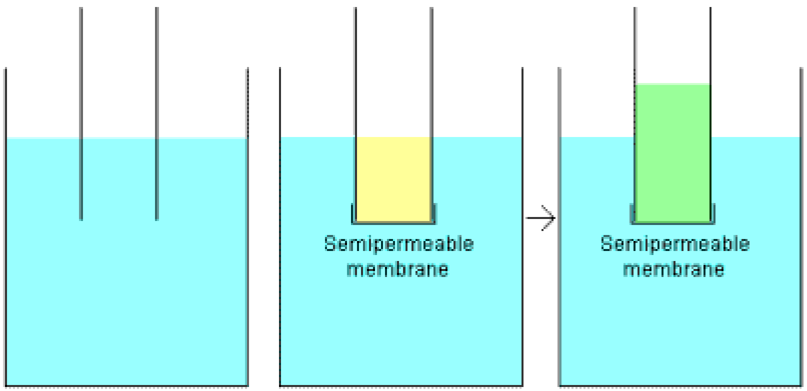
What's next? R/O

By Scott Berry

To understand "reverse osmosis," it is probably best to start with normal osmosis. According to Merriam-Webster's Collegiate Dictionary, osmosis is the "movement of a solvent through a semipermeable membrane into a solution of higher solute concentration that tends to equalize the concentrations of solute on the two sides of the membrane."



On the left is a beaker filled with water, and a tube has been half-submerged in the water. As you would expect, the water level in the tube is the same as the water level in the beaker. In the middle figure, the end of the tube has been sealed with a "semipermeable membrane" and the tube has been half-filled with a salty solution and submerged. Initially, the level of the salt solution and the water are equal, but over time, something unexpected happens -- the water in the tube actually rises. The rise is attributed to "osmotic pressure."

A semipermeable membrane is a membrane that will allow some molecules to pass through but not others. Plastic wrap is a membrane, but it is impermeable to almost everything we commonly throw at it. The best common example of a semipermeable membrane would be the lining of your intestines, or a cell wall. Gore-tex is another common semipermeable membrane. Gore-tex fabric contains an extremely thin plastic film into which billions of small pores have been cut. The pores are big enough to let water vapor through, but small enough to prevent liquid water from passing.

In the figure above, the membrane allows passage of water molecules but not salt molecules. One way to understand osmotic pressure would be to think of the water molecules on both sides of the membrane. They are in constant Brownian motion. On the salty side, some of the pores get plugged with salt atoms, but on the pure-water side that does not happen. Therefore, more water passes from the pure-water side to the salty side, as there are more pores on the pure-water side for the water molecules to pass through. The water on the salty side rises until one of two things occurs:

- The salt concentration becomes the same on both sides of the membrane (which isn't going to happen in this case since there is pure water on one side and salty water on the other).
- The water pressure rises as the height of the column of salty water rises, until it is equal to the osmotic pressure. At that point, osmosis will stop.

Osmosis, by the way, is why drinking salty water (like ocean water) will kill you. When you put salty water in your stomach, osmotic pressure begins drawing water out of your body to try to dilute the salt in your stomach. Eventually, you dehydrate and die.

Nature dislikes imbalance, and reverse osmosis takes advantage of this natural need. Osmosis is the movement of water across a semipermeable membrane from the side that is less concentrated, and more pure to the salty, more concentrated side. This continues until either the concentration is equal, or the pressure on the concentrated side becomes strong enough to stop the flow.

In *reverse* osmosis the process happens in reverse, due to the pressure of a high pressure pump. The pump applies a strong pressure to the concentrated side, forcing water molecules over to the pure side, and leaving the salt, minerals and other impurities to be removed as waste. While the percentage of feedwater to pure water is large, the process is very efficient in removing contaminants. The following chart reflects expectations:

Contaminant	% Removal Efficiency
Suspended Solids	100
Bacteria	99.5
Viruses	99.5
Pyogens	99.5
Organics	97-99.5
Monovalent Inorganics	94-96
Divalent Inorganics	96-98
Trivalent Inorganics	98-99

Because this process removes contaminants so efficiently, it is very cost effective for pre-purifying tap water, which is then purified again before use in other technologies. It removes a high percentage of bacteria and pyrogens, so it is often combined with the ion exchange to prolong the life of "polishing" cartridges in deionization systems. It also provides high quality pre-purified water which is suitable as-is for many routine laboratory purposes.