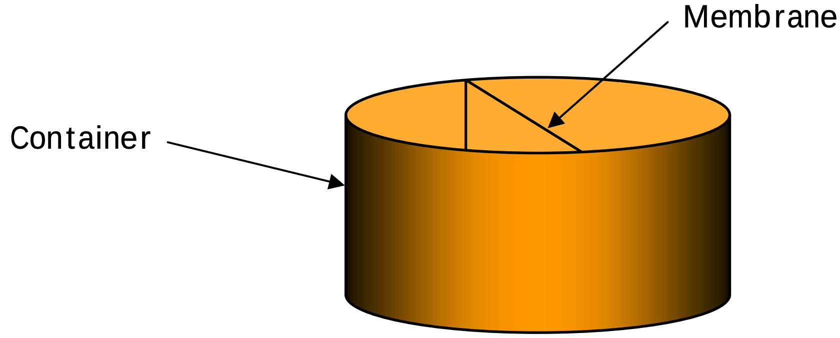
Osmosis

This article is a reply to an e-mail sent me by a student. The student asked that I explain *osmosis*. This particular essay contains no mathematics; but it does develop some definitions. Definitions are part and parcel of both physics and mathematics. Definitions must be clear and unambiguous in order to be useful. In constructing definitions, the ideas involved must often be taken apart and carefully sorted into bins. This essay uses a fairly straightforward example to demonstrate this process.

OK. Here goes:

Imagine a container divided by a membrane.



Now imagine filling the container with fluid (say, water) so that there is fluid on *both sides* of the membrane. Finally, imagine that the fluid on *one side* of the membrane has some solid material (say sugar or salt) *dissolved* in it while the fluid on the other side remains clear.

If the membrane was removed and the fluids in the two sides of the container were allowed to mix freely, the dissolved solid would eventually become *evenly distributed* throughout the container.

If the membrane is left in place, one of several things can happen. To begin, either the membrane *will* allow material to pass through itself or it *will not*. If it *will not* allow material to pass through itself, then the two fluids will remain separated. No mixing will occur.

Now suppose that the membrane *will* allow material to pass through itself. Three additional possibilities now appear:

1. The membrane will allow only the fluid (but not the dissolved solid) to pass through itself;
2. The membrane will allow only the dissolved solid (but not the fluid) to pass through itself;

3. The membrane will allow both the fluid and the dissolved solid to pass through itself.

The first possibility is called *osmosis*. Osmosis occurs in living cells as a means of controlling fluid flow into and out of the cell. If we use an *osmotic membrane* in our experiment above, then fluid will flow from the clear side of the container to the side containing the dissolved solid, dropping the level on the clear side, and raising the level on the side with the dissolved material. The original solution of dissolved material is thus diluted. Only the external application of pressure can stop this process from occurring. The *smallest pressure* needed to stop the process is called the *osmotic pressure*.

The second possibility is called *dialysis*, and is used in some complex medical procedures, particularly involving patients who have lost kidney function. Dialysis uses a *semipermeable* (*half permeable*) *membrane*, which actually allows materials to pass in both directions *but at unequal rates*. (The osmotic membrane described above is actually a semipermeable membrane also.) In the case of dialysis, there is a net flow of dissolved material into the clear fluid, equalizing the concentration of dissolved material on both sides. The level of the side originally containing the dissolved material drops while the level that was originally clear rises. Again, the original solution is diluted.

The third possibility is called *permeability*, and the membrane is called a *permeable membrane*. The effect is much the same as if no membrane were present, but equalization of the two sides is apt to take longer.

I can demonstrate osmosis with *dye* dissolved in *water*. When I place a flower with a cut stem into the dye-water, the dye will pass from the water into the stem and be carried (by osmotic pressure from cell to cell) up the plant stem and into the flower petals. Eventually I will be able to see the veins in the flower because they have become full of dye. You might be interested in trying this experiment at home. Just please be careful when handling the materials.