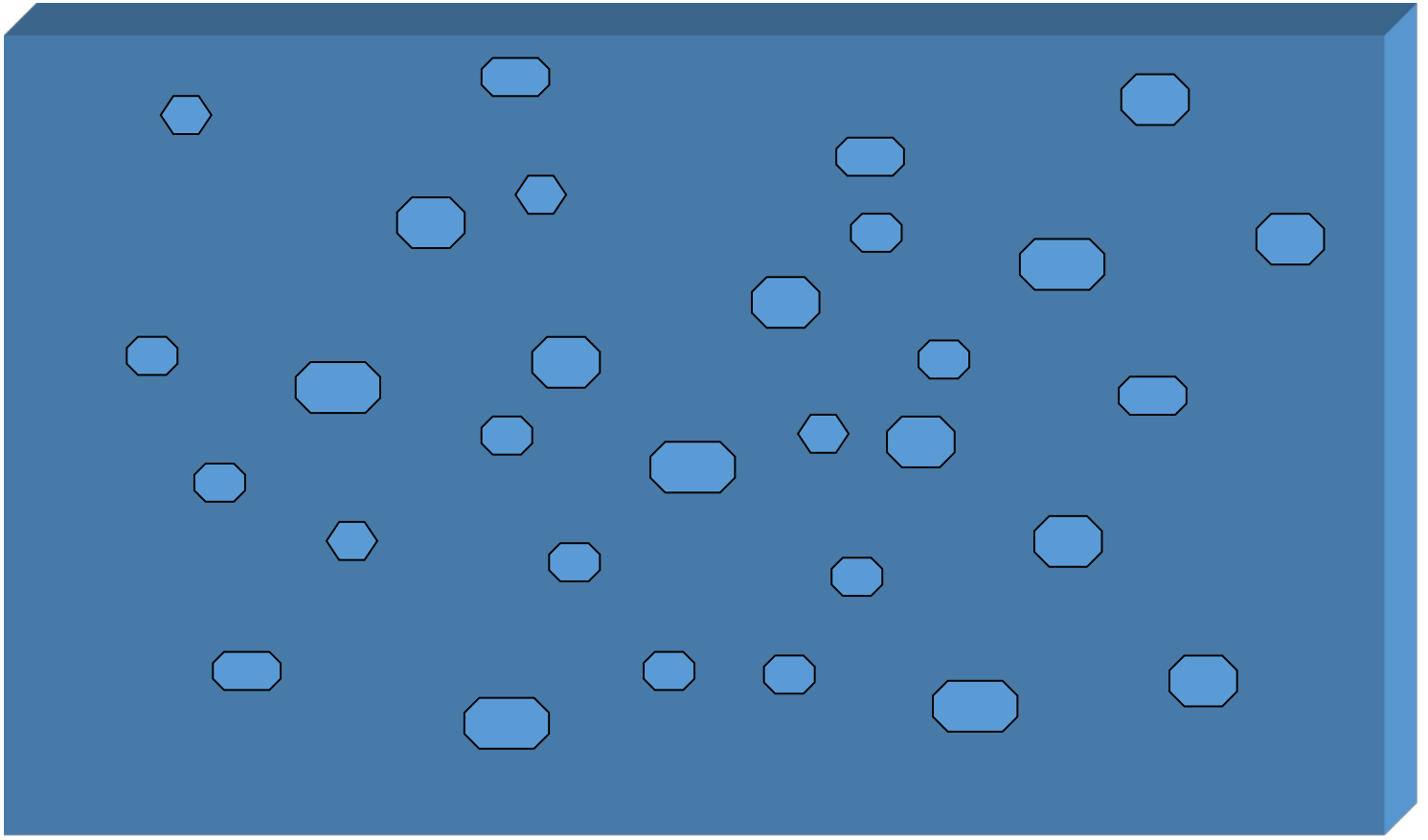
Supercooled Cloud Formed in Chest Freezer



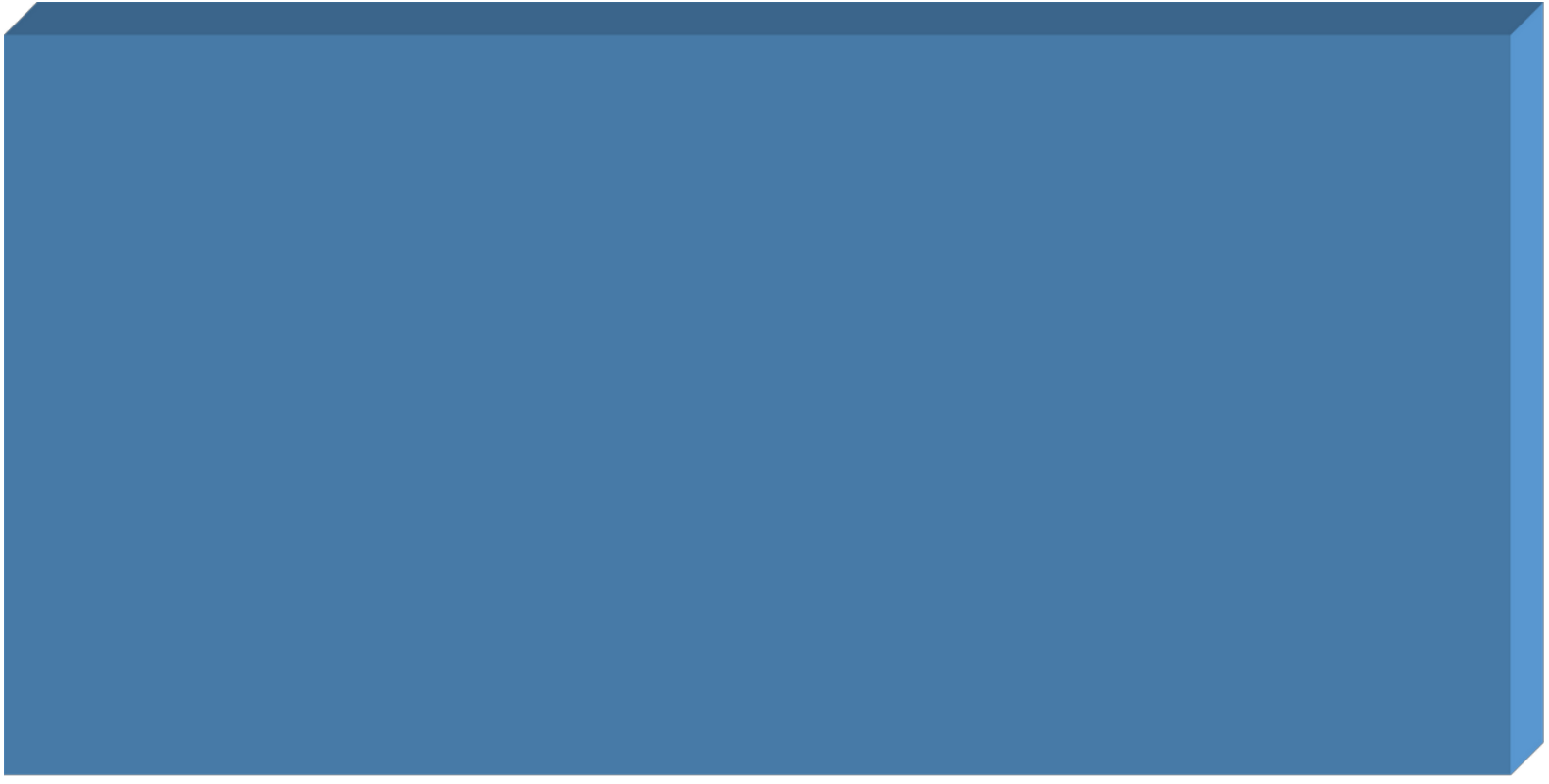
Dry Ice Introduced to the Supercooled Cloud



In time, the water droplets disappeared and the ice crystals grew large.



As time continued, the large ice crystals fell out, leaving only the ice at the bottom of the box and no cloud.



Chamber Observational Window Videos

http://aerosol.atmos.und.edu/CloudChamberVideos_2018.html

June 21, 2018 – **3:14**

0:23 - Injection starts.

1:14 - Start to see some ice.

2:16 - More turbulent eddies.

2:33 - Ice is becoming more prevalent.

3:52 - In the upper right corner, a large dark area.

5:22 - Ice continue to increase.

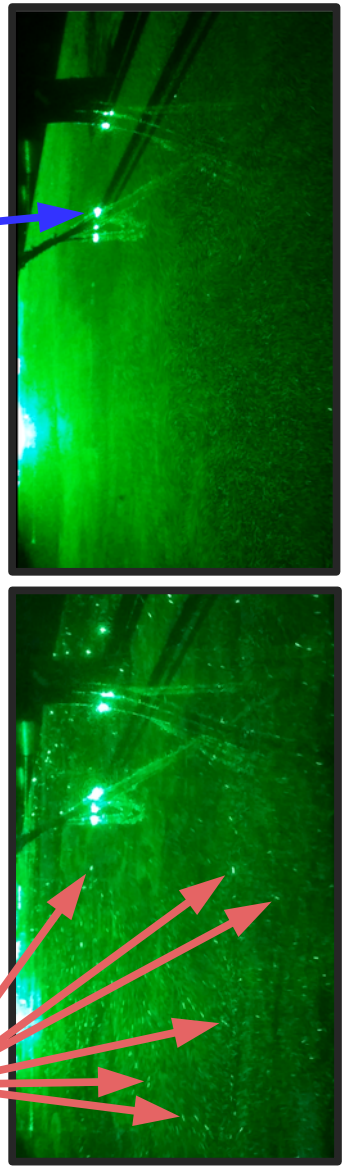
7:00 - Water drops depleting as more dark spots apparent

8:37 - Very little super cooled drops left.

9:06 – Lot of the ice particles apparent.

9:33 - Water drops increasing.

10:15 - Chamber mainly ice particles.



Would this happen in a real cloud?

- This question was addressed and finally tried November 13, 1946.
- Vincent Schaefer dropped about 1.5 kg of dry ice into stratiform cloud in western Massachusetts.

What likely is the cause the whole observed in the image above?

What was the result of putting dry ice into stratiform cloud in western Massachusetts?

- A hole appeared in the cloud
- Ice crystals fell from the base of the cloud
- Ice crystals fell about 600 m below cloud base before sublimating in the dry air below cloud base.

Meanwhile, back at in the laboratory

- The mechanism causing this phase change was being investigated.
- Bernard Vonnegut proposed a different method to achieve the same results.

Early History: Summary of the Concept

- Once an ice crystal formed, it would continue to grow.
- If a crystal is introduced that looks like an ice crystal, ice would continue to grow on that "seed" crystal.

Are there any substances that have a crystal structure similar to that of ice?