

Urine: Your Own Chemistry

By Doris R. Kimbrough

If ordinary body functions gross you out, you should probably stop reading this article right now. If not, urine luck! Bad pun? Let's move on. But first, you might want to take a quick restroom break. The power of suggestion can get a little intense.

Urine is a fascinating solution of a variety of salts and water-soluble *organic* chemicals—carbon-containing molecules. Typically, it is slightly acidic, with a pH of around 6, but the pH can range from 4.8 to 7.5, depending on the individual and his or her diet. The composition of your own urine depends on your overall health, what you have been eating and drinking, and any medications you may be taking. This is why *urinalysis*, the chemical analysis of urine, is so important in health care and in drug testing in the contexts of law enforcement, employee screening, and athletic competitions.

A balancing act

You probably already know that your kidneys are responsible for the production of urine. But you may not be aware of the very complicated balancing act that the kidneys perform for your good health. The kidneys help maintain the right fluid levels and pH in your body tissues while keeping the concentration of a bunch of different substances in your blood within the proper ranges. Urine is the result of this very complicated system. Excess salts and even water are toxic if they build up in body tissues. The kidney excretes these along with any other dangerous or unnecessary chemicals that may be circulating in your blood. If your kidneys fail, you get very sick, very fast! (See "Kidney Dialysis—The Living Connection" in the April 2001 issue of *ChemMatters*.)

The principle component of urine is plain old water, H₂O. Your kidneys keep fluid levels in your blood and other cells balanced through a reverse osmosis/osmosis process (see Figure 1). At the same time, they balance your *electrolytes*, the vital ions that are present in your cells, like Na⁺, K⁺, Ca²⁺, Cl⁻, and H₂PO₄⁻. If you drink a lot of water, your urine is dilute.

Lots of water means low concentrations of other stuff. If you are dehydrated or your kidneys aren't functioning properly, your urine gets more concentrated. Less solvent means higher concentrations of *solutes*.

Why yellow?

Urine is yellow because it contains a chemical called *urochrome* (YUR-oh-kroh-m). Urochrome, yellowish brown in solution, is a very large molecule that is formed from hemoglobin in old, used-up red blood cells. The liver dismantles these cells, recycles what it can, and releases the urochrome into the blood stream. The kidneys recognize urochrome as a waste product and excrete it. People who are ill with kidney or liver disease often develop a yellow pallor because of the buildup of urochrome in the bloodstream.

How deeply yellow your urine is depends upon how much water you have been drinking and how much water you have lost through sweating and respiration. It is always healthier to have pale yellow urine. The pale color indicates that you are hydrated and that your kidneys are working properly. If you take vitamins, you may have noticed that your urine becomes extremely yellow shortly after taking a vitamin pill containing B vitamins. This is due to riboflavin (Vitamin B₂), which is yellow in color. Your kidneys simply excrete what you don't need through your urine—vitamins included—often resulting in some unusual colors for a while. Nutritionists joke that people who take excessive amounts of vitamin supplements excrete the most expensive urine in the world.

Molecules in the mix

Three other nonionic chemicals besides urochrome that are found in normal urine are *urea*, *uric acid*, and *creatinine* (see Figure 2). In humans, urea results from the normal breakdown and use of protein. Uric acid results from the breakdown of nucleic acids (DNA and RNA). And creatinine is produced as a waste product from the chemical reactions involved in muscle function. Creatinine is one of the substances that doctors and health technicians sometimes analyze in your urine. If your metabolism is normal and your kidneys are functioning properly, your "creatinine output" will be steady and within a certain range,

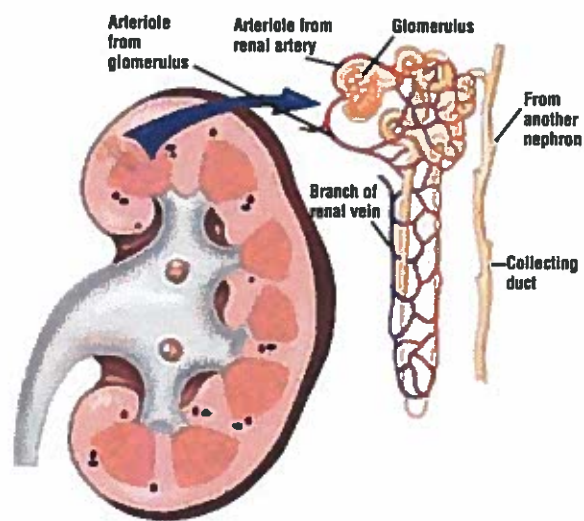


Figure 1. In thousands of tiny kidney filtering units, water and molecules leave the blood through the glomerulus. The optimum amount of these substances is reabsorbed into the blood by reverse osmosis. The remaining waste products collect to form urine.

depending on your size and activity. Abnormally high or low creatinine output indicates something is wrong.

There are many other nonionic substances in your urine. Their identity and concentration depend upon what you have been eating and drinking recently. For instance, about half of the people reading this article may have noticed that their urine smells funny after eating asparagus. It's nothing to worry about. The funny smell is due to two sulfur-containing chemicals in asparagus. Your body breaks these chemicals down into smaller molecules, some of which have a characteristic odor. Interestingly, heredity is involved. Not everyone produces the same smaller molecules, and not everyone is able to smell them. Similarly, coffee drinkers and people who consume certain kinds of spices may also notice unusual odors in their urine.

Pee in a cup

Urinalysis, the chemical analysis of urine, yields critical information about the overall chemical composition of body fluids—information that is useful in many diagnoses. Besides monitoring creatinine as described above, health professionals monitor a variety of other substances and properties. When you submit a urine sample, the technician first records the specific gravity or density of the sample. If it is too high, you could be dehydrated or possibly have a kidney disease. The pH is also important. If pH is too high or low, certain solid precipitates may form as kidney stones in the urine—a painful condition requiring treatment. Urine may be tested for sugar and ketones. High levels of either of these signal potential diabetes. Protein or blood in the urine is a sign of infection somewhere in the urinary tract.



Something that should definitely NOT be in urine is bacteria. It may come as a surprise that urine is sterile. In theory, it would even be safe to drink. Gross, yes, but potentially lifesaving for people like earthquake victims trapped without any water. A cloudy urine sample generally signals the presence of bacteria, indicating a bladder or kidney infection to be treated with antibiotics. Interestingly, a class of chemicals, called anthocyanins (see Figure 2), which is present in various berries, most notably cranberries, helps prevent bladder infections by interfering with the bacteria's ability to cling to the wall of the bladder.

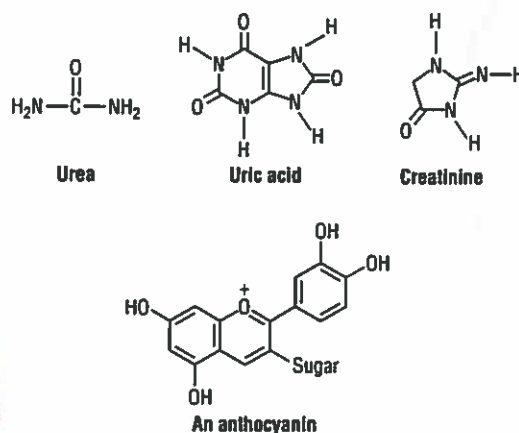


Figure 2. Urea, creatinine, and uric acid are three waste products found in normal urine. Variations in their concentrations can indicate changes in the way your metabolism and your kidneys are functioning. Anthocyanins present in cranberries help prevent bladder infections by interfering with bacteria's ability to cling to the bladder wall.

Athletes, racehorses, and drug offenders also routinely undergo urine testing. The urine indicates the presence of any drugs or medications—legal or illegal—in the body. Sometimes, the chemical itself is excreted in the urine. More commonly, a metabolite of the drug is excreted. A metabolite is one of the chemicals that is formed when your body breaks down a drug into smaller molecules. Scientists have studied how we metabolize drugs and certain supplements used and often misused by athletes. Using an analytical technique called *mass spectrometry*, they can detect even tiny amounts of these molecules or their metabolites. (See "Drug Detection at the Olympics" in the December 2000 issue of *ChemMatters*.)

Finally, we'll leave you with some things to keep in mind even if *urine good health*. (Sorry!) To keep your kidneys and bladder healthy and functioning properly, drink plenty of fluids, even more when exercising. Enjoy an occasional glass of cranberry juice, use common sense in taking vitamin supplements, and stay clear of illegal drugs and dangerous supplements. And just think! From now on you'll appreciate your own set of chemicals every time you flush! ▲

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