Assignment Details

Prompt 1: Name a chemical compound (i.e., Sodium Chloride or table salt) that you have heard of and explain the effect it has had on society.

You may have to do outside research on that compound's effect on society.

Prompt 2: Consider the statement "The ability to recognize the possibilities in an unexpected result deserves to be lauded (praised) rather than dismissed..." Explain whether you agree or disagree in relation to a science experiment and why.

Your response must be typed and may be no longer than one page, size 12, times new roman font, double spaced, with an MLA header.

INTRODUCTION

For the want of a nail the shoe was lost.
For the want of a shoe the horse was lost.
For the want of a horse the rider was lost.
For the want of a rider the battle was lost.
For the want of a battle the kingdom was lost.
And all for the want of a horse-shoe nail.

OLD ENGLISH NURSERY RHYME

IN JUNE 1812, Napoleon's army was 600,000 strong. By early December, however, the once proud Grande Armée numbered fewer than 10,000. The tattered remnants of Napoleon's forces had crossed the Berezina River, near Borisov in western Russia, on the long road of retreat from Moscow. The remaining soldiers faced starvation, disease, and numbing cold—the same enemies that had defeated their comrades as surely as had the Russian army. More of them were to perish, ill clad and ill equipped to survive the bitter cold of a Russian winter.

Napoleon's retreat from Moscow had far-reaching consequences on the map of Europe. In 1812, 90 percent of the Russian population consisted of serfs, the outright property of a landowner, bought, sold, or traded at whim, a situation closer to slavery than serfdom ever was in western Europe. The principles and ideals of the French Revolution of 1789–1799 had followed Napoleon's conquering army, breaking down the medieval order of society, changing political boundaries, and fomenting the concept of nationalism. His legacy was also practical. Common civil administration and legal codes replaced the widely varying and confusing system of regional laws and regulations, and new concepts of individual, family, and property rights were introduced. The decimal system of weights and measures became the standard instead of the chaos of hundreds of different local scales.

What caused the downfall of the greatest army Napoleon had led? Why did Napoleon's soldiers, victorious in previous battles, falter in the Russian campaign? One of the strangest theories to be advanced can be captured by paraphrasing an old nursery rhyme: "all for the want of a button." Surprising as it may seem, the disintegration of Napoleon's army may be traceable to something as small as the disintegration of a button—a tin button, to be exact, the kind that fastened everything from the greatcoats of Napoleon's officers to the trousers and jackets of his foot soldiers. When temperatures drop, shiny metallic tin starts to change into a crumbly nonmetallic gray powder—still tin, but with a different structural form. Is this what happened to the tin buttons of Napoleon's army? At Borisov one observer described Napoleon's army as "a mob of ghosts draped in women's cloaks, odd pieces of carpet or greatcoats burned full of holes." Were Napoleon's men, as the buttons on their uniforms fell apart, so weakened by the chilling cold they could no longer function as soldiers? Did the lack of buttons mean that hands were used to hold garments together rather than carry weapons?

There are numerous problems in determining the veracity of this theory. "Tin disease," as the problem was called, had been known in northern Europe for centuries. Why would Napoleon, a great believer in keeping his troops fit for battle, have permitted its use in their garments? And the disintegration of tin is a reasonably slow process, even at the very low temperatures of the 1812 Russian winter. It makes a good story, though, and chemists enjoy quoting it as a chemical reason for Napoleon's defeat. And if there is some truth to the tin theory, then one has to wonder whether, if tin did not deteriorate in the cold, the French might have continued their eastward expansion. Would the

yoke of serfdom have been lifted from the Russian people half a century earlier than it was? Would the distinction between western and eastern Europe, which roughly parallels the extent of Napoleon's empire—a testament to his lasting influence—still be apparent today?

Throughout history metals have been pivotal in shaping human events. Apart from its possibly apocryphal role in Napoleon's buttons, tin from the Cornish mines in southern England was highly sought after by the Romans and was one reason for the extension of the Roman Empire into Britain. By 1650 an estimated sixteen thousand tons of silver from the mines of the New World had enriched the coffers of Spain and Portugal, much of it to be used supporting wars in Europe. The search for gold and silver had an immense impact on exploration, settlement, and the environment of many regions; for example, the gold rushes of the nineteenth century in California, Australia, South Africa, New Zealand, and the Canadian Klondike did much to open up those countries. As well, our language contains many words or phrases invoking this metal—*goldbrick, gold standard, good as gold, golden years.* Whole epochs have been named in tribute to the importance of metals. The Bronze Age, when bronze—an alloy or mixture of tin and copper—was used for weapons and tools was followed by the Iron Age, characterized by smelting of iron and the use of iron implements.

But is it only metals like tin and gold and iron that have shaped history? Metals are elements—substances that cannot be decomposed into simpler materials by chemical reactions. There are only ninety naturally occurring elements, and tiny amounts of another nineteen or so have been made by man. But there are about seven million compounds, substances formed from two or more elements, *chemically* combined in fixed proportions. Surely there must be compounds that have also been pivotal in history, compounds without which the development of human civilization would have been very different, compounds that changed the course of world events. It's an intriguing idea, and it is the principal unifying theme underlying each chapter of this book.

In looking at some common and not-so-common compounds from this different perspective, fascinating stories emerge. In the Treaty of Breda of 1667 the Dutch ceded their only North American possession in exchange for the small island of Run, an atoll in the Banda Islands, a tiny group in the Moluccas (or Spice Islands), east of Java in present-day Indonesia. The other signatory nation to this treaty, England, gave up its legitimate claim to Run—whose only asset was its groves of nutmeg trees—to gain the rights to another small piece of land halfway around the world, the island of Manhattan.

The Dutch had staked their claim to Manhattan shortly after Henry Hudson, seeking a Northwest Passage to the East Indies and the fabled Spice Islands, visited the area. In 1664 the Dutch governor of New Amsterdam, Peter Stuyvesant, was forced to surrender the colony to the English. Protests by the Dutch over this seizure and other territorial claims kept the two nations at war for nearly three years. English sovereignty over Run had angered the Dutch, whose monopoly of the nutmeg trade needed only the island of Run to be complete. The Dutch, with a long history of brutal colonization, massacres, and enslavement in the region, were not about to allow the English to keep a toehold in this lucrative spice trade. After a four-year siege and much bloody fighting, the Dutch invaded Run. The English retaliated by attacking the richly laden ships of the Dutch East India Company.

The Dutch wanted compensation for English piracy and the return of New Amsterdam; the English demanded payment for the Dutch outrages in the East Indies and the return of Run. With neither side about to back down nor able to claim victory in the sea battles, the Treaty of Breda offered a face-saving opportunity for both sides. The English would keep Manhattan in return for giving up their claims to Run. The Dutch would retain Run and forgo further demands for Manhattan. As the English flag was raised over New Amsterdam (renamed New York), it seemed that the Dutch had got the better part of the deal. Few could see the worth of a small New World settlement of about a thousand people compared to the immense value of the nutmeg trade.

Why was nutmeg so valued? Like other spices, such as cloves, pep-

per, and cinnamon, nutmeg was used extensively in Europe in the preservation of food, for flavoring, and as medicine. But it had another, more important role as well. Nutmeg was thought to protect against plague, the Black Death that sporadically swept across Europe between the fourteenth and eighteenth centuries.

Of course, we now know that the Black Death was a bacterial disease transmitted from infected rats through the bites of fleas. So wearing a nutmeg in a small bag around the neck to ward off the plague may seem just another medieval superstition—until we consider the chemistry of nutmeg. The characteristic smell of nutmeg is due to *isoeugenol.* Plants develop compounds like isoeugenol as natural pesticides, as defenses against grazing predators, against insects, and fungi. It's entirely possible that the isoeugenol in nutmeg acted as a natural insecticide to repel fleas. (Then again, if you were wealthy enough to afford nutmeg, you probably lived in less crowded conditions with fewer rats and fewer fleas, thus limiting your exposure to the plague.)

Whether nutmeg was effective against the plague or not, the volatile and aromatic molecules it contained were undoubtedly responsible for its esteem and value. The exploration and exploitation that accompanied the spice trade, the Treaty of Breda, and the fact that New Yorkers are not New Amsterdamers can be attributed to the compound isoeugenol.

Considering the story of isoeugenol has led to contemplating many other compounds that have changed the world, some of them well known and still vitally important to world economy or to human health, and others that have faded into obscurity. All of these chemicals have been responsible for either a key event in history or for a series of events that altered society.

We decided to write this book to tell the stories of the fascinating connections between chemical structures and historical episodes, to uncover how seemingly unrelated events have depended on similar chemical structures, and to understand the extent to which the development of society has depended on the chemistry of certain compounds. The idea that momentous events may depend on something as small as a molecule—a group of two or more atoms held together in a definite arrangement—offers a novel approach to understanding the growth of human civilization. A change as small as the position of a bond—the link between atoms in a molecule—can lead to enormous differences in properties of a substance and in turn influence the course of history. So this book is not about the history of chemistry; rather it is about chemistry in history.

The choice of which compounds to include in this book was a personal one, and the final selection is by no means exhaustive. We have chosen those compounds we found the most interesting for both their stories and their chemistry. Whether the molecules we selected are definitely the most important in world history is arguable; our colleagues in the chemical profession would no doubt add other molecules to the list or remove some of the ones we discuss. We will explain why we believe certain molecules were the impetus for geographic exploration, while others made possible the ensuing voyages of discovery. We will describe molecules that were critical to the development of trade and commerce, that were responsible for human migrations and colonization, and that led to slavery and forced labor. We will discuss how the chemical structure of some molecules has changed what we eat, what we drink, and what we wear. We will look at molecules that spurred advances in medicine, in public sanitation, and in health. We will consider molecules that have resulted in great feats of engineering, and molecules of war and peace—some responsible for millions of deaths while others saving millions of lives. We will explore how many changes in gender roles, in human cultures and society, in law, and in the environment can be attributed to the chemical structures of a small number of crucial molecules. (The seventeen molecules we have chosen to focus on in these chapters—the seventeen molecules referred to in the title—are not always individual molecules. Often they will be groups of molecules with very similar structures, properties, and roles in history.)

The events discussed in this book are not arranged in chronological historical order. Instead, we have based our chapters on connections—the links between similar molecules, between sets of similar molecules, and even between molecules that are quite different chemically but have properties that are similar or can be connected to similar events. For example, the Industrial Revolution owes its start to the profits reaped from a slave-grown compound (sugar) on plantations in the Americas, but it was another compound (cotton) that fueled major economic and social changes in England—and chemically the latter compound is a big brother, or maybe a cousin, of the former compound. The late-nineteenth-century growth of the German chemical industry was due, in part, to the development of new dyes that came from coal tar (a waste material arising from the production of gas from coal). These same German chemical companies were the first to develop man-made antibiotics, composed of molecules with similar chemical structures to the new dyes. Coal tar also provided the first antiseptic, phenol, a molecule that was later used in the first artificial plastic and is chemically related to isoeugenol, the aromatic molecule from nutmeg. Such chemical connections are abundant in history.

We were also intrigued by the role serendipity has been accorded in numerous chemical discoveries. Luck has often been cited as crucial to many important findings, but it seems to us that the ability of the discoverers to realize that something unusual has happened—and to question why it occurred and how it could be useful—is of greater importance. In many instances in the course of chemical experimentation an odd but potentially important result was ignored and an opportunity lost. The ability to recognize the possibilities in an unexpected result deserves to be lauded rather than dismissed as a fortuitous fluke. Some of the inventors and discoverers of the compounds we discuss were chemists, but others had no scientific training at all. Many of them could be described as characters—unusual, driven, or compulsive. Their stories are fascinating.