DEPARTMENTS

Question From the Classroom
Is it true that there are no plans to ban DHMO, one of the most hazardous substances on the planet?
This potentially deadly chemical is everywhere you look! Read the facts and decide whether or not to go with the flow.

ChemHistory
Clean Water and Edward Frankland
Today, we take it for granted that our tap water is free of deadly germs. A century ago, Edward Frankland saved thousands of lives by showing Londoners how to safeguard their water supply.

Chemsumer
Antibacterials—Fighting Infection Where It Lives
Do cleaning products marked “antibacterial” really do the job? Although they make our hospitals and cafeterias safer places, some scientists think the products go too far in the fight against germs.

Chem.matters.links
And WHY is there an elephant on the cover of ChemMatters? Find out how this lovely “party animal” got to be our October cover girl!

CM Puzzler
Here are two symbols from our “Periodic Table of the Elephants”. Which chemical elements do they represent?
Answers appear in the margin of page 16.

FEATURES

Tapping Saltwater for a Thirsty World
Earth may be known as the watery planet, but not all of the water is fit to drink. Some thirsty regions are looking to chemistry for ways to turn abundant saltwater into sale drinking water.

Activity: Filtered vs. Straight From the Tap
Our tap water may be safe to drink, but many of us prefer to filter it for a better taste. Do some tests to find out how filtered water and tap water compare.

The Search for Martian Water
Finding water on Mars may not be as exciting as finding little tentacled monsters, but scientists think it’s the next best thing. Where there’s water, life as we know it is possible.

Urine: Your Own Chemistry
This is about as personal as chemistry gets! The urine you excrete tells a story about your health, your diet, and any medications you’ve been taking.

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**Q.** Is it true that there are no plans to ban DHMO, one of the most hazardous substances on the planet?

**A.** You are absolutely correct! Although such notorious substances as DDT, dioxin, and carbon tetrachloride were banned when they turned out to pose serious health and environmental threats, a far more dangerous chemical, dihydrogen monoxide (DHMO), remains legally available for use by industries and ordinary citizens. The Coalition to Ban Dihydrogen Monoxide encourages all of us to become informed and to join them in advocating immediate action to stop the proliferation of this dangerous substance. You can access their Web page at [www.netreach.net/~rjones/no_dhmo.html](http://www.netreach.net/~rjones/no_dhmo.html) and their research page at [www.dhmo.org](http://www.dhmo.org).

According to the coalition, DHMO is odorless, tasteless, and potentially deadly. Most human deaths attributed to DHMO are caused by accidental inhalation of its liquid form; however, solid DHMO is known to cause severe, potentially fatal tissue damage. Even moderate DHMO ingestion contributes to sweating and urination; overdoses cause nausea, vomiting, and body electrolyte imbalance. In its gaseous state, DHMO causes severe, sometimes deadly burns. Despite widespread warnings about the hazards, DHMO dependency pervades all cultures; prolonged DHMO substance withdrawal is always fatal.

It’s important to read the well-documented facts about the DHMO threat before making your own decision to support the ban.

**Dihydrogen monoxide:**
- is the major component of acid rain.
- contributes to the greenhouse effect.
- was reportedly dropped on American troops during the Vietnam War.
- erodes acres of our natural landscape and valuable farmland.
- accelerates corrosion and rusting of many metals.
- causes many crystalline substances to break apart spontaneously.
- causes dangerous electrical short-circuiting.
- decreases the effectiveness of automobile brakes.
- is present in cancerous tumors.
- is discharged from the eyes of babies suffering from colic.

Widespread DHMO contamination of the environment is evident on every continent. Vast quantities of DHMO permeate every stream, lake, and reservoir in America today—with the cleanest waterways showing the highest concentrations, in excess of 999,000 parts per million. Furthermore, DHMO pollution is global. Not even the Antarctic is immune. At the South Pole, significant DHMO concentrations were recorded deep within polar ice. And this just in: NASA’s Mars-orbiting spacecraft Odyssey has spotted deposits of DHMO on our neighboring planet. Its presence throughout the solar system is now suspected by NASA scientists.

The economic implications are especially severe. DHMO causes millions of dollars of property damage in virtually every coastal state in the United States. But interior states are equally at risk. In 1993, there was a severe DHMO exposure in the Midwest, which affected crop failures and property damages with losses estimated in the billions of dollars.

Unbelievable though it may seem, DHMO continues to be used in many industries as an industrial solvent and coolant. It’s the number-one food additive, even in those foods advertised as “organic” and “natural.” Companies dump vast quantities of waste DHMO into rivers and oceans. Presently, nothing can be done to stop them, because this practice is still legal!

Can we afford to continue to ignore the DHMO threat? The U.S. government refuses to ban the production, distribution, or use of this damaging chemical, citing its importance to the economic health of this nation. U.S. military organizations continue to conduct DHMO experiments at taxpayers’ expense. And federally funded research is likely to result in the construction of an increasing number of multibillion-dollar DHMO facilities for generating electrical power.

Are you ready to take action? Before heading for the picket lines, you may wish to do some additional fact-finding about DHMO—this time, with the help of your chemistry textbook. Think back to what you’ve learned about compound naming and formula writing. Carbon dioxide, for example, has the chemical formula: CO₂. What would be the formula for dihydrogen monoxide (DHMO)? And its common name?

If you’re still stumped, read the fine print: If you still have not put two and two together (or perhaps it should be two and one together), DHMO is water — good old, ordinary, everyday H₂O! Now go back and reread the fact sheet above. Don’t you agree? It’s all accurate! You might want to try an experiment of your own. Draw up a DHMO fact sheet, and see how many signatures you can get on a petition to ban the substance. Several reports show that nearly 90% of the population, after reading the horrific “facts about DHMO,” will sign such a document! Now that’s scary!
Clean Water and Edward Frankland

From Prometheans in the Lab by Sharon Bertsch McGrayne
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As six major epidemics of cholera swept the globe during the 19th century, fecally contaminated drinking water killed millions of people. For more than 30 of those terror-filled years, the resolute courage of one chemist, Edward Frankland, protected the public health.

Edward Frankland believed that water was guilty until proven innocent, and he condemned tainted water with the righteous conviction of a law-and-order prosecutor. As the illegitimate son of a rich lawyer and a chambermaid, however, Frankland had to hide his origins. So he is almost unknown today, although during his lifetime he was one of Britain’s most important chemists.

Frankland discovered the fundamental principle of valency—the combining power of atoms to form compounds. He gave the chemical “bond” its name, and popularized the notation we use today for writing chemical formulas. He codiscovered helium, helped found synthetic organic and structural chemistry, and was the father of organometallic chemistry. He was also the first person to thoroughly analyze the gases from different types of coal, and—dieters take note—the first to measure the calories in food.

In the 1860s, Frankland had just turned his attention to reforming science education in Britain when London fell prey to the epidemic that had been sweeping Europe—cholera. The disease causes vomiting, fever, and profuse, watery diarrhea. Half of all people with severe and untreated cholera die of dehydration and electrolyte imbalance.

A total of six cholera pandemics—all now thought to have originated in Bangladesh—circled the world during the 19th century. For 50 years, there were never more than six years of relief between the end of one pandemic and the beginning of another. Responsible for an estimated 20,000 deaths in England alone, the epidemic prompted Queen Victoria’s personal physician to remove the handle from the polluted Broad Street pump in London in the first recorded, appropriate measure to prevent waterborne disease.

Cities were particularly easy prey for cholera, as urbanization and industrialization polluted water supplies. Although London’s water was the most notorious, it was probably not the worst. And although cities in the United States were late to industrialize, they too had problems as cities grew and the middle classes demanded more water for bathtubs, showers, and toilets. Chicago, for example, used Lake Michigan as both a water reservoir and a sewage dump.

Disease and contagion were already widely associated with decaying human and animal waste when Frankland took over as London’s water consultant in 1865 and as virtually the only working member of the Rivers’ Pollution Commission in 1868. Little was known about clean water. Although some experts thought that decaying matter directly caused disease or indirectly nurtured disease-causing microbes, others regarded feces-rich water as no more than unacceptably disgusting. Until the German bacteriologist Robert Koch identified the cholera bacillus in 1883, no one knew how the disease spread from human feces to drinking water to human victim and back again.

As the disease devastated cities, clean water issues threatened to tear British society apart. Arguing for “the greatest good for the greatest number”, liberals demanded government action. In contrast, industrialists and Parliament argued that government should not interfere with business, even when the public health was at risk. No one objected to pollution in general or to uncontrolled urbanization and industrialization, but terrified of cholera, people demanded sanitary water.
For 30 years, Frankland was a strong voice—often the only voice—for clean water. Unfortunately, no one knew for sure what clean water was. Frankland staked out a radical position: whatever the deadly agents were, they were almost certainly introduced into water by sewage, so any trace of sewage raised a red flag. He became convinced later that some of the microscopic bacteria in water probably caused fatal diseases.

Frankland approached the problem as a chemist. He devised sensitive new techniques for determining the amount of organic nitrogen in water samples. As a working hypothesis, he assumed that the organic nitrogen originated in sewage or manure. Previous methods had underestimated the amount of ammonia and urea, the main nitrogen-rich components of raw sewage.

Frankland’s method was laborious and expensive. It took other chemists six months to learn. State-of-the-art science for the times, his methods erred on the side of caution. In widely published, monthly reports to the government, Frankland ran horrifying tables that compared the pure well water sold by one of London’s water companies with the nitrogen-tainted river water sold by seven other companies.

Soon Frankland was the world’s leading authority on water issues. During the 1870s and 1880s, Frankland and his assistants conducted more than 11,000 analyses of water for clients from Asia, South America, India, and Europe. He worked for water companies, gas companies, brick works, breweries, copper mines, hospitals, asylums, schools, mansions of the landed gentry, and Buckingham Palace.

He stressed that water’s appearance should not be used as an indication of its safety. “The other day, a gentleman brought to me two samples of well water for examination. I reported both as exhibiting great previous sewage contamination; he protested that it was impossible as the waters were bright and sparkling … a week later, he informed me that the source of contamination had been discovered. One of the wells was situated close to a large cesspool; the other received the drainage from a dog kennel.”

Communities everywhere disregarded Frankland’s advice to treat sewage by spreading it on farmland. Because sewage treatment was expensive, communities concentrated not on treating their sewage, but on transporting it elsewhere. In saving themselves, they contaminated water supplies downstream.

Unlike many of his competitors, Frankland relied on experiment rather than speculation. When another analyst declared that sewage would be purified after it flowed 7 miles downstream, Frankland countered with his findings: “I find that percolation through 5 feet of gravely soil removes much more organic impurity from sewage water than does a flow of 50 miles in a river at a rate of one mile per hour.”

After Koch’s momentous discovery of the cholera bacillus in 1883, cheap and effective treatment of sewage became possible. The civil engineering of water and sewerage mains, reservoirs, sand filtration, and chlorination made waterborne diseases a thing of the past in much of North America and Western Europe.

Chlorine, introduced to London’s water during a typhoid epidemic in 1905, was particularly important. Chlorine is not only cheap, but it also lasts long enough to destroy any pathogens that leak into the water through cracks in pipes.

The use of chlorine to treat water saved countless lives. However, late in the 20th century, after scientists learned how to identify tiny traces of chemicals in huge samples, it was found that chlorine bleach produces small amounts of chloroform, a suspected liver carcinogen in humans, and dioxin, a highly toxic hydrocarbon.

Today, paper bleaching mills and many European water systems are replacing chlorine with other chemicals such as ozone and chlorine dioxide. Compared to chlorine, these compounds are more expensive, faster acting, and more rapidly decomposed.

More than a century after Frankland’s important discoveries, scientists led by Rita R. Colwell, current director of the National Science Foundation in Arlington, VA, demonstrated that crustaceans infested with the cholera bacillus flourish in plankton blooms in warm, brackish coastal and inland waters fertilized with organic nutrients. During a plankton bloom, drinking one glass of untreated water can give a person cholera. In the late 1990s, scientists discovered that simply filtering water through fabric removes most of the Cyclops crustaceans that harbor deadly cholera.

Cholera was, and is, predominantly a disease of the poor. An official investigation of the 1832 cholera epidemic in Paris showed that up to 53 out of every 1000 inhabitants in the poorest neighborhoods died, compared to only 8 per 1000 in wealthy areas. Despite all advances in science and technology, the sewage-contaminated water that ravaged the 19th century is still a scourge of poor, developing countries at the beginning of the 21st century. Fully 25% of the population in developing nations still drink dilute sewage.

**About the book**

*Prometheans in the Lab: Chemistry and the Making of the Modern World* tells the dramatic stories of nine chemists whose discoveries shaped the Western world. Their lives demonstrate the benefits and costs of technology, the rise of the environmental movement, and science’s growing ability to identify and solve pollution problems. Other scientists profiled in the book are Nicolas Leblanc (cheap soap); William Henry Perkin (cheap dyes); Norbert Rillieux (cheap sugar); Fritz Haber (fertilizer and poison gas); Thomas Midgley, Jr. (leaded gasoline and safe refrigeration); Wallace Hume Carothers (synthetics); Paul Hermann Mueller (DDT); and Clair C. Patterson (lead-free gasoline and food).
They’re multiplying! Not only bacteria, but products for killing them! Store shelves are loaded with new antibacterial soaps, household cleaners, hand gels, and laundry products designed to take us beyond clean. These products significantly reduce the number of germs in our surroundings. You have to wonder! Do they work? And maybe even more fundamentally—do we need them? Some researchers even suggest that there is a downside to being too clean!

Before you start longing for a more relaxed approach to hygiene, you might want to check some history. In the mid-19th century, it was common for patients to die from infections contracted during a variety of medical procedures, most notably, childbirth. Why? They were regularly infected by their own doctors who didn’t wash their hands.

We have Dr. Ignaz Semmelweiss to thank for convincing doctors to avoid spreading infection to their patients by means that today seem obvious. In 1847, this Viennese physician recommended that doctors wash in a chloride of lime solution after performing autopsies, and wash with soap and water between patient visits. With these simple improvements in medical practices, hospital mortality rates declined dramatically.

It took a little longer for people to make the connection between illness caused by contaminated food and the simple hygiene practices we take for granted today. One hundred years ago, few people washed their hands, even before eating. A weekly bath was considered more than adequate. Gradually, doctors, scientists, and home economists educated the public about the dangers of bacteria, teaching the basic practices for safe food handling in processing plants, restaurants, and homes.

**Bacteria are everywhere**

In biology class, you learned about bacteria spores—tiny resistant airborne structures that begin to thrive when they encounter the warmth, moisture, and organic nutrients necessary for their growth. At home, the most likely places to find these ideal conditions are in your bathroom and kitchen—and on you! As you touch objects and surfaces—cabinet surfaces, doorknobs, desks, computer keyboards, faucet handles, shoes, food items—spores attach to your moist hands. From there, they can either begin growing with the conditions you provide, or they can transfer to other surfaces. Moist food products are especially attractive to many bacteria. There are actually harmless, even beneficial types, but many bacteria are infamous for making our lives miserable. They can cause food poisoning, intestinal illnesses, skin infections, body odor, and many other problems.

Although the kitchen may not be the germiest place in your house, it can be the home of some potentially dangerous varieties. Here bacteria are transferred from hands to raw meat and unwashed vegetables to countertops, cutting boards, back to hands, and on to other foods. But bathrooms are not far behind kitchens in germ concentration. When you flush the toilet, about 600,000 bacteria fly out and land on nearby surfaces.

And school? It probably won’t
come as a shock that even the cleanest classrooms don’t get very good
grades. University of Arizona researcher Charles Gerba found that office
desks host about 400 times more bacteria than public toilet seats. School
desks may be even worse because of the number of people who
use each one. So what are we to do in this germy world?

Beyond soap and water, there are new products available for keeping
our hands as free of unwanted germs as possible. Bacteria-killing
products—currently marketed as antibacterials—for hand sanitizing
come in two main categories: those containing ingredients like alcohols,
which kill bacteria upon contact, and those containing ingredients like
triclosan or triclocarban, which leave a bacteria-killing residue on the
hands to prevent recontamination for several hours. Thus, both kill bac-
teria, while differing in the way they act.

Products like alcohol-based gels do not require water to rinse off
the product, making them especially convenient when water is not
around. Your teachers may have bottles or dispensers of these products
in their classrooms.

Ethyl alcohol (CH₃CH₂OH) is the most common
active ingredient in hand sanitizer gels, killing bacte-
ria by blasting open their cell walls. However, the
bacteria-killing action stops when the alcohol evapo-
rates from your hands.

For consumer antibacterial soaps, the most
common active ingredients are triclosan and triclocarban. One of the
ways in which these chemicals kill bacteria is by inhibiting an enzyme
needed for growth. As an added advantage, triclosan remains on the skin to kill bacteria
for four to six hours.

Triclocarban

Antibacterials:
Good or bad?

So, if these products kill bacteria,
then antibacterial products are the
perfect super weapons for our
war against infection.

Right? Although not
denying the effective-
ness of these prod-
ucts, some doctors
and scientists worry
about risks that may
accompany the overuse of
antibacterial products.

Your skin is home to a naturally occurring colony of “good” bacte-
ria. Without causing any infection, they occupy your skin and prevent
other bacteria from moving in. Antibacterial soaps don’t discriminate
between good and bad bacteria. As your skin is recolonized by bacteria,
some unwanted varieties can find a home.

A more serious potential problem is bacterial resistance. As bacte-
ria are exposed to antibacterial agents, susceptible bacteria die, leaving
the more resistant ones to reproduce. Bacterial resistance is well docu-
mented with the misuse of antibiotic drugs in treating infections. (See

“Antibiotics in the
Food Chain”,
October 2000,
ChemMatters.)

Now, some doc-
tors are worried
that use of
antibacterial clean-
ing products will
lead to the same
resistance, making
bacteria even
harder to fight.

One scientist
leading the argu-
ment against the
use of antibacte-
rial products for
both personal and
surface cleaning is Dr. Stuart Levy, director of the Center for Adaptation
Genetics and Drug Resistance at the Tufts University School of Medi-
cine. He says, “The main disadvantage of using antibacterial products is
the potential for producing bacteria resistant to them and to antibiotics.
Without a proven benefit of the antibacterial product over the detergent
or soap itself, there is no reason to use products containing these chem-
icals.” Dr. Levy does not oppose the use of hand-sanitizing alcohol gels
that do not leave a residue.

Other scientists maintain that antibacterials have an important
place in our ongoing struggle against infection. Richard Sedlak, vice
president of Technical and International Affairs of The Soap and Deter-
gent Association points out that any relationship between bacterial resis-
tance and the use of antibacterial products should show up in real-world
studies. However, to date, such studies fail to show higher levels of
resistant bacteria after use of antibacterial soaps.

Many experts agree. In June 2002, the European Commission on
Health and Consumer Protection reported their own findings, stating: “At
high (biocidal) concentrations, triclosan is very effective and unlikely to
produce a major problem of antimicrobial resistance.” The key phrase
here is “high concentrations.” At concentrations too low to actually kill
bacteria, some resistant forms could still slip through. Nevertheless, the
commission found no real-world evidence for this problem occurring.

While we argue over the choice of weapons, our war against the
bacteria in our surroundings continues. Are we getting the message?
Despite all the obvious advantages to simple hand-washing practices,
a recent survey done by the American Society of Microbiology
revealed that only 67% of adults were observed to wash their hands in
public restrooms.

Roberta Baxter is a science writer who lives in Colorado Springs, CO. Her most
recent ChemMatters article, “Forensics: Finding the Chemical Clues”, appeared
in the April 2002 issue.

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The elemental elephant

When students at Patapsco High School and Center for the Arts in Dundalk, MD, heard about a contest inviting artists from around the country to submit designs for decorating two hundred 800-pound statues destined for Washington, DC’s, city streets, they were interested. Washington is a city of politics, so it wasn’t surprising that the 200 “party animals” would come in 2 equal herds—200 donkeys and 200 elephants.

Then somebody came up with a great idea! Why not depict the elements of the Periodic Table as elephants?

Hearing that their design was accepted by the District of Columbia’s Commission on the Arts and Humanities, the artists at Patapsco High went to work. Research had to be done before anyone picked up a paintbrush.

Sophomore Talbolt Johnson explained “We each got a Periodic Table with the instructions to pick out elements we’d like to do. But first we had to come up with plans for how we would picture them as elephants.”

“We had about three weeks to work out our plans,” said Tiffany Wert, a senior.

“The whole group worked together. We used the Web, a lot of textbooks, and got advice from our chemistry teachers.” According to teacher and magnet school coordinator Farrell Maddox, “Now we all know more about chemistry than we ever expected to know!”

Selected for the corner of 16th and M Streets, the “elemental elephant” was an instant celebrity when she arrived in April 2002 to stand in front of the Washington headquarters of the American Chemical Society. Dressed in a colorful Periodic Table—the Periodic Table of the elephants that is—she was one of the most alluring of the “Party Animals” to delight tourists and office workers throughout the spring and summer.

This September, the “party” ended. Individual statues were sold at auction, the proceeds going to the sponsoring commission for funding grants in art and art education.

Although the city misses the colorful visitors, we can still visit them, at least for a while, at www.partyanimalsdc.org. And the ACS pachyderm lives on at www.chemistry.org/elephant.html.

Now here’s a challenge for you. How could you use your school mascot in a similar project? The Periodic Table of the Tigers? Wolves? Vikings? Warthogs? If you decide to try it, send us your ideas at chemmatters@acs.org.

National Chemistry Week celebrates the chemistry of clean

Mark your calendars for National Chemistry Week 2002, October 20–26. This year the theme is “Chemistry Keeps Us Clean.”

National Chemistry Week (NCW) is a fun-filled, community-based celebration sponsored annually by the American Chemical Society (ACS). In observance of NCW, many ACS local membership sections conduct exciting and creative activities including chemical demonstrations and hands-on activities, workshops for teachers and students, contests and games, open houses and public displays, as well as media interviews and broadcasts. During NCW, you’ll find these lively events in schools and universities, libraries and museums, industries, parks, and even shopping malls.

If your class or your science club would like to get involved, contact your local section of ACS to find out how you can join in on their plans for the celebration. You can find local leadership information at chemistry.org/local sections.

To learn more about this year’s National Chemistry Week theme, go to chemistry.org/ncw.