Investigating Osmosis in Chicken Eggs WIP

Keywords: egg, Hypertonic, Hypotonic, Osmosis

Meta Description

Learn how to change the size of an egg, making it either bigger or smaller, through simple kitchen chemistry!

Learning Objectives

To demonstrate and compare the effects of osmosis.

To understand how changing osmotic potential effects the net movement of water

Key Terms

Osmosis
Osmosis is the movement of water across a semipermeable membrane from a region of high solute concentration to a region of lower solute concentration.

Solute
The substance which has been dissolved into another substance (this second substance is known as the solvent e.g. water)

Membrane
A layer acting as a barrier against specific substances.

Semi-permeable
Selectively allows certain substances to pass while prohibiting the entrance of other substances.

Hypotonic
A solution with lower solute concentration when compared to another solution.

Hypertonic
A solution with higher solute concentration when compared to another solution.

Isotonic
When two solutions have equal solute concentrations.

Method

Step 1
Place the egg very gently into the base of the container. Make sure that the egg does not crack, if it does, replace the egg.

Step 2
Pour vinegar on top of the egg, making sure that the egg is fully submerged.

Step 3
Leave the egg in the vinegar for about 24 hours.

Step 4
If egg shell does not dissolve in 24 hours, replace the vinegar in the container with a new vinegar solution and leave for another 24 hours.

Step 5
When the shell has dissolved, remove the solution and carefully rinse the naked egg.

Step 6
Compare how a normal egg looks with how the naked egg looks.

Step 7
Place the naked egg back in the container.

Step 8
Submerge the naked egg with corn syrup.

Step 9
Bend a spoon and use it to hold down the egg in the container.

Step 10
Leave the naked egg in the corn syrup for a further 24 – 48 hours.

Step 11
Pour out the corn syrup and give the resultant shrivelled egg a rinse.

Step 12
Compare the resultant egg with a normal egg.

Step 13
Fill the container with water, add a few drops of food colouring and stir the solution.

Step 14
Place the shrivelled egg in the container and leave it for a few days (24-48 hours should do).

Step 15
Observe the new egg shape.

Alternative Method

Be creative in this experiment. Use other chemicals found in your kitchen such as coffee. Predict what will happen and after you conducted the experiment and check if your prediction was correct.

If you would rather eat your eggs instead of using them for this experiment, you can use fruits or vegetables instead. Potatoes work well.

Precautions

1. Use gloves and overalls when handling the food colouring, since it can easily stain.
2. Corn syrup can be very messy so make sure you have some tissues close by.
3. Some people are allergic to eggs. If you are one of them, do not worry, use a potato instead (or other vegetables/fruit). http://acaai.org/allergies/types/food-allergies/types-food-allergy/egg-allergy

Narrative

Imagine a large room which is divided into two areas by a wall, along the wall there is a row of tiny gates. In one half of the room there are 50 people and on the other side of the wall there are only 5 people. Among the people, there are cats, roughly the same number of cats on both sides of the rooms. While the humans are too large to pass through the tiny gates, the cats can easily pass through and are free to move to both areas of the room.

After some time it was noted that the number of cats increased dramatically in the area where there were more people. But why?

You are trying to grow a nice selection of lettuce in the garden, however, every morning you come out to water your beautiful plants just to see that they have been someone else's midnight snack. The culprit? Slugs! You have been told that putting salt around the plants can protect your lettuce, so just before bed you surround your plants with salt and go to bed. The next morning you find pristine lettuce, surrounded by shriveled up remains of slugs. All the moisture from the slugs has been drawn out of the slugs.

Questions

Why do we remove the eggshell?
To reveal the egg membrane.

Why does the egg expand in vinegar?
To reveal the egg membrane.

Why does the naked egg change shape in corn syrup?
Water moves out of the egg.

Why does the eggshell dissolve in the vinegar?
The acid in the vinegar reacts with the eggshell (calcium carbonate).

Why did the egg float when left for a couple of hours in the vinegar solution?
Carbon dioxide forms when the egg shell dissolves causing the egg to float.
https://www.exploratorium.edu/cooking/eggs/activity-naked.html

Brief Explanation

Over time, the eggshell dissolved after being placed in the vinegar. This occurs due to a reaction between acetic acid (vinegar) and calcium carbonate (eggshell) to produce carbon dioxide. The egg swelled because there was a higher concentration of water in the vinegar, compared to the inside of the egg. This causes a net movement of water into the egg through its outer, semi-permeable membrane. This is due to a process called osmosis.

When the egg was dipped in the corn syrup, the naked egg shriveled and decreased in size. This is again caused by osmosis, but in the reverse direction. The egg shrunk in size since there is a lower concentration in the water than in the corn syrup. This causes more water to move out of the egg, into the corn syrup through the semi-permeable membrane.

When the egg is placed in the water containing the colouring dye, the coloured water enters the egg, causing the egg to expand and colouring the egg. (same as with vinegar).
https://www.youtube.com/watch?v=SrON0nEEWmo

Detailed Explanation

Egg placed in vinegar (hypotonic solution)

The egg shell dissolves in the vinegar. This occurs since the egg shell is made of the compound calcium carbonate (base) which reacts with the acetic acid found in vinegar. The equation for the acid-base reaction is shown below :

$CaCO_3 (s) + CH_3COOH(l) \; Ca(CH_3COO)_2(aq) + CO_2(g) + H_2O(l)$

$CaCO_3$ = calcium carbonate (eggshell)
CH_3COOH = acetic acid (vinegar), pH
$Ca(CH_3COO)_2$= calcium acetate
H_2O = water
CO_2 = carbon dioxide

The production of carbon dioxide gas during this reaction is what causes the egg to float in the solution. The removal of the shell exposes the cell membrane. This membrane acts as a semi-permeable membrane, since it allows some particles to pass through depending on their size. In this case the particles which can pass through the membrane are water molecules.

The movement of molecules in a medium is totally random, however in diffusion (and osmosis) there is generally an overall movement of the number of molecules, we call this net movement. In what direction this net movement occurs depends on the relative concentration of the two solutions. With more water molecules moving from areas with a lower concentration of solute molecules (dissolved molecules) to areas with higher concentration, than in the reverse direction. The difference between these concentrations is called a concentration gradient. This is a passive process that does not require any energy, osmosis will happen until the concentration gradients are equal, and there is no net movement of molecules.

However, why does water move from a solution of high solute concentration to a solute of lower concentration? The answer is simple, by chance. Suppose, there is a solution having a high salt concentration and a solution with low salt concentration, divided by a semi-permeable membrane. Since the water molecules are not stationary but are in constant movement, they can migrate from one solution to the other after passing through the pores of the semi-permeable membrane. The solution with a higher solute concentration, has a greater number of salt molecules relative to the low solute concentration solution. These salt molecules are larger than the pores present in this semi-permeable membrane so they cannot pass through. However, they can interfere with the movement of the water molecules between the membranes. The greater the number of salt molecules, the lower the chance of the water molecules moving to the other side of the membrane. Hence, water molecules found in the solution of a lower salt concentration, have less resistance in flowing through to the other side of the membrane. This causes a net flow of water from the area with a low salt concentration to an area of high salt concentration, and this is what is known as osmosis.

http://www.madsci.org/posts/archives/2002-02/1014825690.Cb.r.html
https://www.khanacademy.org/science/biology/membranes-and-transport/diffusion-and-osmosis/v/osmosis

Egg placed in the corn syrup (hypertonic solution)

The corn syrup contains an overall lower concentration of water molecules compared to the inside of the egg. Therefore, there is a resultant net movement of water from the inside of the egg to the corn syrup solution until an equilibrium is reached with the sugar molecules outside of the egg.

Egg placed in the water containing the food colouring

The egg swelled when placed in the water. Since water molecules moved in the egg, the egg therefore takes up the colour of the food colouring. This proves that water is in fact moving in to the egg and is the cause of the swelling. The food colouring is also allowed through the semi-permeable membrane.

Applications and Research

Applications
The phenomena of osmosis is utilized for spaceflight applications to produce safe drinking water whilst in space. They use what is known as a Forward Osmosis Bag to turn the dirty water present into purified water using sugar and a semi-permeable membrane.
https://www.nasa.gov/mission_pages/station/research/experiments/846.html

Another interesting use of osmosis is for the generation of clean energy. This time a salinity gradient is used for the generation of electrical energy. The difference in pressure across the semi-permeable membrane allows for the generation of electrical energy.
http://dc.engconfintl.org/membrane_technology_vii/27/

Research
A very common use of osmosis is for seawater desalination. These use the concept of reverse osmosis to purify water which is very useful for islands since they are surrounded by seawater as in the case of the island, Malta. It must be noted that osmosis occurs naturally, however, reverse osmosis requires a high pressure to push water from a high salt concentration to a low concentration.
http://puretecwater.com/reverse-osmosis/what-is-reverse-osmosis

Investigation

- Try experimenting with different liquids present in the kitchen and observe their effects on the egg.
- Use different sodium chloride concentrations such as 0%, 10%, 20%, 30%…100%. Use a weighing balance to weigh the egg before placing in the saline solution and after. When there is no change in mass, then the solution is isotonic that is the concentration of solutes inside the egg is equal to the concentration of solutes outside the egg.
- Try varying the temperatures, to see if temperature has an effect on rate of osmosis. Be careful not to cook the egg though!

Subjects

Biology
Chemistry

Education

Primary
Secondary

Time Required

1 day or more
Preparation: 72-96 hours
Conducting: 30 minutes
Clean Up: 5 minutes

Cost

0 – 10 €

Recommended Age

6 – 9
10 – 12
13 – 16

Number of People

1 participant

Supervision

Required

Location

Indoors
Laboratory

Materials

Egg
Vinegar
Corn Syrup
Container
Spoon
Food Colouring
Apron
Gloves

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Sources

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Science fair ptoject-osmosis in eggs

Naked Eggs:Osmosis

Osmosis with an egg

The Sci Guys: Science at Home – SE1 – EP14: The Naked Egg and Osmosis

Egg Osmosis Hypertonic vs hypertonic solutions)

Osmosis

In da club- membranes and transport

Experiments with Eggs -TRAFFIC LIGHT Color Eggs

Additional Content

Blue Energy (Beginner)

Real-life Appliation Osmosis (Intermediate)
Where is reverse osmosis used? (Advanced)

Cite this Experiment

Aquilina, M. C., & Styles, C. (2019, October 30). Investigating Osmosis in Chicken Eggs. Retrieved from http://steamexperiments.com/experiment/investigating-osmosis-in-chicken-eggs/

First published: **October 30, 2019**
Last modified: **November 6, 2019**