COSMOS LESSONS

Chemistry

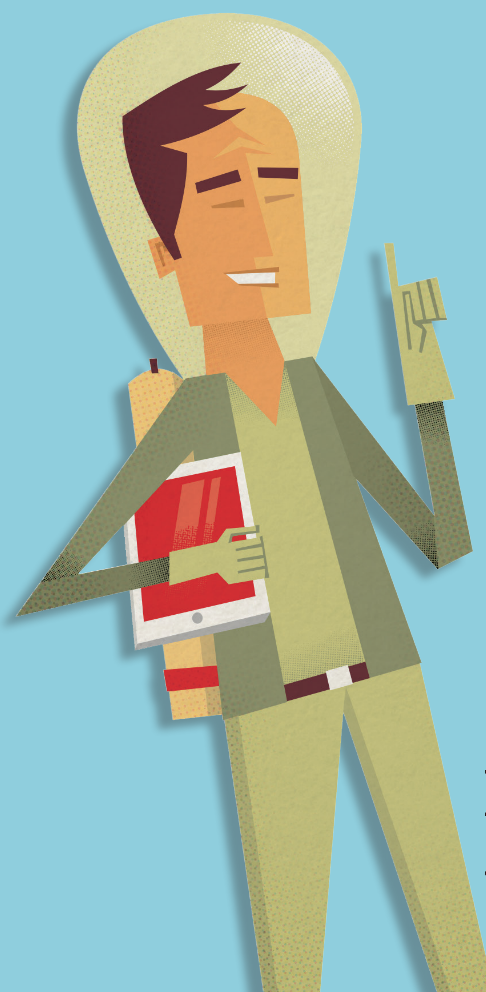
Solutions: Bringing things together

The melting of glaciers is often described as an example of the negative effects of global warming, but have scientists discovered a *silver lining*?

In this lesson you will investigate the following:

- What is a mixture?
- Are there different types of mixtures?
- What is a solution and how is it related to solutes and solvents?
- What does solubility mean and how can this be represented?

So let's heat things up and begin our investigation!



This is a print version of an interactive online lesson. To sign up for the real thing or for curriculum details about the lesson go to **www.cosmosforschools.com**

Introduction: Solutions (P1)

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Scientists have discovered that melting glaciers are releasing huge amounts of iron into the sea. The glaciers pick up the iron when they grind up the rocks they cross as they creep slowly forward – and there's an awful lot of it. Scientists estimate that one million tonnes – the weight of 125 Eiffel Towers – is released every year.

When the glacial ice melts, the iron doesn't dissolve in the seawater. It usually combines with oxygen in the water to make iron oxides, a rusty red substance you have probably seen on old pipes. But under the glaciers there is very little oxygen, so the iron stays mostly pure. And because the particles are very small, they sink very slowly.

That gives the phytoplankton – microscopic single-celled marine plants – time to feed on the iron, which is a vital nutrient for life.

Scientists think this is good news for the planet, too. The phytoplankton absorb carbon dioxide, the greenhouse gas that is to blame for global warming, from the seawater. The more phytoplankton there are, the more carbon dioxide they absorb. When that happens, the ocean can then absorb more carbon dioxide from the air, reducing the amount of the greenhouse gas that lingers in our atmosphere.

Read or listen to the full *Cosmos* magazine article here.

Minerals often get trapped in ice. Sometimes the minerals are already mixed in the water when it freezes, while at other times the minerals become trapped in the ice after it has formed, as is often the case in glacial ice. Credit: iStock.

Question 1

Brainstorm: The introduction describes an interaction between iron-containing glaciers and phytoplankton. This type of glacial ice can be described as a *mixture.* Use the mind map below to brainstorm what you already know about mixtures.

Mixtures

Gather: Solutions (P1)

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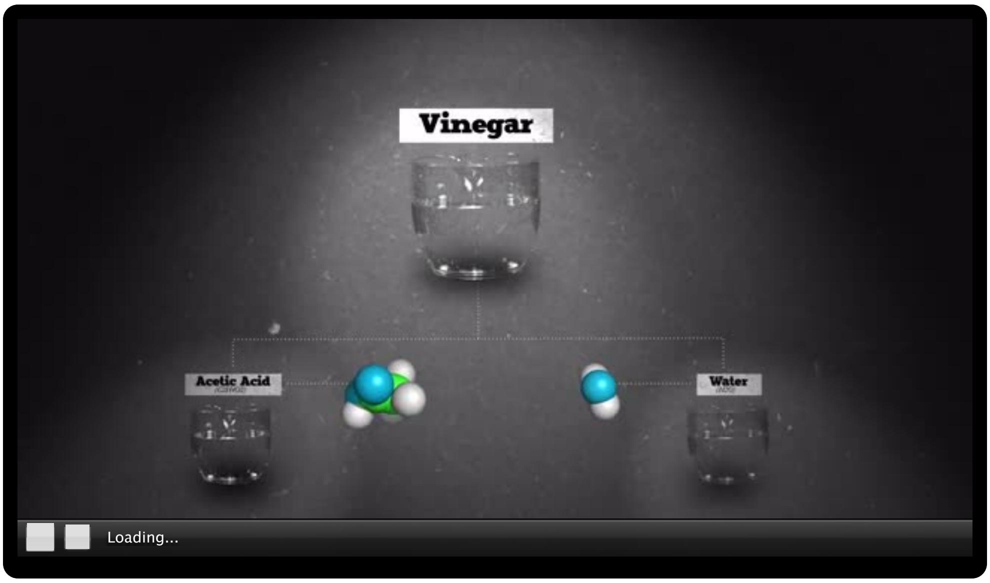


Credit: TedEd / YouTube.

Question 1

Think: How would you explain what a mixture is to a Grade 5 student?

Hint: You might like to use your own examples of solutions, colloids and suspensions, or examples from the video.

Question 2

Remember: An example of a solution found in macaroni salad is vinegar.

- True
- False

Question 3

Deduce: All mixtures are solutions.

- True
- False

Credit: dsecms / YouTube.

Question 4

Define: The term homogeneous is mentioned in the song. What is a *homogeneous mixture*? Use your definition to propose what you think a *heterogeneous mixture* might refer to.

Hint: the prefix "hetero" usually refers to "different".

Question 5

Describe: What is meant by the term *aqueous solution*?

Question 6

Think: When caffeine is dissolved in water to make a cup of coffee, the caffeine can best be described as the:

- ☐ solvent
- ☐ sediment
- ☐ solution
- ☐ solute

Question 7

Complete: Use the table below to construct a list of solutions and their respective solutes and solvents. For some cells there may be more than one acceptable response. The bottom row has been left empty for you to provide your own example.

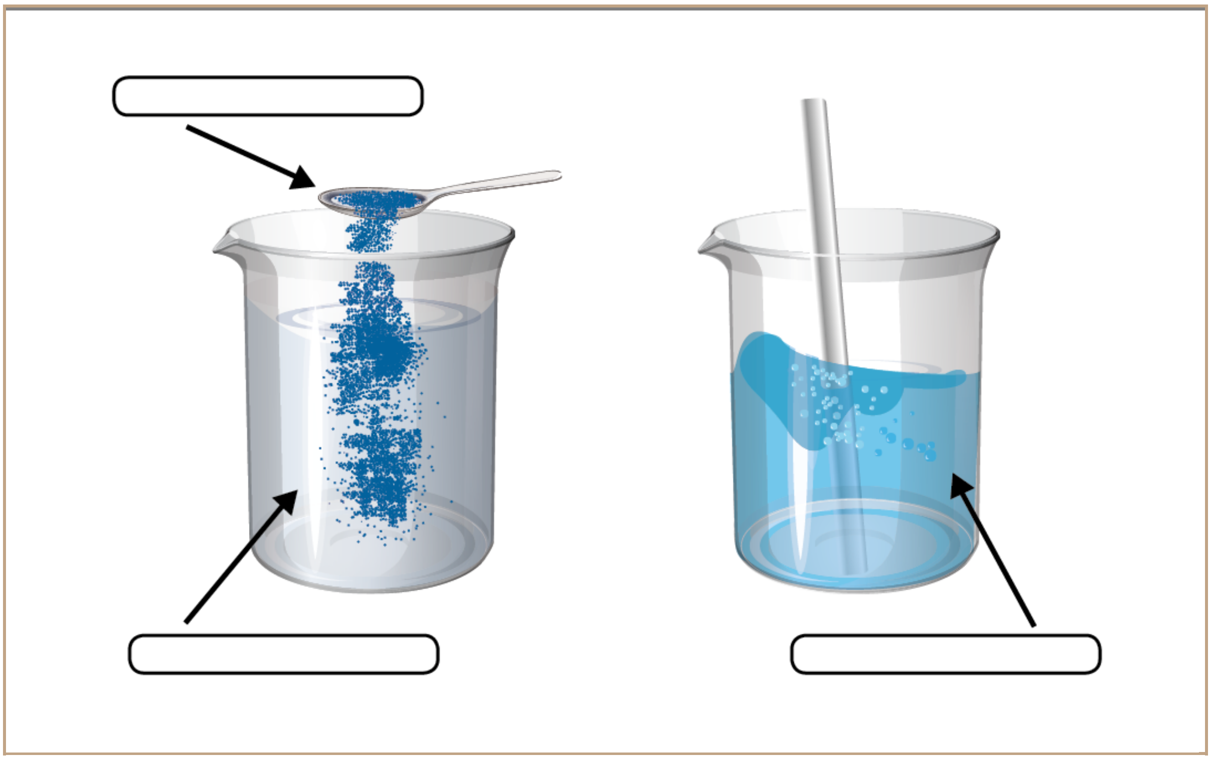
Hint: Remember that the solvent is doing the dissolving and is usually the more abundant substance. The first row has been done for you.

Solution	Solute	Solvent
smog	smoke	air
fizzy drink		water
24 carat gold ring	copper	
iron rich glaciers		
a glass of cordial		
air		

Question 8

Match: Use the following terms to label the image below:

- solution
- solute
- solvent



Process: Solutions (P1)

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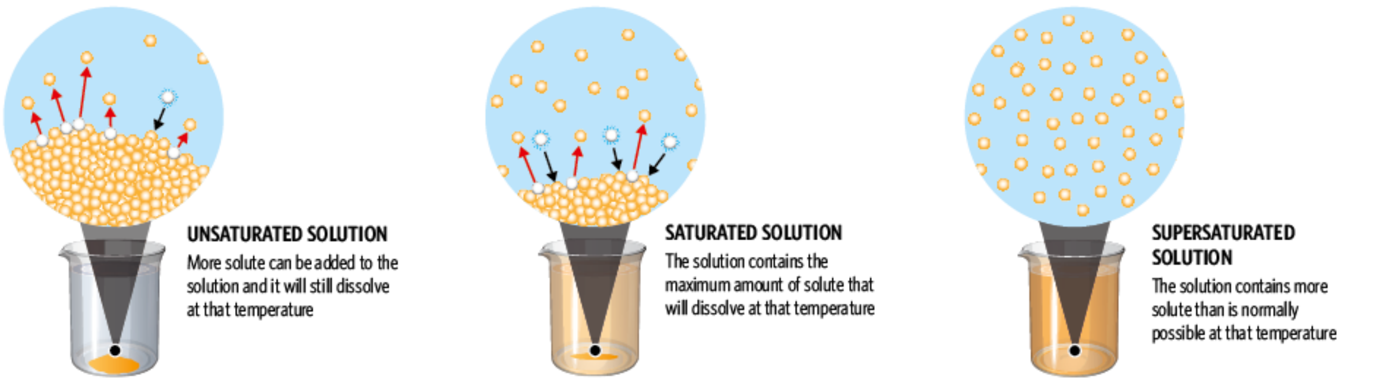
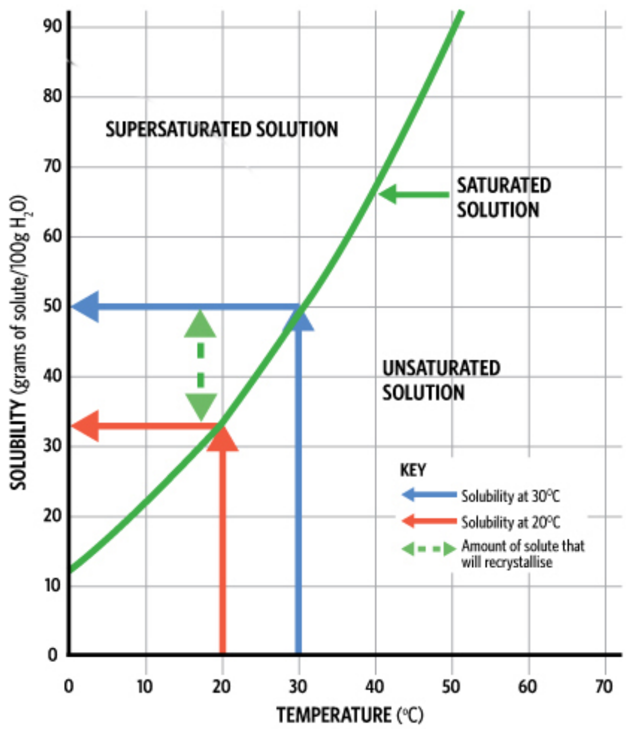


Solubility is a measure of how much solute can be dissolved in a given amount of solvent at a particular temperature. As such, we can describe solubility as being *temperature dependent*. A graphical representation of the relationship between solubility and temperature can be seen below.

A solution that contains the maximum amount of solute for a given temperature is said to be *saturated*. A solution that contains more than the maximum amount of solute for a given temperature is said to be *supersaturated*, while a solution that contains less than the maximum amount of solute for a given temperature is said to be *unsaturated*.

Observe the solubility curve on the right. You can see that if you were to add 50 grams of potassium nitrate to 100 grams of water at 30°C, the solution would become saturated.

If such a solution were then cooled, it would become supersaturated and crystals will begin to reform in a process known as *recrystallisation*. Cooling the solution to 20°C would leave just 32 grams of the solute in solution while the rest, 18 grams, would recrystallise.



Solubility curve for potassium nitrate in water

Question 1

Calculate: What is the maximum mass of potassium nitrate that would dissolve in 100 g of water at 50°C?

Question 2

Calculate: At what temperature will 65 grams of the solute dissolve in 100 grams of water?

Question 3

Describe: What would you expect to observe if a saturated aqueous solution of potassium nitrate is cooled from 50°C to 10°C.

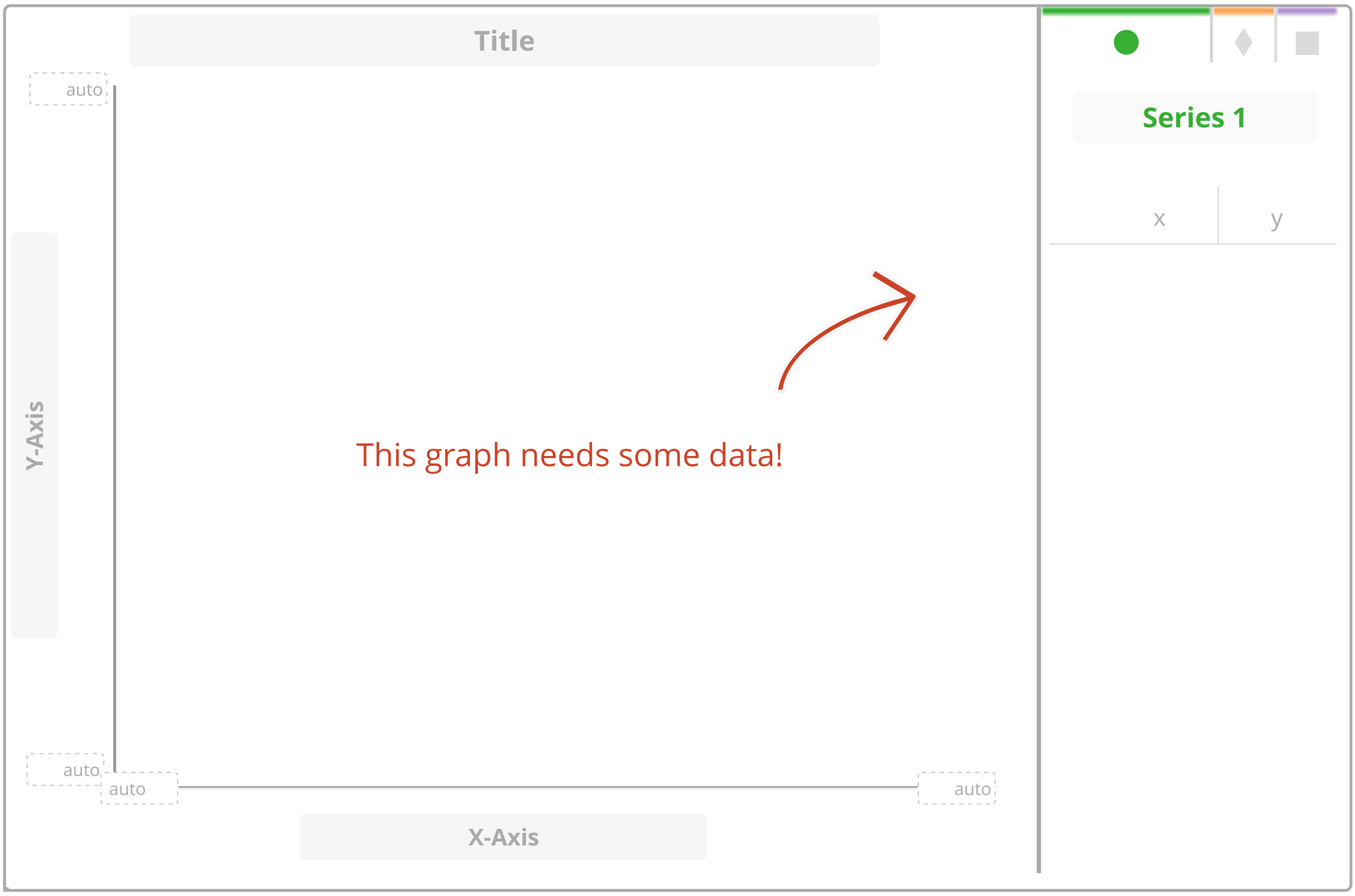
The data in the table below should be used to answer the questions that follow.

Temperature (°C)	Maximum mass of sodium nitrate that dissolves in 100 grams of water (grams)
0	73
10	80
20	88
30	95
40	104
50	113
60	122
70	136
80	148

Solubility of sodium nitrate in water.

Question 4

Plot: Use the data presented in the table above to plot the relationship between the solubility of sodium nitrate solution and temperature.



Question 5

Classify: If 130 grams of sodium nitrate was dissolved in 100 grams of water at 50°C, would the solution be classified as *unsaturated*, *saturated* or *supersaturated*? Explain.

Question 6

Compose: Write a short song that explains unsaturated, saturated and supersaturated solutions. You may wish to simply type out the lyrics of your song below, or upload an audio or video recording of your song instead.

Hint: A good educational song is catchy and humorous!

Apply: Solutions (P2)

Experiment: Hot ice sculptures

Aim

To build on our understanding of solutions, solubility and recrystallisation by creating a hot ice sculpture.

Materials

- 160 g sodium acetate
- Water
- 250 mL conical flask
- Hot plate
- Large beaker
- Small beaker
- Mortar and pestle
- Heatproof mat
- Stirring rod
- Petri dish
- Thermometer

Procedure

1. Add water to the large beaker so that the surface of the water sits about 5 cm above the bottom.
2. Add water to the small beaker so that it is half full.
3. Place both beakers on the hotplate and allow the water to come to the boil.
4. Using a mortar and pestle, crush 160 g of sodium acetate to remove any large lumps.
5. Add all but a few grams of the sodium acetate into a 250 mL conical flask and gently sit the flask down in the boiling water

bath (large beaker).

6. Carefully and bit by bit, pour boiling water from the small beaker into the conical flask while gently stirring so that the crystals of sodium acetate *only just* completely dissolve. This will require approximately 50 mL of water.
7. Carefully remove the conical flask from the water bath and place it on a heatproof mat to let it slowly cool.
8. Add one or two crystals to the liquid in the flask. Don't take your eyes off the liquid! Record your observations.
9. Return the flask to the water bath to re-dissolve your solution *(Note: you may need to add a small amount of water as some will have evaporated earlier)*
10. Once redissolved slowly pour small amounts of the solution into a waiting petri dish.
11. Your solution should recrystallise as you pour it, but if it does not, you can begin this process by placing a single crystal from your flask in the petri dish or by gently touching the first drops of solution, then sculpt your ice as the crystals form!
12. Take a picture of your sculpture to upload later on!

Question 1

Identify: Clearly state the *solute* and the *solvent* in this experiment.

Results

Question 2

Record: Use the space provided in the table to record your observations at the various sages of this experiment.

Experiment stage	Observation
Heating of the mixture	
Cooling of the mixture	
Addition of one or two crystals	

Question 3

Record: Use the project space to upload any images you have recorded of your hot ice sculpture. You should also record any further comments that can support your images.

Conclusion

Question 4

Conclude: In the space provided, respond to your aim by explaining what you have learnt about solutions, solubility and recrystallisation.

Career: Solutions (P2)

Brought to you by the University of Adelaide

Jon Hawkings loves the cold. As a glacial biochemist at the University of Bristol, he studies how glaciers play an unexpectedly important role in supporting life in the freezing Arctic oceans.

Growing up in the small town of Brentford in West London, Jon Hawkings didn't ever dream about becoming a scientist. In high school, he studied geography, biology, history and economics, but his love for science didn't really blossom until he went to university, where he was offered the opportunity to be a research assistant in Svalbard. Svalbard is a cluster of icy islands between Norway and the North Pole, populated by people, polar bears and reindeer – though more than half of the islands are covered by glaciers. It was on this trip he learned how enjoyable, diverse and challenging a career in science could be.

Jon describes himself as a “glacial biogeochemist”, which means he studies the chemical, physical and biological processes that shape glacial environments. He is especially interested in investigating how melting glaciers affect ocean ecosystems. Jon has found that water from melted glaciers has higher concentrations of nutrients like nitrogen, phosphorus and iron than water in the polar oceans. This means that the nutrients trapped in the glaciers essentially "feed" the organisms in surrounding oceans when those glaciers melt.

An average day at work for Jon can involve anything from doing experiments in the lab to watching satellite images of melting of ice sheets to writing reports at his computer. But Jon says that the favourite part of the job by far is travelling to places like Svalbard to carry out fieldwork for his research.

Apart from exploring and analysing glaciers, Jon enjoys being with friends and family, watching movies, and hiking and camping outdoors. He is also a fan of brewing his own beer – a skill that he says makes him rather popular at parties.

Question 1

Discover: Jon's favourite part about his work is that he gets to go travelling to places like Svalbard. Where would you like to travel to? Perform an internet search to find a science job that would require you to travel there.

Cosmos Live Learning team

Education director: Daniel Pikler
Education editor: Bill Condie
Art director: Robyn Adderly
Profile author: Yi-Di Ng
Lesson author: Deborah Taylor
