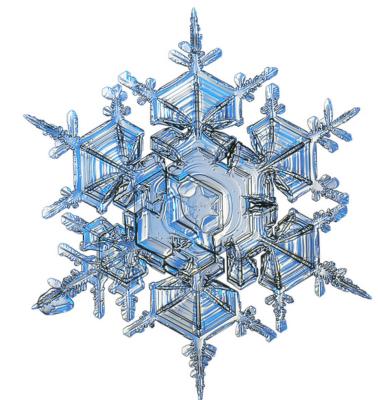
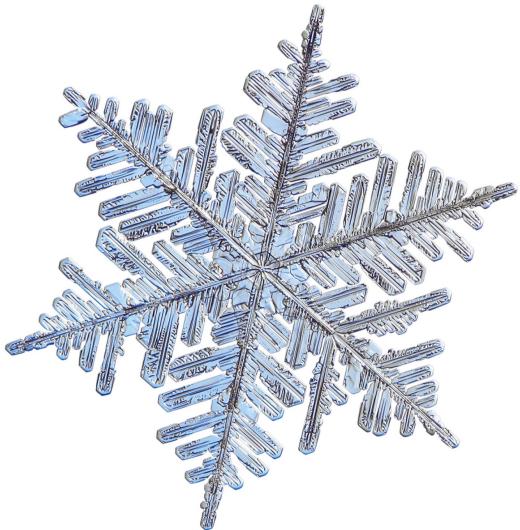


# Math in Nature

## Snowflakes and Studying How they form

By Andrew Leduc

Scientist at Northeastern University in Boston



# About Me



- Graduate Student Researcher at Northeastern University in Boston
- Member of the Slavov Laboratory

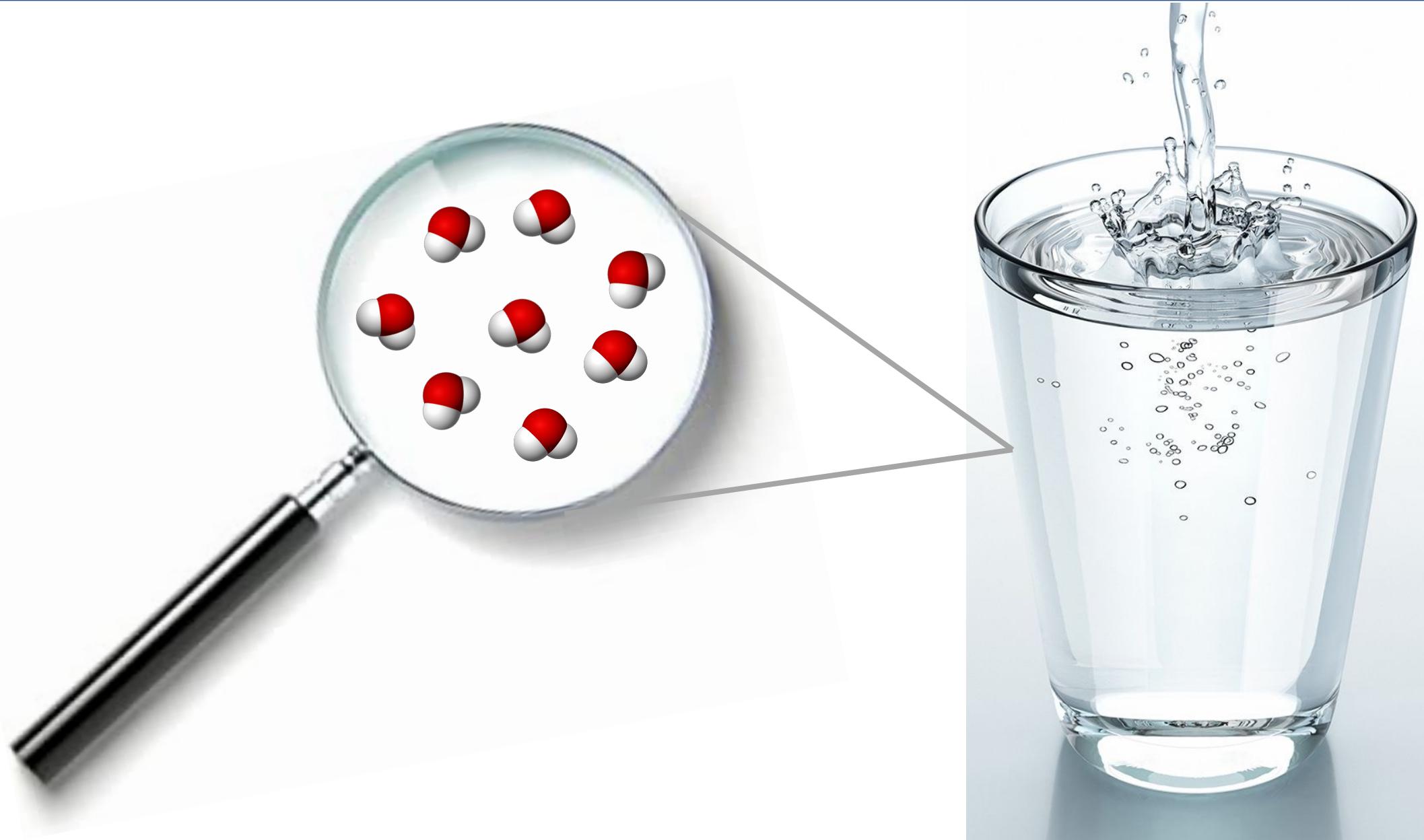


A photograph of a snowy London skyline at night. In the foreground, a snow-covered railing runs along a path. Bare trees are heavily laden with snow. In the background, the illuminated London Eye and the Palace of Westminster with its iconic Elizabeth Tower (Big Ben) are visible across the River Thames. A white boat is docked on the right bank.

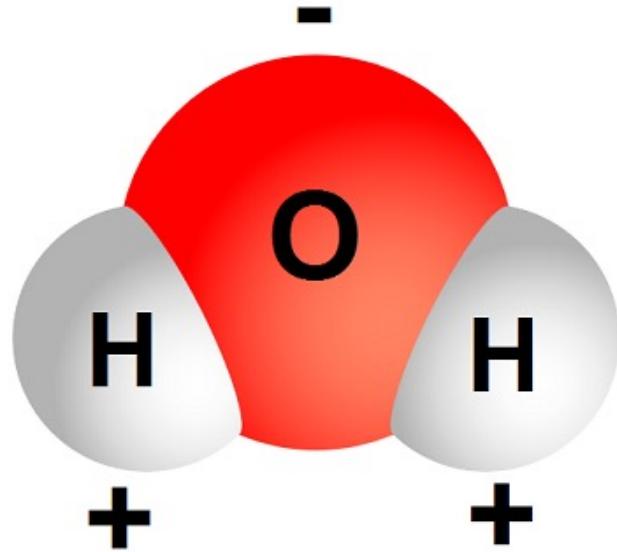
Why Are all Snowflakes Different?

# What are Snowflakes Made of?

# Snowflakes are Made of Water

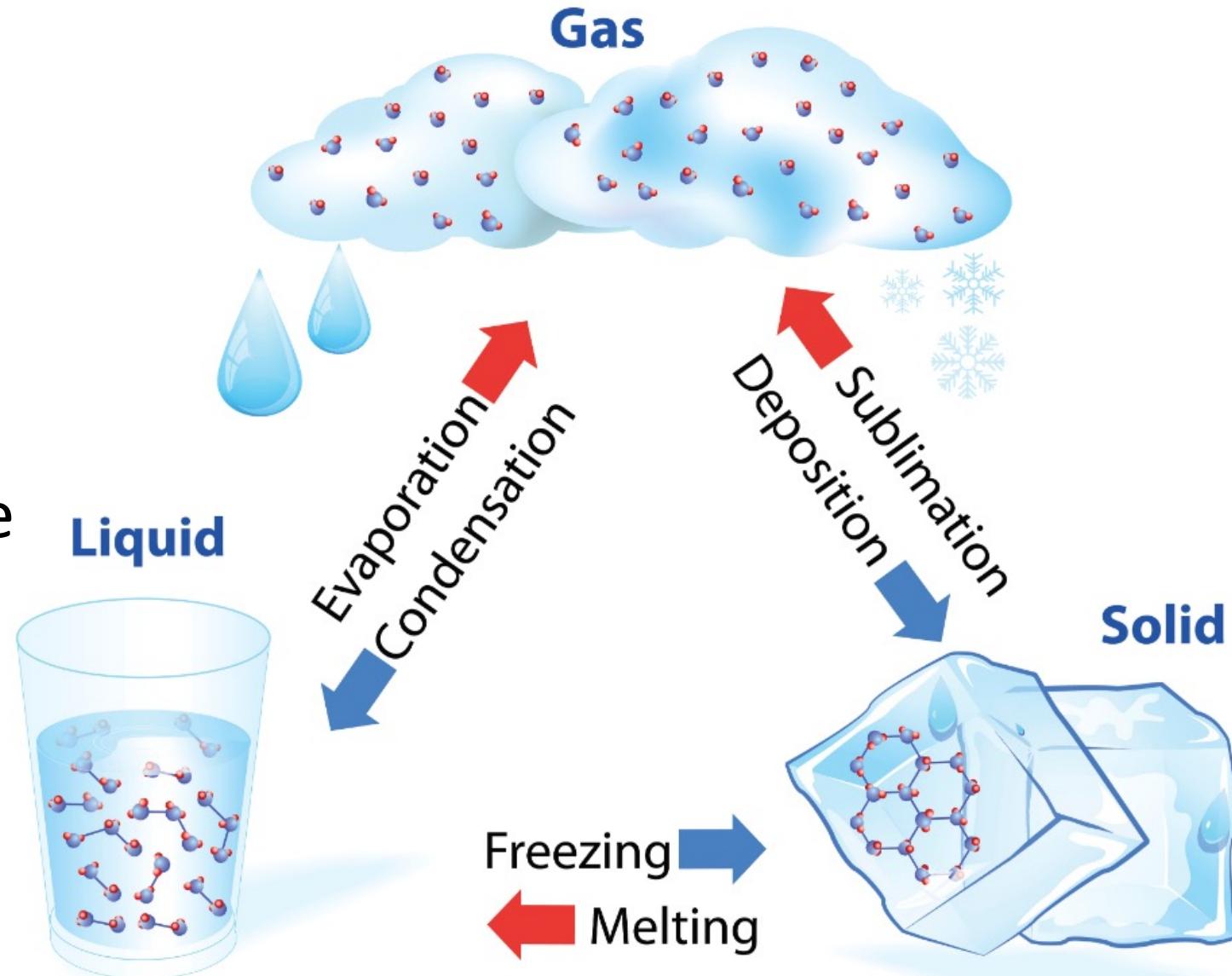


# What is water made of?



# Different Forms of Water

Water can take different shapes base on temperature



# What is a Snowflake

Cold Air

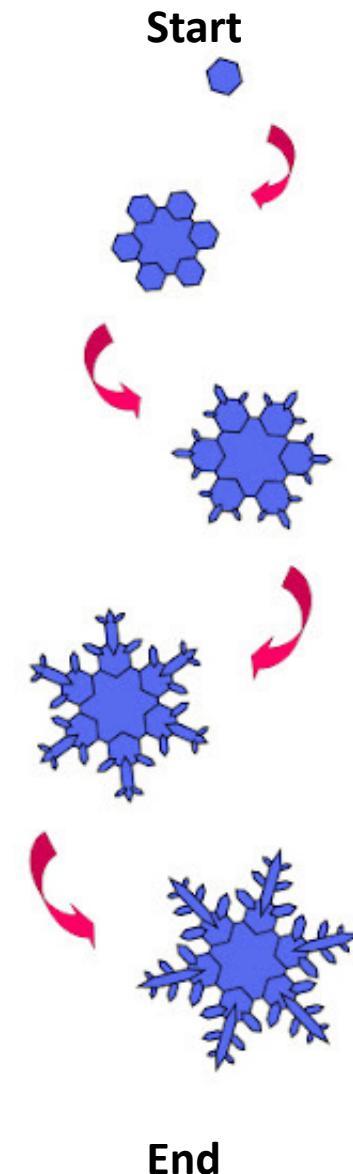


Rain Cloud



# So why are all snowflakes different?

- As snowflakes fall, they collide and stick together with smaller snowflakes
- How the snowflakes stick depends on the temperature and pressure at each point along path
- Each path is random and different, so each snowflake is different!



# What is a Snowflake

Faster Wind Means  
Snowflakes collide  
faster



More Rain Means  
More Snowflakes  
Bump into Each other



Colder Air  
Means Smaller  
Snowflakes



# Using math to understand snowflakes

Equations?

$$\begin{aligned} n &= N \cdot m_0 = \frac{V_e}{N_A} \frac{m}{N_A} E = \frac{E_c}{q} \int_{-a/L}^{+a/L} \sin(\alpha) \\ &= l_0 (1 + d \Delta t) I = \frac{V_e}{R + R_i} 2 \frac{\sin \alpha}{\sin \beta} \\ E &= m c^2 \\ E &= \frac{1}{2} \hbar \sqrt{k/m} \quad \beta = \frac{\Delta I c}{\Delta T_0} \quad \phi_e = \frac{\Delta \phi}{\Delta T_0} \quad \phi = \frac{2\pi \sin \beta}{\lambda} \end{aligned}$$

Andrew's Law of snowflakes:

Wind + Amount of rain + Temperature = Shape of snowflake?

# Using math to understand snowflakes

A different approach using simple computer programs

Computer Program: Set of instructions you give to a computer for the computer to follow

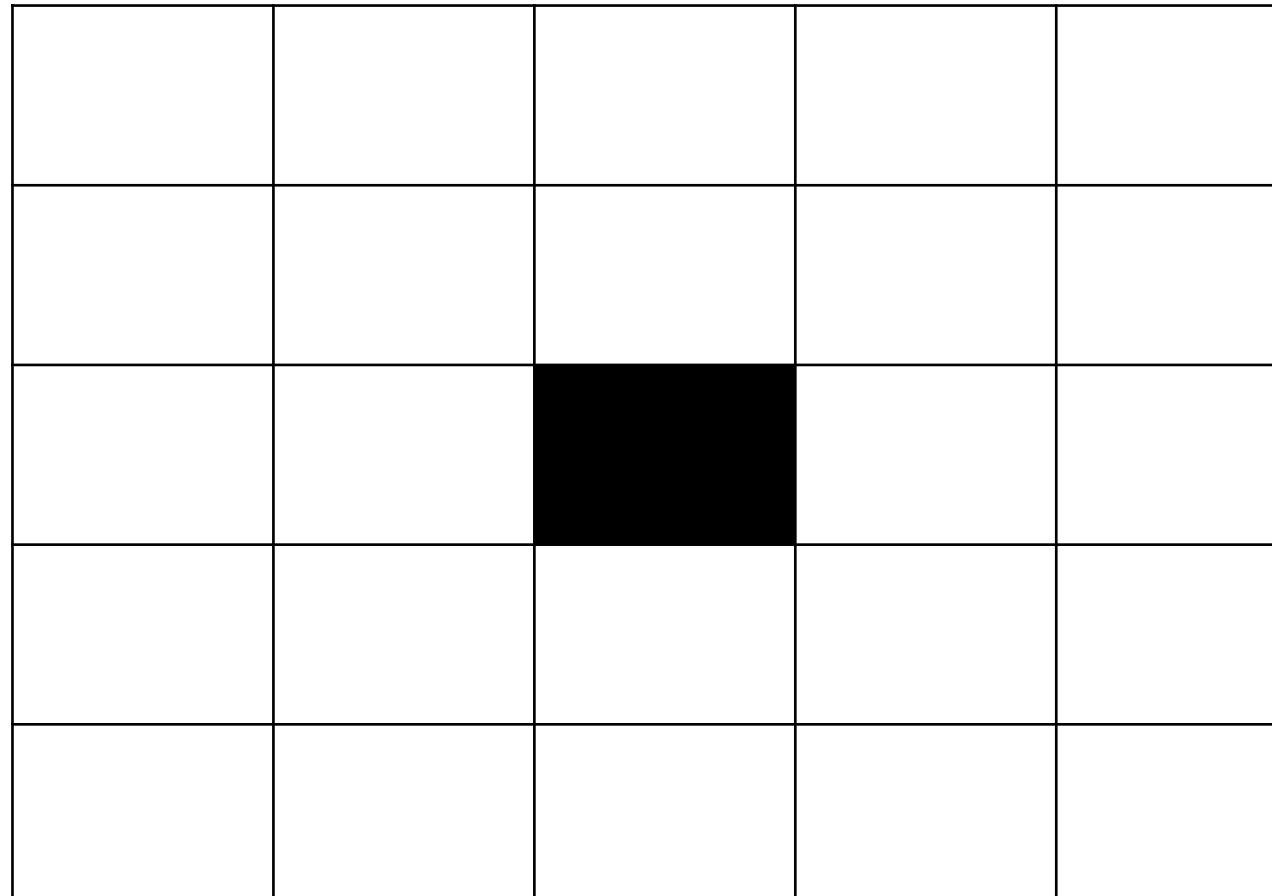
# Using math to understand snowflakes

A different approach using simple computer programs

**Step 0**

## Example Computer Program

- If a white block touches a black block, change from white to black
- Repeat first step 10 times



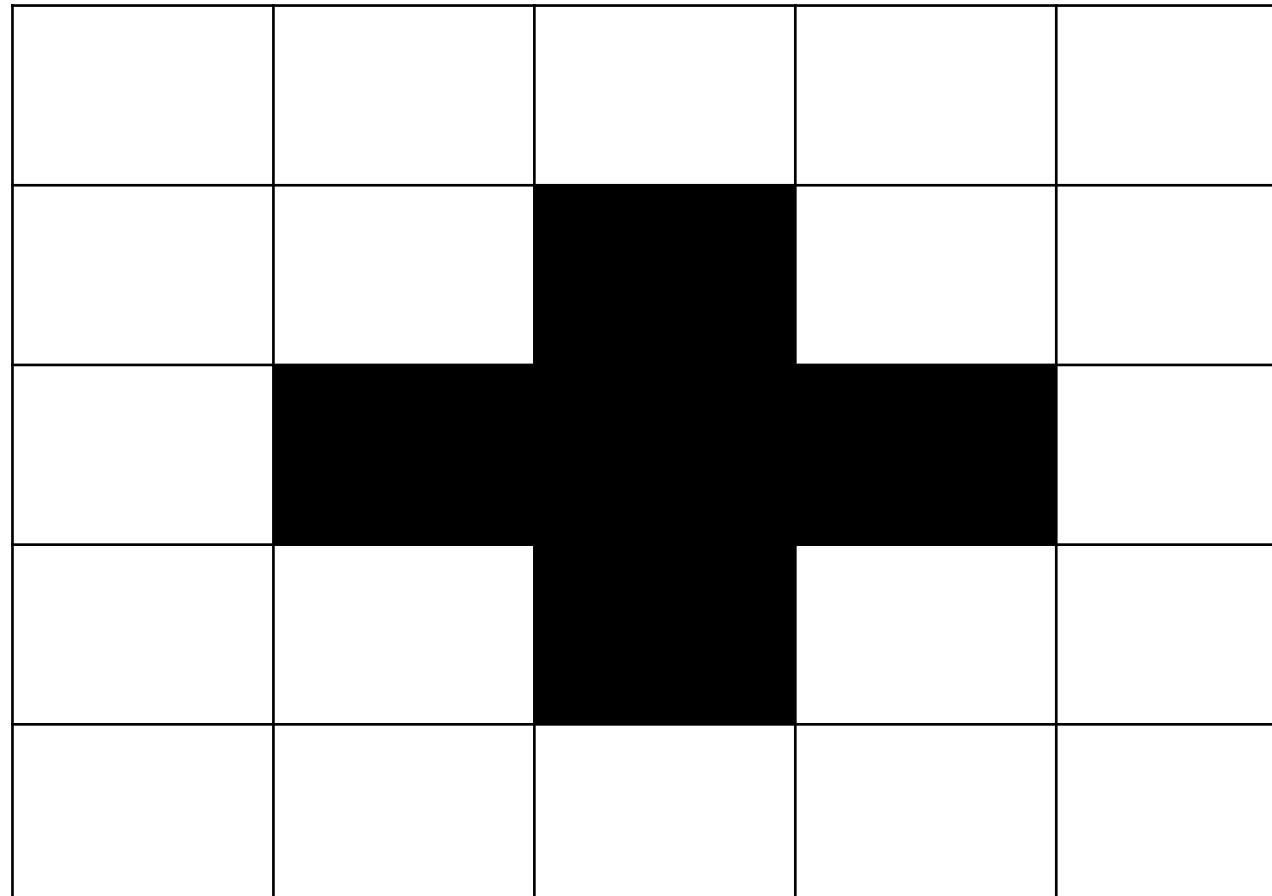
# Using math to understand snowflakes

A different approach using simple computer programs

**Step 1**

## Example Computer Program

- If a white block touches a black block, change from white to black
- Repeat first step 10 times



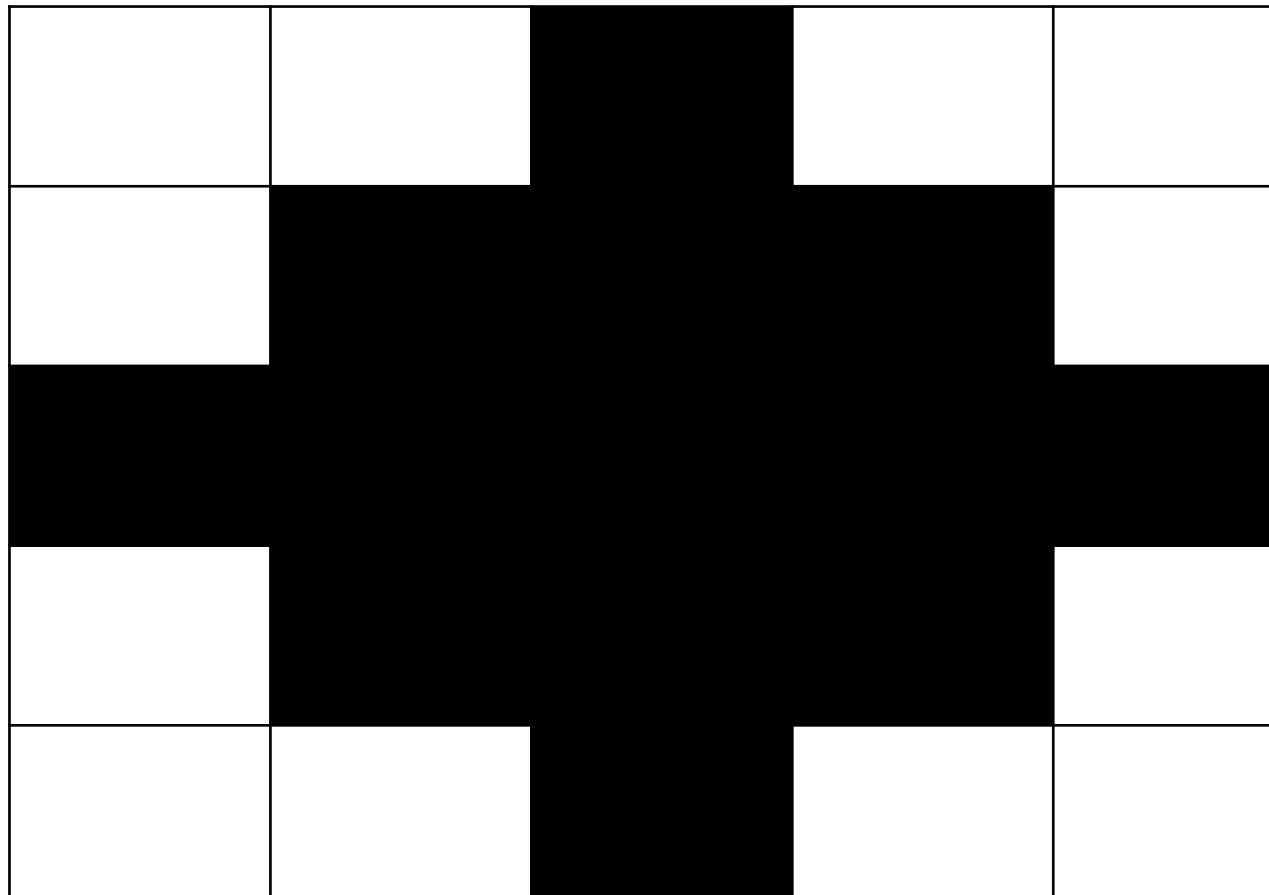
# Using math to understand snowflakes

A different approach using simple computer programs

**Step 2**

## Example Computer Program

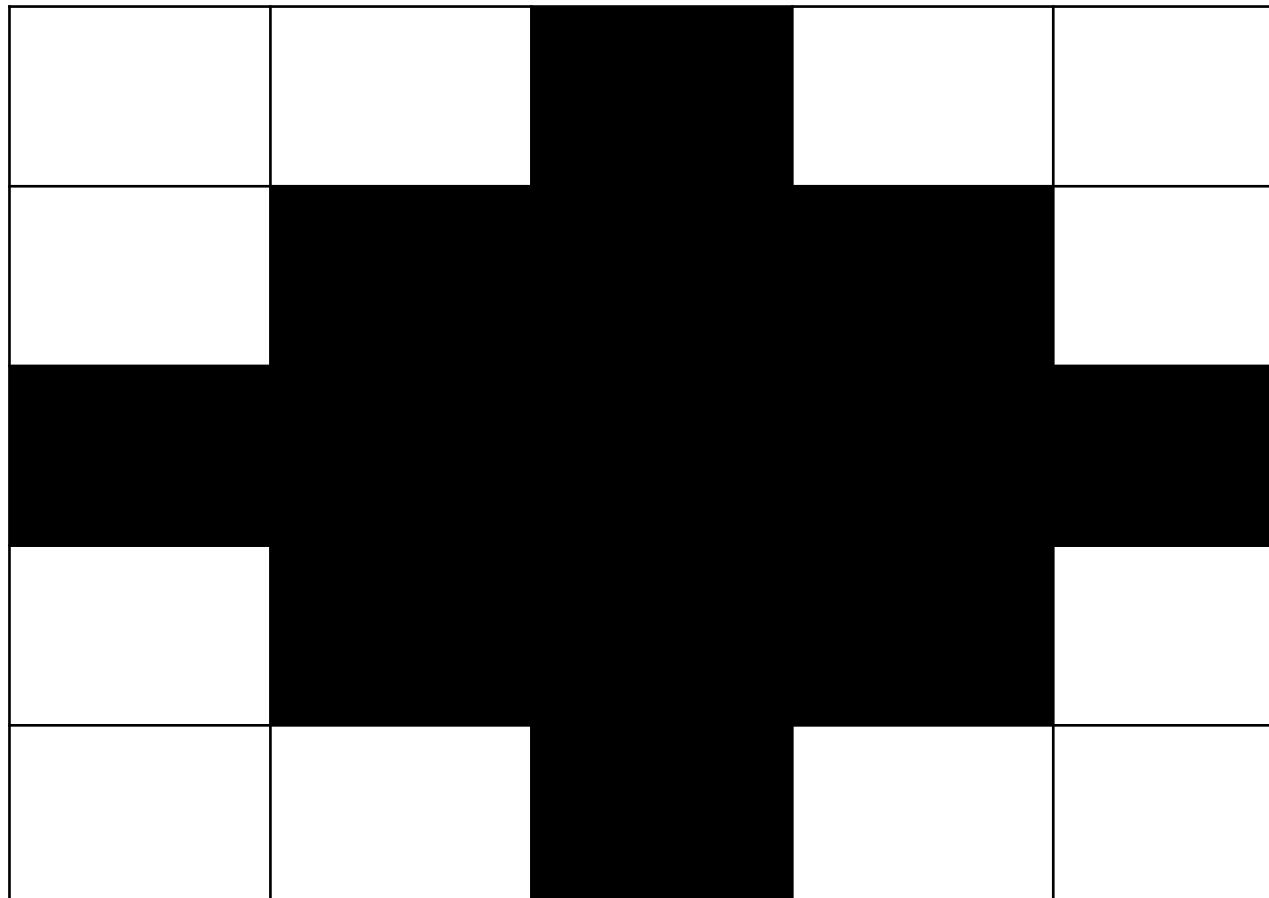
- If a white block touches a black block, change from white to black
- Repeat first step 10 times



# Using math to understand snowflakes

A different approach using simple computer programs

**Step 2**

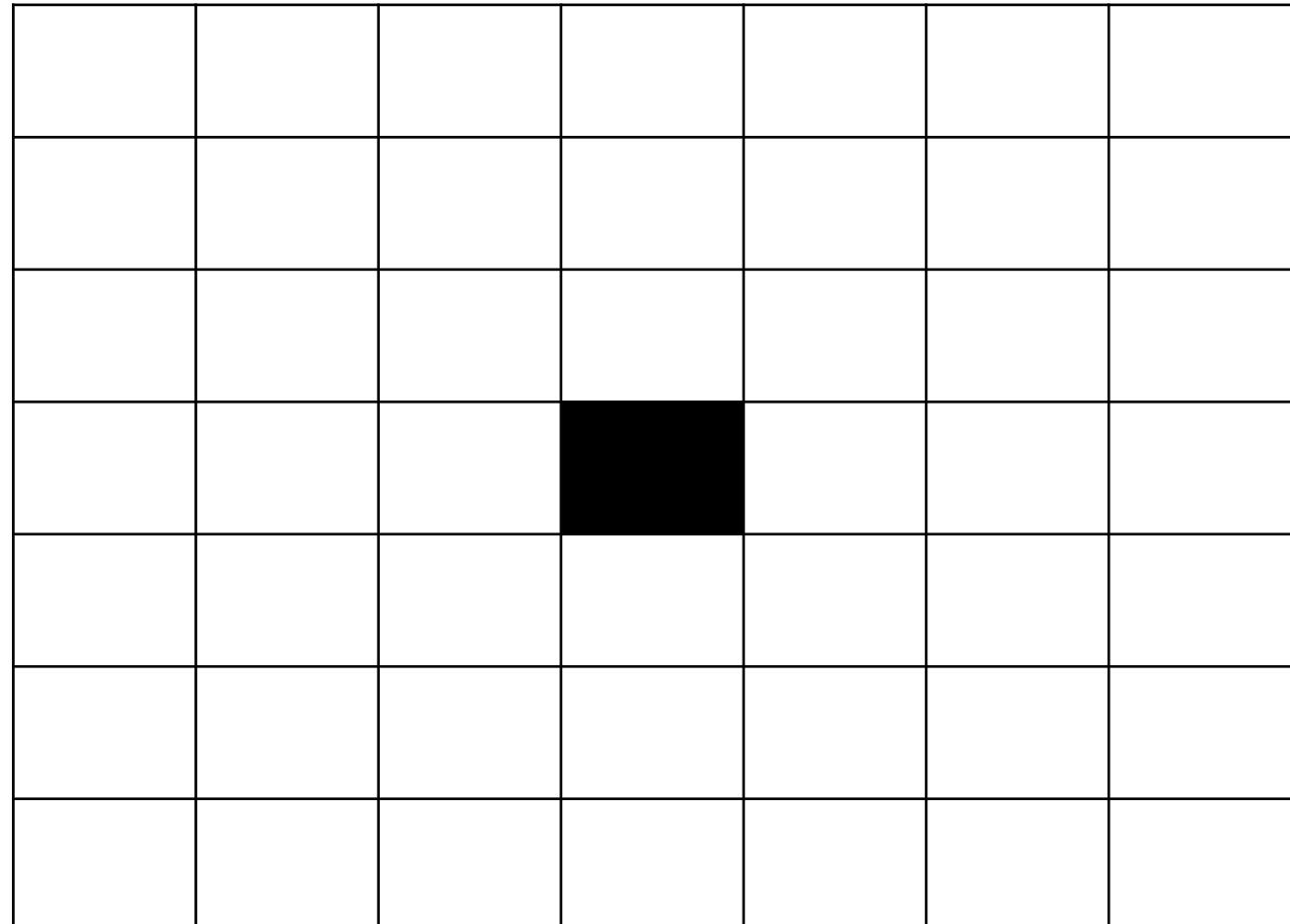


Each step represents  
snowflakes colliding  
together

# Using math to understand snowflakes

A different approach using simple computer programs

**Step 0**



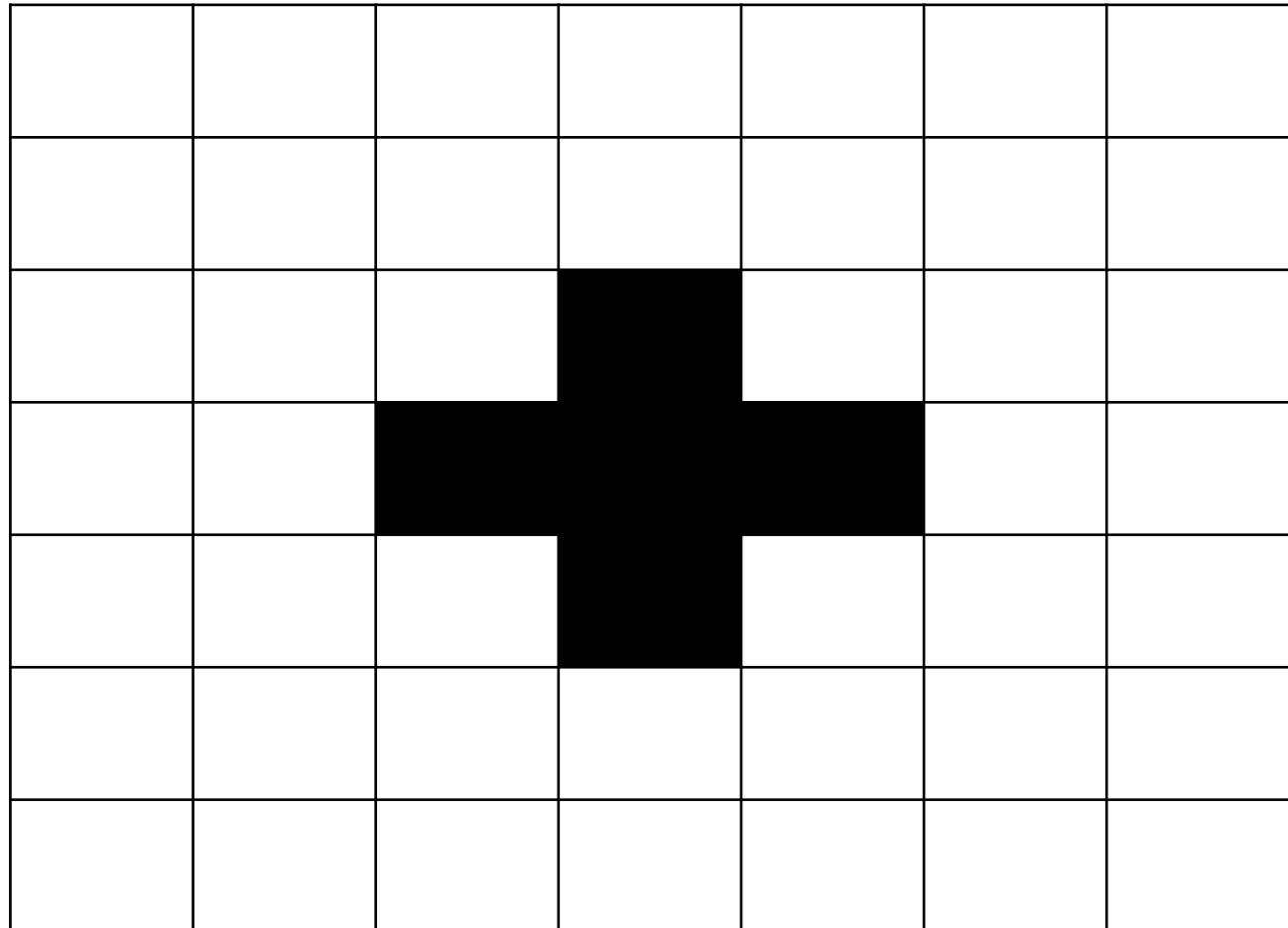
- If a white block touches only ONE black block, change from white to black
- Repeat first step 10 times

# Using math to understand snowflakes

A different approach using simple computer programs

Step 1

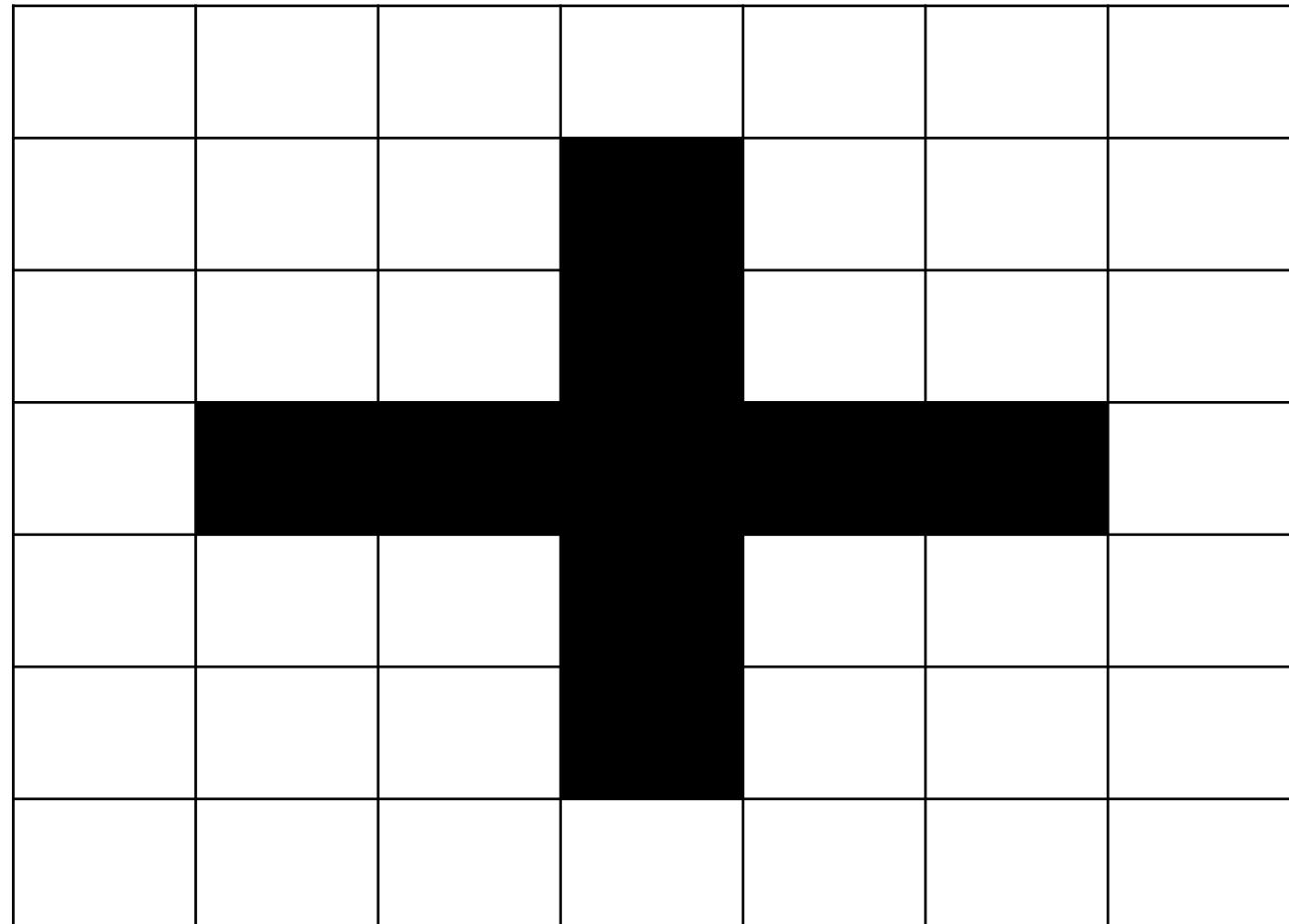
- If a white block touches only ONE black block, change from white to black
- Repeat first step 10 times



# Using math to understand snowflakes

A different approach using simple computer programs

Step 2

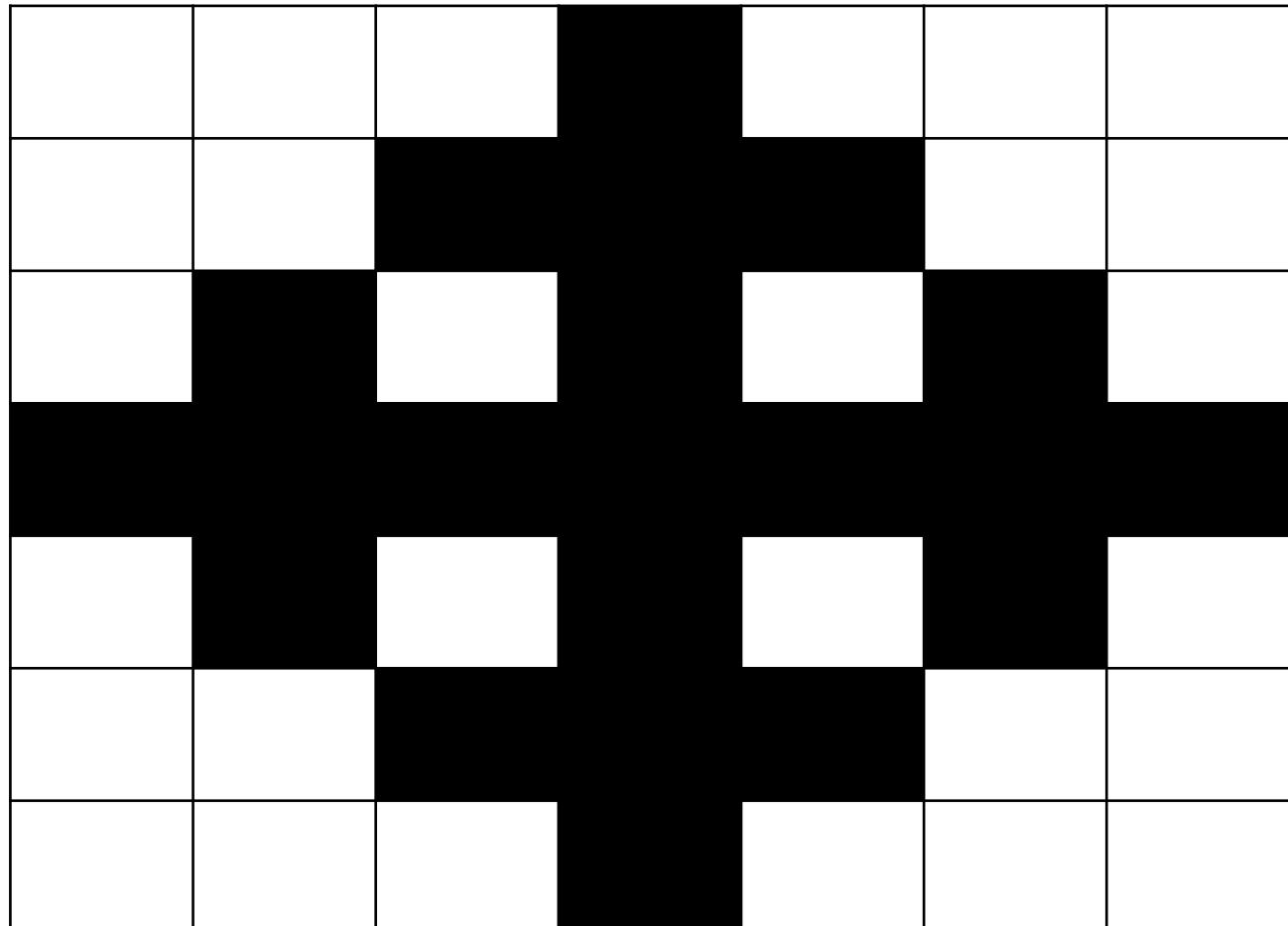


- If a white block touches only ONE black block, change from white to black
- Repeat first step 10 times

# Using math to understand snowflakes

A different approach using simple computer programs

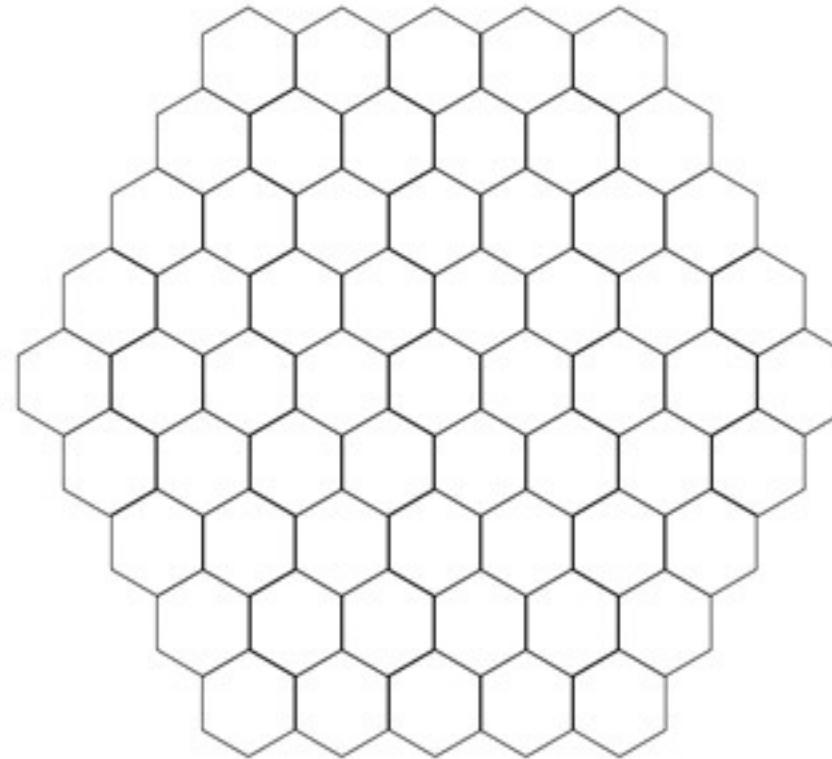
Step 3



- If a white block touches only ONE black block, change from white to black
- Repeat first step 10 times

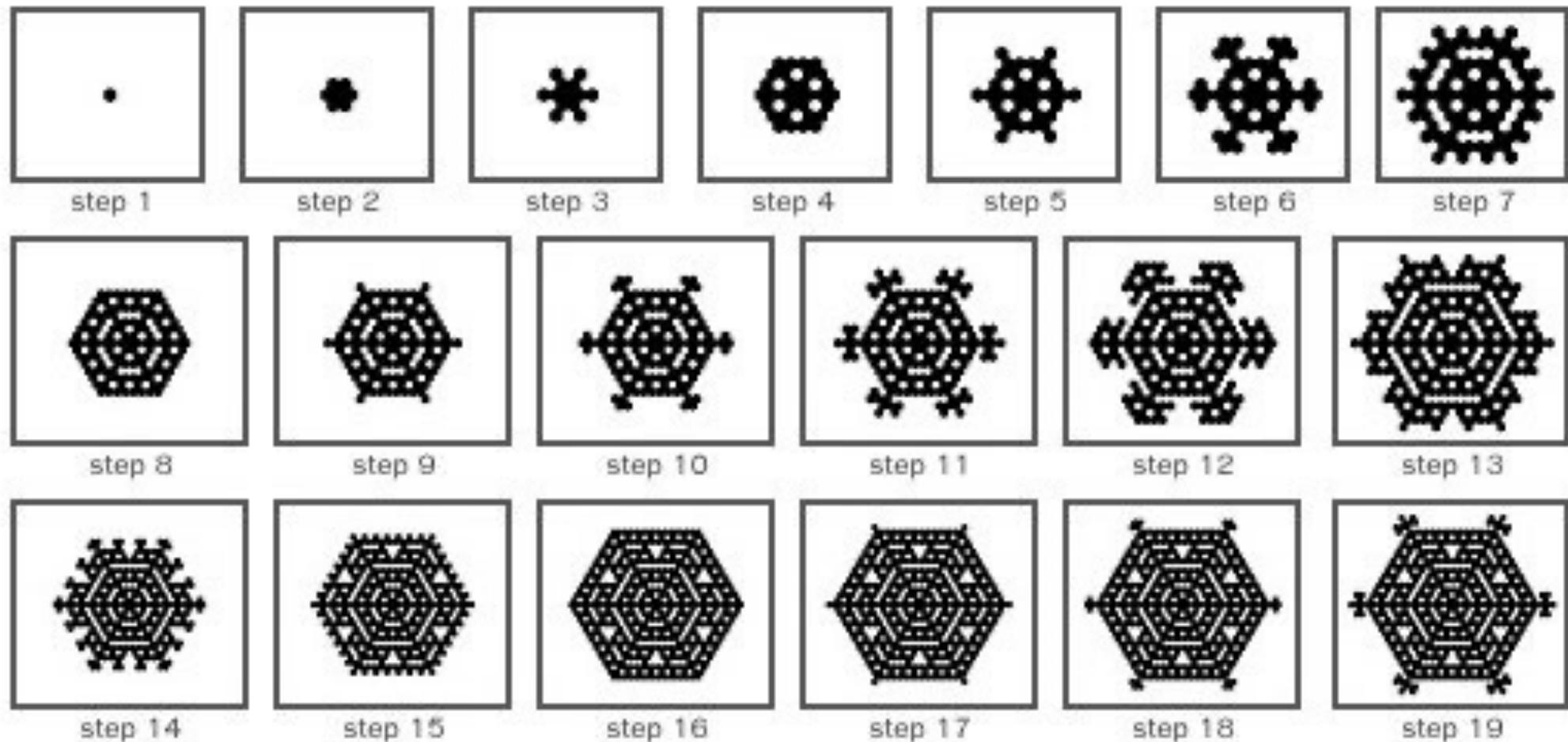
# Using math to understand snowflakes

How else can we try to change our computer program?

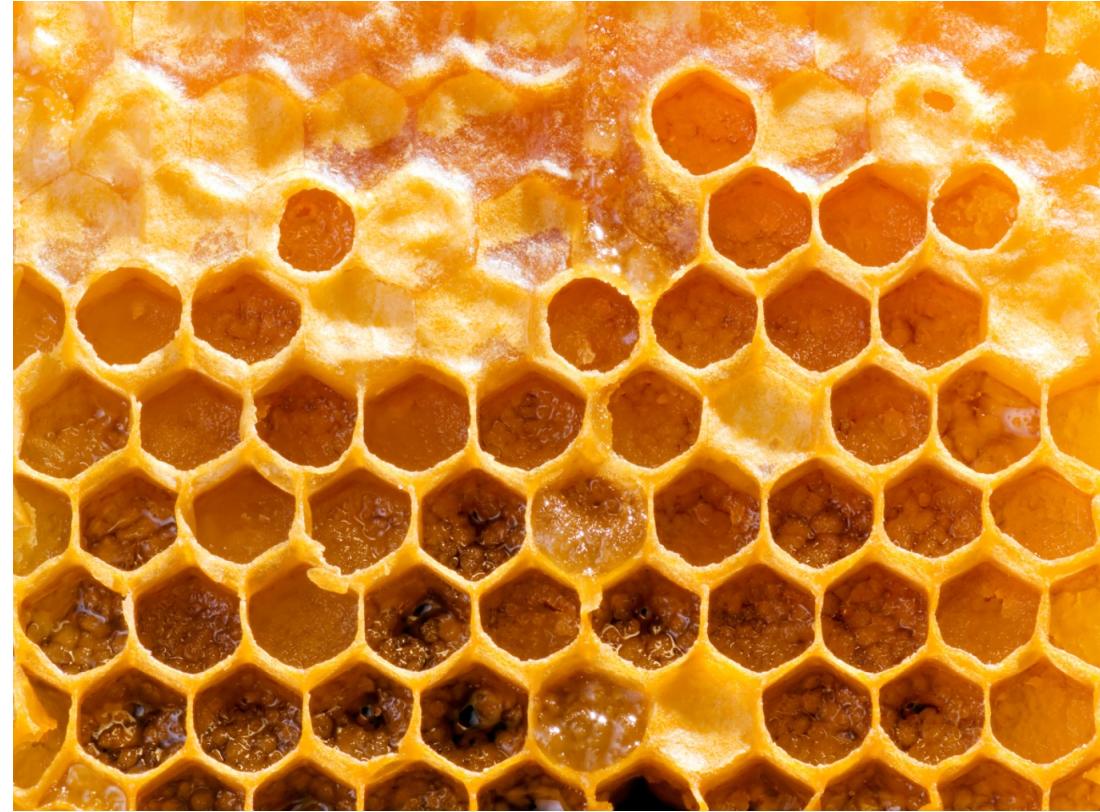
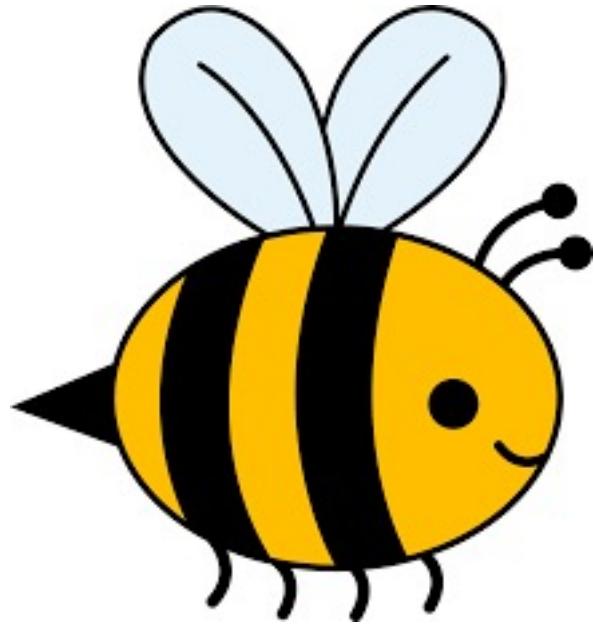


# Using math to understand snowflakes

Different computer programs make different snowflakes

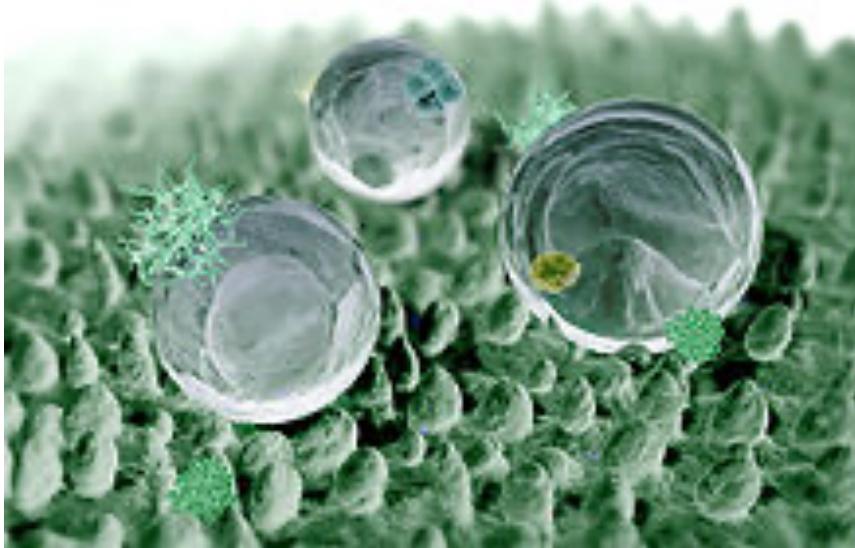


# Other Examples of Math In Nature!



# Other Examples of Math In Nature!

Leaves Surface Repels Water



# Other Examples of Math In Nature!

## Rings in Plants



# Other Examples of Math In Nature!

## Shapes of Animals



Thanks Guys!