Learning from Raisins

Introduction

When we add a drop of ink to water, the ink starts spreading throughout the water (solvent). Similarly, if we add a spoonful of salty water to a glass of water, the whole water becomes salty after some time. It means that when a substance present in a high concentration in a liquid comes in contact with a liquid having a lower concentration of that substance, diffusion of substance from a high concentration region takes place spontaneously and it spreads out. However, when we put a barrier between these liquids like a plastic or metal sheet, diffusion should not happen!

However, in nature, we have certain special barriers that can stop the diffusion of some substances and allow other substances to pass through them. An example is peels of some vegetables, or membranes in our body cells. Such special barriers are known as semi-permeable membranes and can lead to special kinds of diffusions.

Now, we will perform a small experiment using raisins (produced by drying grapes) to study a special kind of diffusion.

Materials: (Requirements for 3-4 groups)

- 100 g Raisins (dry)
- 200 g Sugar or Sucrose
- Food colour (green/blue/red – any one)
- 1 weight balance (pocket scale)
- 500 mL Water (Clean tap water)
- [Per group] 5 Glass or plastic containers of 50 mL capacity, 2 beakers of 100 mL capacity, 1 Measuring cylinder (10 mL capacity), forceps without sharp point
- [Optional] 1 Insulin syringe (It has a fine needle to make very small prick in raisins)

  Note: Raisins are readily available in any grocery store. While buying, please check that they are intact, medium or large-sized (around 1 cm or above in length) with greenish yellow or light brown coloured. While selecting for the experiment, do not use very dark brown, small, deformed fruits. Preferably choose fruits with undamaged stalks.

Task 1. Preparing for the experiment

Prepare the following solution (the quantities mentioned are sufficient for 3-4 groups of students, each group doing a set of experiments).

1. 40% Sucrose solution: Dissolve 20 g sugar in 25-30 mL of water. When all the sugar dissolves, make up the volume to 50 mL.
2. Saturated Sucrose solution: Take 50 mL water in a beaker or container and add ~40-50 g of sugar. Try to dissolve it as much as possible. This is closer to a saturated solution of sucrose.
3. Food colour solution: Dissolve a pinch of food colour in around 5 mL water to make a concentrated solution.

Task 2. Fun with raisins

1. Take 3 containers of 50 mL capacity or 50 mL beakers. Label them with numbers 1 to 3.
2. Weigh about 7-8 raisins (use entire ones without breaking their stalks) and record the weight in Table 2. Put them in container no. 1. Similarly add weighed raisins in containers no. 2 and 3.
3. Add 10 mL of water in container no. 1. All raisins should get completely immersed. If not, add another 5 mL of water but *remember to keep amount of solution constant in all the 3 containers.*
4. Add 10 mL of 40% sucrose solution in container no. 2 and 10 mL of saturated sucrose solution in container no. 3.
5. Now put 2-3 drops of food colour solution in container no. 1, 2 and 3. Mix it well by gently swirling.
6. Summarize the constituents of your containers in Table 1.
7. Cover all the containers to avoid evaporative loss of liquid. Note the time and keep them undisturbed for 45 minutes. In the meantime, try answering the following questions.

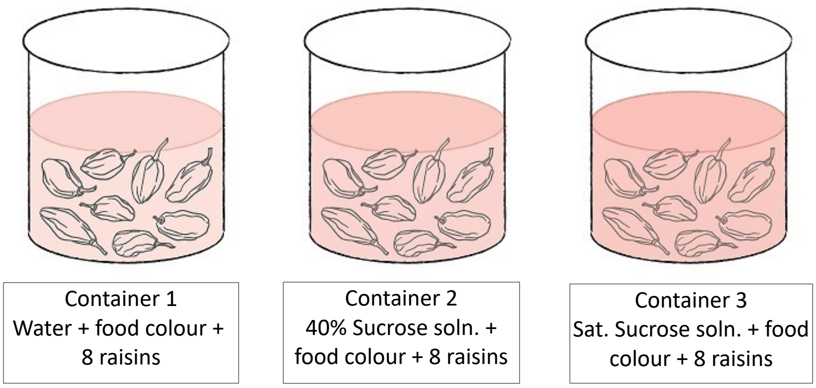


Figure: Containers with their constituents

Table 1: Summarize the contents of each container in the table below (+ represents added and – represents not added):

Container no.	Raisins (Dry)	10 ml Water (+/-)	10 ml Sucrose Solution (+/-)	Food colour in water (+/-)
1				
2				
3				

Q1. What do you think is the role of dye (food colour) in this experiment?

Q2. What do you expect will happen in each of the containers?

- After about 45 minutes, carefully remove raisins from container no.1 using forceps having blunt ends. Do not prick/damage the raisin while holding it with the forceps. Gently tap it to the side wall of the container side to drain off excess liquid. Observe any change in shape/ colour of raisins, and note in Table 2.
- Gently blot the raisins (dry their surface) on tissue paper and weigh them together.
- Measure the amount of water in container no.1 using measuring cylinder. Note down your observation in Table 2.
- Repeat it for the rest of the containers.

Table 2: Write about the shape before and after and also the volume of liquid from each container. The shape can be categorised as 'more shrunken', 'no change' or 'swollen'. (the original shape while starting the activity should be considered as 'Shrunken')

Container No.	Shape of raisins		Mass of raisins (mg)			Approximate Volume of liquid in container (mL)		
	Initial	Final	Initial	Final	Difference	Initial*	Final	Difference
1.						10		
2.						10		
3.						10		

*Can be 15 or 20 mL as per the requirement. But should be constant in all containers.

Q1. Now that you have recorded all the details and done all calculations, can you tell if the mass difference is same in all containers? If the initial mass of raisins is different in different containers, then calculate the mass difference per gram of raisins to compare.

Q2. Why did the raisins change in shape?

Q3. What according to you was going inside the raisin?

Q4. Why were different concentrations of sucrose used?

Q5. What happens in container no. 3?

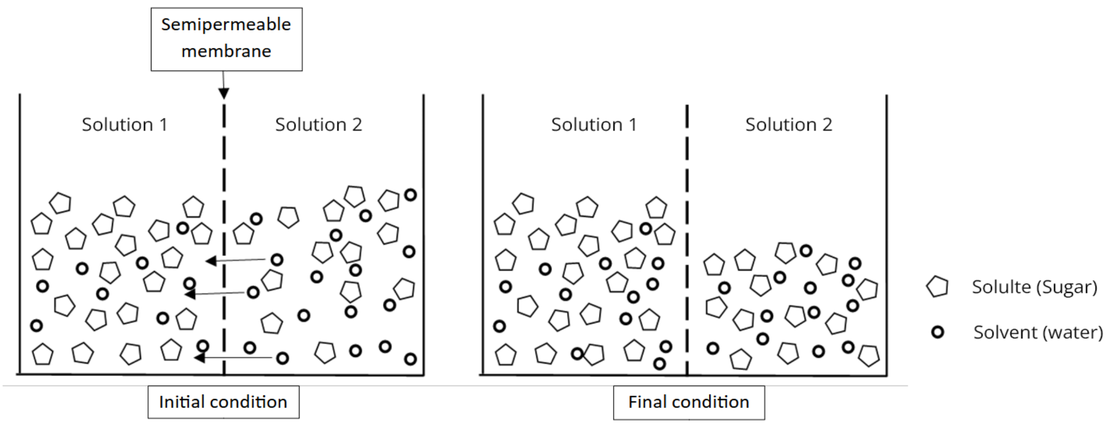
Q6. Why is this not a simple diffusion? Which container can be used to demonstrate?

Q7. Was the change in the mass of raisins in each container related to the change in the water volume you observed for that container?

Q8. Was any semi-permeable membrane present in the above experimental setup? If yes, what did it allow to pass through and what did it stop from passing through?

Task 3. A look at osmosis

Net movement of water across a semipermeable membrane from a solution of lesser to one of greater solute concentration is known as osmosis. The membrane must be permeable to water but not to solute molecules. One should not confuse it with imbibition, which is a diffusion of water in colloidal solids (mostly proteins in biological systems) which results into swelling of latter. Eg. Pulses soaked in water. Imbibition never takes place between two liquids of differing concentrations.



Representation of movement of solvent molecules

The figure above is given for representative purposes. Pentagons represent sugar or any molecule that cannot pass through the middle membrane while circles represent water molecules which can readily cross the membrane. Initially two sugar solutions of different concentration are added on two sides of semipermeable membrane. As it can be seen, left compartment has higher sugar concentration than right. But membrane does not allow sugar molecules to diffuse towards right compartment of lower solute (sugar) concentration. Water molecules being in higher concentration on right side can cross the membrane and move towards its lower concentration. The net movement stops when water molecules OR solvent concentration becomes equal on both sides. It is shown in 'final condition.' *(For ease of understanding, pressure difference is not considered here.)*

Q1. Table below presents a few situations. These situations may involve one or more of the processes (diffusion, osmosis, or imbibition). Indicate the predominant process (diffusion or osmosis). If the process is osmosis, identify the semi-permeable membrane in the example.

	Situations	Diffusion / osmosis	Semi-permeable membrane (if osmosis)
i	Gulab jamun dipped in sugar syrup after frying.		
ii	Whole raw mango stored in salt solution becomes salty from inside.		
iii	Potato slices sprinkled with salt become wet		
iv	Adding sabza (sweet basil) seeds in water.		
v	Intake of water from soil in plants		
vi	Dipping tea bag in hot water for making tea		

Q2. Certain membranes allow water to pass through but not sugar. Can you give examples of such membranes?

Opening and closing of leaf stomata also involves swelling and shrinking of guard cells. Is it likely that this process may be happening due to osmosis? Discuss among your friends.

Q3. These days we hear a lot about RO filters in water purification units. RO stands for reverse osmosis process. RO filters are used to get rid of excess salts and minerals dissolved in water. Can you find out why it is called 'reverse' osmosis?

Q4. There are some factors mentioned in the following table that may or may not affect both the processes, and some factors play a key role in these processes, i.e. diffusion and osmosis in aqueous solutions. Put a tick (√) in the appropriate boxes as per your understanding:

	Factors involved/affecting	Diffusion	Osmosis
A	Solute movement		
B	Water movement		
C	Semi-permeable membrane		
D	Concentration difference		
E	External heating		

Q5. There are many fishes that live in marine water. How do you think they survive in such salty water (without losing their body water or without absorbing outside water)?

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Q6. Can you think of any examples in the human body/environment where osmosis plays an important role?

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