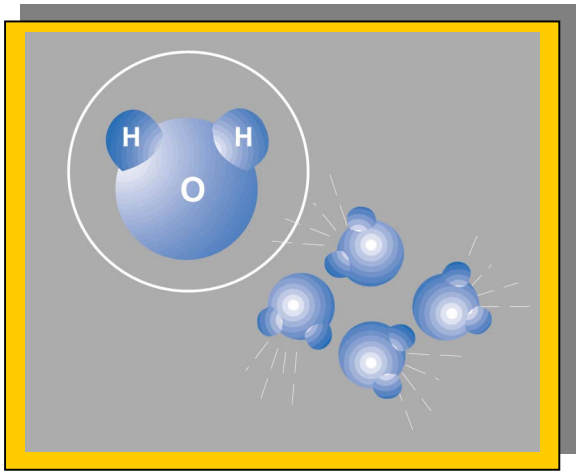
Dynamic Design: The Cleanroom

Terrific Tension

STUDENT TEXT



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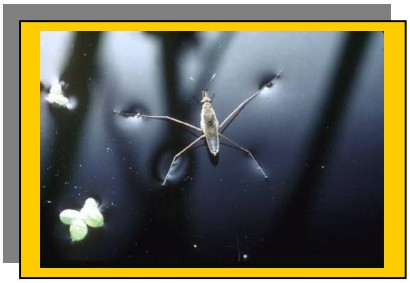
In the cleanroom at Johnson Space Center, a large amount of time is spent cleaning component parts for the assembly of the spacecraft. In the Student Text, “The Cleaning Room” you read about the procedure that scientists use to clean these parts and why assembling the payload in a clean environment is important. Surface tension affects how things get cleaned. In this text you will learn about surface tension in water, and some organisms that interact with this surface tension. You will also find out how soap and detergent work to break surface tension on things that we clean everyday.

Water molecules are made up of one oxygen atom that bonds with two hydrogen atoms. In water near the surface, molecules are engaged in a tug of war with their neighbors on every side. The molecules are pulled from every direction resulting in no net force at all. At the surface however, there is very little up pull for every down pull since there is no liquid above the surface. The surface molecules therefore tend to be pulled back into the liquid. This is what causes surface tension. Surface tension can be seen when one blows a bubble; the surface of the liquid gets stretched. The “stretchy outer skin” of a liquid is called surface tension. Surface tension is the “skin” on the surface of water caused by water molecules being very close together.

You have probably heard the saying that oil and water do not mix. Oil and water do not dissolve in each other. If oil and water were put into the same container, stirred and left alone, two layers would form. Which would be at the top? You have probably heard of giant oil spills in the ocean that do terrible harm to our environment. But some organisms secrete small amounts of oil in order to survive on or in the water.



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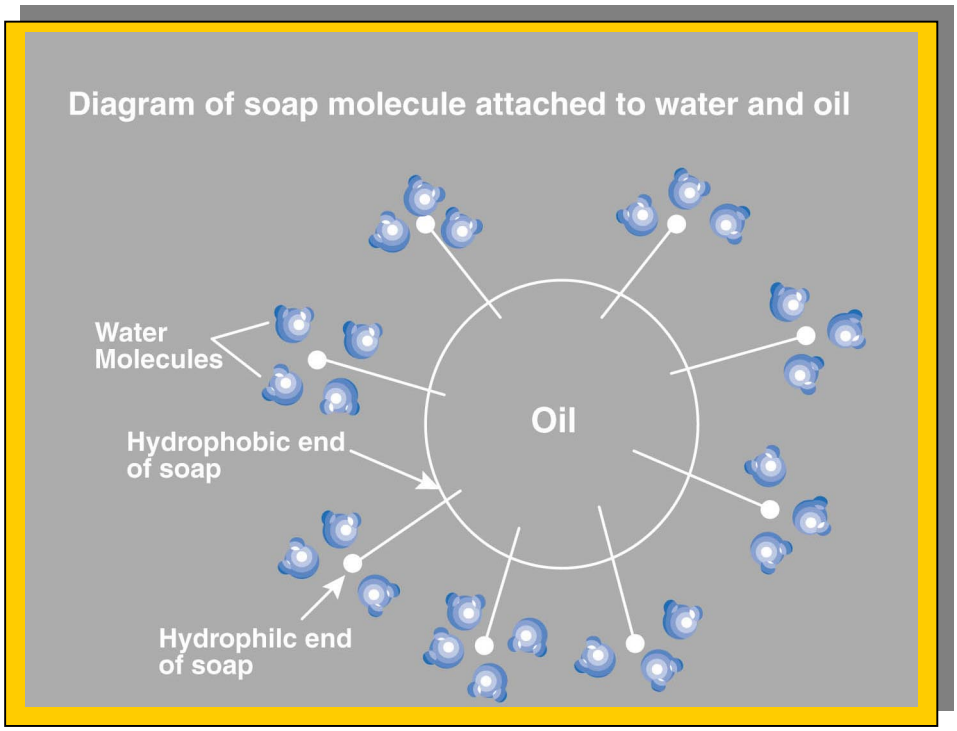
In the wetland environment, surface tension is helpful to some organisms and harmful to others. Surface tension is the force that draws water into the pores of the soil and is also the force that conducts water through plants. Several animals make use of the surface tension in water for transportation. The most famous is an insect called the water strider. These insects have long legs that allow them to hunt prey on the surface of water. The foot segments of waterstriders have oil glands that repel water. Waterstriders have been found hundreds of miles from land in areas containing large amounts of seaweed. Surface tension on water has substantial force. The lightweight water strider probably could not break through the surface of the water even if it wanted to. Other less well known insects can walk upon the water as well. These water walkers include the water measurer, the water springtail, and numerous flies. Walking on water is not restricted to insects. In fact a water shrew, which is the size of a small mouse, can run across small ponds. Surface tension can be a problem for insects that live under the water and need to breathe air. The young of mosquitos called wrigglers rise to the surface to get air through breathing tubes. These tubes have hydrophobic (water hating) hairs that are greasy. These hairs repel the water molecules on the surface and allow the breathing tubes to break the surface tension. What consequences would polluting the water with soaps and detergents have on the animals mentioned in this paragraph?

Soap is formed from a chemical reaction between sodium hydroxide (NaOH) and fat. A soap molecule is a long chain of carbon atoms with hydrogen atoms bonded to each one. A sodium or potassium is attached to one end of the chain. The formula for sodium stearate soap is $CH_3 (CH_2)_{16}CO_2^-Na^+$. How do soap molecules reduce the surface tension in water? In a soap-and-water solution the hydrophobic ends of the soap molecule do not want to be in the water at all. Soap molecules that find their way to the surface squeeze between the surface water molecules, pushing their hydrophobic ends out of the water. This separates the water molecules from each other. Since the surface tension forces become

smaller as the distance between water molecules increases, the soap molecules that squeeze through decrease the surface tension. Think of what happened when you put soap on the water containing pepper. To what extent did your results with soap vary from the results with detergent?



Detergents are synthetic household chemicals that have a cleansing action similar to soap. Unlike soap, which is made from natural fats, detergents are made from petroleum. Phosphates, which were once used in detergents, are now restricted or banned in many areas because they cause water pollution. Detergents have replaced soaps in cleaning laundry and dishes since they work in both hard and soft water. Unlike soap, detergents do not produce soap scum that makes clothes look gray. An example of a detergent is sodium lauryl sulfate, which has the chemical formula of $Na^{+}CH_3 (CH_2)_{11}OSO_3^{-}$. Liquid detergent is used in the cleanroom at Johnson Space Center to clean component parts. Think of some commercials for different liquid detergents. What claims do these ads make?

Water molecules are polar, which means that one side is more positively charged than another part, which is relatively negatively-charged. Oils and fats are non-polar or neutrally charged molecules. Soap and detergent molecules are composed of long chains of carbon and hydrogen atoms. At one end of the chain is an arrangement of hydrophilic (water loving) atoms. The other end is hydrophobic but attaches easily to grease. Soap and detergent work to suspend oils and fats in water. The soap or detergent molecule forms a connection between the charged water molecules and the neutral grease molecules. The end of the soap molecule that is charged mixes with water. The other end that is not charged has a shape that easily mixes with grease. When one washes dishes, the "greasy" end of the soap or detergent molecule attaches itself to the grease on your dirty plate, letting water seep in underneath. The particle of grease is pulled loose and surrounded by soap molecules, all of which are then carried off by water when rinsed.

Since the amount and size of the solar wind samples to be collected on the Genesis spacecraft are so very small, even the smallest amount of contamination can threaten the results of the mission. The actions of detergent together with ultra pure hot water and the use of friction allow the tools and components to be cleaned so as not to cause contamination on the collector wafers. This attention to detail in the cleanroom prior to launch will result in a sample return of solar wind that will be a national treasure for many years.