**How Desalination Works**

Reducing salt water to its basic elements -- salt and water -- is so simple that it's become a science lesson for first-graders. In fact, a "solar still" can turn salt water into fresh water in just a few days. Simply fill a large bowl with salt water and set an empty glass at the center. Then cover the bowl -- empty glass and all -- with plastic wrap that has a small hole poked in the middle. Place the contraption in direct sunlight, and watch the water cycle at work: The salt water evaporates, leaves salt crystals behind, and creates condensation that rises, gathers on the plastic membrane and drips into the empty glass. The resulting fresh water is good enough to drink [source: [Williams](http://www.education.com/activity/article/Take_salt_out_of_salt_water/)].

But why remove salt in the first place? Turns out, drinking salt water can kill you. Ingesting salt signals your [cells](http://science.howstuffworks.com/life/cellular-microscopic/cell.htm) to flush water molecules to dilute the mineral. Too much salt, and this process can cause a really bad chain reaction: Your cells will be depleted of moisture, your kidneys will shut down and your [brain](http://health.howstuffworks.com/brain.htm) will become damaged. The only way to offset this internal chaos is to urinate with greater frequency to expel all that salt, a remedy that could work only if you have access to lots of fresh drinking water [source: [Thompson](http://www.livescience.com/mysteries/071217-salt-water.html)].

People -- especially those in water-starved parts of the world -- have been searching for fresh water solutions for centuries. Turns out the same folks who built giant sphinxes and drove horse-drawn chariots also thirsted for clean, pure water [source: [Jesperson](http://www.nesc.wvu.edu/old_website/ndwc/ndwc_DWH_1.html)]. Even in modern times, entire populations struggle with a cruel irony; they are surrounded by salt water, but lack drinking water. The scarcity sometimes spurs deadly conflicts. In 2009, onlookers killed a family in drought-ridden India for collecting water from a municipal well before it ran dry [source: [Pacific Institute](http://www.worldwater.org/conflict/list/)].

But what if an abundant supply of fresh water could be created from salt water? A large-scale desalination operation -- using principles similar to a simple classroom project -- could change the world. On the next page, we'll explore why it's not always so easy to turn salt water into drinking water.

**Desalination at Work**

There's more than one way to separate [salt](http://science.howstuffworks.com/innovation/edible-innovations/salt.htm) from [water](http://science.howstuffworks.com/environmental/earth/geophysics/h2o.htm), but nearly 90 percent of the time, only one of two methods are used: multistage flash and reverse osmosis [source: [WorldPumps.com](http://www.worldpumps.com/view/924/focus-on-sea-water-desalination)].

Remember why it's so bad to drink salt water? When your cells pass water through the outer membrane to keep you from dehydrating, osmosis is occurring. By moving the water through the membrane, the [cell](http://science.howstuffworks.com/life/cellular-microscopic/cell.htm) is attempting to equalize its high internal salt concentration with a low external salt concentration. That's called osmosis. **Reverse osmosis** occurs when, for example, you put salt water on one side of a semi-permeable membrane and pressure moves the water molecules through the filtering membrane as the larger molecules -- including salt molecules -- stay trapped behind. For salty sea or ocean water, a considerable amount of pressure is required to move the water through a filter, where each pore is just a fraction of the size of a human hair [source: [American Chemical Society](http://portal.acs.org/portal/acs/corg/content?_nfpb)]. This means a series of pumps are usually in play, all exerting pressure on the water [source: [WorldPumps.com](http://www.worldpumps.com/view/924/focus-on-sea-water-desalination)].

Unlike reverse osmosis, which relies on a membrane to filter out salt molecules, the **multistage flash** method uses heat to convert salt water into fresh water. Why such an unusual name? "Flash" refers to rapidly bringing the water to a boil, and this happens multiple times, or in stages. As the salt water enters each stage of the conversion unit, it is subjected to externally supplied steam heat and pressure. During each stage, water vapor forms and is collected. This water vapor is fresh water and the left-behind salty concentrate is known as brine. In multistage flash distillation -- as with reverse osmosis -- chemicals or water softening agents are not usually added [source: [Organization of American States](http://www.oas.org/DSD/publications/Unit/oea59e/ch21.htm)].

So if desalination is possible, why aren't large-scale plants quenching the world's thirst for fresh water? Only about 15 billion gallons -- two-tenths of a percent of the fresh water consumed around the globe each day -- is desalinated salt water [source: [Schirber](http://www.livescience.com/environment/070625_desalination_membranes.html)]. On the next page, we'll explore where the newest generation of salty water converters are cropping up.

**Water Solutions**

[Water](http://science.howstuffworks.com/environmental/earth/geophysics/h2o.htm) covers at least 70 percent of the world's surface. But 97 percent of it is too salty to drink [source: [Frederick](http://www.gcrio.org/CONSEQUENCES/spring95/Water.html)]. This, coupled with inequalities in water distribution and geographic availability, means water scarcity is a reality for many people. In fact, a lack of water affects four out of 10 people in the world [source: [World Health Organization](http://www.who.int/water_sanitation_health/decade2005_2015/en/index.html)]. There can be serious health consequences from not having enough water. Sometimes it means people get their water from contaminated sources. Poor-quality water can spread diseases like cholera, typhoid fever or salmonella [source: [World Health Organization](http://www.who.int/water_sanitation_health/wwd7_water_scarcity_final_rev_1.pdf)].

Turning brackish or [salty](http://science.howstuffworks.com/innovation/edible-innovations/salt.htm) water into fresh water could impact both the meager rations of water and the ever-increasing demand. This is especially true for some coastal communities in the United States struggling with a fresh water shortage [source: [California Ocean Resources Program](http://resources.ca.gov/ocean/97Agenda/Chap5Desal.html)]. In addition, desalination plants can provide a reliable water source even when a drought is afoot.

In 2009, there were more than 1,400 desalination plants operating in the world, producing more than 15 billion gallons of water per day. Another 244 plants are under construction, many of them in the Middle East [source: [International Desalination Association](http://science.howstuffworks.com/environmental/earth/oceanography/desalination4.htm)]. However, the world's largest [reverse osmosis](http://science.howstuffworks.com/reverse-osmosis.htm) desalination plant, which opened May 2010, is located on the Mediterranean coast of Israel [source: [Dow](http://news.dow.com/dow_news/prodbus/2010/20100622a.htm)]. And, construction is underway in Carlsbad, Calif., to create the Western hemisphere's largest desalination plant, estimated to produce 50 million gallons of drinking water every day [source: [Poseidon](http://www.carlsbad-desal.com/)].

Still, there's often a public perception that desalinated water doesn't taste good and isn't good for you. In Israel, for example, many people are increasingly reluctant to drink desalinated tap water because of health concerns [source: [Mizroch](http://www.jpost.com/Home/Article.aspx?id)]. But desalinated water -- straight from the tap -- is generally safe to drink. A study in Saudi Arabia, for example, found no significant differences between desalinated water served on tap and bottled water -- except for the fact that desalinated tap water doesn't leave empty plastic bottles behind [source: [Ahmad](http://www.springerlink.com/content/e17638g87182326k/)].

But what if it were possible to carry a portable desalination device to produce your own personal supply of fresh drinking water? The idea may not be as far-fetched as you think

**Future of Desalination**

As the number of desalination plants worldwide continue to grow, so do concerns about developing new technology to power the plants. Currently, large-scale desalination efforts require a lot of energy to operate and often are high-maintenance affairs, thanks to lots of working parts like membranes that tend to foul frequently [source: [Schirber](http://www.livescience.com/environment/070625_desalination_membranes.html)].

Costs are another concern: During the past five decades, public and private investment in developing desalination technology has reached more than a billion [dollars](http://money.howstuffworks.com/currency.htm) worldwide. And even with the progress that's been made, the idea that desalination would do away with water scarcity is far from reality. And that's because it's still really, really expensive to plan, build and manage desalination plants [source: [Water Science and Technology Board](http://www.nap.edu/openbook.php?record_id)]. In fact, the average cost to turn one acre-foot -- about 325,000 gallons -- of salt water into fresh [water](http://science.howstuffworks.com/environmental/earth/geophysics/h2o.htm) ranges from $800 to $1,400 and requires a significant amount of energy [source: [American Chemical Society](http://portal.acs.org/portal/acs/corg/content?_nfpb)].

Producing fresh water using reverse osmosis costs about one-third less than multistage flash, largely because of the costs of the thermal energy used by the latter method in the boiling process [source: [Water Science and Technology Board](http://www.nap.edu/openbook.php?record_id)]. Unfortunately, both processes -- as with all desalination techniques -- create brine. This by-product of desalinated water contains high concentrations of salt and, when released back into a natural body of water, can cause damage to marine life. That's because brine, which is usually denser than the water into which it's released, settles atop low-lying sediment where it depletes surrounding waters of oxygen [source: [University of Texas at Austin](http://www.ce.utexas.edu/prof/hodges/site2006/project_pages/project_desalination_brine.htm)].

These cost and environmental concerns are all part-and-parcel of the next round of improvements in desalination technology and processes. Light-weight portable desalination devices are being developed by researchers in Korea and at the Massachusetts Institute of Technology. The units produce enough fresh water to support several people. The process uses gravity -- simply pour saltwater into the top of the device -- to remove salt and other sediments using 1,600 filters [source: [MIT](http://www.sciencedaily.com/releases/2010/03/100323161505.htm)].

Like these solar-powered portable units, large-scale reverse osmosis plants, although still in the planning stages, could also greatly decrease desalination plants' reliance on fossil fuels. In fact, the National Science Foundation granted $2.5 million to a team of experts at the University of Michigan studying solar energy's impact on desalination technology [source: [Richard](http://www.treehugger.com/files/2008/06/water-desalination-ottawa-student.php)]. In addition to government funding in the United States and abroad, private funding sources are beginning to pay attention to developing more efficient desalination efforts. One thing is certain: If the desalination process improves, it could have the potential to change entire water-poor regions for the better.