

# Connecting Biology to Life ● Diffusion and Osmosis

## ● Do Fish Drink Water?



The coral is an osmoconformer, while the grouper is an osmoregulator.

### ● A Fish Walks into a Bar...

Everyone knows that fish live in water, but do they ever actually drink the stuff? “Do fish drink water?” might sound like a trick question (or even the start of a joke), but the answer actually tells us a great deal about **osmosis** and how it works to help some animals survive in their environments. Let’s investigate the answer to this surprisingly scientific question.

### ● Some Conform, Others Don’t

Invertebrate animals (those without backbones) living in the salty seawater of oceans are generally **osmoconformers**. This means that the concentration of solutes (including salts, sugars, and other dissolved molecules) in their cells is the same as the concentration of solutes in seawater. Since seawater is **isotonic** to their cells, invertebrates do not need to gain or lose water.

Most aquatic vertebrate animals are **osmoregulators**, meaning that their cells contain a concentration of solutes that is different than the water around them. The internal systems of osmoregulators work to regulate their internal water levels.

Fish have a concentration of solutes in their cells that is less than that of seawater, but greater than that of freshwater. (See the measured quantities of these concentrations in the chart on the left.)

SOLUTE CONCENTRATIONS IN UNITS OF mOsm/L	
SUBSTANCE	mOsm/L
freshwater lakes and ponds	20 to 40
cells and blood of most vertebrates	300
seawater oceans	1000 or more

“mOsm/L” is for “milliOsmoles per Liter,” the unit of measurement scientists use to measure the concentration of solutes.

The solute concentration levels of most vertebrates fall in between the levels of freshwater and seawater.

**Aquatic invertebrates:** osmoconformers living in an isotonic environment

**Freshwater fish:** osmoregulators living in a hypotonic environment

**Seawater fish:** osmoregulators living in hypertonic environment

### ● Osmosis Occurs in the Gills

Water doesn’t move easily through a fish’s skin (like it can through a cell membrane), but it can move through the linings of the fish’s gills with great ease. A fish’s gills must be extremely permeable so that oxygen from the water can enter the capillaries in the gills and provide the fish with oxygen.

When saltwater (from the ocean) flows over the gills of a fish, the water is **hypertonic** to the blood in the capillaries in the gills, causing water to move out of the gill tissue where it is lost. This means that saltwater fish are constantly losing water out of their bloodstream through osmosis.

When fresh water (from lakes and streams) flows over the gills of a fish, the water is **hypotonic** to the blood in the capillaries in the gills, causing water to move into the gill tissue. This means that freshwater fish are constantly gaining water into their bloodstream through osmosis.

### ● Science Review Column

**osmoconformer** An organism that regulates water loss and gain by maintaining the solute concentration of its body fluids at the solute concentration of its environment.

**osmoregulator** An organism that regulates water loss and gain by maintaining the solute concentration of its body fluids within a narrow range that differs from that of its environment.

**diffusion** Passive transport (occurring spontaneously without input of energy) in which a particle (the solute) is dissolved in a gas or liquid (the solvent) and moves from an area of higher solute concentration to an area of lower solute concentration.

**osmosis** A type of passive transport in which water diffuses across a membrane in order to equalize the concentration of water inside and outside the cell. The direction of osmosis is determined by the total amount of solutes on either side of the membrane. Water will always move toward the side that has a greater concentration of solutes.

**solute** A substance (like salt) that is dissolved in the solvent (like water).

**tonicity** For a cell in solution, a measure of the concentration of solutes outside the cell relative to that inside the cell.

**isotonic** Solutions with equal concentrations of solutes.

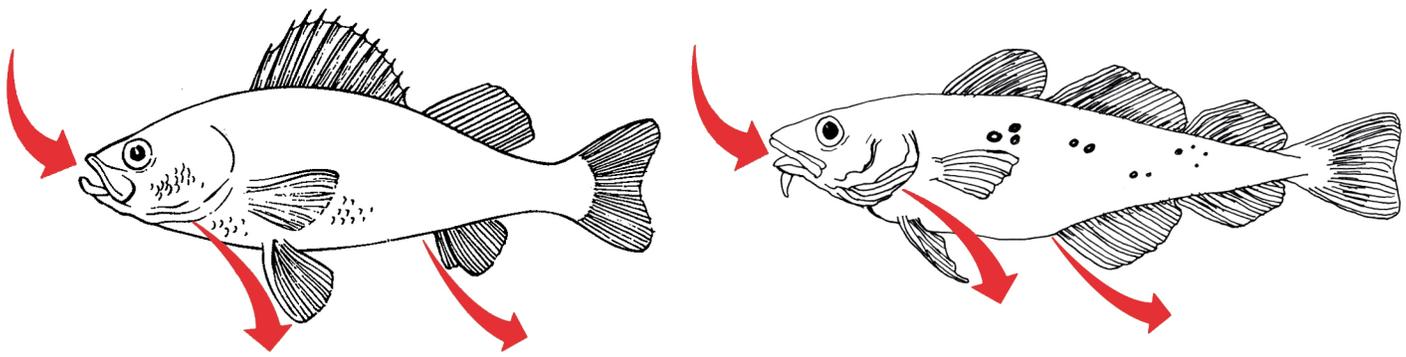
**hypertonic** Of two solutions, the one with a higher concentration of solutes.

**hypotonic** Of two solutions, that with a lower concentration of solutes.

## ● **The Loss and Gain of Water by Osmosis in Fish Is Dealt with by Osmoregulation**

To counter the effects of osmosis in their gills, both freshwater and seawater fish have to undergo osmoregulation, but since the results of osmosis are opposite on them, so too must be the type of osmoregulation in which freshwater and seawater fish engage.

The figure below shows all of these key differences occurring between freshwater and seawater fish. We have already discussed the different effects of osmosis at the gills of fish. Now we need to look at what is coming in through their mouths and at what each is excreting.



**A Tale of Two Fishes: Freshwater and seawater fish are both osmoregulators, but for two different reasons and with two different responses.**

## ● **Water Enters the Mouth, but then What?**

Both freshwater and seawater fish have water coming into their mouths, but what they do next gives us the two answers to our question, “Do Fish Drink Water?”

Freshwater fish have water coming in through the mouth but since it is hypotonic compared to their tissues, all of that water is directed over the gills and out through the gill covers. Freshwater fish don’t drink water. But since the water coming into the mouths of saltwater fish is hypertonic, they send some of it down through their digestive tract, the same way humans drink (and the rest goes over the gills). Seawater fish do drink water.

## ● **Two Different Endings**

We have the answers to our question, but the story isn’t quite over. The differences between freshwater and seawater fish include their very different types of excretion. Since water moves into a freshwater fish’s bloodstream through the gills, the fish must excrete large amounts of urine. This urine is highly diluted (in the same way that your urine will be clear if you drink more water than your system requires). Since water moves out of the seawater fish’s bloodstream through the gills, the fish excretes very little urine. But this urine is very concentrated with lots of wastes and dissolved salts (in the same way that your urine is dark when you get dehydrated).