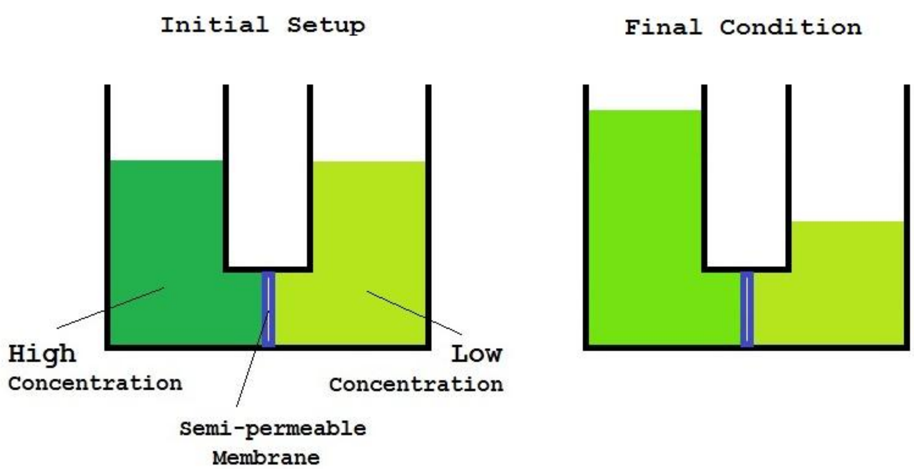
Reverse Osmosis

Whether it is a small filter under your sink or a massive desalination plant in the desert, reverse osmosis drives the purification of a lot of water systems.

You may have heard the term reverse osmosis before and knew it had something to do with filtering. But how exactly does it work? Let's start by talking about osmosis itself.

Most things in nature tend to move from a higher concentration to a lower concentration. If you put a tea bag in water, the tea will wind up diffusing through the water to equalize the concentration. This process is called diffusion. Nature normally wants to achieve an equilibrium so when you have high concentrations of a material in one area, the material will want to move to an area of low concentration. You can see this if you put a drop of food coloring in a glass of water. The color will diffuse throughout the water and not just stay in one place.

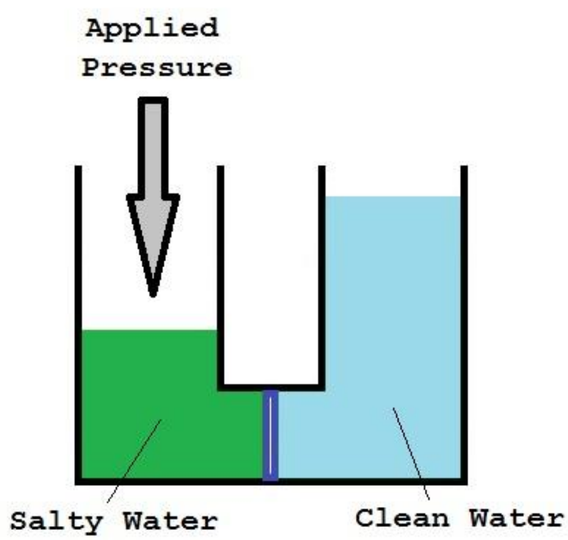
Osmosis is a type of diffusion, but we add a barrier between the high and low concentrations. This barrier is called a **semi-permeable membrane**. This membrane selectively allows some materials to pass while it blocks others. For osmosis, water can pass through this membrane, but other particles are stopped. Let's look at what this looks like:



In our initial setup, we have two columns of water. One column has a water solution with a high impurity concentration (like salt) and the other has a low concentration solution (maybe even pure water). They are separated by the semi-permeable membrane. If we allowed these two columns to mix, they would create one liquid with a uniform impurity content. But they are not mixing. The semi permeable membrane is allowing the water to move through, but the salt is not allowed to pass. Nature desires there to be some sort of equilibrium. So, if only the water can pass the membrane, how can this help equalize the concentrations?

If the water moves from the low concentration it will make that water more concentrated and if it moves into the high concentration, it will dilute the water there and make it less concentrated. And that is exactly what happens. Water from the low concentration side moves through the membrane to the higher concentration side. This is osmosis. When this system reaches equilibrium, the left column of water is at a higher level than the right side. Since water can pass through the permeable membrane, you might expect it to equalize back out to the same level on both sides. But we already established that the water won't move to the area of lower concentration. This means that there is a pressure at the membrane that is created because of this process that is allowing the columns to be at different heights. This is called **osmotic pressure** and is key to our reverse osmosis process.

Like many processes in nature, osmosis is reversible. If we use the above apparatus and apply a pressure to the high concentration side that exceeds the osmotic pressure, we will drive the water through the membrane and leave all the salt behind.



This is the reverse osmosis process. This can be used to filter water or even to make fresh water from seawater. Osmosis is a natural process that requires no energy. To reverse this, we must add energy to the system. As of 2013, the largest seawater reverse osmosis (SWRO) plant in the world was the Sorek plant located in Israel. It can produce 624,000 cubic meters of desalinated water per day (about 165 million gallons).