Clean Water and Edward Frankland

In 19th century Britain, Frankland was a strong voice—often the only voice—for clean water.

PHOTO AND ILLUSTRATION FROM ACS ART ARCHIVE FILE

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.

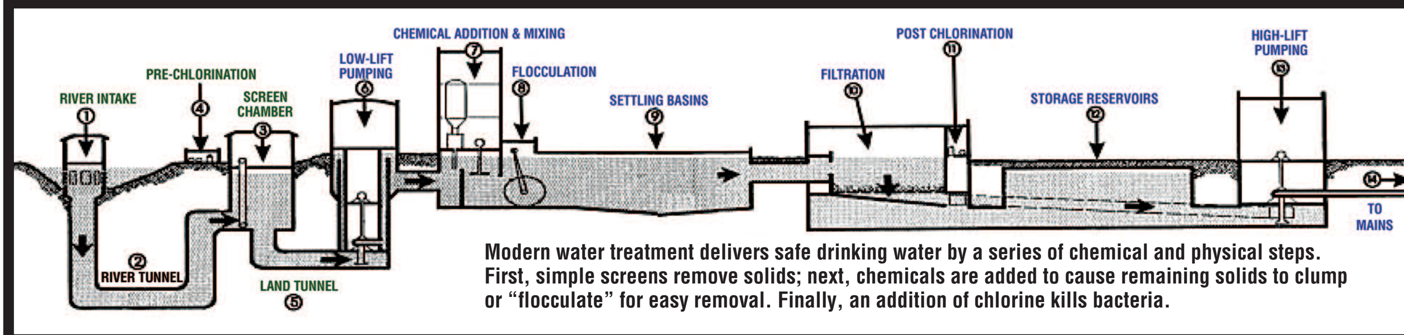
In the 1860s, Frankland had just turned his attention to reforming science education in Britain when London fell prey to the epidemic that had been sweeping Europe—cholera. The disease causes vomiting, fever, and profuse, watery diarrhea. Half of all people with severe and untreated cholera die of dehydration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



Modern water treatment delivers safe drinking water by a series of chemical and physical steps. First, simple screens remove solids; next, chemicals are added to cause remaining solids to clump or "flocculate" for easy removal. Finally, an addition of chlorine kills bacteria.

PHOTO BELOW BY RAYMOND WARRIOR, COURTESY OF MICHIGAN DEPARTMENT OF WATER TREATMENT

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 gravelly 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.

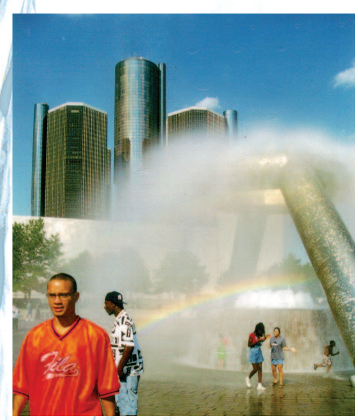
Chlorine, introduced to London's water during a typhoid epidemic in 1905, was particularly important. Chlorine is not only cheap, but it also lasts long enough to destroy any pathogens that leak into the water through cracks in pipes.

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.


Today, most cities take clean water for granted.

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).**