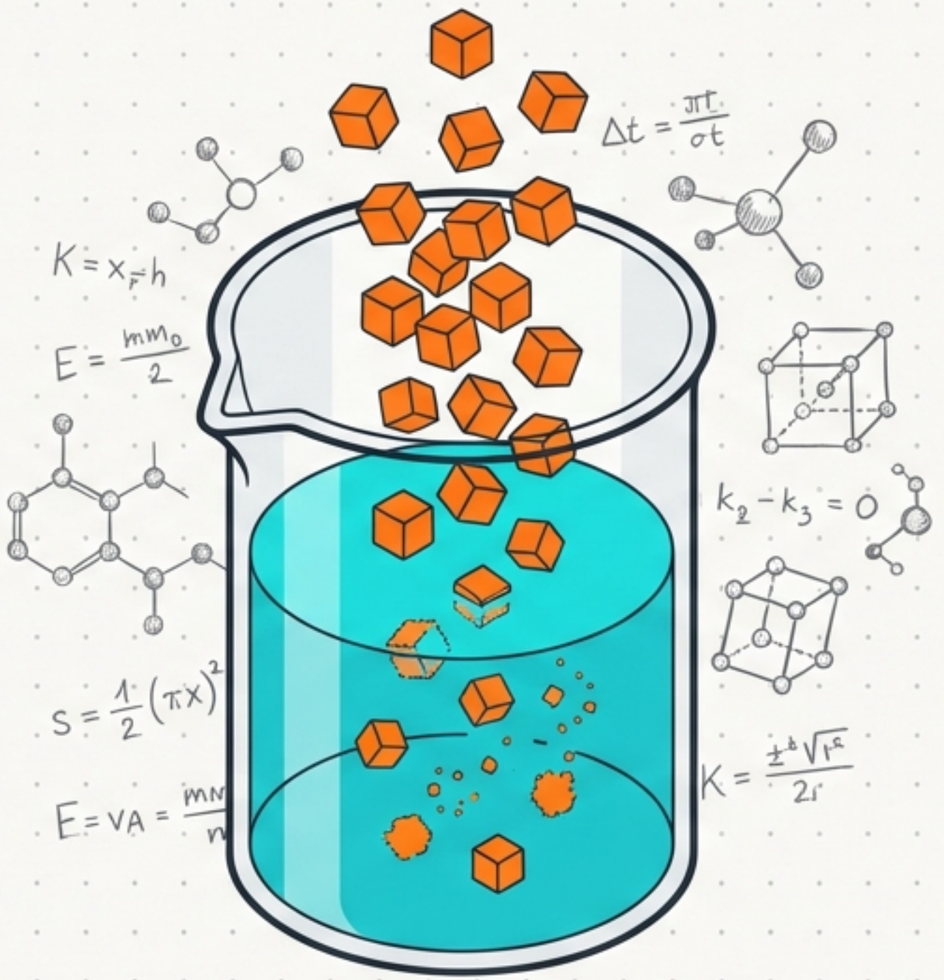
Chapter 2

Properties of Materials

A Masterclass on Solutions, Solubility, and Separation



We start here: What happens when solids disappear?

2.1 Dissolving: Mixing solids and liquids.

2.2 Solubility: Concentration and limits.

2.3 Investigation: Plotting the data.

2.4 Separation: Dividing the invisible.

Think like a scientist:
Rule: Dissolving requires BOTH a solute and a solvent mixing completely.

Solute

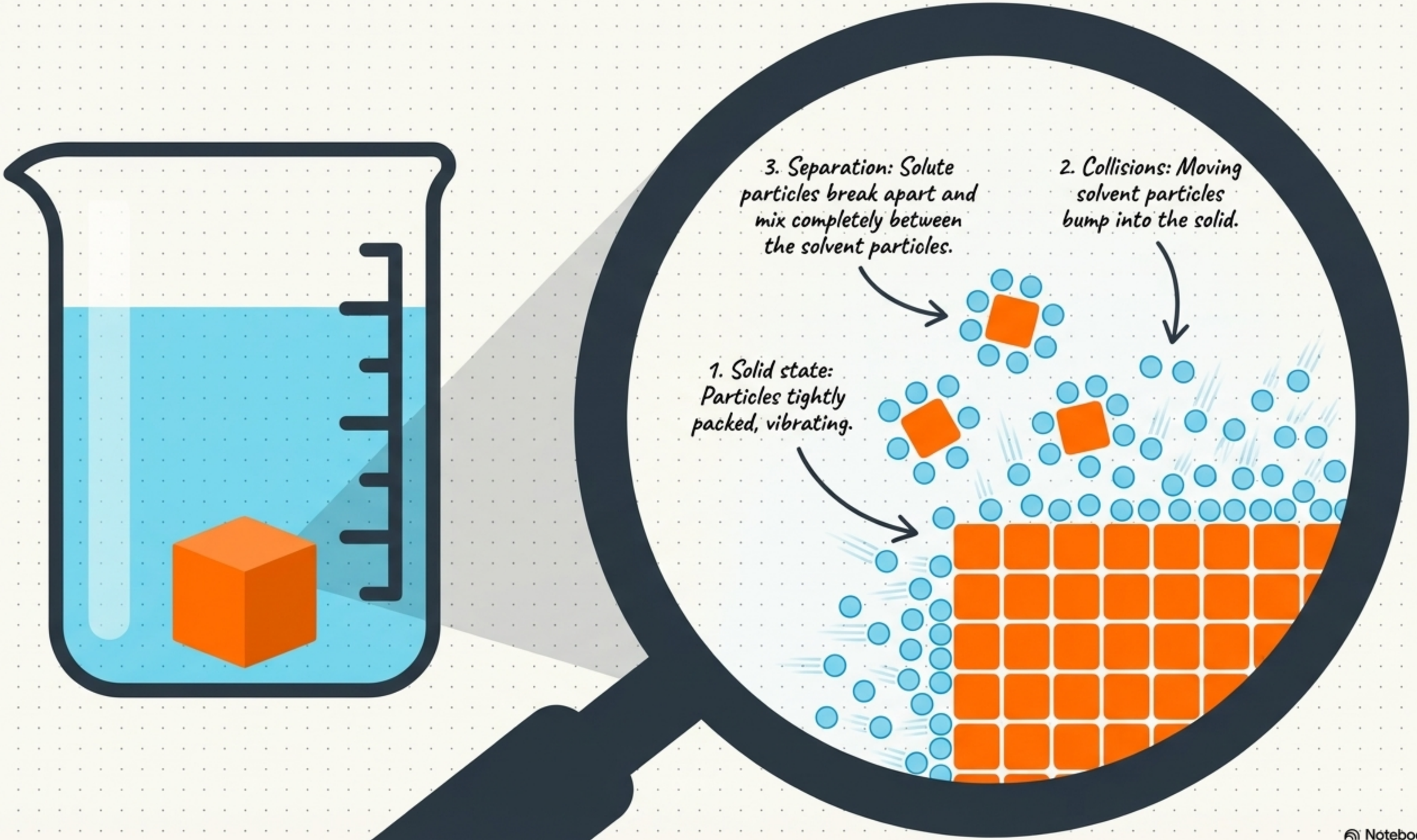
(The solid being dissolved)

Solvent

(The liquid doing the dissolving)

Solution

(The uniform mixture formed)


3. Separation: Solute particles break apart and mix completely between the solvent partioles.
2. Collisions: Moving solvent particles bump into the solid.
1. Solid state: Particles tightly packed, vibrating.

Transparent (True Solution)

- Light passes through.
- It may have color (like this blue copper sulfate), but it is clear.
- Particles are fully dissolved.

Opaque (Not a Solution)

- Blocks light.
- Looks cloudy.
- Particles are suspended, not completely dissolved.

Conclusion: If it is opaque, it is NOT a solution.

The Misconception Matrix: Melting vs. Dissolving

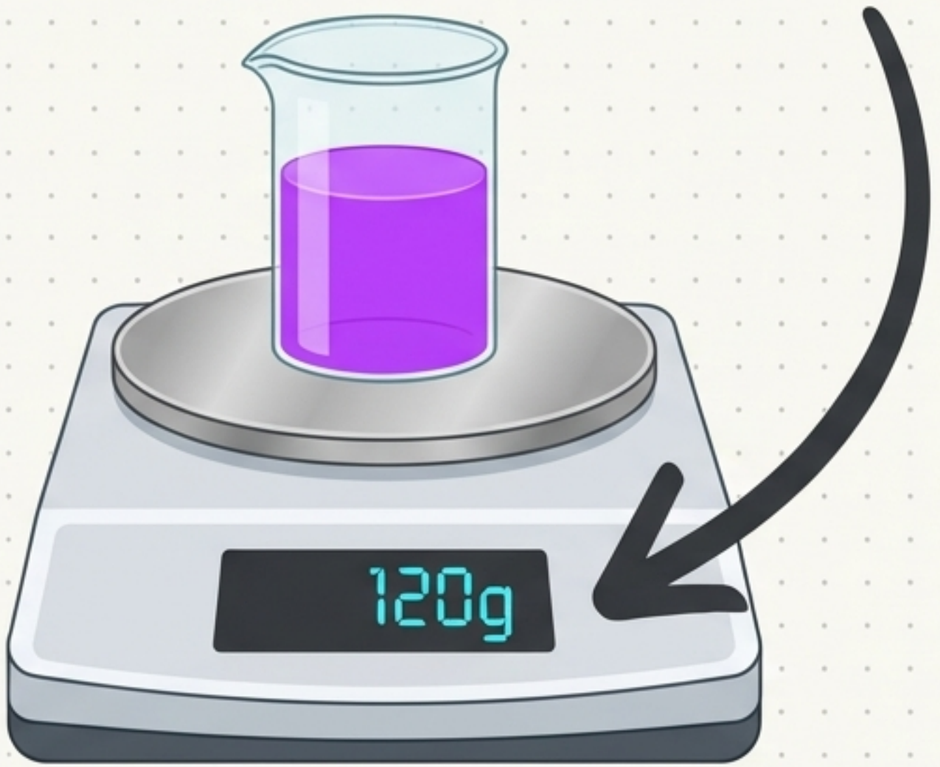
Melting	Dissolving
	
Mechanism: Requires heat. **Substances:** Only 1 substance changing state (Solid -> Liquid).	**Mechanism:** Requires mixing. **Substances:** Requires 2 substances (Solute + Solvent).

This is the crucial difference!

The Rule of Conservation of Mass

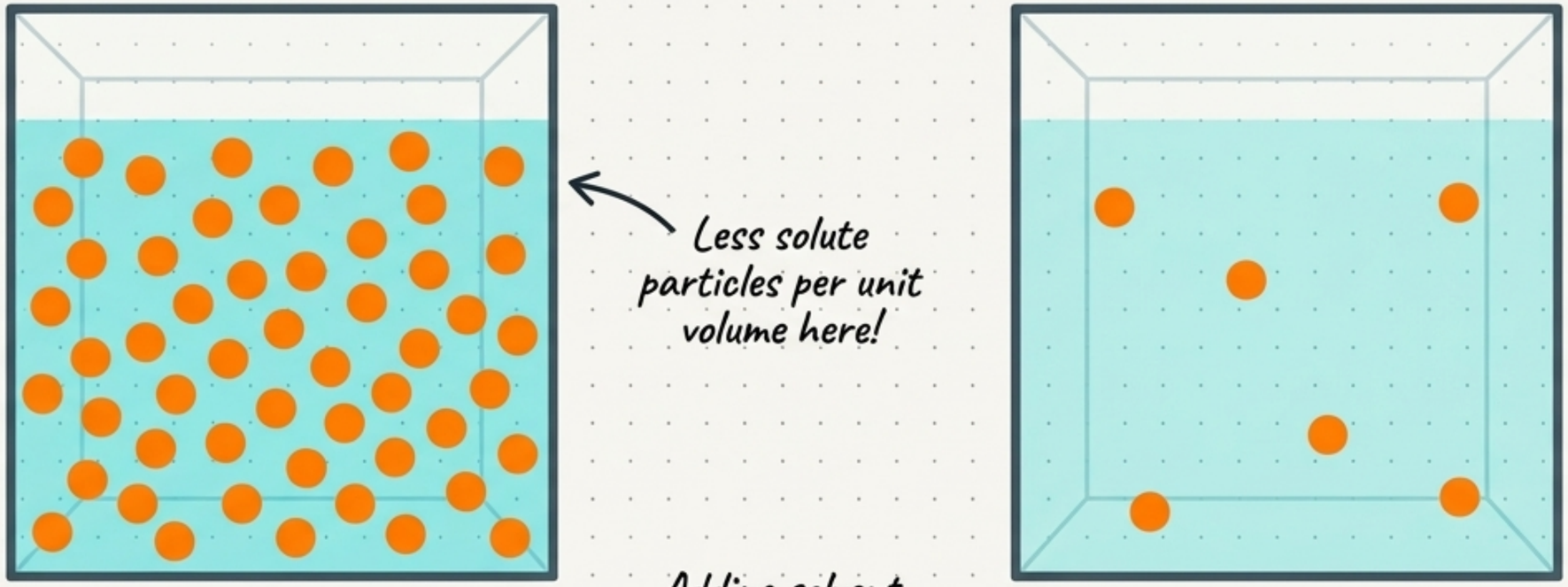
The solid "disappeared", but no mass is lost! The particles are just hiding between the water molecules.

Before
100g (solvent) + 20g (solute)



After

The Concept of Concentration



High Concentration
(Many solute particles in a given volume)

Adding solvent reduces concentration

Low Concentration / Dilute
(Few solute particles)

Math in the Lab:

Doubling volume = Halving concentration

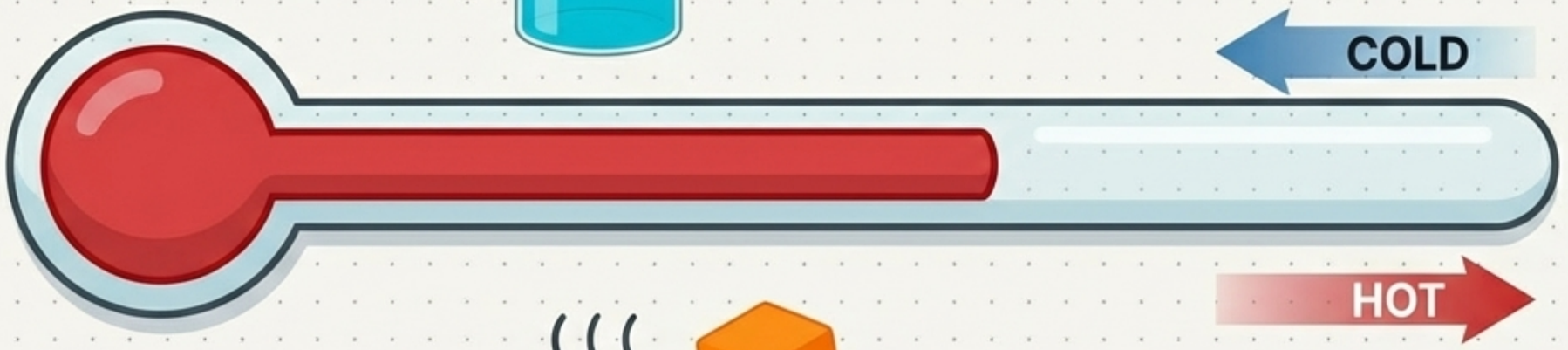
How do you make a solution exactly half as concentrated?

Keep the solute mass the same, but exactly DOUBLE the volume of the solvent (water)!

Temperature & Solubility

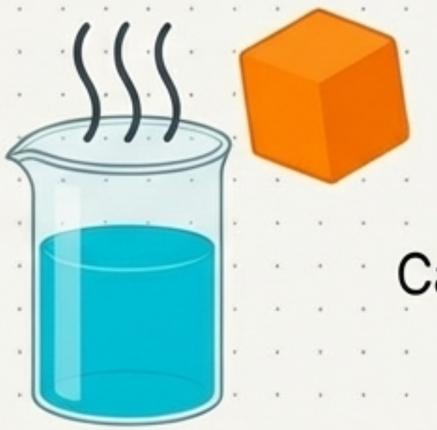
100g water
@ 20°C

Can **dissolve 204g of sugar.**
Beyond this, it becomes a saturated solution (no more will dissolve).



Higher temperatures give particles more energy to vibrate, move, and break apart solute particles faster.

100g water
@ 80°C



Can dissolve **362g** of sugar.

Lab Control Panel

Independent Variable

(We turn/change this)

Dependent Variable

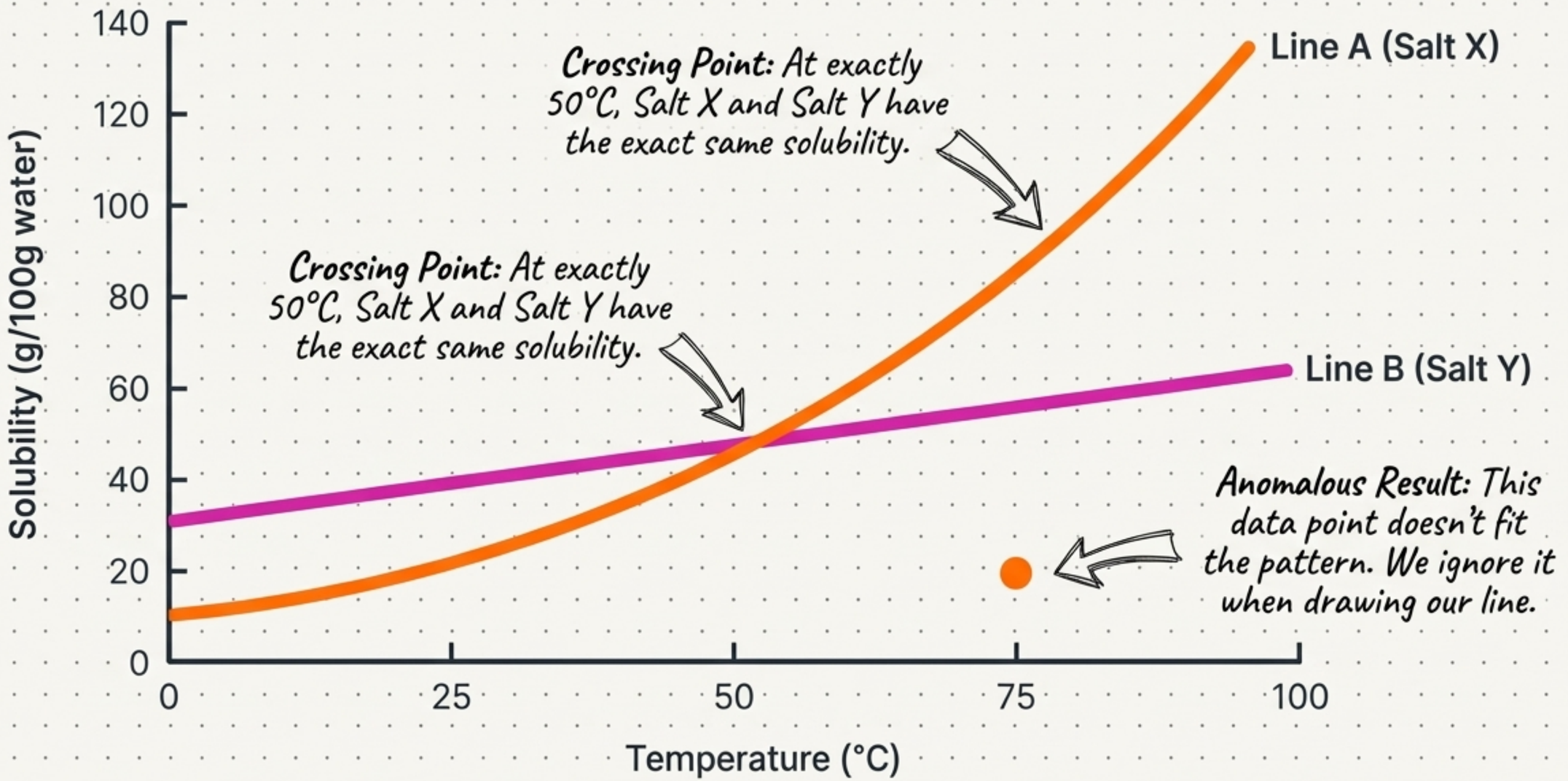
(We measure this result)

Control Variables

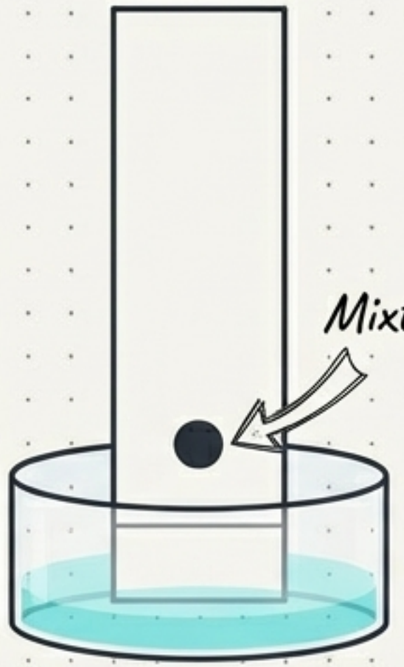
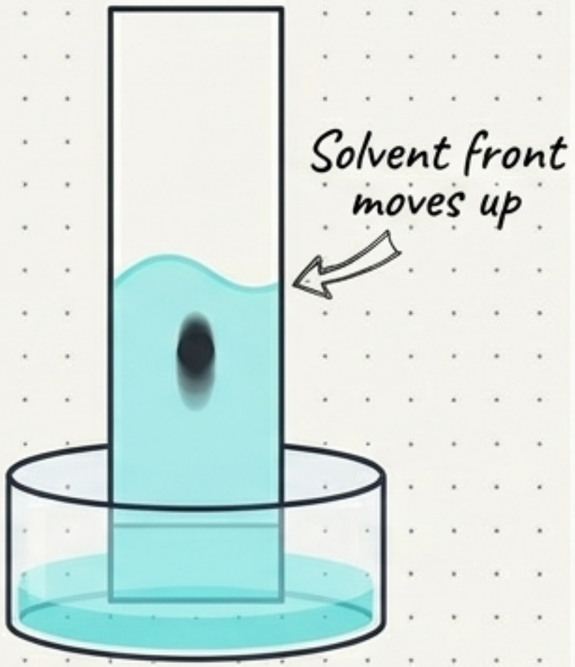
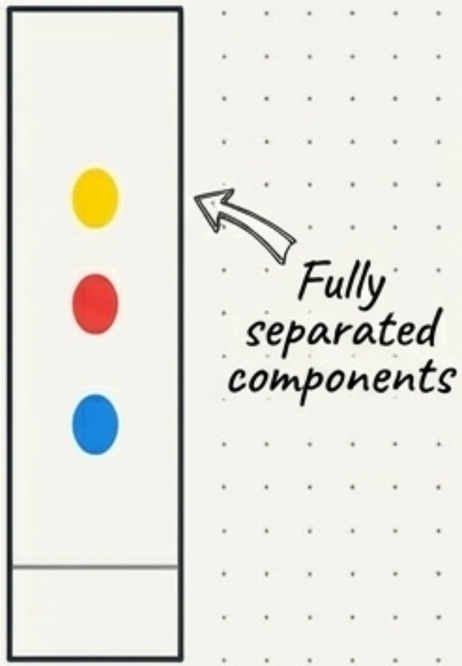
(We lock these so they stay exactly the same)

Example: Investigating Temperature vs Solubility		
Independent	**Dependent**	**Control**
Temperature of the water (e.g., 20°C, 30°C, 40°C)	Mass of salt that dissolves (measured in grams)	Volume of water, type of salt, stirring speed

Interpreting Solubility Curves



Separating the Invisible

Step 1: Spotting	Step 2: Traveling	Step 3: The Chromatogram
		
A spot of mixture (e.g., black ink) is placed on the paper, dipped slightly into a solvent.	The solvent soaks up the paper (reaching the 'solvent front'). It carries the dissolved substances with it.	Different substances stick to the paper differently, traveling at different speeds. The mixture separates!

Connecting the Dots: Designing a Sports Drink

The Mix

We must successfully dissolve solid salts and sugars (solutes) into water (solvent) to make a uniform solution.

Uniform Solution

The Taste

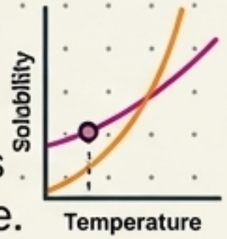
We must calculate the exact concentration so it isn't too weak or too strong.

$$C = \frac{m}{V}$$

Exact Concentration

The Fridge Test

We plot a solubility graph across temperatures to ensure the sugars won't turn back into solid crystals when stored in a cold fridge.



Caveat Stable at Cold Temps

The Safety Check

Food scientists use chromatography to separate and test the food dyes, ensuring no banned chemicals are used.

Caveat Safe Ingredients

Module Mastery Checklist

- [x] I can define solute, solvent, and solution using particle theory.
- [x] I understand that mass is always conserved during dissolving.
- [x] I can change solution concentration by altering solvent volume.
- [x] I can correctly identify Independent, Dependent, and Control variables in an experiment.
- [x] I can read a solubility graph and spot anomalous results.
- [x] I know how chromatography separates mixtures into a chromatogram.