**PEOE – A cup of tea**



Your teacher is going to add a teabag to some water at room temperature.

It will **not** be stirred or heated.

**Predict**

What will happen to the tea and the water during the rest of the lesson?

**Explain**

Explain why you think this will happen.

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| Your teacher will now add the teabag to the water. |

**Observe**

Watch what happens to the tea and the water during the rest of the lesson.

**Explain**

Was your prediction correct?

If not, how would you explain what you observed?

*Biology > Big idea BCL: The cellular basis of life > Topic BCL1: Cells > Key concept BCL1.4: Diffusion and the cell membrane*

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| **Response activity** |
| **PEOE – A cup of tea** |

**Overview**

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| Learning focus: | Molecules move through the cell cytoplasm by diffusion, and some molecules can enter and leave a cell by diffusing through the cell membrane. |
| Observable learning outcome: | Explain diffusion as the net movement of particles from an area of their higher concentration to an area of their lower concentration. |
| Activity type: | Practical PEOE (predict, explain, observe, explain) |
| Key words: | diffusion, particle, net movement, concentration gradient |

This activity can help develop students to explore and build explanations of diffusion across a membrane at the particle level by challenging them to apply concepts they have been taught to make predictions, followed by group discussion. It can be used in response to the following diagnostic questions:

* Diagnostic question: Across the membrane
* Diagnostic question: In and out of a cell
* Diagnostic question: Dead cell

**What does the research say?**

Students can struggle to understand and explain diffusion because of the apparent disconnect between what happens at the macroscopic level and what happens at the particle level – e.g. molecules collide and move in random directions and do not stop, but there is *net* movement from high concentration to low concentration until equilibrium is reached (AlHarbi et al., 2015; Stains and Sevian, 2015). Johnson (1998) summarises research in which it was found that even students who appreciate that a substance is made up of particles showed very little appreciation of the intrinsic, random movement of particles.

Various researchers (Odom, 1995; Tomažič and Vidic, 2012; Stains and Sevian, 2015; Oztas and Oztas, 2016) have described common misunderstandings about diffusion in school children that can persist in students up to university level, including that:

* molecules move only in one direction, from an area of higher concentration to an area of lower concentration (a failure to understand the random movement of particles versus the concept of *net* movement);
* movement of particles stops after the concentration gradient between two areas has been equalised by diffusion (possibly because students interpret “no net movement” to mean “no movement of particles”).

Some students believe that diffusion requires an external force or mechanical event (rather than resulting from the intrinsic movement of particles), a misunderstanding that may be linked to students’ everyday experiences of stirring and dissolving, such as stirring sugar into tea (Çalýk, Ayas and Ebenezer, 2005; Stains and Sevian, 2015).

A number of researchers have described constructivist approaches that enable students to build their own explanations of diffusion, which may help to develop students’ understanding and overcome misconceptions, including group discussion and challenging students to apply concepts they have been taught to make predictions (Christianson and Fisher, 1999).

**Ways to use this activity**

This activity takes the form of a predict-explain-observe-explain (PEOE) activity, which allows students to apply what they know to make predictions, and to build explanations for what they have predicted and what they observe.

Students should complete this activity in pairs or small groups, with time allowed for each group to engage in discussion to agree their predictions and explanations. It is through the discussions that students can check and develop their understanding. If students in any group cannot agree, you may be able to direct them with some careful questioning.

To begin, each group should discuss the activity and use their scientific understanding, firstly to predict *what* they think will happen, and then to explain *why* they think it will happen.

Students now carry out the practical, or watch a demonstration. You will need to decide whether it is better for each group to carry out the practical and risk some unexpected observations, or to demonstrate the activity so that everyone observes the same thing.

After the practical each group should be given the opportunity to change, or improve their explanation in light of their observations. A good way to review your students’ thinking might be through a structured class discussion. You could ask several groups for their explanations and put these on the whiteboard. Then ask other groups to suggest which explanation is the best and why, the through careful questioning work up a clear ‘class explanation’.

A useful follow up is for individual students to then write down explanations in their own words – without reference to the class explanation on the board (i.e. cover it up).

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the each group. For example, you may choose to select a student with strong prior knowledge as a scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

**Equipment**

For the class:

* teabag
* cup or beaker of water at room temperature
* visualiser or overhead projector (optional)

The water should be at room temperature to avoid convection effects.

**Expected answers**

Students should predict that the water will eventually turn brown (or “tea-coloured”), or that the tea will mix with and spread throughout the water.

Good scientific explanations for this will include the following ideas (adapted from Odom, 1995):

* The particles/molecules of tea (and of the water) are constantly moving.
* Diffusion results from the random movement and collisions of the particles/molecules – so no stirring or heating is required.
* The particles/molecules of tea will move through (holes in) the walls/membrane of the teabag.
* The particles/molecules of tea will move throughout the water particles/molecules.
* The particles/molecules will move in all directions.
* There will be a net movement of particles/molecules from an area of their higher concentration (inside the teabag) to an area of their lower concentration (the rest of the water).
* Diffusion causes the particles/molecules to become uniformly distributed/mixed.
* Movement of the particles/molecules will continue after they have become uniformly distributed/mixed, but there will be no further net movement.

Marek (1994) reported that some students thought that a substance diffuses through water because the water is semi-permeable (or selectively permeable); this would indicate that students are mis-applying a term they have heard in the context of diffusion across membranes and do not really understand what it means.

If students think that the particles/molecules of dye move only in one direction (from where they are in higher concentration to where they are in lower concentration), this would indicate a failure to understand the random movement of particles versus the concept of *net* movement. This misunderstanding highlights one of the difficulties in understanding the process of diffusion, i.e. that what happens on the particle scale is fundamentally different from what happens on the observable scale (Stains and Sevian, 2015).

**Acknowledgments**

Developed by Alistair Moore (UYSEG).

Images: pixabay.com/OpenClipart-Vectors (153171)

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