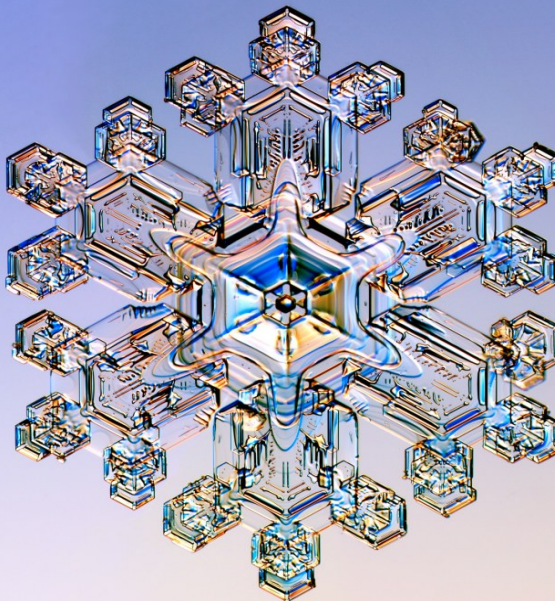
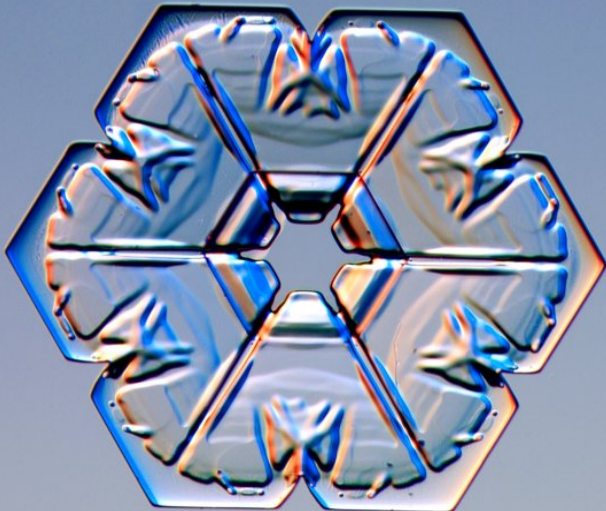
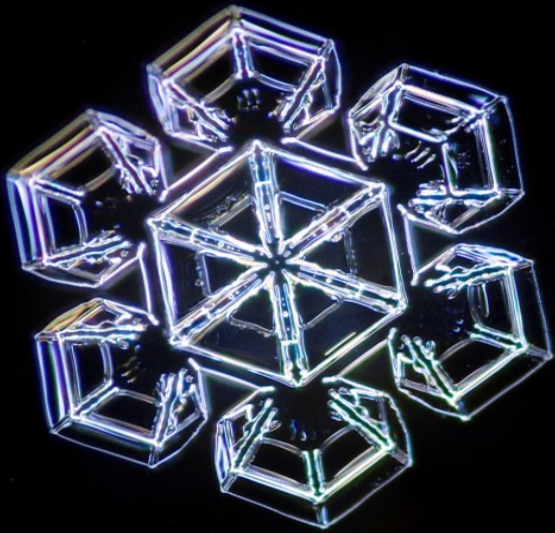


Formation of snowflake

Fujun Du

Completely based on: SnowCrystals.com,
a site owned by Kenneth G. Libbrecht.



Formation of snowflake

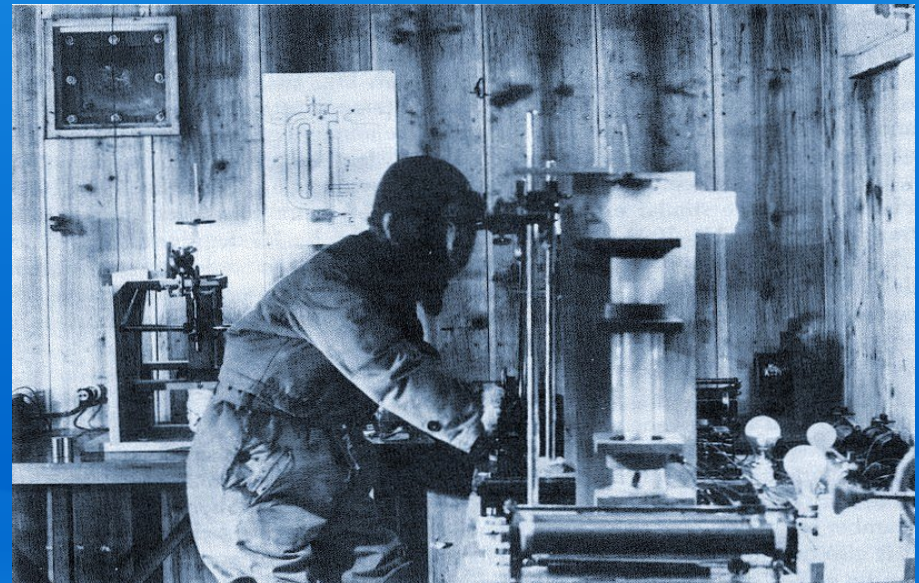
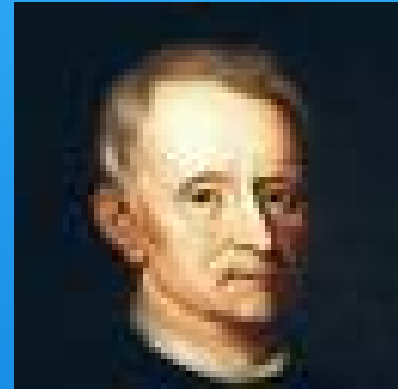
Questions:

1. Why the snowflakes are so symmetric?
2. Why "no two snowflakes the same"?



History of snowflake research

1611 -- Johannes Kepler
1635 -- René Descartes
1665 -- Robert Hooke
1931 -- Wilson A. Bentley
1954 -- Ukichiro Nakaya



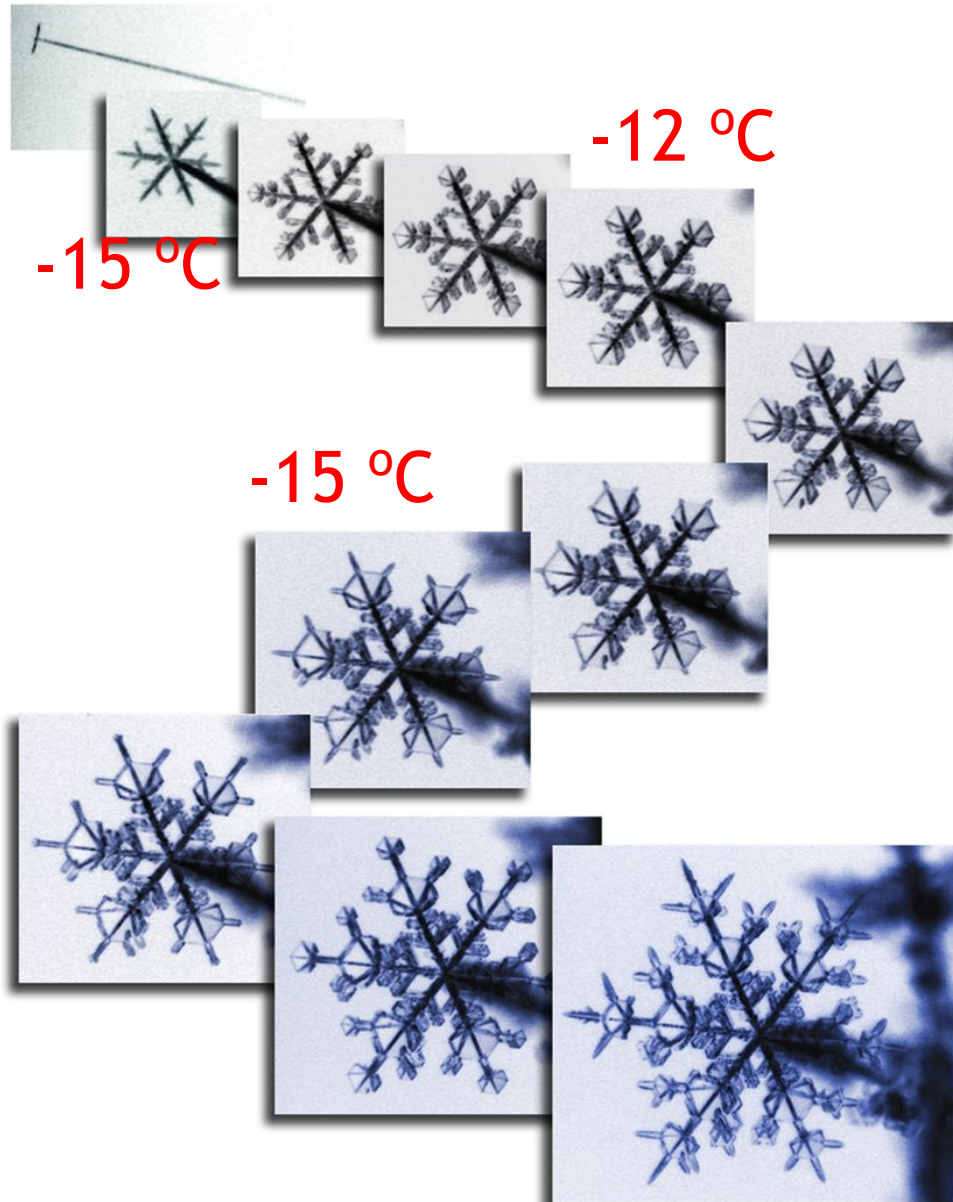
Laboratory study

Electric needles



Temperature dependence

-5 °C

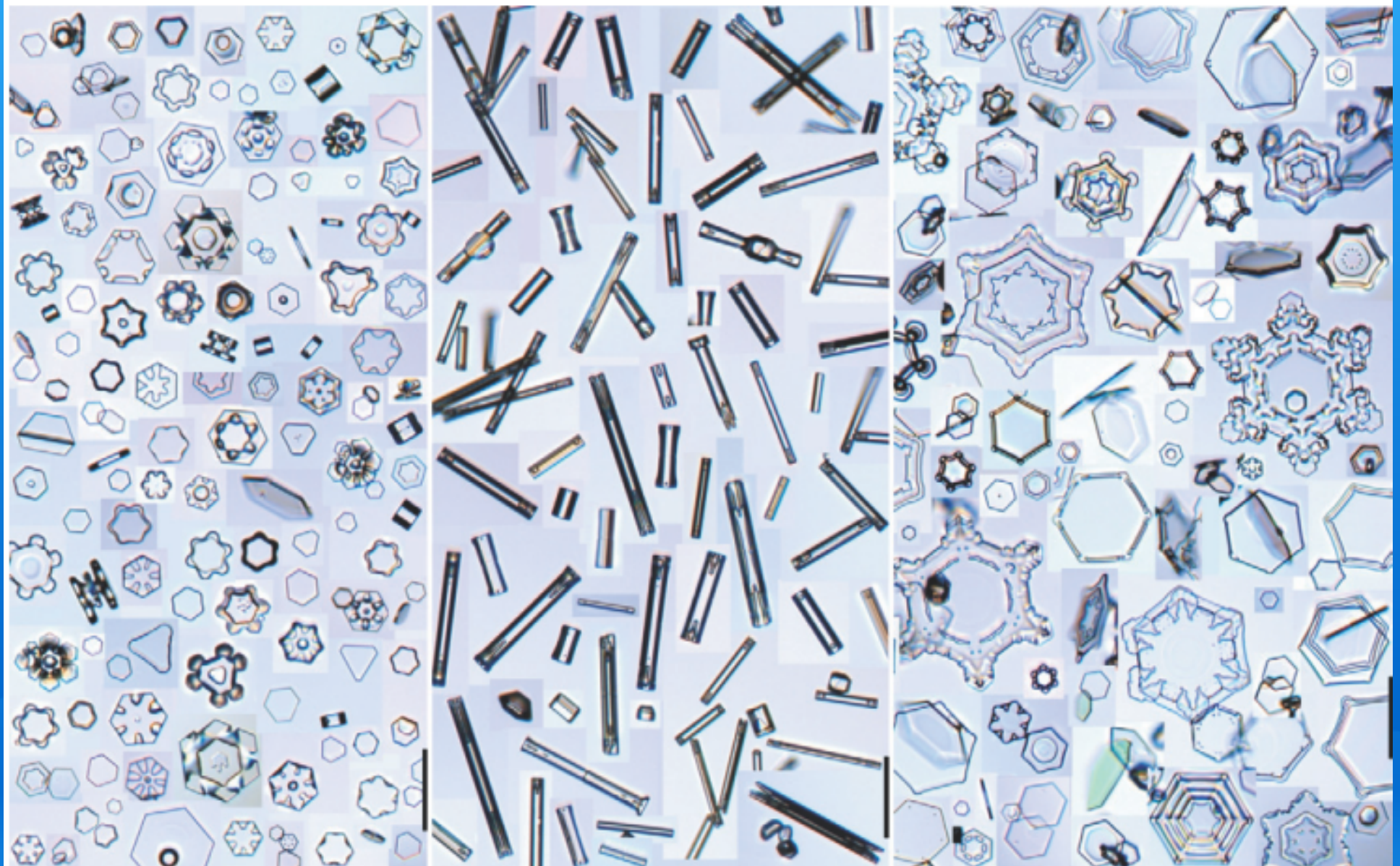


Temperature dependence

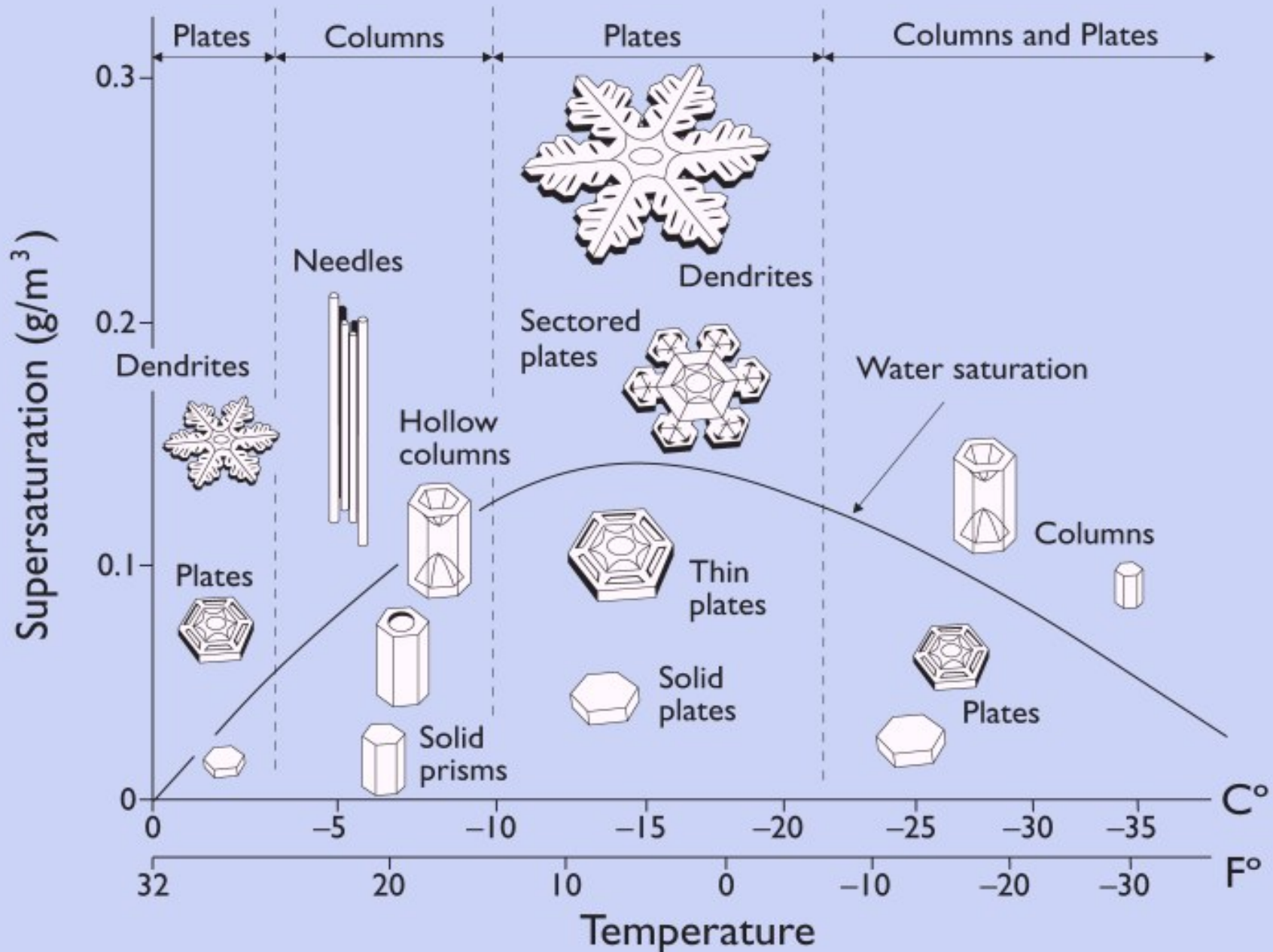
-2 °C

-5 °C

-15 °C



Temperature, humidity



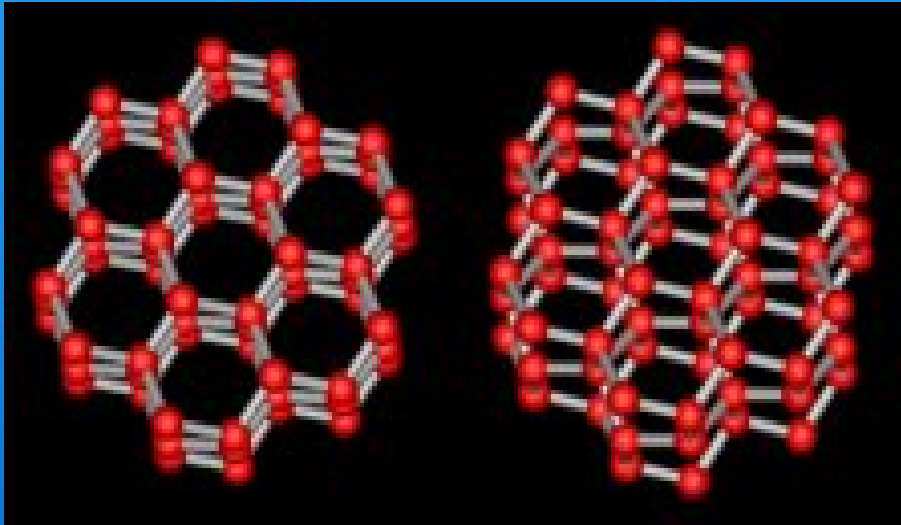
The answer

- Why the snowflakes are so symmetric?
 - They are not always symmetric.



The answer

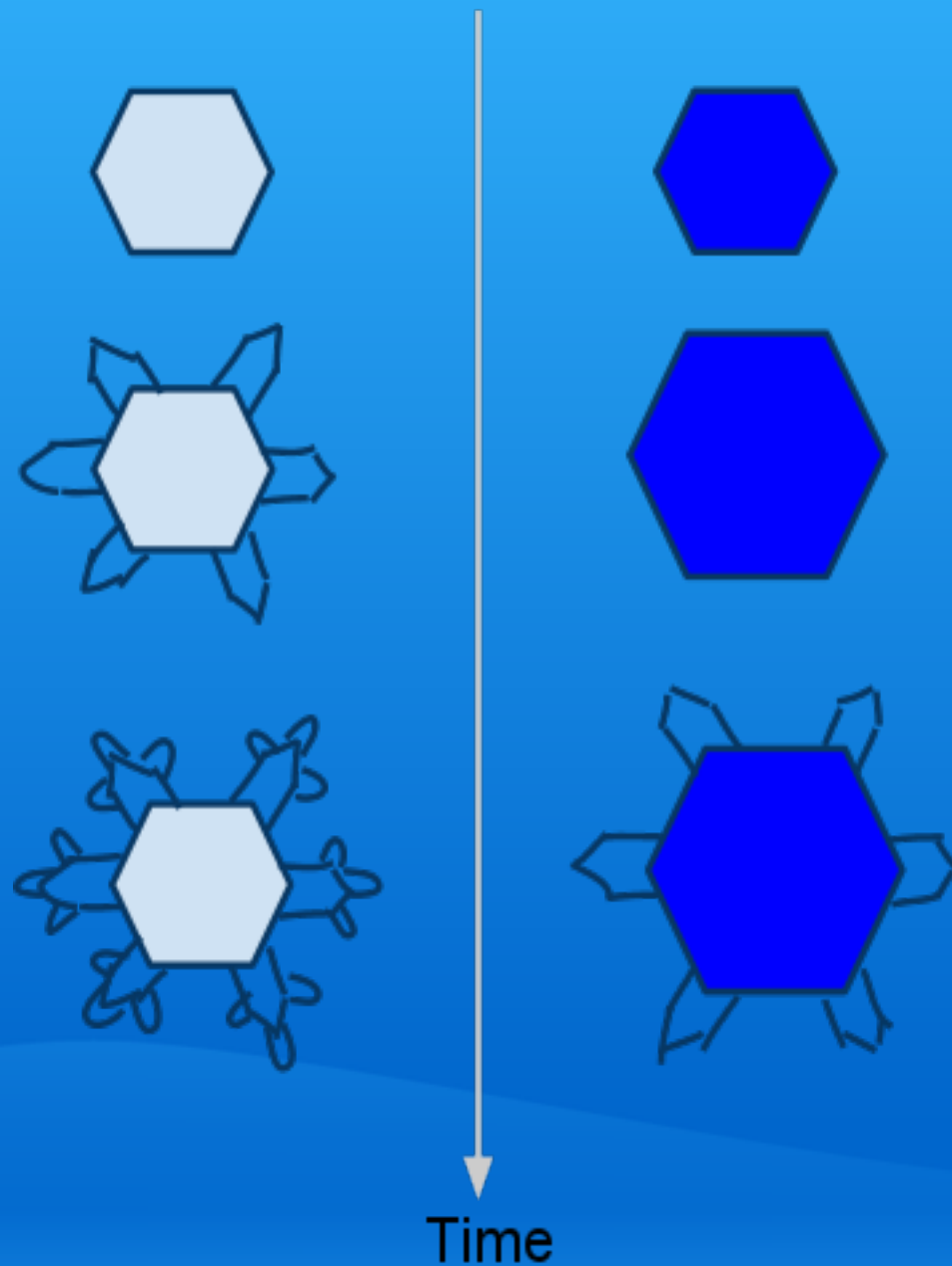
- For those which are symmetric ...



The answer

- No two alike?
 - At nano-scale, two snowflakes can be exactly the same.
 - Small snowflakes can be very similar.
 - The large ones are all different.

The life of a snowflake



Uniform physical condition
in a small scale



Uniform growth of each
side of a snowflake



Symmetric morphology

Sensitive dependence on
physical condition (humidity
and temperature)

Different history



No two snowflakes alike

Discussion

- Relation to astro-chemistry
- Relation to climate
- Relation to biology
- Relation to fabrication of semiconductor

