Try This

Water in the oceans

As you know, water in the oceans is salty. This may be obvious, but it has some consequences for how the ocean water mixes – or doesn't mix. There are distinct bodies of water in the oceans which mix only very slowly. These experiments will help to show you why this is.

Part 1 The density of salt water

You will need

- small pot, jar or glass
- bowl or plate
- salt
- teaspoon
- digital balance (optional)

You can add salt to a full glass of water without it overflowing.

What you do

Fill the small glass to the brim with water and stand it in the bowl, which should be dry. Carefully pour salt a teaspoon at a time into the glass and stop when it overflows. If you are very careful you should be able to get at least 3 or 4 teaspoons of salt into the already full glass. (If you start with the bowl and glass on the balance, you will be able to measure the mass of water and salt as you add them.)

What is going on?

Part of the answer is that water has high surface tension and will bulge slightly at the surface – but this isn't enough to account for 3 teaspoons of salt. Table salt is the ionic compound sodium chloride. As it dissolves, the sodium and chloride ions separate and act independently of each other. They fit into the spaces between the water molecules as shown in the diagram.

The volume of the water has not changed but the mass has. Each teaspoon of salt has a mass of about 5 g. You could find or estimate the mass of your water and salt. The water in the glass I used had a mass of 70 g and a volume of 70 cm^3 (pure water has a density of 1 g/cm^3). The density for the water before and after the salt is added can be calculated using density = mass/volume:

fresh water: density = 70/70 = 1.00 g/cm^3
salt water: density = 85/70 = 1.21 g/cm^3

The salt water has a higher density than the fresh water. This becomes important in the ocean when salt and fresh water meet, for example where a river meets the sea, although the density of seawater is lower than this.

When glaciers melt they pour fresh water into the salty oceans.

Part 2 Mixing fresh and salty water

You will need

- 2 jugs
- tall drinking glass (the narrower the better)
- salt
- spoon
- 2 colours of food colouring

Salt and fresh water form layers which are surprisingly stable – they will remain like this for hours.

What you do

Fill both jugs with water. To one add a handful of salt and stir until it dissolves. Keep adding salt until you can get no more to dissolve. Stir in some food colouring. Add some of the other food colouring to the other jug. Half fill the tall glass with the salt water. Tip it to one side and carefully pour the fresh water down the side of the glass. Stand the glass upright and you should see two distinct layers in the water.

What is going on?

The pure water is less dense than the salty water, so it floats on top. This is important in the oceans as it affects how different bodies of water mix. For example, water from melting glaciers is fresh so tends to sit above the saltier water of surrounding oceans. The Mediterranean Sea is very warm so water evaporates leaving it saltier than the surrounding oceans. As Mediterranean seawater pours into the Atlantic Ocean it sinks.

Part 3 Freezing salty water

You will need

- ice cube tray
- salt and fresh water with food colouring left over from Part 2
- access to a freezer or the ice compartment of a fridge

What you do

Fill about 4 sections of the ice cube tray with coloured fresh water and about 4 with coloured salty water. The colours help you to remember which is which. Place in the freezer for at least 2 hours.

You will find that the fresh water forms normal ice cubes but the salty water forms slush. This is because the salt is excluded as the water freezes so what you have is ice and salt water that is saltier than you started with. Salty water has a lower freezing point than fresh water and the freezing point goes down as the saltiness increases. Seawater is less concentrated than this and does freeze at about -2 °C, although the exact temperature depends on how salty it is.

This separation by freezing happens in the polar regions, especially near Antarctica. The salt is excluded when the first sea ice forms leaving sea water which is very cold and very salty. This sinks to the bottom of the ocean.

Andrew Mandemaker

Sea ice forming in Antarctica leaves saltier water behind.

Vicky Wong is Chemistry editor of Catalyst.