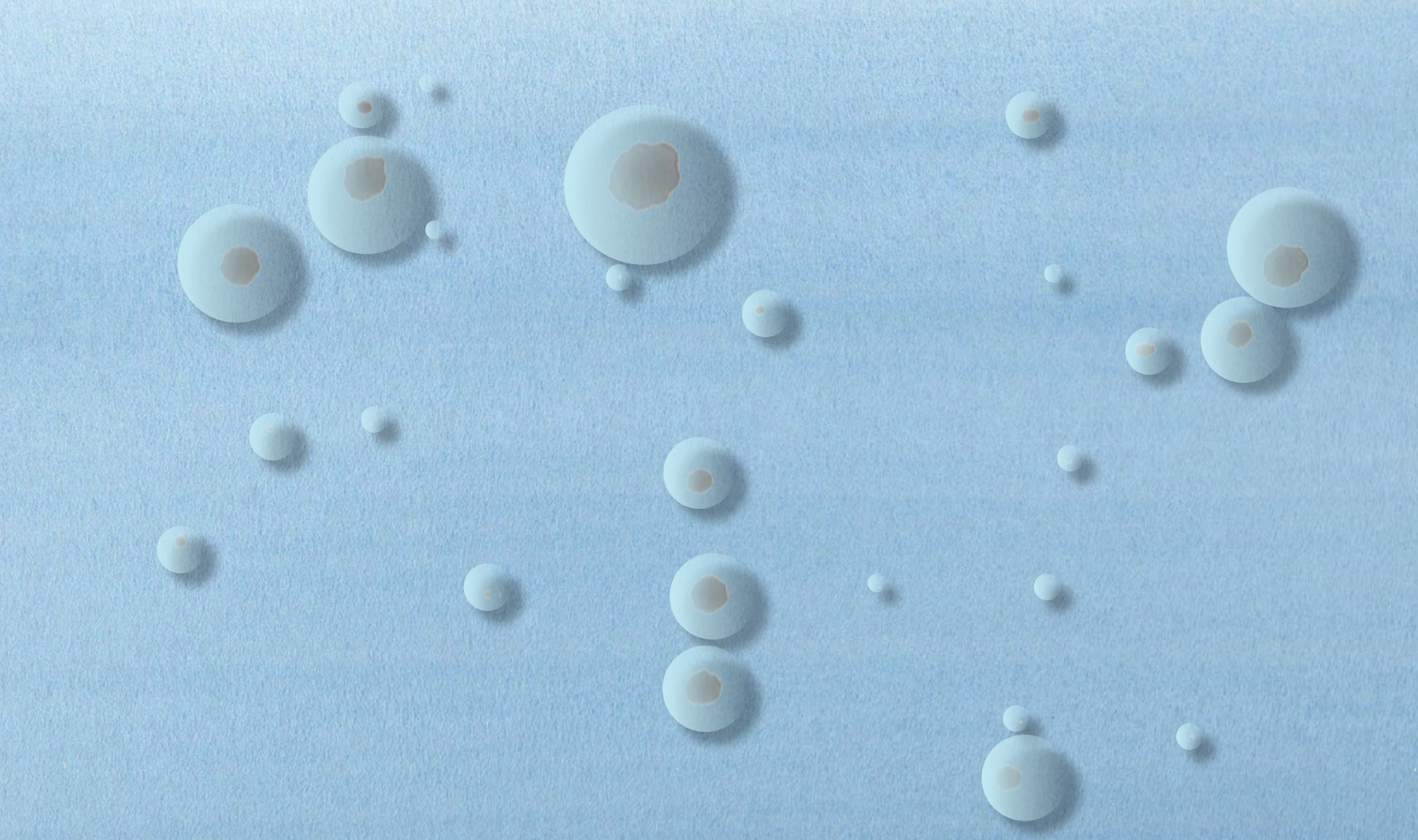
# The Science, Art and Math of a Snowflake

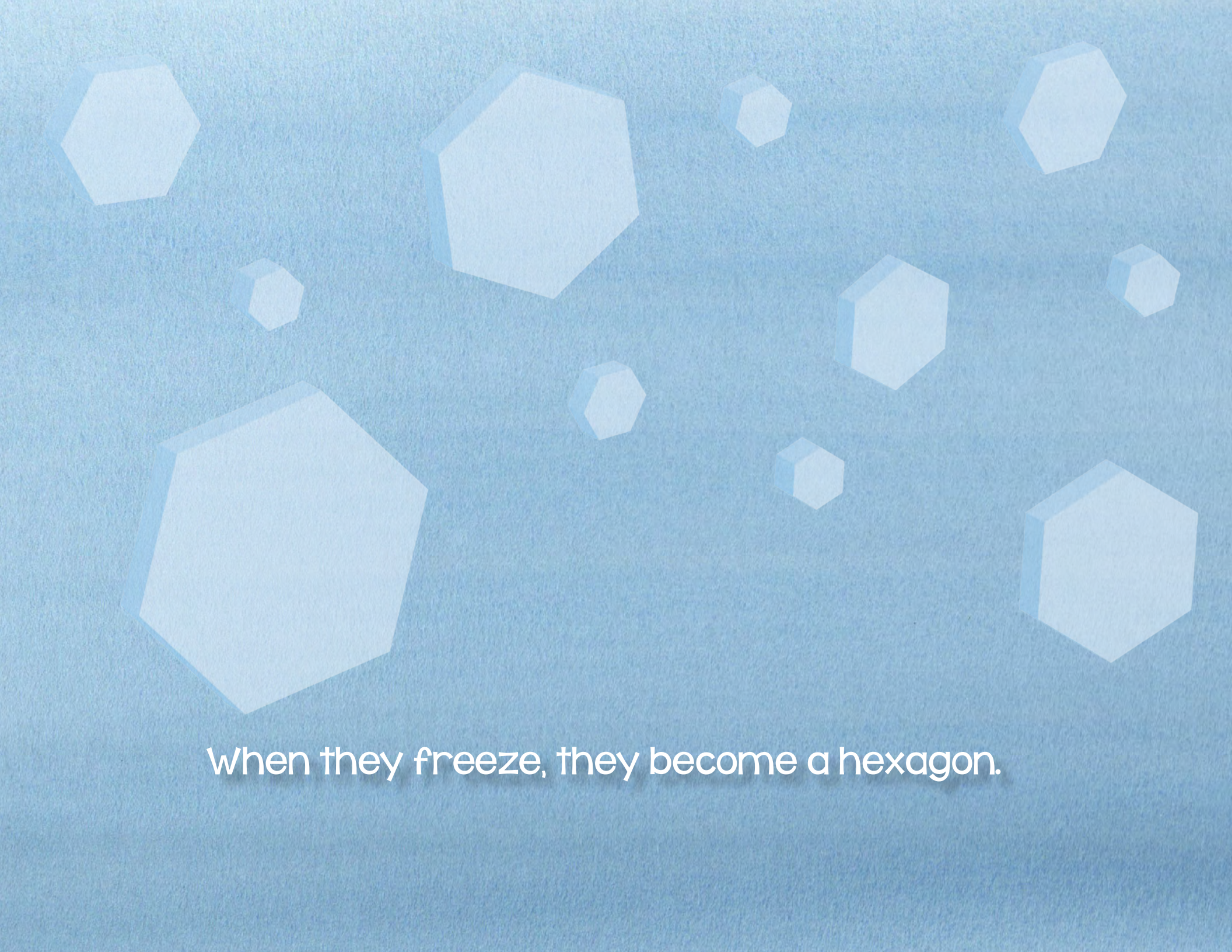
View in Full Screen Mode

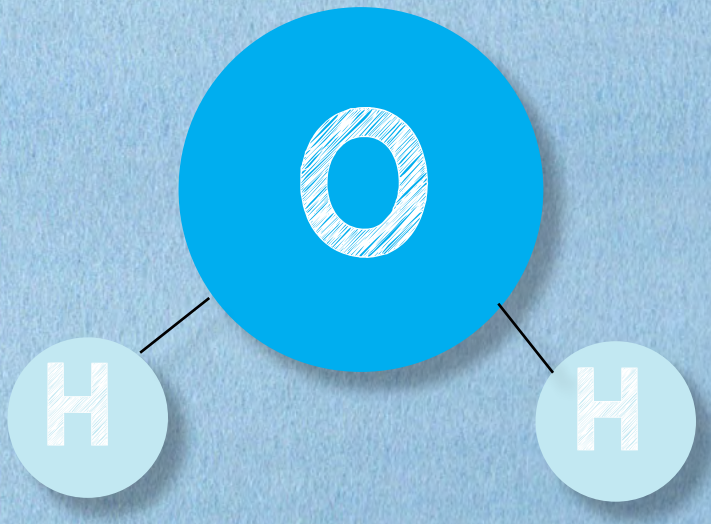
Snowflakes are not just frozen raindrops.
They are actually made from snow crystals.
When snow crystals stick together they form snowflakes.
(ref)


Snow crystals start out as tiny specks of dust in clouds.



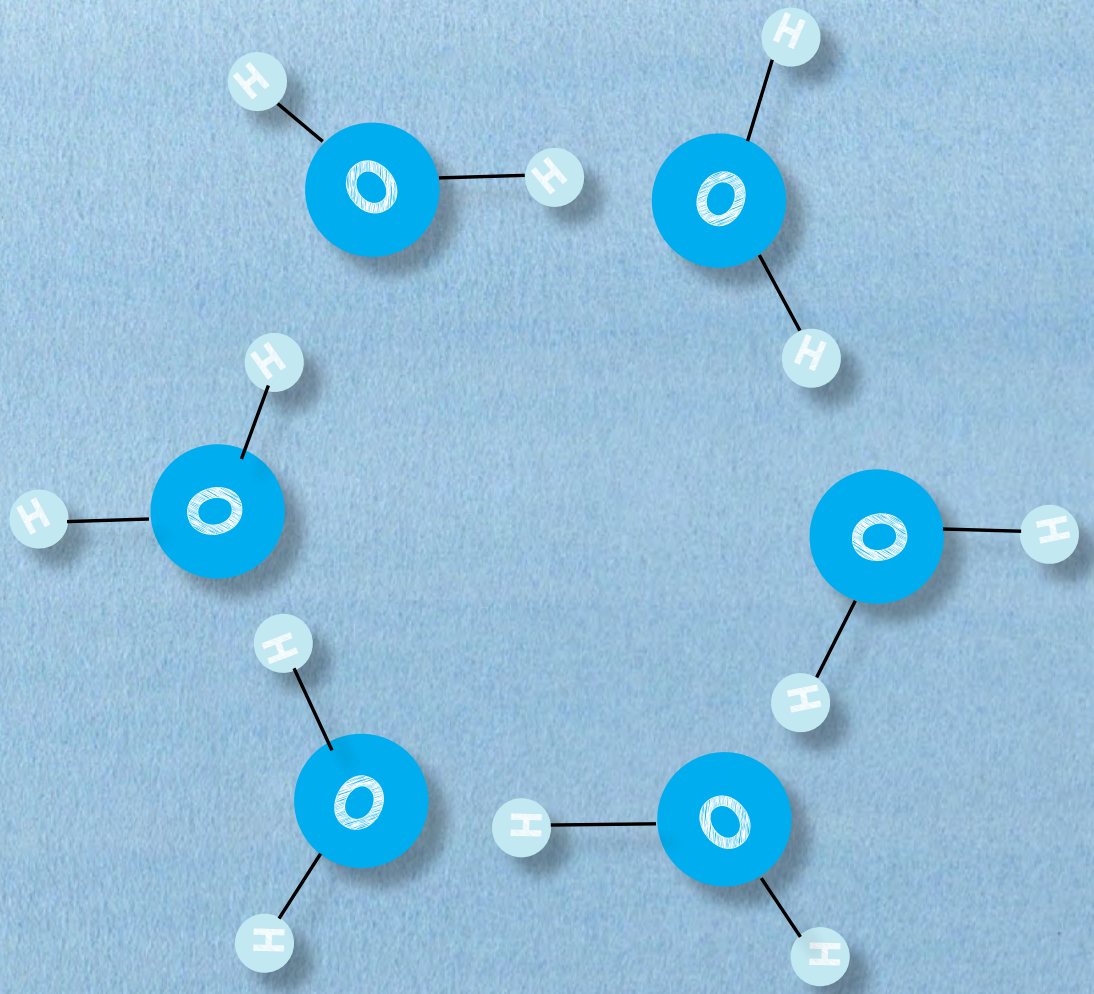
These particles become the nuclei
(center) of snow crystals.
First, water droplets stick to the dust
and begin to freeze.


When they freeze, they become a hexagon.




A WATER MOLECULE CONTAINS 2 HYDROGEN MOLECULES AND 1 OXYGEN MOLECULE. THAT IS WHY WATER IS CALLED H2O.

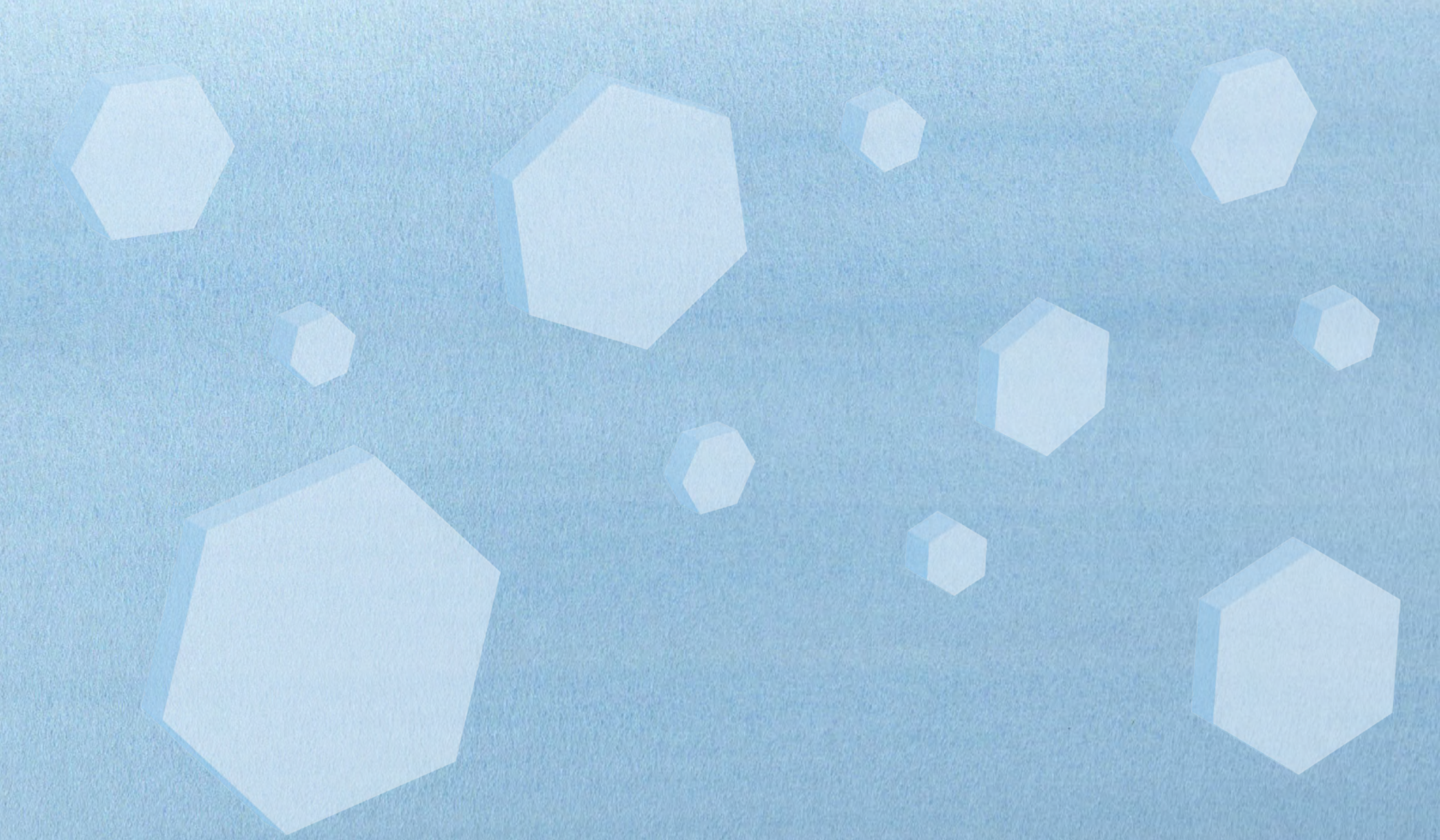
The water molecules form hexagons because of the structure of a water molecule.




When they stick together, they make a hexagon shape.

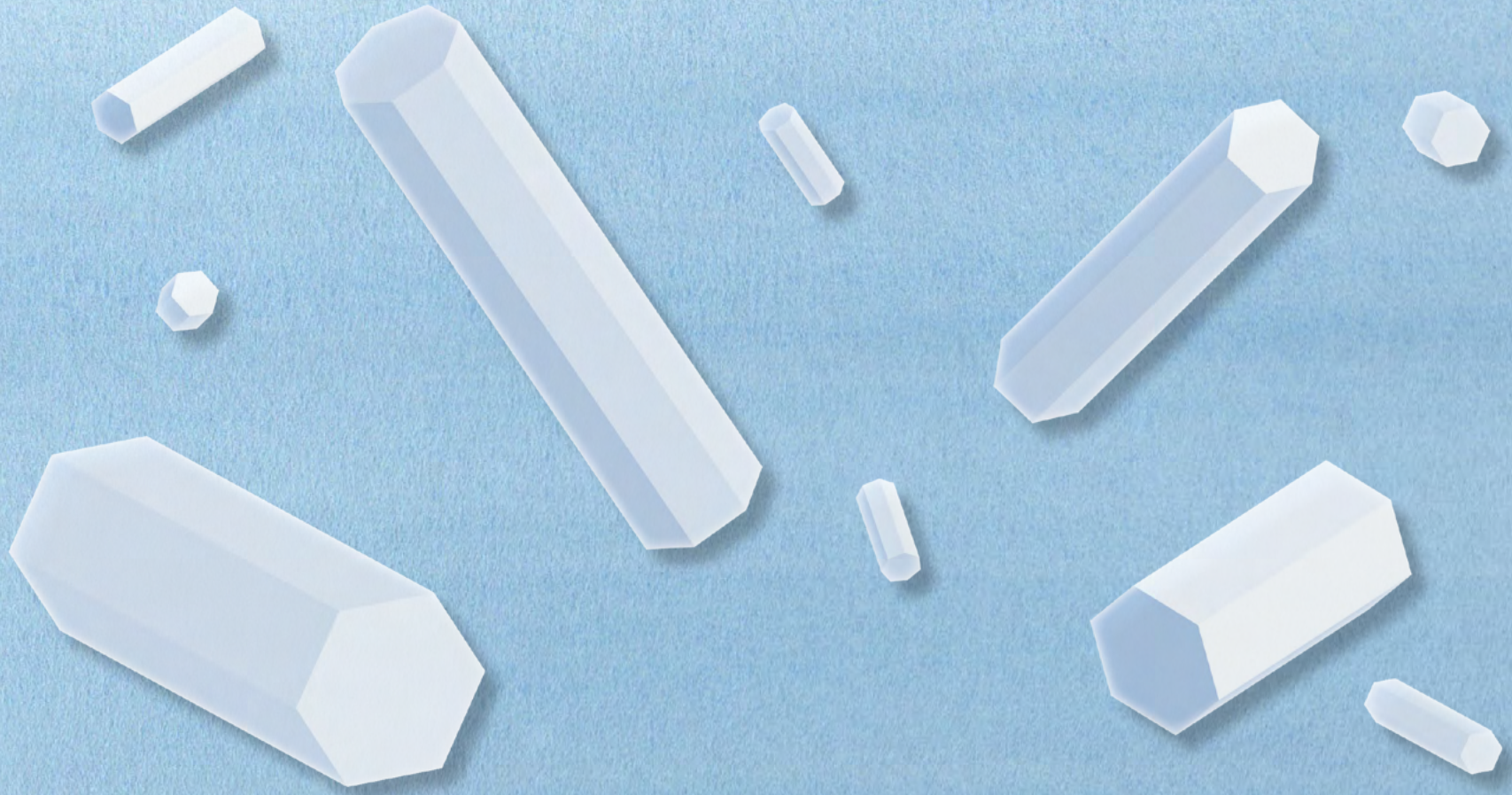
Actually, some of the molecules twist and form a 3D hexagon grid.

(ref)



What happens from there, depends on the temperature and humidity surrounding the frozen hexagon.

If the humidity stays low, snowflakes remain plates.
When you see sparkles in the snow, it's because of the plates,
this usually happens when it's very cold out.



At the right temperature and humidity,
the plates are stacked to make columns.
If you look closely, some snowflakes are actually columns.

The original plate is in the center of each of these snow crystals.

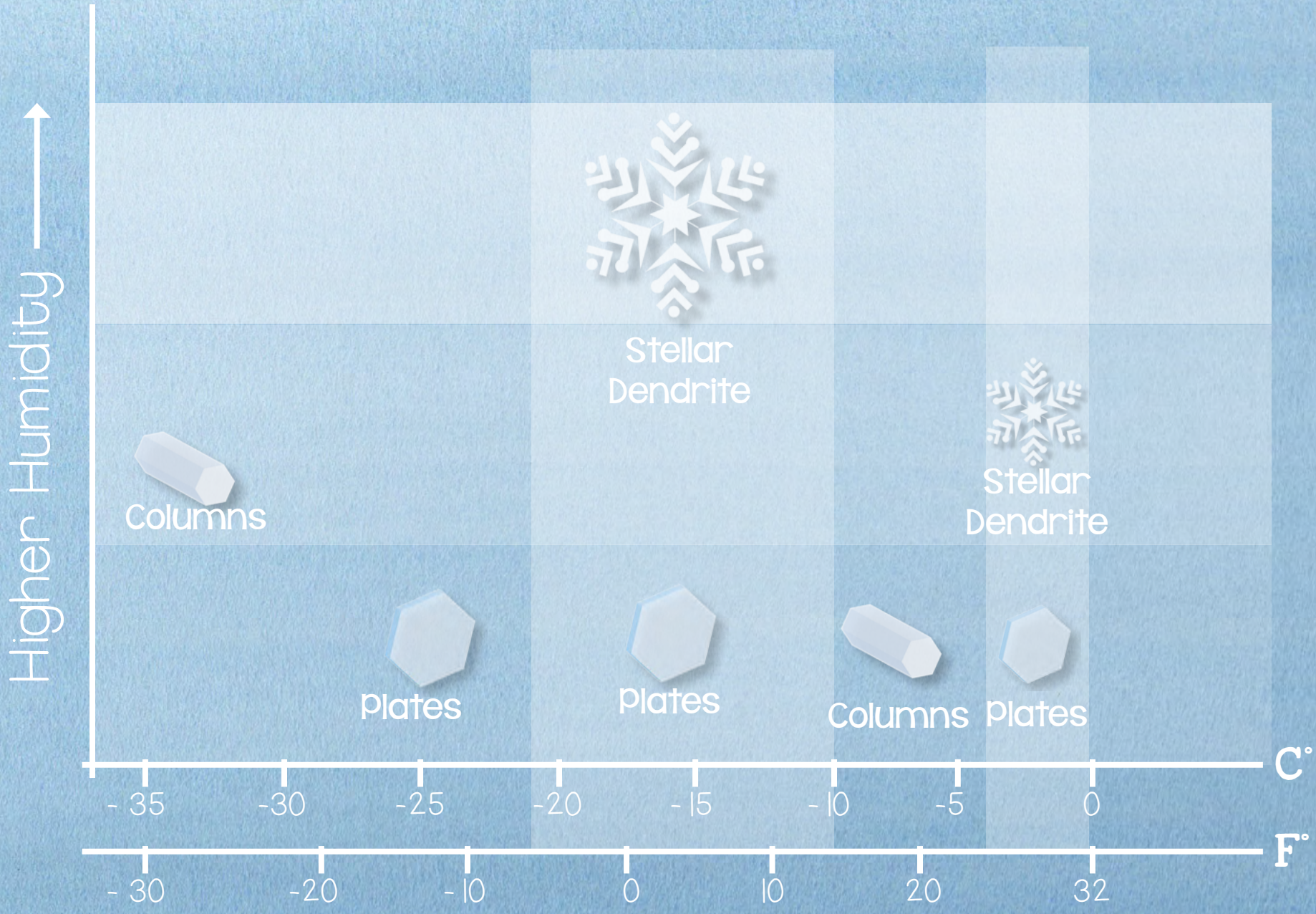
Intricate snowflakes (**stellar dendrites**) are formed with a combination of high humidity and the right temperature.

**stellar** - like a star
**dendrite** - a crystallized form with a branching treelike structure

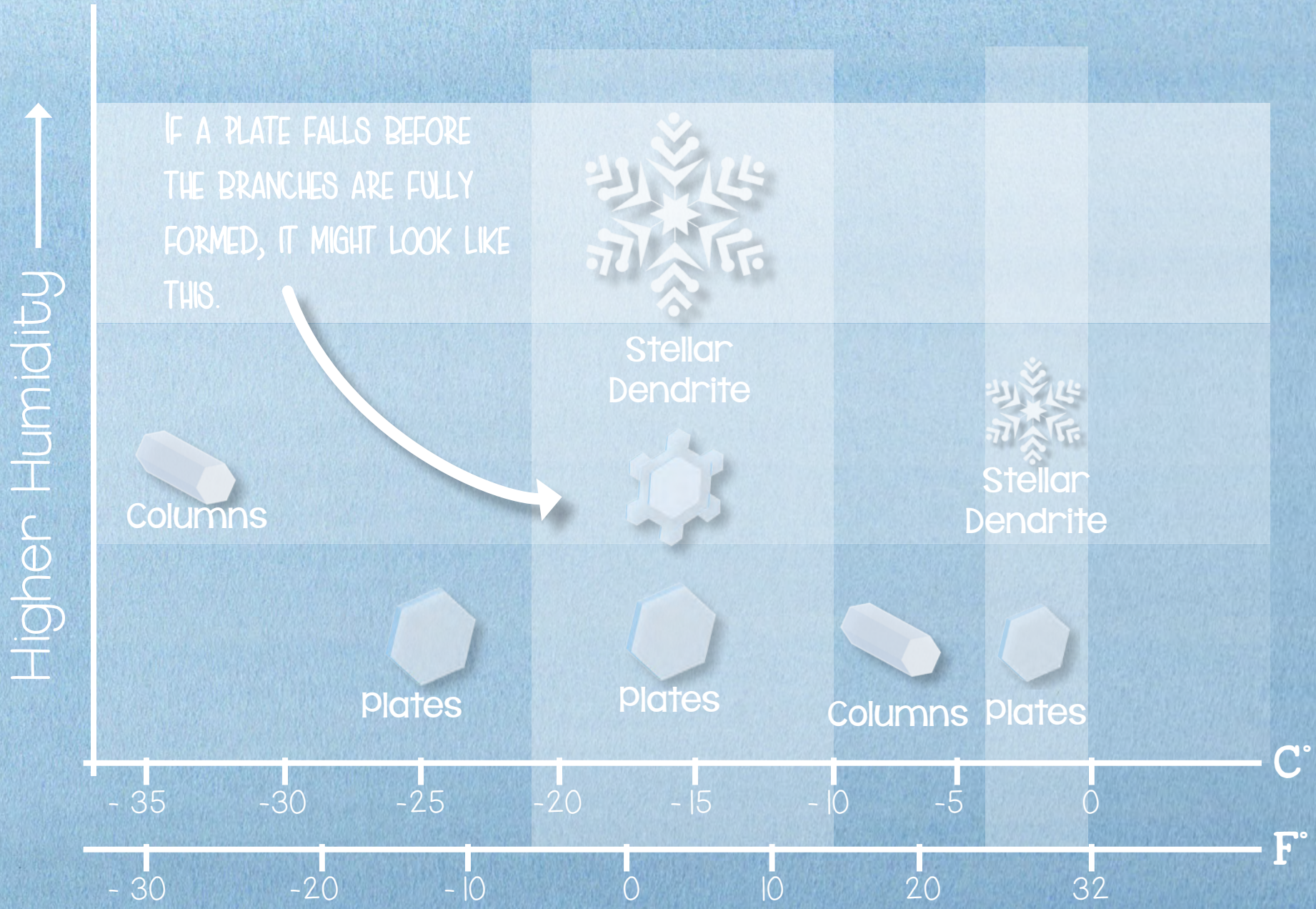
The exact shape of the snow crystal
is determined by
the path it takes as it falls to earth.

The formation of a snow crystal is called a
**physical morphogenesis**

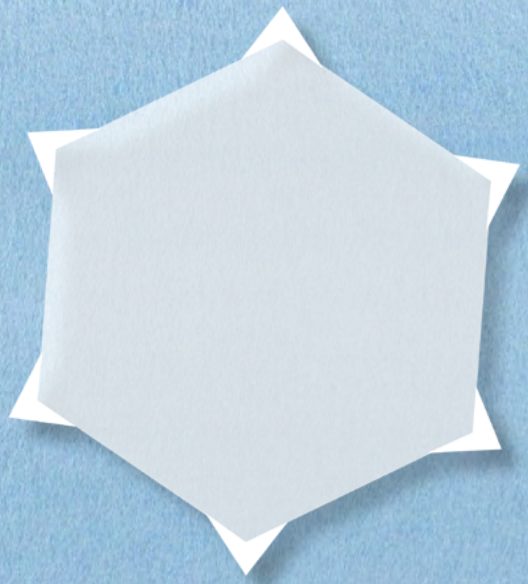
**physical** - having material existence.
**morph** - to gradually change from one shape to another.
**genesis** - the origin or the beginning of something.
**physical morphogenesis** - the development of the form and structure of a physical object. (Opposed to a biological organism.) (ref)



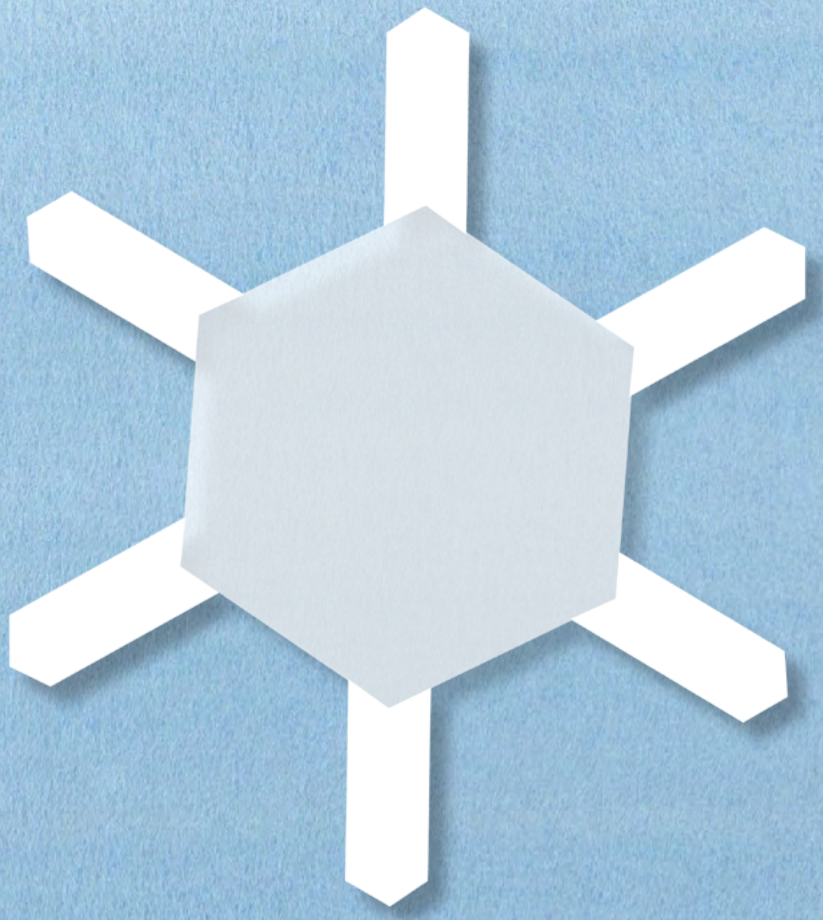

This chart (ref) shows the humidity and temperature needed to form different shapes in the snow crystal.


Higher Humidity
If a plate falls before the branches are fully formed, it might look like this.
Stellar Dendrite
Stellar Dendrite
Columns
Plates
Plates
Columns
Plates
C°
- 35
-30
-25
-20
- 15
- 10
-5
0
F°
- 30
-20
- 10
0
10
20
32

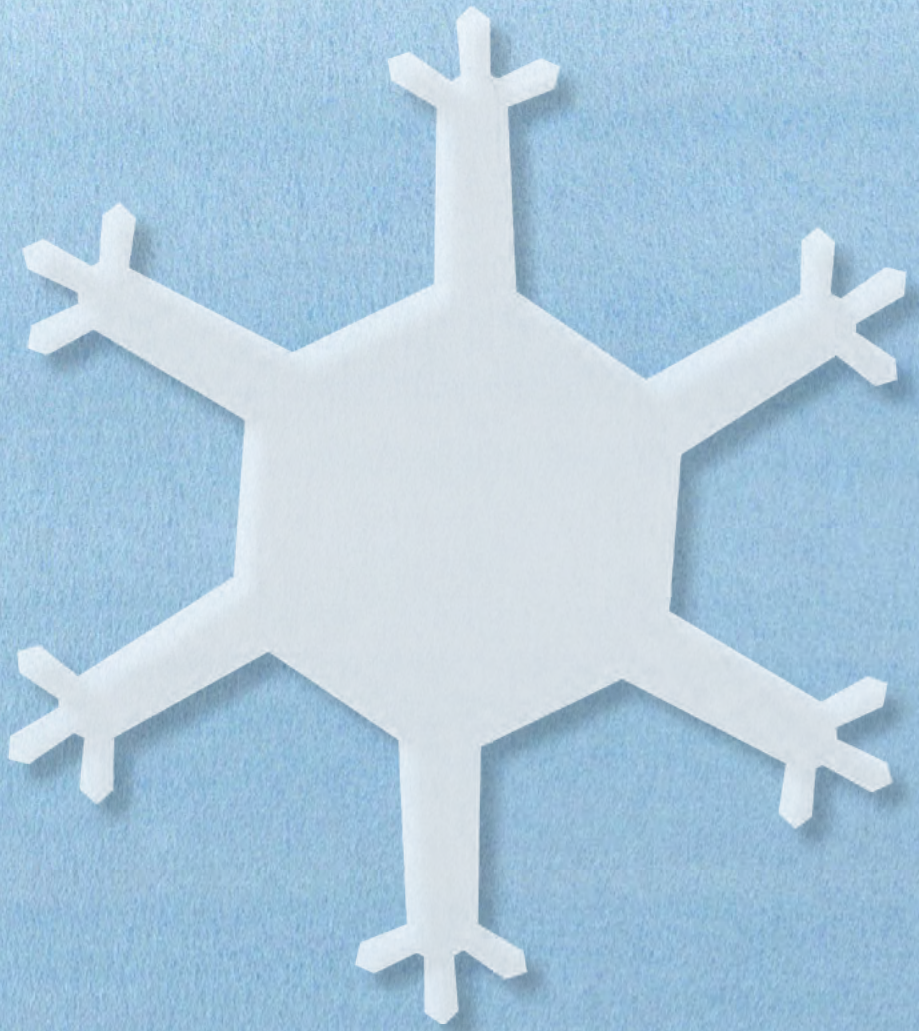
Let's take a look at how a stellar dendrite is formed.



The hexagon collects more molecules on its corners,
because they stick out more,
so they grow faster.



Branches are formed.



Each corner of the branches now forms
its own branches.

Branching often results in fractals.
Fractals repeat in self-similar shapes. (ref)

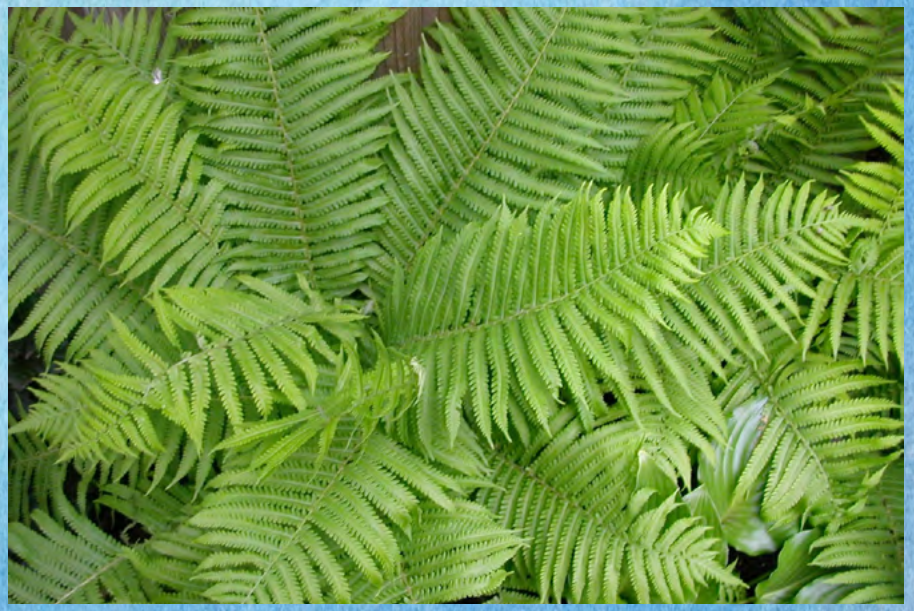
More about fr

Fractals are way to find order in irregular shapes.
Not every irregular shape is a fractal, though.
In order to be a fractal there must show self-similarity when comparing the overall shape to the shape of a small detail. In other words, they have the same shape repeated at different **scales**.
A fern is a classic example of this. *

**scale** - the size of one object compared to another object.

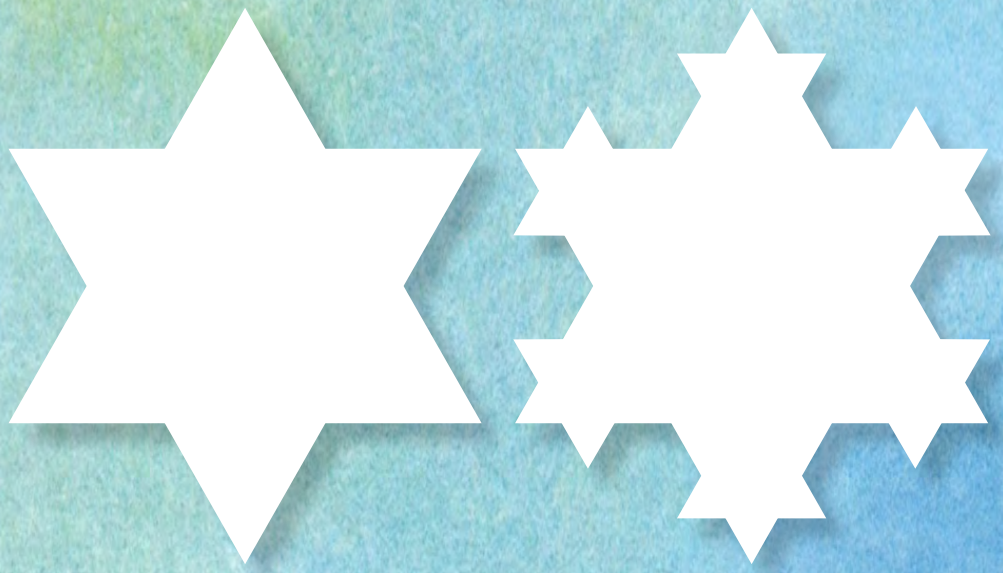
* By Nature's Design, Pat Murphy pg. 92

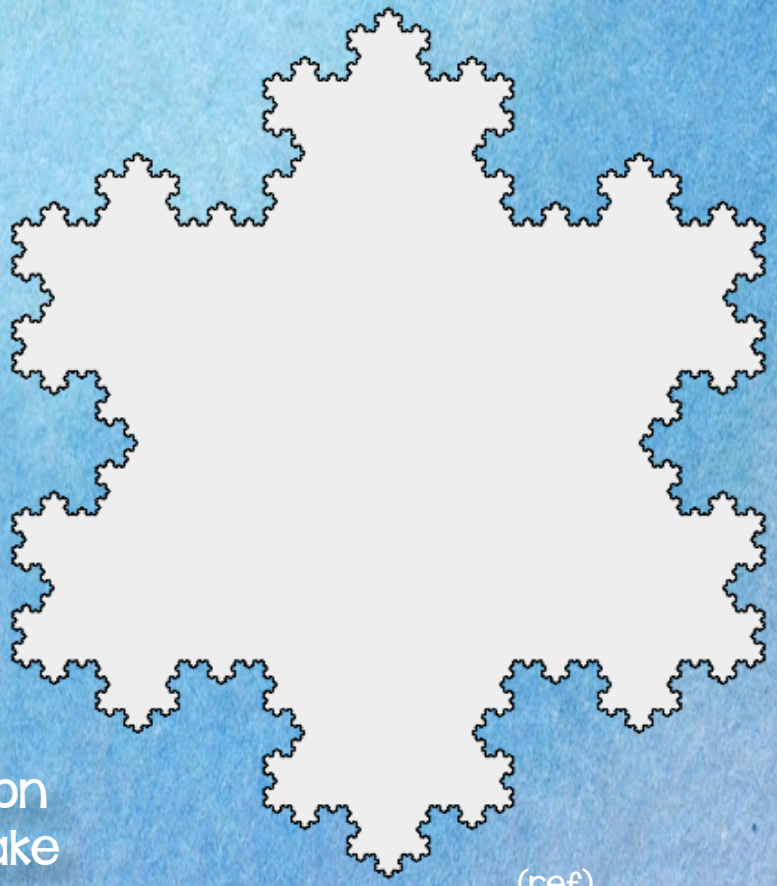
Some fractals grow smaller and more intricate by branching, such as a tree, and others grow larger and form a spiral, such as a shell.



With plants, like sunflower (seed area) and ferns, the fractals happens precisely and the resulting shape is predictable.

# The Koch Snowflake





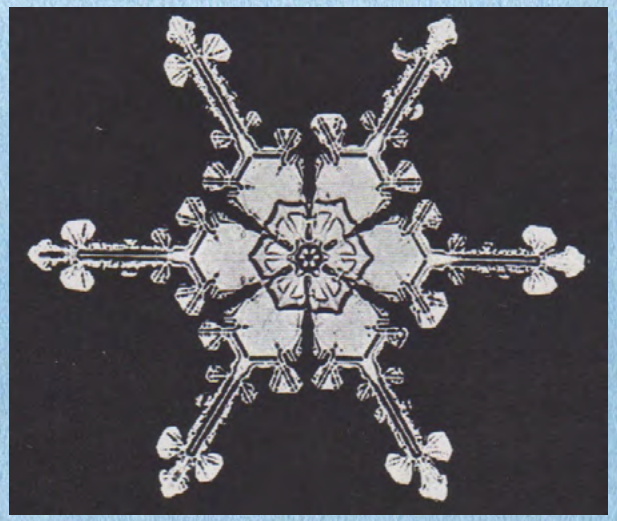
(ref)

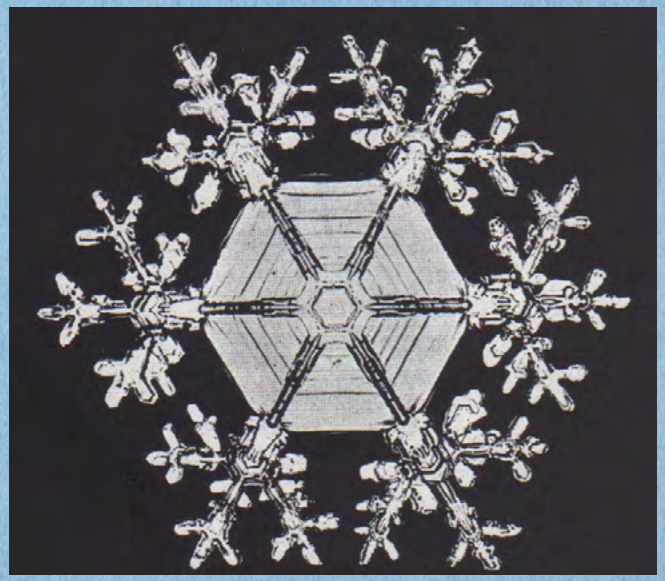
The Koch Snowflake was developed by Helge von Koch, and show what happens when a snowflake shape is made from a triangle that fractals with no variations.

With snowflakes, however,
variations in the atmosphere change the shape of the
additional branches or layers of snow crystals.

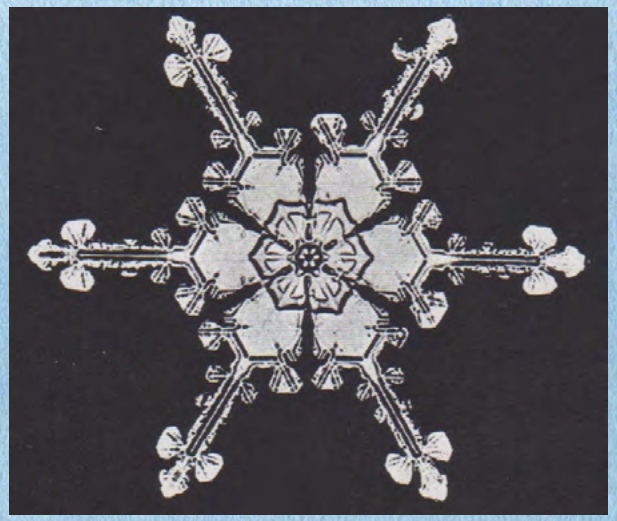
These are actual snowflake photomicrographs taken by W. A. Bentley in the 1920's. He was the first persons to photograph and Classify the Various shapes of snowflakes. He took more than 2000 photomicrographs of snowflakes.

**micro**- very small
**graph**- to make an image
**photomicrographs** - a photograph made through a microscope

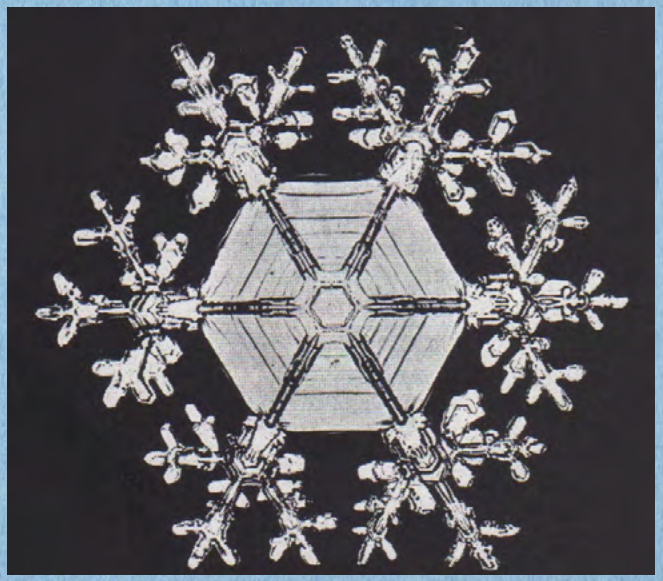




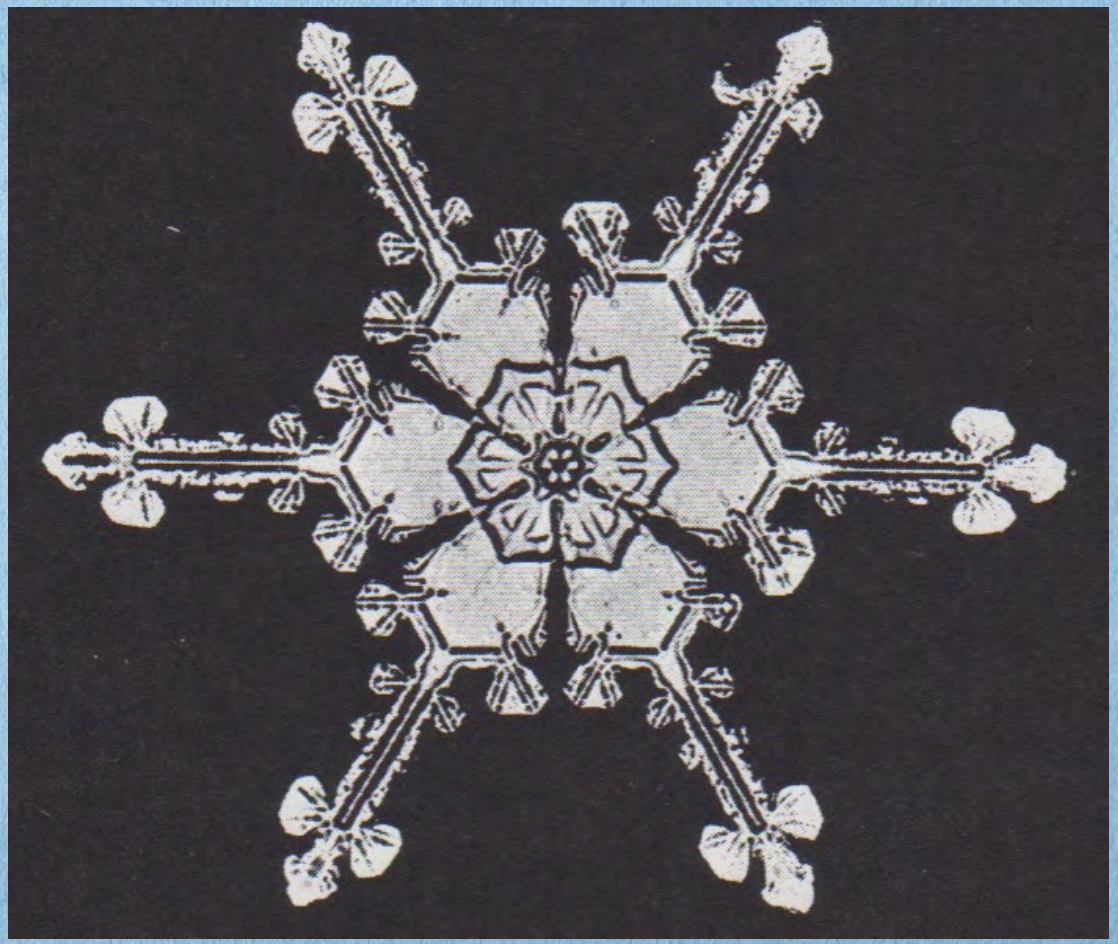
As a snow crystal grows, it falls to the earth and passes through different layers of the atmosphere. The way the snow crystals looks depends on the temperature and humidity of the layers it passed through.
This unique combination of changes gives each snow crystal its unique shape.



Can you find a place in each snowflake where the design changed because the temperature and humidity changed as it was falling and growing?



# See if you can find the following things in this snow crystal:

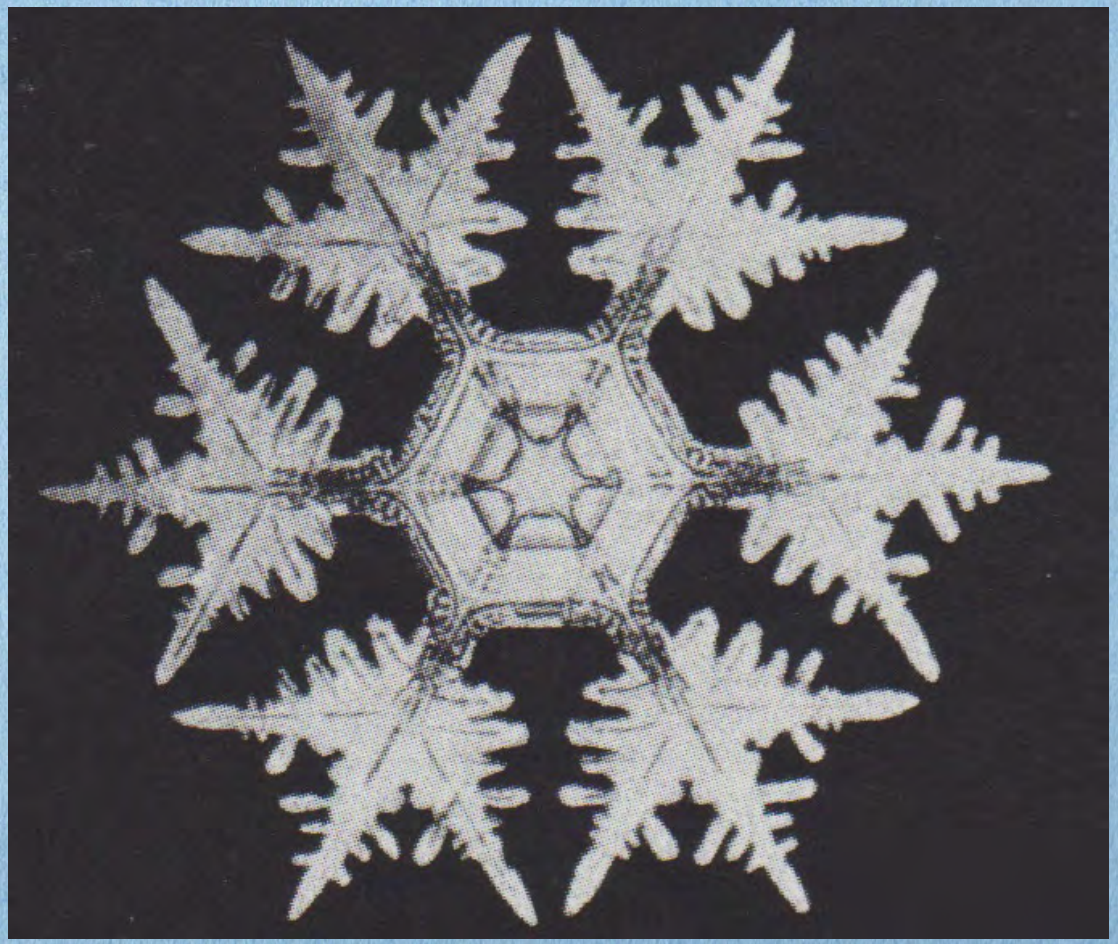


Find a hexagon in the center of this snow crystal.

Point to the 6 Branches that were formed from the corners of the hexagon.

Find a place where each branch started making Side Branches.

# See if you can find the following things in this snow crystal:



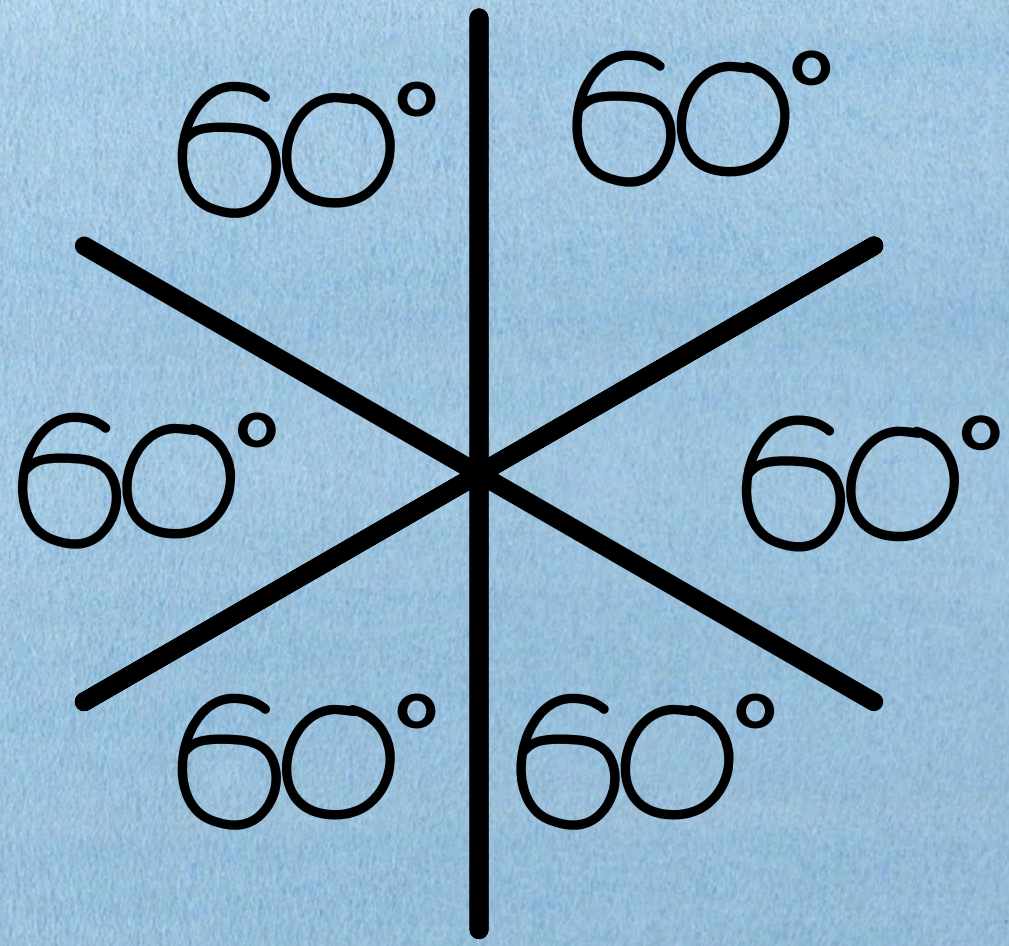
Find where fractals were formed in this snow crystal.

Find where the snow crystal design changed from a plate to a stellar dendrite.

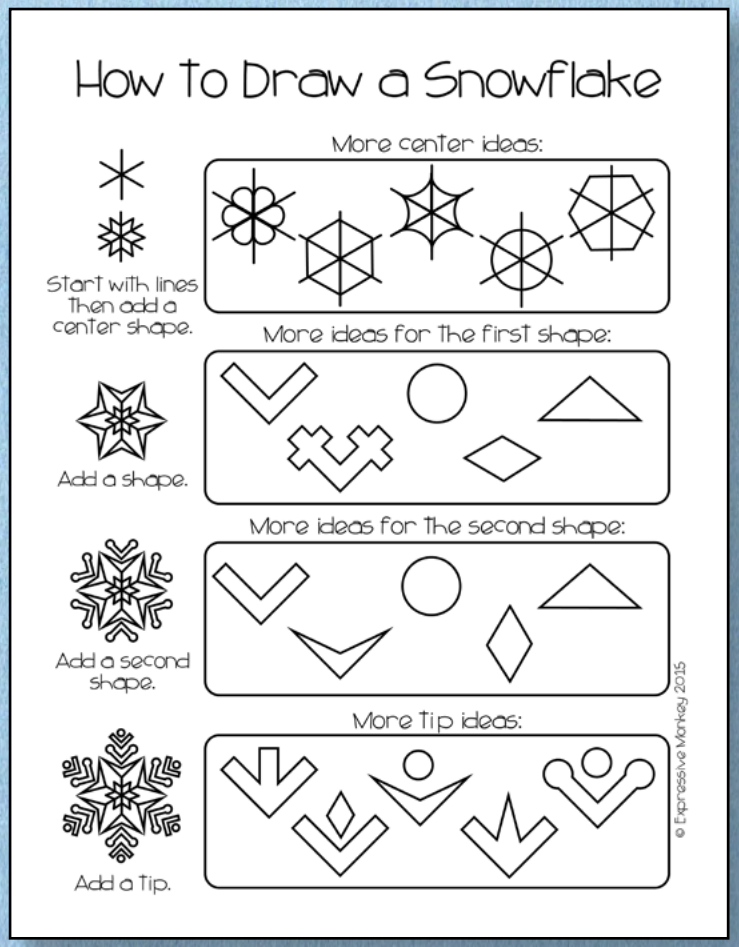
Find a hexagon.

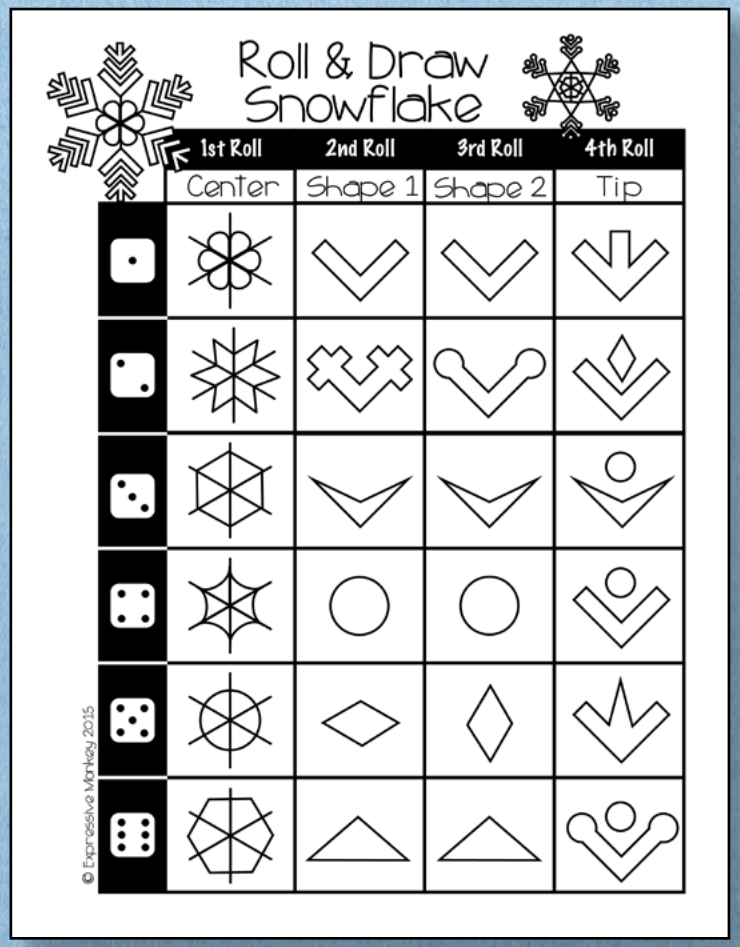
So, just like people, snowflakes and snow crystals can attribute their uniqueness to the path they took as they were formed and grew. Just as our place in life and experiences shape who we are.

We don't always have control over where our path in life takes us, but we can celebrate our uniqueness as a record of our journey, just as we admire the uniqueness of a snowflake.

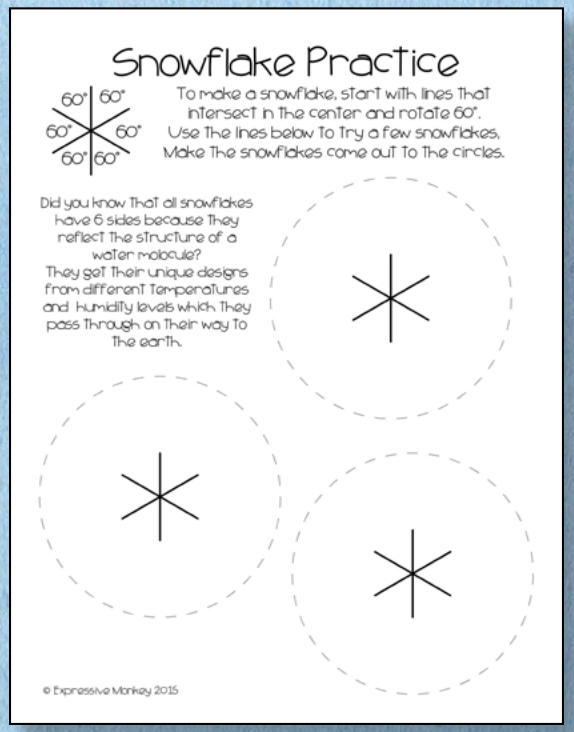


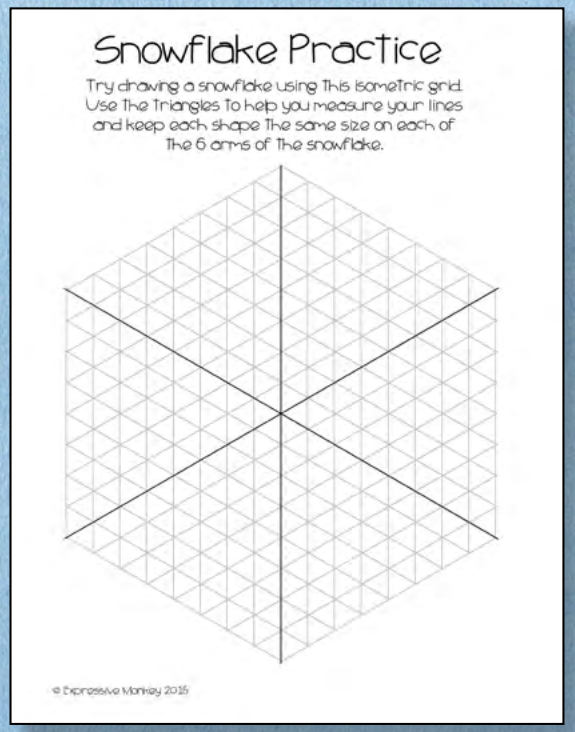

Start your snowflake drawing by making 3 lines
that intersect and form six branches
at 60° angles from each other.

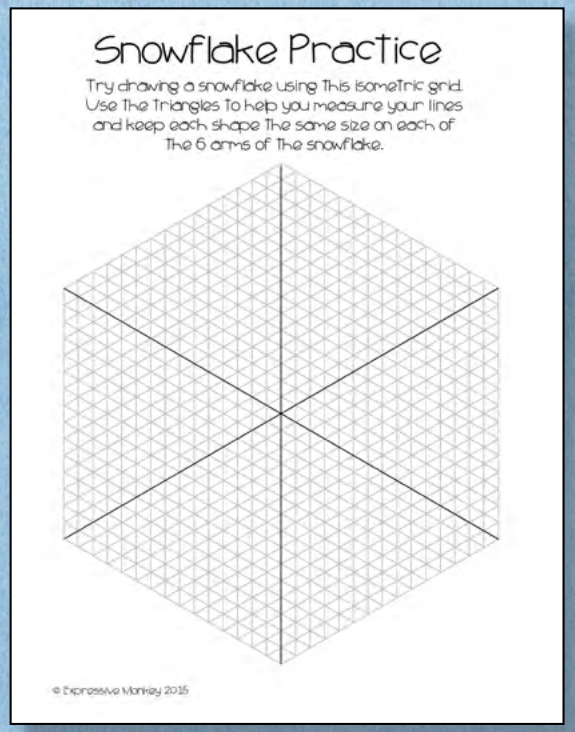



Roll dice or make choices about the center design and 3 additional designs that you will add to each branch.




You can draw on white paper,
or use one of these sheets to help you get started.
The second and third sheets use an **isometric** grid to help draw a snowflake using **radial symmetry**.

**isometric** - without change of shape or size.
**isometric grid** - a method for representing a 3D image in 2D. (Can you see a cube.)
**radial symmetry** - exact shapes facing each other around an axis.

# References

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Snow Crystal Morphology Diagram
This is also called the Nakaya Diagram, after Japanese physicist Ukichiro Nakaya, who discovered this behavior by growing snow crystals in his lab in the 1930s

Morphology - The study of the form of things.

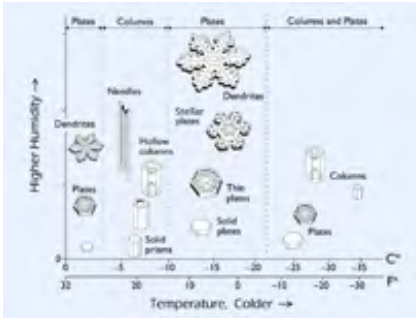
More about Ukichiro Nakaya
http://www.famousscientists.org/ukichiro-nakaya/

Snow Crystal Website:
http://www.snowcrystals.com/

Snowflake Bentley Website

http://snowflakebentley.com/WBsnowflakes.htm

More about Bentley
http://siarchives.si.edu/history/exhibits/stories/wilson-bentley-pioneering-photographer-snowflakes




Click to ZOOM

By Nature's Design, Pat Murphy pg. 92

(If you skipped it and want to look at it now.)