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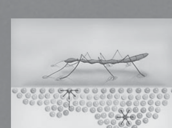
Surface Tension Meaning and Practical Applications

Surface tension is a physical phenomenon that we observe in our daily life. Raindrops take a spherical shape. 'tears of wine' are seen in a glass on pouring an alcoholic beverage in it, formation of spherical soap bubbles - all these are examples of surface tension. Read this Buzzle article for a better understanding of this phenomenon.

Surface tension in water arises from high interactions between water molecules, known as hydrogen bonding. As the value of surface tension of water is high, water has a high boiling point.

The force of attraction between like molecules in a liquid lends it a tendency to contract at the surface. Hence, the surface is said to be under 'tension'. Surface tension is the property of a liquid surface to resist external force. It is the reason why the surface of a water body looks like a stretched membrane. Surface tension causes 'capillary action', due to which water travels through the stems of plants, and blood flows through the small vessels in our body. Following are the basic concepts about molecular forces that we need to know before understanding surface tension.



Water striders can walk on water because of the surface tension of water.

? Cohesive forces are intermolecular

forces between similar molecules. For example, the force of attraction between two water molecules is cohesion.

? Adhesive forces are intermolecular forces between dissimilar molecules. The force of attraction between a water molecule and air is adhesion.

? Range of molecular forces is the maximum distance up to which intermolecular forces are effective.

? A sphere drawn with the molecule as the center and the range of molecular forces as the radius is known as the sphere of influence.

? Surface film is the layer of surface of liquid whose thickness is equal to the range of molecular forces of attraction of the molecules at the surface.

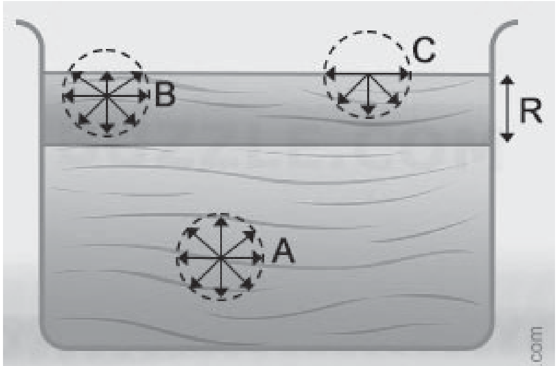
Forces acting on water molecules

What is Surface Tension?

Consider the molecules A, B, C of a liquid (let us say, water) as shown in the adjoining figure. Molecule A is well inside the water, B is at the surface film (R), and C is on the surface. The sphere of influence of molecule A is totally inside the liquid. Hence, it is acted upon with an equal and opposite cohesive force from the remaining molecules. Therefore, the net force acting on molecule A is zero.

A part of the sphere of influence of molecule B is above the surface of the water. Hence, adhesive forces from air molecules act on molecule B. Due to this, the cohesive forces from molecules below and around B pull it down. Thus, the net unbalanced downward resultant cohesive forces pull molecule B down in the water.

Half of the sphere of influence of



Forces acting on water molecules

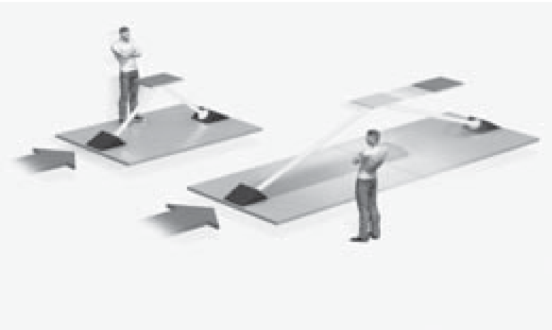
molecule C lies in the water, while the other half is in the air. The cohesive forces act against the adhesive forces, and C is pulled inside due to the resultant unbalanced cohesive force.

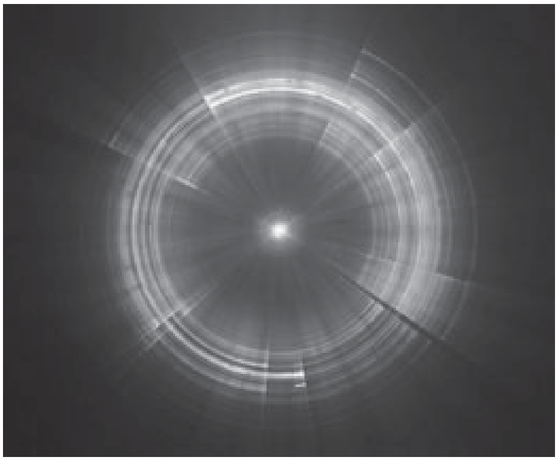
Due to these cohesive forces, the surface area of the liquid reduces. Thus, surface tension can also be defined as the force per unit area necessary to expand the surface of a liquid.

Practical Applications

Apart from mercury, water has the greatest surface tension of any liquid. Let us take a look at some examples of surface tension of water.

? Water striders are insects that can walk on the surface of water because of surface





tension of water

? Mosquito eggs can float on water because of its surface tension. Kerosene is sprayed on water so that the mosquito eggs sink and the breeding stops.

? Warm water is used for washing purpose as heating increases the surface area and reduces surface tension. This action is replicated by adding detergents to cold water.

? A needle placed on water can be made to float due to the surface tension of water. If the surface is ruffled, the needle will quickly sink.

Other Examples of Surface Tension

? The test for jaundice involves the use of surface tension properties. Sulfur powder is sprinkled on the urine sample. If it does not contain bile, the sulfur powder floats due to surface tension. If bile is present in the sample, the surface tension of urine reduces and the sulfur powder sinks.

? Toothpaste contains soap, which reduces the surface tension and helps it spread freely in the mouth.

? Disinfectants have low surface tension, which allow them to spread through cell walls of bacteria.

Surface Tension of Some Liquids

Liquid Surface tension

(N/m)

Water at 20°C 0.0727

Soapy water(typical) 0.0370

Mercury at 20°C 0.4355

Tissue fluids (typical) 0.050

Glycerin 0.0631

Thus, surface tension is an essential physical phenomenon. As mentioned earlier in this Buzzle article, it has various day-to-day practical applications.

Read more at Buzzle: http://www.buzzle.com/articles/surface-tension-meaning-and-practical-applications.html

Does the Fourth Dimension of Time Exist?

Time is the fourth dimension, other than the three dimensions of space. Time makes change possible or else we would be living in a static universe. Let us explore what we mean by time and how Einstein's special relativity dealt the fatal blow to absolute time of Newtonian mechanics.

The time has come for you to question the very nature of time. Can time be considered to be a fundamental physical dimension, on par with the space dimensions? If it is indeed so, then why can't we travel back and forth in time, just as we move through the space dimensions? Let's find out.

What is Time?

Time is our way of keeping track of changes that are constantly happening in the universe. Time arises due to the dynamic nature of the universe or one could say, that the dynamism is possible, because there is time.

In a way (without implying any creationist overtones), you could say that time must have been invented, so that all things do not happen at the same moment and space was made, so that all things do not happen at the same position! By time, we mean a series of changes or events that occur. Those events that happen periodically, like the rising and setting of the Sun, the rotation and revolution of the Earth, around the Sun are used as references to calibrate and measure time. Our clocks are synchronized with these periodically repeating events to keep track of time. So in a way, time is felt or

understood, only as a result of changes in the material world we perceive. To put it simply, time is change.

What Does a Dimension Mean?

A dimension is a degree of freedom of a system. In simple words, it is the number of ways or directions in which change can take place in a system. Let us understand what do we mean by the dimension of our universe, our world. Imagine an ant walking on a very thin thread. The width of the thread is such that it can either move forward or backward on the thread, it cannot move sideways. That is, its freedom of movement is restricted to one dimension. It has one degree of freedom and therefore one dimension. Similarly, an ant moving on a flat disk can move straight or sideways but not up and down, so its degrees of freedom is two. Hence it's moving on a two dimensional object.

Now imagine a flying ant like 'atom ant', it can move straight ahead or back, sideways, as well as up and down. Its degree of freedom is three, so it's moving as we all do in three space dimensions because the degrees of freedom are three.

How is Time the Fourth Dimension?

Now ask yourself, how would movement in all these dimensions be possible, if there was no concept of time? You will find that dynamism in space would not be possible if there was no time. When all of those ants were moving, they moved in time too. So the ant on the thread had not one, but two degrees of freedom. One was space and the other is time. That is, it was moving in two dimensions. Similarly in this world, we move in three space dimensions plus one time dimension.

However, time as a dimension is unique and different from other space dimensions. In space dimension, you can move ahead and backwards, there is no restriction on that. Conversely, in time, you can only move in one direction. In time, you cannot move backwards, only forward. This has far reaching implications which we will discuss further, but first let us understand how Einstein's special relativity theory changed our perceptions of space and time.

Einstein and the Unification of Space Time

In 1905, a Swiss patent clerk, Albert Einstein put forth a theory called special relativity which dealt the fatal blow to the old established bastion of Newtonian mechanics, which had the perception of an 'absolute time'. The theory revolutionized the way we see nature and the universe.

The basic postulate of special relativity is that no information can travel faster than the velocity of light in vacuum and it is constant. The second postulate is that all laws of the physical world should remain the same in any inertial reference frame. By inertial reference frame, we mean a co-ordinate system of reference moving at a constant velocity or which is stationary. Any other co-ordinate system moving with constant velocity with respect to a co-ordinate system at rest is also an inertial reference frame.

Newton's mechanics had the concept of absolute time. That is, no matter which reference frame people are using, their clocks if compared show the same time. Special relativity changed this perception. The necessity that the speed of light should be constant forces us to abandon the absoluteness of time! That is, different

observers in different reference frames show different times in their watches, but the laws of physics will remain the same. In fact the faster you move in space, the slower you move in time. This is often termed as time dilation. Time is not absolute, it is relative.

This forced the world to abandon the concept of separate ideas of space and time and a single unified concept of spacetime came into existence. Some found it in Einstein's name itself. 'Ein' means 'one' in German. Split up his name as ' EIN+ST+EIN', ST meaning space time. If you see, it literally means 'one space time'; just a lucky coincidence one would say! Time was realized as the 4th dimension.

Let us try to understand what time dilation is. We are all continuously moving not just in three dimensional space but in four dimensional spacetime. Consider a racing car moving on an absolutely straight race track at a constant velocity. It is moving in one dimension and takes some time to reach the finish line. Now consider that it's trying to reach the finish line, but on an oblique path. Its velocity is now distributed over two dimensions and therefore it's taking longer for the car to cover the same distance. Its velocity in the original one dimension has reduced.

In a similar way, all objects in the real world are moving in a four dimensional spacetime, at a constant velocity as that of light. Sounds astounding but it's true. Only the velocity is distributed over dimensions and most of it is in the time dimension.

When the objects are at rest, they are moving only in the time dimension. Now when they start moving, their velocity increases in the three space dimensions, and therefore it slows down in the time dimension. Therefore, the faster you move in the three space dimensions, the slower

you go in the time dimension. This causes time dilation. This is a bit difficult to understand, but if you give it adequate time to sink in, it's simple.

The Arrow of Time

The uniqueness of time dimension is that you can travel only forward in it, not backward. This fact has profound implications. It protects causality, that is the law of cause and effect. That is, cause should precede effect and it should not be the other way round. This irreversibility of time is inbuilt through the concept of entropy.

If you study thermodynamics, you will come across the law that entropy or disorder in the universe always increases, never can it decrease. You can understand the law of entropy, by just observing the irreversible nature of natural phenomena. That is, a cup falling down and breaking, can never be restored to the same condition, with every atom in place, as it was. The irreversibility implied by entropy could be described by the popular line from the Humpty Dumpty nursery rhyme, which says: All the King's horses and all the King's men, couldn't put Humpty together again! For every system, disorder always increases. Entropy increase is unidirectional, just as the unidirectionality of time. Thus it is no coincidence that the thermodynamical arrow of time and the arrow of time flow, point in the same direction, as they both preserve causality. As a consequence, traveling back in time impossible, as it would violate causality and the law of entropy. However, special relativity does allow for the possibility of time travel to the future.

Creatures living in a two dimensional flat world will find it difficult to imagine what a three dimensional world would look like. Similarly, we, living in a world of three space dimensions find it impossible to imagine four dimensional spacetime! Still, through many indirect experimental tests the idea of four dimensional space time has been tested beyond doubt.

Concept of time as the fourth dimension is very subtle and elusive. I hope the time you have spent reading this article has lifted the veil over the mystery of time just enough, for you to investigate it further.

Read more at Buzzle: http://www.buzzle.com/articles/does-the-4th-fourth-dimension-of-time-exist.html

Time Dilation Explained

The phenomenon of time dilation is one of the most astounding effects of the physical world, predicted by special and general theory of relativity. In this article, you will find a simple explanation of the same.

Albert Einstein delivered two major blows to the established order of physics, through his presentation of special and general theory of relativity, published in 1905 and 1915. While the special theory unified space and time into a single entity, general theory of relativity showed gravity to be an effect of the curvature of spacetime.

Albert Einstein first destroyed Newton's idea of absolute time and then went on to show the flaws in Newton's theory of gravitation, by presenting the general theory of relativity, in 1915. This theory showed that matter bends or warps the spacetime around it and motion of objects is affected by this curvature. Special and general theory of relativity are two separate theories. One describes motion, according to inertial frames of reference, while the other deals with the equivalence of accelerated frames and gravity. One phenomenon that is commonly predicted by both theories is time dilation.

According to Special Relativity

Special theory of relativity is based and derived from two very basic postulates. One states that the speed of light is constant in vacuum and unattainable, while the other states that the laws of physics should remain exactly same in all inertial frames. An inertial frame is any frame that is moving at a constant velocity, with respect to a fixed frame or is at rest with respect to it.

Now, consider a guy sitting in a spaceship, which is moving at a constant velocity in a specific direction with respect to a fixed frame, with no other forces acting on it, other than the spaceship's own propulsive force.

Then, the principle states that time will slow down for the spaceship, with respect to the time associated with the fixed frame. The larger the velocity of the spaceship, more will be the dilation of time and slower will it move for the spaceship. This effect is quantified by the following equation:

?t' = ?t / v(1 - v2 / c2)

In this physics formula, ?t' is the time interval for a person on the spaceship, while ?t is the time interval for the rest frame of reference. Here, v is the constant velocity of the spaceship and c is the speed of light (3 x 108). The factor - c (speed of light) comes into the picture because the entire theory is based on special relativity, which has constancy of light speed to be its central tenet. The above equation states that the faster the spaceship moves, slower will be its running clocks. This is a consequence of the fact that time is relative and local in nature and not absolute for all.

The degree of dilation is entirely decided by the ratio 'v/c', that is the ratio of the particle's speed, relative to the speed of light. Therefore, the speed of light factor is an essential part of the equation, without which, quantification cannot occur. To know how the equation is derived, you must study special theory of relativity in greater detail.

According to General Relativity

The phenomenon of time dilation due to gravitation is a bit more difficult to grasp and a full understanding will require that you study general relativity. So here, I purely explain the phenomenon but to know why it happens so, you will have to go deep into the theory.

The basic idea is the following. Time slows down in presence of a gravitational potential. The closer an object is to a gravitational potential, slower will time be for it. Thus, for a satellite moving in orbit around the Earth, a clock will be faster, compared to a clock on the Earth's surface.

The gravitational time dilation equation will vary according to the spacetime geometry and therefore, the degree of dilation will entirely depend on the degree of bending of spacetime, caused by a massive object. The spacetime around a black hole is supposed to be so extremely warped, that time virtually comes to a standstill for an object observed falling into it.

To know these things in more detail, you have to deeply explore and understand the special and general theory of relativity. One of the best introductions to special relativity is the book 'Spacetime Physics' by Taylor and Wheeler, which is highly recommended reading, if you want to explore the beautiful and astounding theory. For understanding the general theory of relativity, you will need some mathematical expertise in differential geometry and tensors. A good place to learn it from is 'Spacetime and Geometry: An Introduction to General Relativity' by Sean Carroll. However, know that this is an advanced physics text and will take some hard work to understand. I can assure you that it will all be worth the effort.

Read more at Buzzle: http://www.buzzle.com/articles/time-dilation-explained.html

Chemistry

Chemistry: Green and clean

Chemists are finding ways to save energy, cut waste and boost safety

Jennifer Weeks

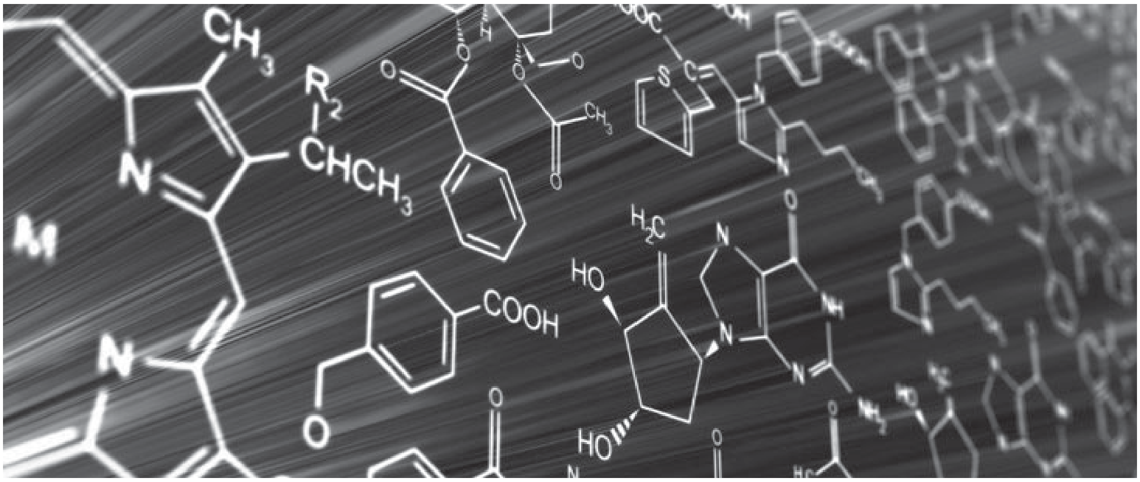
https://student.societyforscience.org/article/chemistry-green-and-clean

This high tech skateboard is made from rugged polycarbonate plastic. Yet its building blocks — molecules of bisphenol A — can pose problems once they get into water, foods and more. Fortunately, green chemists are at work on solutions for that and a host of other problems. Their goal: to make consumer products safer and kinder to the environment.

Vivian Nguyen/ Stanford University

People have used chemistry to improve their lives for tens of thousands of years. An early example: fire. Our prehistoric ancestors tamed flames to transform plants and animal products — that is, to cook them into food. Over time, their descendants learned about the chemical properties of rocks and other minerals, and of chemicals derived from plants and animals. They mixed materials together. Sometimes, they also applied heat, pressure or both. Through trial and error, they learned how to make new and useful materials. Paints and soap are two notable early examples.

Today, chemistry plays a role in almost



every product imaginable. Manufacturing companies have registered more than 83,000 chemicals with the U.S. government. Many of these find use in everything from foods and plastics to trucks and electronics.

Making, using and disposing of these chemicals, however, can pose risks to people or wildlife. Some chemicals, after all, are made from toxic raw materials, such as mercury or lead. Making other chemicals requires huge amounts of energy, clean water or other natural resources. And as we use them or discard them as trash, many chemicals can pollute the air, water or soil.

This high tech skateboard is made from rugged polycarbonate plastic. Yet its building blocks — molecules of bisphenol A — can pose problems once they get into water, foods and more. Fortunately, green chemists are at work on solutions for that and a host of other problems. Their goal: to make consumer products safer and kinder to the environment.

EPA

In the early 1990s, chemist Paul Anastas called for a change. While working for the U.S. Environmental Protection Agency, or EPA, he recognized that chemists usually probe possible risks of chemicals long after they have developed them. Anastas urged his fellow chemists instead to design products that would be safer and cleaner from the start.

The color green is often associated with anything that is good for the environment. So Anastas called this new field "green chemistry." (It's also sometimes called sustainable chemistry.)

In 1998, Anastas and a fellow chemist, John Warner, published 12 principles of green chemistry. They recommended that chemists cut wastes, reduce the toxicity of the materials they use and produce goods using processes that are safer. They also called for designing new chemicals that will break down harmlessly in the environment.

Today, Terry Collins directs the Institute for Green Science at Carnegie Mellon University in Pittsburgh, Pa. Green chemists work in laboratories, just as other chemists do. However, green chemists share a different goal, Collins explains. "We are working to develop a field of chemistry that can replace polluting technologies, one product or process at a time."

Peel dirt right off of clothes

Green chemists often start by identifying chemical products or processes that are wasteful, polluting or toxic. Then they find ways to make them kinder to the environment. That might mean changing a process so that it uses less energy. Or it could mean swapping out harmful ingredients for alternatives. Some alternatives might be safer. Others might have the advantage of breaking down in the presence of water or sunlight.

A surfactant is a chemical that helps liquids mix that would not regularly do so. To accomplish that, one end of the surfactant is hydrophilic (attracted to water). The other end is hydrophobic (repels water).

SuperManu/Wikimedia Commons (CC BY-SA 3.0)

One family of chemicals targeted by green chemists are known as surfactants (Sur-FAK-tuntz). They help mix liquids that would not ordinarily do so. Examples include oil and water. Each surfactant molecule has one end that is hydrophilic (HI-droh-FIL-ik). That means it is attracted to water. The other end is hydrophobic (HI-droh-FO-bik). It repels water.

Surfactants are important ingredients in laundry detergents. They help lift dirt, which usually contains oils, out of clothes. In the United States, nonylphenol ethoxylates (NON-ul-FEE-null Ee-THOX-uh-lates) are a common class of surfactants. Because of their long name, chemists usually just refer to them as NPEs.

After use, NPEs go down the drain. From there, they flow into wastewater-treatment plants. Few such plants can remove NPEs from wastewater. So when they release treated water into lakes and rivers, NPEs will remain part of the mix. Eventually, NPEs will break down to form another chemical called nonylphenol. This chemical is “extremely toxic” to fish and green plants, EPA notes.

Canada and the European Union have banned NPEs in detergents. The United States, however, still uses thousands of tons of these chemicals every year. Not surprisingly, researchers have been finding high levels of nonylphenol in waters across North America.

Fruity alternative

Ramaswamy Nagarajan is a plastics engineer at the University of Massachusetts in Lowell. He and his students are developing a substitute for NPEs. They started with a green source — apple and orange peels. Microbes in the Gulf of Mexico inspired their choices.

A NASA satellite spotted oil from the 2010 Deepwater Horizon spill off the coast of Louisiana more than a month after the disaster began. Bacteria broke down some of the oil. That inspired a plastics engineer to work on a surfactant that would do the same thing.

NASA

The 2010 Deepwater Horizon oil spill released almost 5 million barrels of crude oil in the Gulf. Afterward, bacteria in the water started breaking down the oil. Nagarajan learned that the microbes had made natural surfactants. These substances contained long chains of linked sugar molecules, called polysaccharides (PAH-lee-SAK-uh-RIDES). So the Lowell research team turned to a natural source of polysaccharides for their new green surfactants.

“We are using pectin,” explains Nagarajan. Fruit peels and many other food wastes contain this edible polysaccharide. In fact, home canners put pectin in their jams and jellies to make them gel. Best of all, Nagarajan notes, “bacteria can break it down.” Natural pectin degrades harmlessly. Eventually, it vanishes from the environment — unlike the persistent and harmful nonylphenol.

To turn pectin into a surfactant, the chemists add a group of atoms to each pectin molecule. The process takes 30 minutes in a special laboratory microwave oven. When it’s done, each pectin molecule now has a hydrophilic, or water-loving, chemical group (a collection of bound atoms) at one of its ends. At the other end: an oil-loving chemical group.

Green chemists still face more work ahead before pectins become widely used surfactants. One problem: their size. As large molecules, pectins do not dissolve well in water. Nagarajan’s team is now working to overcome that. Their surfactant also does not yet remove very oily or greasy dirt as well as do commercial laundry detergents. "That's because it doesn't have many hydrophobic groups," explains Nagarajan. "But we have found a way to add them and are getting better results."

The group also plans to confirm that their pectin-based surfactants will eventually break down into harmless substances. And biologists at their university are testing whether it causes allergic reactions in people with sensitive skin. They don't think it will, but they want to be sure.

For now, Nagarajan and his fellow green chemists have filed an application to patent the pectin surfactant. Meanwhile, several companies have shown an interest in it. So has the EPA: The government agency has provided a grant to fund more of their work on this new family of green chemicals.

Scientists used florescent dye and the chemical compound bromide to track the flow of contaminants in river water. Some of these contaminants can masquerade as hormones and affect animals in the environment.

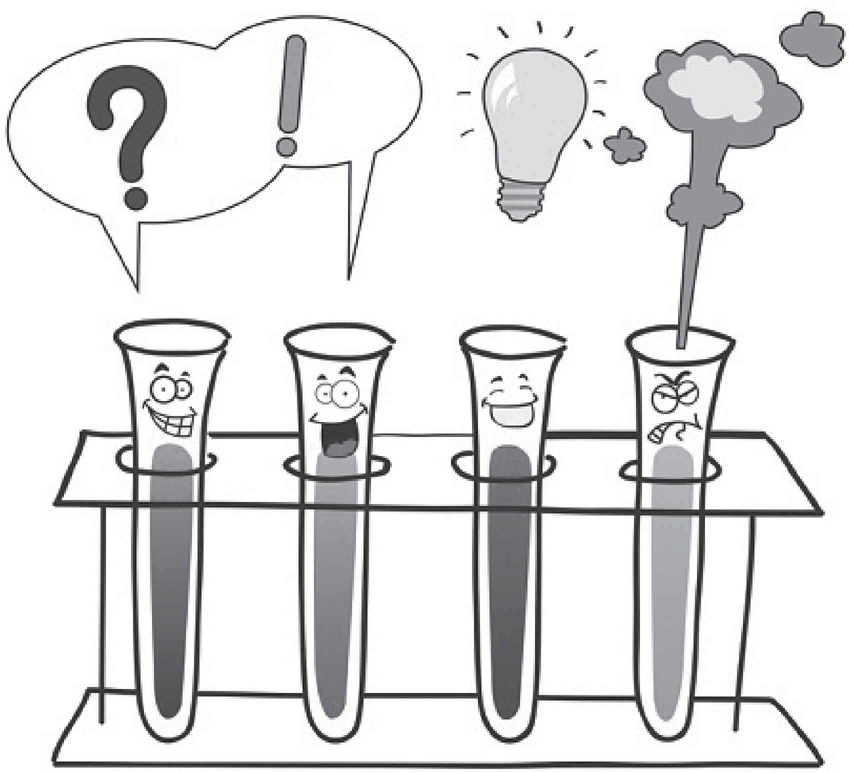
Jeffrey H. Writer, USGS

Time for a breakdown

Sometimes a chemical's job is to do harm. Hand sanitizers and soaps that contain antimicrobials — germ-killing chemicals — are two common examples. But their impacts can persist long after use. For instance, after washing down the drain, these chemicals may affect germs in lakes or streams. Some green chemists are now looking for ways to cut the risks posed when such chemicals get into the environment.

Take triclosan (TRY-kloh-san). Its ability to kill germs on hands, kitchen counters and sponges has made it a popular ingredient in a host of products. But data have begun to emerge showing that in the open environment, triclosan's germ-killing impacts may backfire. How? This chemical might help bacteria resist the killing effects of antibiotic drugs.

Triclosan also can act as an endocrine disruptor. That means it can sometimes mimic the action of hormones. Hormones are potent chemicals. The body produces



them to control important activities, such as growth, sleep and reproduction. When the body encounters chemicals that masquerade as hormones, it may inappropriately turn on or off important cellular activities. That can alter how the body develops or can foster disease.

Green chemists would like to eliminate endocrine disruptors. But that's unlikely to happen. Too many chemicals have this property. And a large number of them have important industrial uses. So the next-best solution would be to find ways to break them down in the environment.

Explainer: What are endocrine disruptors?

Collins, at Carnegie Mellon University, has worked for more than 30 years studying compounds that do just that. He calls these chemical TAMLs. That's short for tetra-amido macrocyclic ligands (TEH-tra A-MEE-doh MAK-roh-SIK-lik LIH-gands). As catalysts, these chemicals turn on or speed up chemical reactions. Combined with a reactive chemical called hydrogen peroxide, TAMLs can break down other chemicals very quickly. It takes only a tiny amount to spur many reactions, all without generating harmful pollution.

TAMLs break down triclosan and many other pollutants that pose risks to aquatic plants and animals, Collins' team has found.

"Endocrine disruptors are changing the makeup of living things. It's a really big problem," Collins says. For instance, by acting like hormones (or interfering with hormones), some of these pollutants can alter the development of animals. In some instances, male fish have been feminized. That means the endocrine disruptors led males to look or behave like females. "But we have an unbelievably effective technique for getting rid of [endocrine disruptors]." He says. He's referring to those TAMLs.

A school of adult zebrafish. The fish are used in laboratories to test the effects of different chemicals. One effect is the feminization of fish — a process that leads male fish to develop female characteristics.

Courtesy of Robert Tanguay

One important concern: TAMLs themselves might be endocrine disruptors. To find out, Collins worked with other green chemists in the United States and Canada to probe that. First, they reviewed lists of known hormone mimics. Then they used computers to predict whether TAMLs might behave in a similar way. For the TAMLs that did, the researchers tested whether those chemicals would bind to cells in the same way that true hormones attach. Next, they analyzed whether these TAMLs also altered the way those cells worked.

Lastly, they tested the effects of TAMLs on fish. For these animal tests, Collins teamed up with Robert Tanguay. He's a biochemist at Oregon State University in Corvallis. Tanguay works with zebrafish. The small tropical fish are good lab animals. They grow quickly. Their embryos also can develop outside of a mother fish.

The scientists exposed zebrafish embryos to the TAML catalysts being developed for use in water treatment. And even high levels of TAMLs did not alter the growth of the fish.

"We've also tested fish swimming around with a TAML catalyst and peroxide, plus a micro-pollutant that feminizes male

fish," says Collins. And still, he reports, "the fish appear to be unharmed." The last step in their testing process is to see whether TAMLs might have impacts in mammals.

If they prove nontoxic there, too, Collins expects his team's TAML catalysts will soon find broad use in breaking down toxic water pollutants.

A close-up of a zebrafish just 15 hours after fertilization. The early developing eye, brain and chevron-shaped muscle bundles are already visible. Green chemists have used zebrafish to test the safety of a new class of chemicals, called TAMLs, designed to treat wastewater.

Courtesy of Robert Tanguay

Bright whites, less waste

If you are reading this article indoors, a chemical called titanium dioxide probably surrounds you. This simple white compound reflects light well. So paint makers use it to whiten or brighten their products. It also shows up in other products, including pudding. (In foods, titanium dioxide appears as "E171" in a list of ingredients.) But getting enough titanium dioxide for all of those products isn't very green.

Titanium is one of the most abundant elements on Earth. It's a building block of many minerals. Companies mine those minerals, then blend the crushed ore with other chemicals. Finally, they heat the mix to more than 900° Celsius (1,652° Fahrenheit). This takes a lot of energy and creates waste.

In 2013, the EPA gave a Presidential Green Chemistry Challenge Award to the Dow Chemical Co. The purpose? To help the company cut the amount of titanium dioxide a paint needs.

The company's solution is a new chemical it calls Evoque (Ee-VOKE). Blending it into paint can cut by up to 20 percent how much titanium dioxide is needed.

"One green chemistry goal is to get every bit of value from materials," explains Mindy Keefe. She's a senior research scientist at Dow in Collegeville, Pa. That's why Evoque shows promise, she says. "Using less titanium dioxide saves energy and reduces waste."

This image shows how Evoque, a

polymer developed by green chemists at Dow Chemical, surrounds a particle of titanium dioxide (shown in white). The polymer (represented by the red spots) pushes apart the particles so they don't clump up.

Dow Chemical Co.

Evoque is a polymer. Polymers are materials made from long chains of a repeating groups of atoms. In paint, the polymer fixes a common problem with titanium dioxide. "Titanium dioxide particles in paint tend to clump together," explains Keefe. "Evoque forms a shell around them and pushes them apart." This makes the paint more reflective. It also helps the paint cover surfaces more evenly and completely.

Scientists at Dow worked for more than 10 years to develop the polymer. In green chemistry, such a long investment in time can be well worthwhile. After all, a new product can benefit the environment for much, much longer than that.

"The more serious the hazard is, the more important it is to find green solutions," concludes Collins at Carnegie Mellon.

Power Words

antibiotic A germ-killing substance prescribed as a medicine (or sometimes as a feed additive to promote the growth of livestock). It does not work against viruses.

antimicrobial A substance used to kill or inhibit the growth of microbes. Manufacturers have added some, such as triclosan and triclocarban, to sponges, soaps and other household products.

bisphenol A A building block of polycarbonate plastics and many commercially important resins. This chemical gained widespread public attention when research showed it could mimic the activity of estrogen, a female sex hormone.

catalyst A substance that triggers or speeds up a chemical reaction without itself being affected.

chemistry The field of science that deals with the composition, structure and properties of substances and how they interact with one another. Chemists use this knowledge to study unfamiliar substances, to reproduce large quantities of useful substances or to design and create new and useful substances.

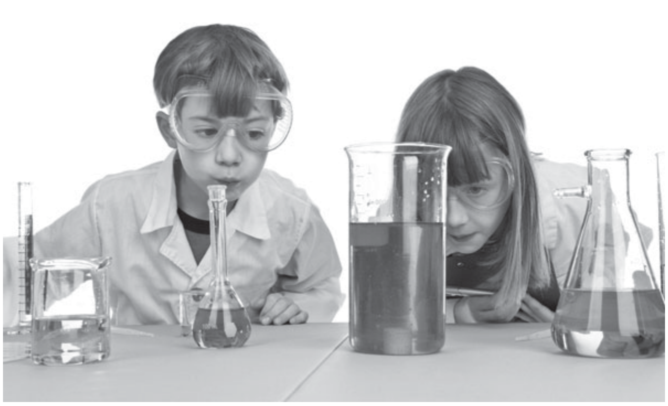
crude oil Petroleum in the form that it comes out of the ground.

embryo The early stages of a developing vertebrate, or animal with a backbone, consisting only one or a or a few cells. As an adjective, the term would be embryonic.

endocrine disruptor A substance that mimics the action (sometimes well, sometimes poorly) of one of the body's natural hormones. By doing this, the fake hormone can inappropriately turn on, speed up or shut down important cellular processes.

engineer A person who uses science to solve problems. As a verb, to engineer means to design a device, material or process that will solve some problem or unmet need.

feminize (in biology) For a male animal to take on physical, behavioral or physiological traits typical of females. It usually results from exposure to an



abnormal amount of female sex hormones — or pollutants that mimic these hormones. Feminizing It is sometimes used as a synonym for demasculinizing. In fact, they can be different. A demasculinized male may appear more feminine too, but largely because it had too little exposure to male hormones, not an excess of female hormones.

green chemistry A rapidly growing field of chemistry that seeks to develop products and processes that will pose little or no harm to living things or the environment.

hormone A chemical produced in a gland and then carried in the bloodstream to another part of the body. Hormones control many important body activities, such as growth. Hormones act by triggering or regulating chemical reactions in the body.

hydrogen peroxide A molecule made of two hydrogen and two oxygen atoms. Highly reactive, it can kill many tiny organisms, including germs. Its scientific symbol is H_2O_2.

hydrophilic Strongly attracted to (or readily dissolving in) water.

hydrophobic Repelling (or not absorbing) water.

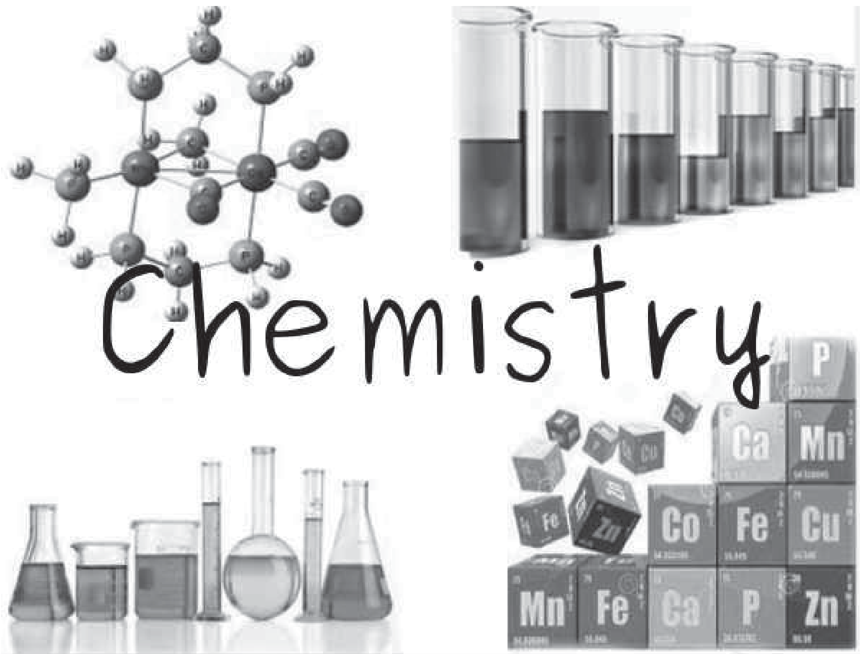
mineral The crystal-forming substances, such as quartz, apatite, or various carbonates, that make up rock. Most rocks contain several different minerals mish-mashed together. A mineral usually is solid and stable at room temperatures and has a specific formula, or recipe (with atoms occurring in certain proportions) and a specific crystalline structure (meaning that its atoms are organized in certain regular three-dimensional patterns).

molecule An electrically neutral group of atoms that represents the smallest possible amount of a chemical compound. Molecules can be made of single types of atoms or of different types. For example, the oxygen in the air is made of two oxygen atoms (O_2), but water is made of two hydrogen atoms and one oxygen atom (H_2O).

nonylphenol The name for a family of pollutants that can survive in the aquatic environment persistent for a long time. These chemicals are used primarily to make NPE surfactants and to strengthen certain plastics. Studies have shown these chemicals can mimic the action of estrogen, a female sex hormone. Animals can accumulate these pollutants from the environment. Nonylphenols can be extremely toxic to aquatic organisms.

nonylphenol exothylates (NPEs) A family of chemicals that are widely used in industry as surfactants and wetting agents. When they break down, NPEs produce nonylphenols, a family of chemical compounds that can be toxic to plants and aquatic animals.

patent A legal document that gives inventors control over how their inventions — including devices, machines, materials,



processes and substances — are made, used and sold for a set period of time. Currently, this is 20 years from the date you first file for the patent. The U.S. government only grants patents to inventions shown to be unique.

pectin A water-soluble substance that binds adjacent cell walls in plant tissue. Pectins also serve as a thickener in making jams and jellies.

peroxide A group of chemicals that contain a "bivalent" pair of oxygen atoms. Each oxygen atom has an unpaired electron orbiting it that is available to form bonds (attachments) with other atoms. Peroxides are oxidizing agents, meaning that they can react vigorously at room temperatures. Some are used as bleaches.

plastic Any of a series of materials that are easily deformable; or synthetic materials that have been made from polymers (long strings of some building-block molecule) that tend to be lightweight, inexpensive and resistant to degradation.

pollutant A substance that taints something — such as the air, water, our bodies or products. Some pollutants are chemicals, such as pesticides. Others may be radiation, including excess heat or light. Even weeds and other invasive species can be considered a type of biological pollution.

polymer Substances whose molecules are made of long chains of repeating groups of atoms. Manufactured polymers include nylon, polyvinyl chloride (better known as PVC) and many types of plastics. Natural polymers include rubber, silk and cellulose (found in plants and used to make paper, for example).

polysaccharide A type of carbohydrate made from long chains of simple sugars. Examples of polysaccharides include plant starches and cellulose (a structural material in trees).

sewage Wastes — primarily urine and feces — that are mixed with water and flushed away from homes through a system of pipes for disposal in the environment (sometimes after being treated in a big water-treatment plant).

surfactant A chemical compound that decreases the attraction between water molecules and makes it easier for water to spread on surfaces and to mix with other substances (such as oil).

TAMLs (tetra-amido macrocyclic ligands).

A family of compounds developed by chemists at Carnegie Mellon University. By working as catalysts, these chemicals turn on or speed up chemical reactions. Combined with hydrogen peroxide, TAMLs can rapidly break down other chemicals.

titanium dioxide A white, unreactive, solid material that occurs naturally as a mineral and is used extensively as a white pigment.

toxic Poisonous or able to harm or kill cells, tissues or whole organisms. The measure of risk posed by such a poison is its toxicity.

triclocarban A germ-killing chemical added to some common products such as hand soaps and sponges.

triclosan A germ-killing chemical added to some common products such as hand soaps and sponges.

waste Any materials that are left over from biological or other systems that have no value, so they can be disposed of as trash or recycled for some new use.

wastewater Any water that has been used for some purpose (such as cleaning) and no longer is clean or safe enough for use without some type of treatment. Examples include the water that goes down the kitchen sink or bathtub or water that has been used in manufacturing some product, such as a dyed fabric.

zebrafish A small tropical freshwater fish belonging to the minnow family. Zebrafish are used frequently in scientific research because they grow quickly and their genetic makeup is well understood.

2,000-Year-Old Water Supply System Uncovered in Jerusalem

Denise Chow

Part of an ancient aqueduct built more than 2,000 years ago to transport water into the city of Jerusalem was uncovered during a recent construction project, according to the Israel Antiquities Authority.

A section of the so-called Lower Aqueduct was discovered in the modern-day neighborhood of Umm Tuba, in East Jerusalem, during efforts to construct a new sewer line. The Lower Aqueduct was originally built more than 2,000 years ago by kings in the Hasmonean dynasty, who ruled Judea and its surrounding regions from about 140 B.C. to 37 B.C., and preceded King Herod the Great.

The sprawling, 13-mile-long (21 kilometers) aqueduct carried water to the capital, and "operated intermittently until about 100 years ago," Ya'akov Billig, director of the aqueduct excavation with the Israel Antiquities Authority (IAA), said in a statement. [The Holy Land: 7 Amazing Archaeological Finds]

The Lower Aqueduct fed from the En Eitam spring, which is located near three ancient reservoirs known as Solomon's Pools that are about 3 miles (5 km) southwest of Bethlehem. As water passed through the channel, it flowed down a gentle slope to Jerusalem, passing through the modern-day neighborhoods of Umm Tuba, Sur Bahar, East Talpiot and Abu Tor, according to the IAA.

"At first, the water was conveyed inside an open channel, and about 500 years ago, during the Ottoman period, a terra cotta pipe was installed inside the channel in order to better protect the water," Billig said.

For nearly 2,000 years, the Lower Aqueduct remained one of Jerusalem's principal sources of water, IAA officials said, which is why city rulers kept the structure so well preserved. About 100 years ago, the channel was replaced by an electrically operated water-distribution system.

The Umm Tuba section of the aqueduct was uncovered by workers at Gihon Company Ltd., who are constructing the new sewer line. Archaeologists at the IAA conducted an excavation of the site following its discovery, but the remains have since been covered up again to preserve the structure and prevent any damage, agency officials said.

Other sections of the extensive aqueduct have been uncovered in the past, including in the Armon Ha-Natziv tunnels in the City of David, on the Sherover promenade in southern Jerusalem and around the Sultan's Pool along the west side of Mount Zion in Jerusalem, IAA officials said.

World's Oldest Stone Tools Predate Humans

Charles Q. Choi

The oldest handmade stone tools discovered yet predate any known humans and may have been wielded by an as-yet-unknown species, researchers say.

The 3.3-million-year-old stone artifacts are the first direct evidence that early human ancestors may have possessed the mental abilities needed to figure out how to make razor-sharp stone tools. The discovery also rewrites the book on the kind of environmental and evolutionary pressures that drove the emergence of toolmaking.

Chimpanzees and monkeys are known to use stones as tools, picking up rocks to hammer open nuts and solve other problems. However, until now, only members of the human lineage — the genus Homo, which includes the modern human species Homo sapiens and extinct humans such as Homo erectus — were thought capable of making stone tools. [See Photos of the Oldest Stone Tools]

Ancient stone artifacts from East Africa were first uncovered at Olduvai Gorge in Tanzania in the mid-20th century. Those stone tools were later associated with fossils of the ancient human species Homo habilis, discovered in the 1960s.

"The traditional view for decades was that the earliest stone tools were made by the first members of Homo," study lead author Sonia Harmand, an archaeologist at Stony Brook University in New York, told Live Science. "The idea was that our lineage alone took the cognitive leap of hitting stones together to strike off sharp flakes and that this was the foundation of our evolutionary success."

However, there were hints of primitive tool use before Homo habilis. In 2009, researchers at Dikika, Ethiopia, dug up animal bones nearly 3.4 million years old that had slashes and other cut marks, evidence that someone used stones to trim flesh from bone and perhaps crush bones to get at the marrow inside. This is the earliest evidence of meat and marrow consumption by hominins — all the species leading to and including the human lineage after the split from the ancestors of chimpanzees. No tools were found at that site, so it was unclear whether the marks were made with handmade tools or just naturally sharp rocks.

Now, scientists report stone artifacts that date back long before any known human fossils. Until now, the earliest known tools were about 2.8 million years old, the researchers said. The artifacts are by far the oldest handmade stone tools yet discovered — the previous record-holders, known as Oldowan stone tools, were about 2.6 million years old.

"We were not surprised to find stone tools older than 2.6 million years, because paleoanthropologists have been saying for the last decade that they should be out there somewhere," Harmand said. "But we were surprised that the tools we found are so much older than the Oldowan, at 3.3 million years old."

It remains unknown what species made these stone tools. They could have been created by an as-yet-unknown extinct human species, or by Australopithecus, which is currently the leading contender for the ancestor of the human lineage, or by Kenyanthropus, a 3.3-million-year-old skull of which was discovered in 1999 about a half-mile (1 kilometer) from the newfound tools. It remains uncertain exactly how Kenyanthropus relates to either Homo or Australopithecus. [Gallery: See Images of Our Closest Human Ancestor]

"Sometimes the best discoveries are the ones that raise more questions than provide answers," study co-author Jason Lewis, a paleoanthropologist at Stony Brook University and Rutgers University in New Jersey, told Live Science. "In any of these cases the story is equally new and interesting. We are comfortable not having all of the answers now."

The stone tools were discovered in the desert badlands of northwestern Kenya, where the arid, rocky terrain resembles a New Mexican landscape.

The artifacts were found next to Lake Turkana in 2011 almost by accident. "We were driving in the dry riverbed and took the left branch instead of the right, and got off course," Harmand said. "Essentially, we got lost and ended up in a new area that looked promising. Something was really unique about this place, we could tell that this zone had a lot of hidden areas just waiting to be explored."

By the end of the 2012 field season, excavations at the site, named Lomekwi 3, had uncovered 149 "Lomekwian" stone artifacts linked with toolmaking.

"It is really exciting and very moving to be the first person to pick up a stone artifact since its original maker put it down millions of years ago," Harmand said.

The researchers tried using stones to knock off and shape so-called flakes or blades — a process known as knapping — to better understand how these Lomekwian stone artifacts might have been made. They concluded the techniques used may represent a stage between the pounding used by earlier hominins and the knapping of later toolmakers.

"This is a momentous and well-researched discovery," paleoanthropologist Bernard Wood, a professor of human origins at George Washington University, who was not involved in the study, said in a statement. "I have seen some of these artifacts in the flesh, and I am convinced they were fashioned deliberately."

Analysis of carbon isotopes in the soil and animal fossils at the site allowed the scientists to reconstruct what the vegetation there used to be like. This led to another surprise — back then, the area was a partially wooded, shrubby environment.

Conventional thinking has been that sophisticated toolmaking came in response to a change in climate that led to shrinking forests and the spread of savannah grasslands. Stone blades likely helped ancient humans get food by helping them cut meat off the carcasses of animals, given how there was then less food such as fruit to be found in the forest. However, these findings suggest that Lomekwian stone tools may have been used for breaking open nuts or tubers, bashing open dead logs to get at insects inside, or maybe something not yet thought of. [Denisovan Gallery: Tracing the Genetics of Human Ancestors]

"The Lomekwi 3 evidence suggests that important evolutionary changes that would later be really important for Homo to survive on the savannah were actually evolving beforehand, in a still-wooded environment," Lewis said.

"The capabilities of our ancestors and the environmental forces leading to early stone technology are a great scientific mystery," Richard Potts, director of the Human Origins Program at the Smithsonian's National Museum of Natural History, who was not involved in the research, said in a statement. The newly dated tools "begin to lift the veil on that mystery, at an earlier time than expected."

This discovery also has implications for understanding the evolution of the human brain, researchers said. Toolmaking required a level of dexterity and grip that suggests that changes in the brain and spinal tract needed for such activity could have evolved before 3.3 million years ago.

The scientists are now looking at the surfaces and edges of the tools under microscopes and with laser scans to try to reconstruct how they were used, "and also studying the sediment in which they were found to search for trace elements or residues of any possible plant or animal tissues that could be left on them after use," Harmand said.

The site is still under excavation, and Harmand said other artifacts could exist from early attempts at knapping.

"We think there are older, even more rudimentary, stone tools out there to be found, and we will be looking for them over the coming field seasons," he added.

The scientists detailed their findings in the May 21 issue of the journal Nature.

Name that tune: what parts of our brains do we use for naming songs?

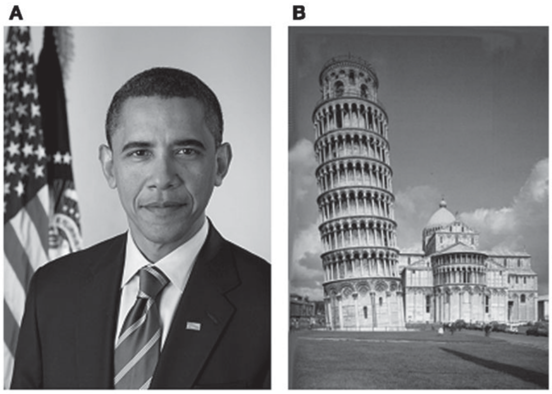
Abstract

Proper nouns refer to unique persons, places, and things. One of those "things" can be songs, and famous songs have specific names like "Take Me Out to the Ballgame" and "Jingle Bells." We conducted a scientific study to determine which parts of the brain are important for the process of naming famous songs. We already had some clues – we knew from previous research that people with damage to the left temporal pole (LTP) lost their ability to name famous people and places (landmarks). These people had strokes or surgery that damaged the LTP, and were unable to come up with names such as "Barack Obama" or "the Grand Canyon." In a new study, we investigated whether persons with LTP damage could name famous musical songs. The participants listened to famous songs and tried to name them. We found that participants with damage to the LTP had difficulty naming these songs. They named significantly fewer songs than participants with damage in other parts of the brain or participants with no brain damage whatsoever. Our findings support the theory that the LTP is the key brain region necessary for naming unique items, and for the first time, we know these items also include music.

Proper nouns are names for unique persons, places, and things. One of these "things" can be songs. Songs have specific names, such as "Take Me Out to the Ballgame" or "Jingle Bells." When you hear a song, you often think of its name. We conducted a scientific study to find out which parts of the brain are important for naming a famous song. We already had some clues about which brain region might be important – we knew from previous research that the left temporal pole (LTP) is an important brain region for naming proper nouns.

The Left Temporal Pole and Proper Naming

Have you ever seen a person and thought, "I know



them! What is their name?" Imagine how frustrating it would be if you could not name people that you saw – even people that you knew very well. Previous research has identified a group of people who experience this on a daily basis. These people have brain damage to the LTP. The LTP is a region on the left side of the brain near the temples (see the colored region in Figure 2). Individuals with damage to the LTP have trouble naming unique items with proper names [1].

Look at the picture in Figure 1A. If I asked you to name this face, you would probably say that this is Barack Obama. A person with damage to the LTP might say that this is the president of the United States, that he has two daughters, or that he was first elected in 2008. While knowing this information shows that they *recognize* the face, they would be unable to tell me his name. The difference between recognizing and naming is important: *recognizing* means that you know who the person is and other information about them (for example, he is the President of the United States). *Naming* means that you are able to give the proper name of the person (for example, Barack Obama).

Figure 1 - Examples of A) famous faces and B) landmarks.

Individuals with damage to the LTP are able to recognize famous faces, but cannot name them. This occurs with other unique items too. Individuals with LTP damage are impaired at naming famous people when they hear their voices [2]. They are also unable to name famous landmarks (Figure 1B), such as the Golden Gate Bridge and the Leaning Tower of Pisa [3]. Knowing this information, we wondered whether individuals with damage to the LTP would also have trouble naming famous musical songs. We predicted that musical songs are similar to faces and landmarks because they all have unique, proper names. Therefore, we predicted that patients with LTP damage would be impaired at naming famous songs.

Participants

The participants in our study were individuals who had brain damage to the LTP. These individuals have brain damage because they had brain surgery or strokes. In total, we studied 10 individuals with LTP damage. Figure 2 shows the exact area of brain damage in these patients. The "hotter" colors (red, orange) show the area, which is the LTP, where most patients have damage.

- Figure 2 - Overlap map for patients with damage to the LTP.

- The image on the left is a view of the brain from the left side. The images to the right (a–e) show slices of the brain through the LTP region. The color bar shows how many individuals have damage to this region, with the "hotter" colors (red, orange) representing higher numbers of individuals with damage.

In addition to the LTP group, we studied a group of individuals with brain damage *outside* the LTP. This is important because it can show if only damage to the LTP impairs naming of famous musical melodies, and not just damage anywhere in the brain. We call this group of individuals brain damaged comparisons (BDC). We studied 10 BDC individuals. Lastly, we studied 10 normal, healthy individuals with no brain damage. This group is called a normal comparison (NC) group. This way, we can see if individuals with damage to the LTP are impaired at naming famous musical melodies compared to people without any brain damage.

Naming Famous Songs

In order to see whether individuals with damage to the LTP had problems naming famous songs, we had participants listen to 52 famous musical songs. For example, this task included songs such as "Row Row Row Your Boat," "The Star Spangled Banner," and "Rudolph the Red Nosed Reindeer." The songs that the participants heard did not have any words; they were just the notes of the tune. After hearing each song, participants rated how familiar they were with the song on a scale ranging from "completely familiar" (a 6 on the scale) to "completely unfamiliar" (a 1 on the scale). Then, they were asked to state the name of the song. If they could not state the name, they were asked to state the lyrics or continue humming/singing the tune of the song.

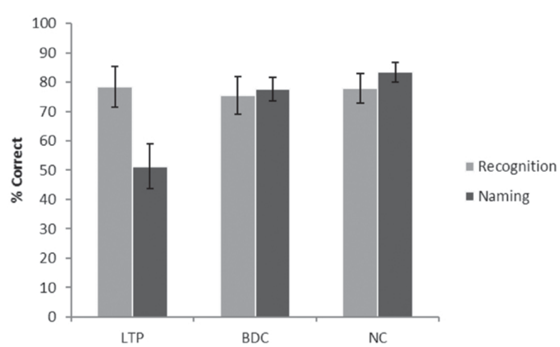
We found that participants in all three groups (LTP, BDC, NC) recognized most of the songs. To correctly recognize a song, a participant had to either: (1) name the song, (2) state the lyrics, (3) continue humming/singing the tune, or (4) rate the song as a 5 or 6 on the familiarity scale. In all three groups, participants correctly recognized about 80% of the songs (Figure 3). There were no differences between the three groups, which show us that the individuals with damage to the LTP group were not impaired at recognizing famous songs.

- Figure 3 - Percent correct for naming and recognizing famous musical melodies.
- Here, we show the scores for the three groups on both recognition (blue bars) and naming (purple bars) of famous musical melodies. This shows that all individuals, on average, recognized around 80% of the melodies. However, for naming the melodies, the BDC and NC groups correctly named about 80% of the melodies, while the LTP group named only 50% of the melodies. This shows us that individuals with LTP damage were impaired at naming famous melodies.

By contrast, when asked to name the song, individuals with damage to the LTP were significantly worse than individuals in the BDC and NC groups. Individuals in the BDC and NC groups correctly named about 80% of the songs, while individuals in the LTP group only correctly named about 50% of the songs (Figure 3).

Conclusion

Our findings support our prediction that individuals with damage to the LTP would be able to recognize famous musical songs, but not name them. These findings help show that the LTP is a critical



region for naming proper nouns of various types, including famous faces, landmarks, and now, songs. Without this brain region, people are impaired at naming unique items. This shows us that the LTP is an important brain region for naming proper items. The LTP is called a “convergence zone” for naming items. What this means is that the LTP does not store the names of the items, but it is a region where the names of items are related to the information about the items. This explains why people with LTP damage are able to say information about the item but not the name. So, next time you hear a song on the radio and think of its name, remember that you are using your LTP!

Original Source Article

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How to learn 30 languages

Some people can speak a seemingly impossible number of tongues. How do they manage it, asks David Robson, and what can we learn from them?

David Robson

Out on a sunny Berlin balcony, Tim Keeley and Daniel Krasa are firing words like bullets at each other. First German, then Hindi, Nepali, Polish, Croatian, Mandarin and Thai – they've barely spoken one language before the conversation seamlessly melds into another. Together, they pass through about 20 different languages or so in total.

Back inside, I find small groups exchanging tongue twisters. Others are gathering in threes, preparing for a rapid-fire game that involves interpreting two different languages simultaneously. It looks like the perfect recipe for a headache, but they are nonchalant. "It's quite a common situation for us," a woman called Alisa tells me.

It can be difficult enough to learn one foreign tongue. Yet I'm here in Berlin for the Polyglot Gathering, a meeting of 350 or so people who speak multiple languages – some as diverse as Manx, Klingon and Saami, the language of reindeer herders in Scandinavia. Indeed, a surprising proportion of them are "hyperglots", like Keeley and Krasa, who can speak at least 10 languages. One of the most proficient linguists I meet here, Richard Simcott, leads a team of polyglots at a company called eModeration – and he uses about 30 languages himself.

With a modest knowledge of Italian and some rudimentary Danish, I feel somewhat out of place among the hyperglots. But they say you should learn from the best, so I am here to try to discover their secrets.

(Credit: Thinkstock) (Credit: Credit: Thinkstock)

Most of us struggle with the simplest phrases - but it needn't be that way (Credit: Thinkstock)

When you consider the challenges for the brain, it's no wonder most of us find learning a language so demanding. We have many different memory systems, and mastering a different tongue requires all of them. There's procedural memory – the fine programming of muscles to perfect an accent – and declarative memory, which is the ability to remember facts (at least 10,000 new words if you want to come close to native fluency, not to mention the grammar). What's more, unless you want to sound like a stuttering robot, those words and structures have to make it to the tip of your tongue within a split second, meaning they have to be programmed in both "explicit" and "implicit" memory.

Speaking extra languages delays dementia by five years or more

That tough mental workout comes with big payoffs, however; it is arguably the best brain training you can try. Numerous studies have shown that being multilingual can improve attention and memory, and that this can provide a "cognitive reserve" that delays the onset of dementia. Looking at the experiences of immigrants, Ellen Bialystok at York University in Canada has found that speaking two languages delayed dementia diagnosis by five years. Those who knew three languages, however, were diagnosed 6.4 years later than monolinguals, while for those fluent in four or more languages, enjoyed an extra nine years of healthy cognition.

(Credit: Getty Images) (Credit: Credit: Getty Images)

If you want to stay sharp in old age, learning a language could be the best neural workout (Credit: Getty Images)

Those lasting benefits are a stark contrast to the failure of most commercial "brain training" games you can download – which generally fail to offer long-term improvements in memory or attention.

Learning a new language as we age is easier than you might assume

Until recently, however, many neuroscientists had suggested that most of us are too old to reach native-like fluency in a fresh language; according to the "critical period hypothesis", there is a narrow window during childhood in which we can pick up the nuances of a new language. Yet Bialystok's research suggests this may have been exaggerated; rather than a steep precipice, she has found that there is a very slight decline in our abilities as we age.

Certainly, many of the hyperglots I meet in Berlin have mastered languages later in life. Keeley grew up in Florida, where he was exposed to native Spanish speakers at school. As a child, he used to tune into foreign radio stations – despite not being able to understand a word. "It was like music to me," he says. But it was only as an adult that he started travelling the world – first to Colombia, where he also studied French, German and Portuguese at college.

He then moved on to Switzerland and Eastern Europe before heading to Japan. He now speaks at least 20 languages fluently, almost all of which were learnt as an adult. “The critical period hypothesis is a bunch of crap,” he says.

(Credit: Getty Images) (Credit: Credit: Getty Images)

Polyglots tend to "inhabit" a language and its culture (Credit: Getty Images)

The question is, how do hyperglots master so many new tongues – and could the rest of us try to emulate them? True, they may just be more motivated than most. Many, like Keeley, are globe-trotters who have moved from country to country, picking up languages as they go. It’s sometimes a case of sink or swim.

Yet even with the best intentions, many of us struggle to speak another language convincingly. Keeley, who is currently writing a book on the “social, psychological and affective factors in becoming multilingual”, is sceptical that it’s simply a question of raw intelligence. “I don’t think it’s a major factor, although it does make it faster to have the analytical ability,” he says.

Cultural chameleons

Instead, he thinks we need to look past the intellect, into the depths of our personality. Keeley’s theory is that learning a new language causes you to re-invent your sense of self – and the best linguists are particularly good at taking on new identities. “You become a chameleon,” he says.

Psychologists have long known that the words we speak are entwined with our identity. It’s a cliche that French makes you more romantic, or Italian makes you more passionate, but each language becomes associated with cultural norms that can affect how you behave – it could be as simple as whether you value outspoken confidence or quiet reflection, for instance. Importantly, various studies have found that multilingual people often adopt different behaviours according to the language they are speaking.

(Credit: Getty Images) (Credit: Credit: Getty Images)

Building friendship is the primary motivation for most hyperglots (Credit: Getty Images)

Different languages can also evoke different memories of your life – as the writer Vladimir Nabokov discovered when working on his autobiography. The native Russian speaker wrote it first in his second language, English, with agonising difficulty, finding that “my memory was attuned to one key – the musically reticent Russian, but it was forced into another key, English”. Once it was finally published, he decided to translate the memoirs back into the language of his childhood, but as the Russian words flowed, he found his memories started to unfurl with new details and perspectives. “His Russian version differed so much he felt the need to retranslate to English,” says Aneta Pavlenko at Temple University in Philadelphia, whose book, The Bilingual Mind, explores many of these effects. It was almost as if his English and Russian selves had subtly different pasts.

Resisting the process of reinvention may prevent you from learning another language so well, says Keeley, who is a professor of cross-cultural management at Kyushu

Sangyo University in Japan. He recently ran a survey of Chinese speakers learning Japanese to examine their "ego permeability" – with questions such as "I find it easy to put myself in other's shoes and imagine how they feel" or "I can do impressions of other people", and whether you can change your opinions to suit the people you are near. As he suspected, the people who score highly on these traits had much greater fluency in their new language.

It is not just about the amount of time spent learning and using languages

How come? It's well known that if you identify with someone, you are more likely to mimic them – a process that would effortlessly improve language learning. But the adopted identity, and the associated memories, may also stop you from confusing the language with your mother tongue – by building neural barriers between the languages. "There must be some type of home in your mind for each language and culture and the related experiences, in order for the languages to stay active and not get all mixed together," Keeley says. "It is not just the amount of time spent learning and using the languages. The quality of the time, in terms of emotional salience, is critical." Indeed, that might explain why Keeley could switch so effortlessly between those 20-odd languages.

Of all the polyglots, Michael Levi Harris may demonstrate these principles the best. An actor by training, Harris also has an advanced knowledge of 10 languages, and an intermediate understanding of 12 more. Occasionally, his passion has landed him in some difficulty. He once saw an online ad for a Maltese meet-up. Going along, he hoped to find a group of people from Malta, only to walk into a room full of middle-aged women and their white lap dogs – an experience he recently relayed in a short film The Hyperglot. You can see a trailer below.

When I meet him in a cafe near the Guildhall School of Music and Drama in London, he effortlessly slips into a rather posh, "received pronunciation" English accent, despite being a native New Yorker. As he does so, his whole posture changes as he melds into the new persona. "I'm not really trying to consciously change my character or my persona. It just happens, but I know that I am suddenly different."

Importantly, Harris thinks that anyone can learn to adopt a new cultural skin in this way – and he has a few tips for how to begin, based on his experiences of acting. The important thing, he says, is to try to imitate without even considering the spelling of the words. "Everyone can listen and repeat," he says. You may find yourself over-exaggerating, in the same way that an actor may be a little over-the-top in their performance to start with – but that's a crucial part of the process, he says. "In acting first, you go really big, and then the director says OK, now tone it down. And you do the same with a language." He also suggests looking carefully at things like facial expressions – since they can be crucial to producing the sounds. Speaking with slightly pouted lips instantly makes you sound a little bit more French, for instance.

Finally, he says you should try to overcome the embarrassment associated with producing "strange" noises – such as the guttural sounds in Arabic, for instance. "You have to realise it's not foreign to us – when you are disgusted, you already say 'eugh'. And if you acknowledge and give your subconscious permission to do it in speech, you can make the sound." That may sound a little silly, but the point is that all this should help you to get over your natural inhibitions. "It's all to do with owning the language, which is what actors have to do to make the audience believe that these words are yours. When you own words you can speak more confidently, which is how people will engage with you."

(Credit: Thinkstock) (Credit: Credit: Thinkstock)

Can thespians teach us all a better way to learn? (Credit: Thinkstock)

There's one big factor that stops people learning languages efficiently…

Even so, most agree that you shouldn't be too ambitious, particularly when starting out. "If there's a single factor that stops people learning languages efficiently, it's that we feel we have to be native-like – it's an unreachable standard that looms over us," says Temple University's Pavlenko. "The ease of expression is what matters to me a lot – finding a better way to express myself, colloquially."

Along these lines, you should also practice a little and often – perhaps just for 15-minute stints, four times a day. "I think the analogies with exercise are quite good," says Alex Rawlings, who has developed a series of polyglot workshops with Richard Simcott to teach their techniques. Even if you are too busy or tired to do serious study, just practising a dialogue or listening to a foreign pop song can help, says Simcott.

In the UK, Australia and US, it is easy to believe that we don't need to make that effort. Indeed, before I met the hyperglots, I had wondered if their obsession merited the hard work; perhaps, I thought, it was just about bragging rights. Yet all of the hyperglots I meet are genuinely enthusiastic about the amazing benefits that can only be achieved by this full immersion in different languages – including the chance to make friends and connections, even across difficult cultural barriers.

Harris, for instance, describes living in Dubai. "As a Jewish person living in the Middle East, I faced challenges. But it turns out that one of my best friends was from Lebanon," he says. "And when I moved away, he said 'when we first met I didn't think I could be friends with you and now you're leaving, I'm distraught'. It's one of the most precious things to me."

As Judith Meyer, who organised the gathering in Berlin, tells me, she saw Ukrainians and Russians, Israelis and Palestinians all conversing at the gathering. "Learning another language really does open up whole new worlds."

Many of Earth's groundwater basins are drying out

The majority of the world's largest aquifers are quickly being drained

Thomas Sumner

Of Earth's 37 largest aquifers, 21 are shrinking, satellite data show. Here, redder regions represent overstressed aquifers. Those buried reservoirs lose more water each year than they gain.

Of Earth's 37 largest aquifers, 21 are shrinking, satellite data show. Here, redder regions represent overstressed aquifers. Those buried reservoirs lose more water each year than they gain.

Around the world, large reservoirs of fresh water lie hidden underground. These groundwater basins are like banks. Water can be deposited, stored or withdrawn.

Now, changes in climate and human water usage are emptying those reservoirs, a new study finds. And it's happening at an alarming rate. Of Earth's 37 largest groundwater basins, 21 lose more water each year than they gain. Details appear in a paper to be published in Water Resources Research.

The conclusion is troubling. That's according to study coauthor Sasha Richey. She is a hydrologist at Washington State University in Pullman. (Hydrology is the study of Earth's water.) Groundwater quenches the thirst of about 2 billion people. It also irrigates crops.

"People need to think about groundwater as an important resource," Richey says. "We're not managing that resource adequately, or even at all, in most of the world."

People extract groundwater by drilling into underground reservoirs called aquifers. Aquifers are refilled when water seeps down through the soil.

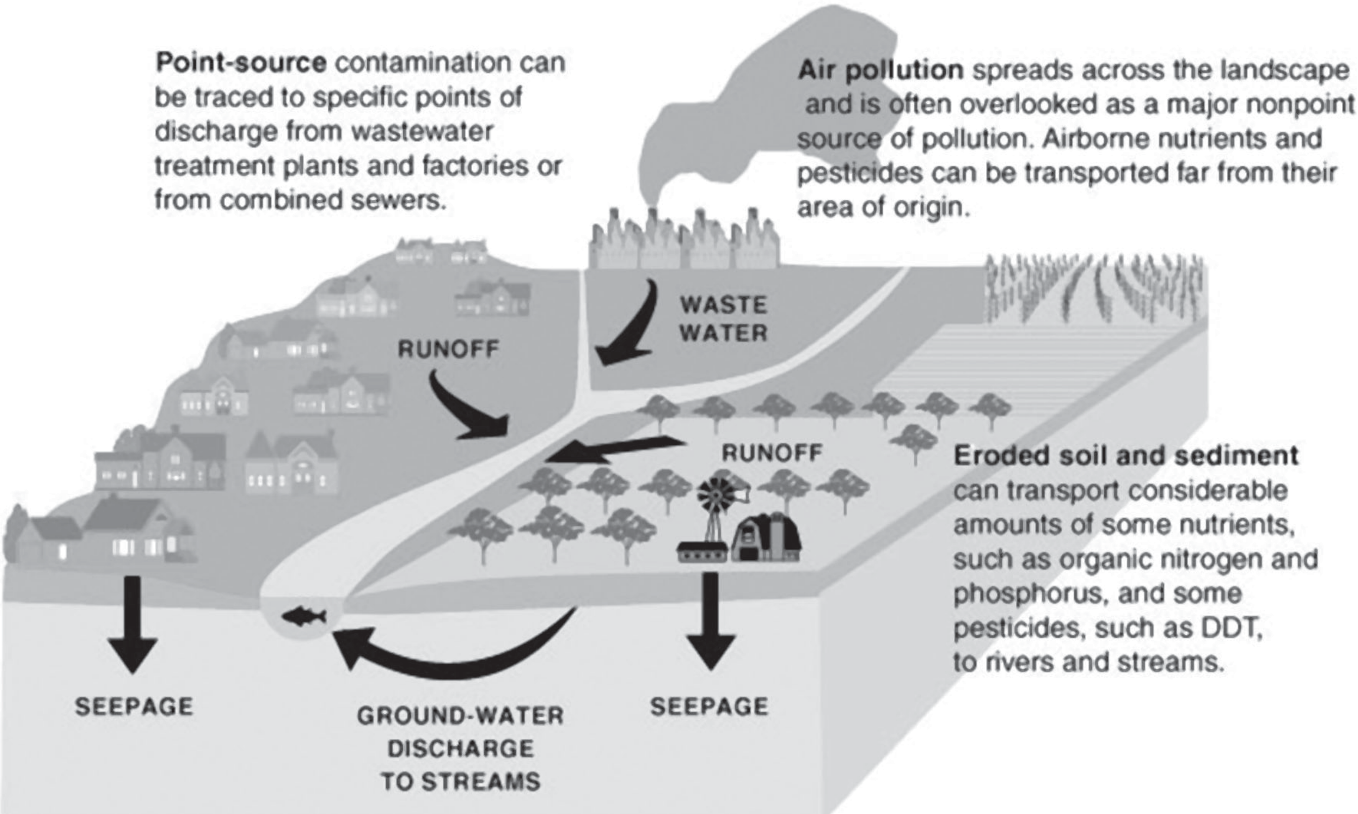
Scientists can monitor groundwater using wells. Water levels drop as an aquifer is drained. This method fails to provide a global picture of changes in water levels, though.

Richey and colleagues instead used data collected by the GRACE mission. These twin satellites measure small changes in Earth's gravity. Variations in the density of Earth's surface cause those small variations in gravity. (Density is a measure of how much mass is contained in a given volume.)

The emptying and refilling of groundwater basins is one way that the density of Earth's surface changes. The GRACE satellites pass over these buried reservoirs regularly. As they do, the satellites "weigh" the mass of the water stored inside.

The researchers examined gravity changes over Earth's largest aquifers from 2003 through 2013. Eight of the studied aquifers lost significant volumes of water over that decade. The researchers classified these aquifers as "overstressed." That means almost no water naturally trickled in to replace water being pumped out. The regions of greatest concern were in the Middle East, northern Africa and northwestern India and Pakistan.

The most dried-up aquifers were in areas near large cities, in heavily agricultural areas



or in arid climates. All three characteristics probably contributed to the extreme stress affecting the basins below central California, Richey says. California has both people and farms. It's also in a multi-year drought. As a result, the state's pumping of groundwater recently has skyrocketed.

The GRACE mission provides valuable information about how global groundwater has changed. It can't measure exactly how much water is left in the aquifers, however, says Gordon Grant. He is a hydrologist with the U.S. Forest Service in Corvallis, Ore. Still, the new work allows scientists to "better understand, like an accountant would, withdrawals and deposits of groundwater around the world."

Power Words

agriculture The growth of plants, animals or fungi for human needs, including food, fuel, chemicals and medicine.

aquifer Rock that can contain or transmit groundwater.

arid A description of dry areas of the world, where the climate brings too little rainfall or other precipitation to support much plant growth.

climate The weather conditions prevailing in an area in general or over a long period.

climate change Long-term, significant change in the climate of Earth. It can happen naturally or in response to human activities, including the burning of fossil fuels and clearing of forests.

density A measure of the consistency of

an object, found by dividing the mass by the volume.

drought An extended period of abnormally low rainfall; a shortage of water resulting from this.

gravity The force that attracts anything with mass, or bulk, toward any other thing with mass. The more mass that something has, the greater its gravity.

groundwater Water that is held underground in the soil or in pores and crevices in rock.

hydrology The scientific study of Earth's water, especially in relation to land. Experts in this field are known as hydrologists.

irrigation The supply of water to land or crops to help growth.

mass A number that shows how much an object resists speeding up and slowing down — basically a measure of how much matter that object is made from. For objects on Earth, we know the mass as "weight."

reservoir A large store of something. Lakes are reservoirs that hold water. People who study infections refer to the environment in which germs can survive safely (such as the bodies of birds or pigs) as living reservoirs.

satellite A moon orbiting a planet or a vehicle or other manufactured object that orbits some celestial body in space.

stress (in biology) A factor, such as unusual temperatures, moisture or pollution, that affects the health of a species or ecosystem. (in physics) Pressure or tension exerted on a material object.

Simple Biology Experiment Ideas

Here are some simple biology experiment ideas for kids, to make the learning process more fun at school...

Biology is a fascinating subject, however in order to get the students interested in the subject, you can make use of some simple experiments to peak their interest. Putting biology into action is a far more interesting way to engage kids instead of sticking to theorized classes. It builds on their keen learning abilities to explore what biology as a subject offers. In case you are looking for some simple biology experiments for kids at school or even at home, here are some suggestions to help you with this.

Simple Experiments for Kids

Experiments need to be simple, in terms of the apparatus used as well as the concepts explained. Generally, you can start with experiments that deal with plants, flowers or even the observation of insects, soil / food samples and so on.

Experiment #1 - Colored Flowers

This is a very simple and fun biology experiment, which will serve to teach children about water absorption systems in plants.

Things Required:

A cup of water

Food color

A flower with an intact stalk

Empty clean flask

Procedure:

First of all, mix the food color in the water. Make sure there are no lumps and that the color dissolves completely in the water.

Now pour the colored water into the flask. Make sure that the flask is clean and doesn't have any impurities on its surface.

Now, take the flowers (with intact stalks) and place them in the flask, so that half of the stalk is submerged under water.

Place the flask on a window sill or any other surface that gets sufficient sunlight.

Tell the children to observe the color of the flowers over a period of time.

Experiment Results:

Plants need water for sustenance; this simple experiment demonstrates how water is absorbed by the stalk, and

distributed throughout the plant to its leaves and flower.

Experiment #2 - Observing Bacteria

Well, although the title might give a notion that the experiment is too advanced - it is not! It is a simple and easy experiment to introduce the children to some species of bacteria.

Things Required:

A compound microscope

Yogurt

Clean empty cup

Water

Unused ink dropper

Microscope slide

Cover slip/glass

Procedure:

First of all, take a small quantity of yogurt (half a teaspoon) and drop this into the cup, adding two teaspoons of water to it.

Mix the yogurt and water with a spoon, so as to create a homogeneous suspension.

Using the ink dropper, place a drop of this yogurt suspension on the clean, sterilized microscope slide. Make sure you don't take more than a drop.

Place the cover slip on the drop of suspension. Now, the slide is ready to be observed under the microscope.

Now simply allow the children to observe the sample under the microscope.

Experiment Results:

Usually the commercially manufactured yogurt include Streptococcus thermophilus and Lactobacillus bulgaricus. You can tell the children about these bacteria which are in fact helpful to our systems, and not harmful like other kinds of bacteria.

Experiment #3 - Flexi Bones

This experiment will show kids how calcium (a mineral) and collagen (a protein), are the two important elements, that are needed in order to keep the bones strong and flexible. If any of the two elements becomes deficit, then there is a possibility that the bones would lose their strength and/or flexibility. Lack of strength can cause them to break easily, while lack of flexibility can cause them to bend, each of which, is a dangerous condition.

On the lighter side, it'll also encourage children to drink lots of milk for calcium and eat dark-green vegetables like spinach, broccoli and collards for collagen.

Things Required:

Drumstick bone - 2 per student

White vinegar (ordinary)

Plastic containers with lids

Procedure:

It is wise to have the students (or their parents) clean the bones thoroughly before wrapping them up in plastic bags and placing them in the refrigerator, for the experiment the following day at school.

Have students place their drumstick bones in a plastic container.

Label the containers as 'Vinegar' and 'Oven'.

In the container labelled 'Vinegar':

Submerge the first bone in vinegar, enough to let it cover the entire bone's surface.

Place the lid on the container, making sure it is airtight.

Leave the bone in vinegar in the school lab for about 3 days.

Have students drain the vinegar out, gently wiping down the bone.

In the container labelled 'Oven':

It is highly advised for parents (or teachers) to be around and use a kitchen mitt when handling the bone, as it will become really hot when baked.

Bake the bone in the oven at 250 degrees for 3 hours.

Remove the bone from the oven and let it cool down.

Experiment Results:

Students will notice that the bone that was soaked in vinegar has a rubber-like texture to it, being extremely malleable when touched. This is because the vinegar's acidic content was able to break down calcium over time. On the other hand, the baked bone will be brittle and would break easily because baking has caused the collagen in the bone to break down.

The bottom line is, therefore, that calcium and collagen both are essential for sturdy and tensile bones.

Kids will be drawn to such experiments if you dedicate a time of the week during school hours to expose them to such interesting practical classes. Have them try similar experiments at home with help from their parents, and have them bring to class their feedback about what they learned from the experiment.

Read more at Buzzle: http://www.buzzle.com/articles/simple-biology-experiment-ideas-for-kids.html

Chimps Can Spot Faces Like Humans Do

Charles Q. Choi,
Live Science Contributor

Chimpanzees can quickly identify the faces of other chimps, as well as those of human adults and babies. These new findings could shed light on human and chimp evolution, scientists say.

Faces are key to human social lives, conveying key data about how one feels. As such, humans are wired to pay special attention to faces. For example, when pictures of faces are mixed in with pictures of other items such as cars and houses, people can detect the faces effortlessly.

Prior research has also shown that humans see faces differently from how they see other objects; for instance, facial recognition is severely hampered when people are shown upside-down faces, or when an image of a face is modified so that the nose and mouth are located beneath the eyes. These past findings suggest that the human brain analyzes faces in a holistic manner — that is, it understands images of faces by looking at the whole.

Increasingly, scientists find that chimps, humanity's closest living relatives, also see faces differently than they do other items. To learn more about the chimp response to faces, scientists first trained three adult chimpanzees named Chloe, Pendesa and Ai to find pictures of a chimp face, a banana, a car and a house among groups of other images on a touch screen. [See Photos of Unique Chimpanzee Faces]

The researchers found that the apes recognized the chimp face very efficiently. "Chimpanzees very quickly find a face in the pile of various objects," said study lead author Masaki Tomonaga, a primatologist and comparative cognitive scientist at Kyoto University's Primate Research Institute in Japan.

However, the chimps' ability to detect a chimp face was significantly hampered when the face was upside down. This suggests that chimps may analyze faces holistically, like humans do.

Chimpanzee playing chess

[Pin It] A vintage photograph of a man playing chess with a chimpanzee.

Credit: Everrett Collection, Shutterstock

In subsequent experiments, the scientists also found that the chimpanzees efficiently detected the faces of human adults and babies, but were unable to identify monkey faces. The researchers suggest this gap may result from long-lasting social experiences between chimps and humans. Faces seen from the front were more easily detected than faces seen from the side, suggesting that eye-to-eye contact is important for chimps, just as it is in humans.

"Both humans and chimpanzees have developed a specialized ability for face processing," Tomonaga said. "This implies that the face plays a very important social role in both species. These results are quite suggestive when considering the evolution of social intelligence. Both species may use facial information for their social lives in the same manner."

Chimpanzees also detected a photo of a banana as efficiently as that of a face.

However, further examination showed that the quick ID of the fruit had to do with its distinctive yellow color. When a black-and-white image of a banana was shown, the chimps took significantly longer to spot the fruit, while no such problem was seen with black-and-white versions of faces.

Future research could explore how well other primates detect faces and at what age chimps learn to quickly detect faces. "How and when do chimpanzee babies acquire such abilities?" Tomonaga asked.

Tomonaga and his colleague Tomoko Imura at Niigata University of International and Information Studies in Japan detailed their findings online today (July 16) in the journal Scientific Reports.

The Naked Truth

(or A Brief History of Clothing - I)

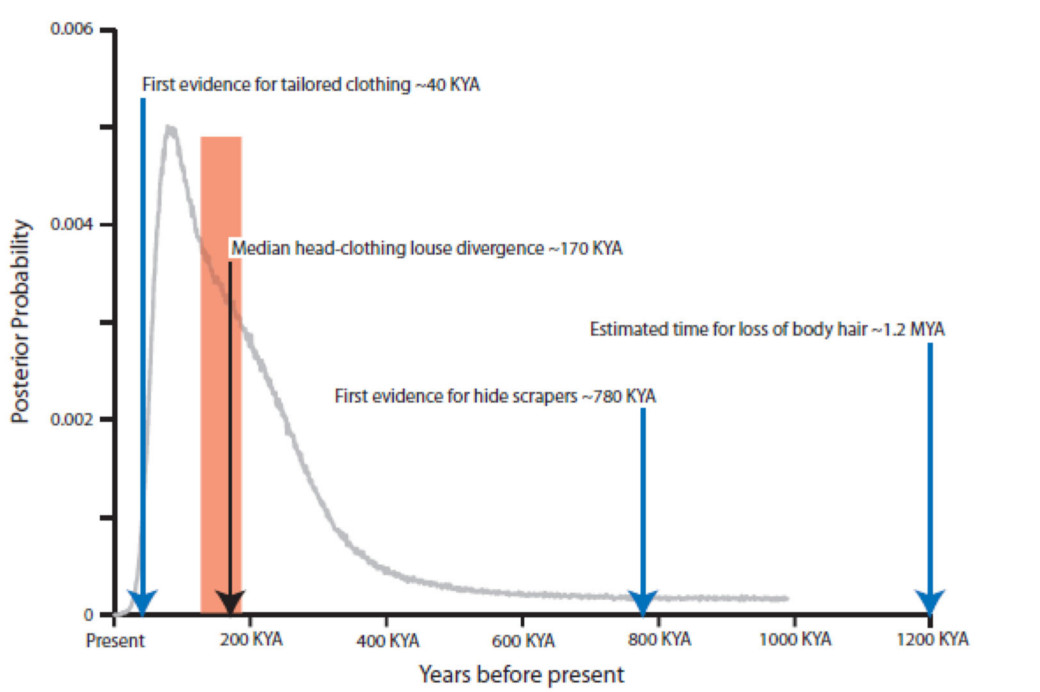
Thiagu Ranganathan

Have you ever wondered why kids say *"Shame Shame, Puppy Shame"* if they see someone naked? Is it that only puppies roam around naked? Why don't they say *"Shame Shame, Hippo Shame"!* It does sound better, atleast to me. Actually, this is something where we have so many options – mosquitoes, bacteria, elephant, dinosaurs, mango trees, sun flowers, apples… You name it and we have it. Tens of thousands of living species around us do not wear clothes. So, it does seem strange that we are the probably the only species who have evolved this method of covering our bodies by cloth.

Not just that, clothing is such an aspect of our lives today that many political leaders across the world seem to win elections based on their promise to provide clothing along with food and shelter. *"Food to eat, clothes to wear and a home to stay"* is a popular political slogan/promise for all times. Clothing is thus considered a very basic need of human beings today. It just doesn't stop being a basic need; it goes beyond that. We wear so many different clothes in our lives of different materials, sizes and colours in our life. We spend significant time of our lives in choosing, buying (for them and others), and wearing clothes. There is also a lot of human and mechanical energy that goes into producing these clothes. There is significant employment generated in the world for production, marketing, transportation and sales of clothes and materials used to make these clothes. Trade between countries involving clothes and materials for making clothes (silk, cotton, wool, flax, etc.,) have existed over thousands of years between countries of different continents. This trade seems to have made and destroyed the fortunes of many economies of the world. An integral part of every culture is about the type of clothes people wear. Yet, we don't seem to know why we, the human beings, started clothing ourselves and when we started doing so? Did our grandparents and their grandparents and their grandparents and parents of their grandparents wear clothes? Did we start wearing clothes a 1000 years ago or 10000 years ago or 20000 years ago?

Recent research has put a tentative date to when we started clothing ourselves and it seems human beings have been wearing clothes from 83,000 years to 1,70,000 years ago. The natural question you might ask is how the researchers came up with this date. The earliest clothes human beings worn were probably made of animal hides. If animal hides were the first dresses for human beings, it can get decayed and it makes it difficult to find the exact time since which human beings wore these clothes.

This would mean we look at some other means. Archaeologists had found the hide scrapers and put the date of earliest hide scrapers to 780,000 years. The problem with saying that the clothes would have been worn since then is that animal hides were used by human beings for various other purposes other than clothing. So, the animal hide scrapers could have been used



to take animal hides for shelters. We also know that eyed needles existed atleast 40,000 years ago. But, the problem in putting that as the date from which we began clothing is that early clothing might not have needed the use of needles. So, the invention of needle just indicates the existence of tailored clothing, but not necessarily clothing itself. The other evidence we have with regard to clothing is that we now know that human beings lost body hair 12,00,000 years ago and clothing was probably not needed when we had body hair. Only when we dropped body hair, did we need clothing to protect ourselves from the cold temperatures. Though there is no single reason that indicates why we are the only primate without dense bodily hair, dropping body hair probably provided human beings the advantage of agility to move and also protected us from blood sucking leeches/lices. Given that presence of body hair would have meant that clothes were not required, human beings were supposed to have started wearing clothes from 40000 years ago to 12,00,000 years ago. This gap is quite wide and research has happened in other field to come up with a more precise date.

An interesting finding from the field of molecular biology has indicated a more precise date of start of human clothing. This research has identified the start of human clothing by identifying the divergence of two lice – clothing lice and head lice. The head lice prefer to stay in human head while the cloth lice prefer to live in clothes of human. The findings are based on few assumptions. Assumption one is that the clothing lice would have diverged from head lice only after human beings started wearing clothes. This does seem to be a reasonable assumption. The other assumption is that the changes required to be made in the genes of related species happen at a somewhat constant rate. Given these two assumptions, the researchers analysed the degree of divergence on the genetic content of head lice and cloth lice. The changes in genetic content of these two lice were identified and the time at which the cloth lice emerged has been estimated as roughly between 83,000 to 1,70,000 years. Interestingly, this also coincides with the outset of ice age (Marine Isotope Stage VI) which is estimated to have occurred between 1,30,000 to 1,90,000 years ago. The invention of clothing could thus have also helped human beings living outside tropics to cope with cold stress caused from this age onwards. Thus, clothing could be one along with invention of other technologies that was the reason that has helped in evolution and survival of human beings.

We thus have some answers to why and when we started clothing ourselves. But, there are various other questions remain: Why do we cloth ourselves with ornaments? What are the different materials that are used historically to cloth ourselves and which of them was used when? How are/ were demand and supply of such materials for clothing dealt with? and so on. Not just these questions, there are also questions like why don't sport person wear cotton clothes? We can look at these questions in future articles.