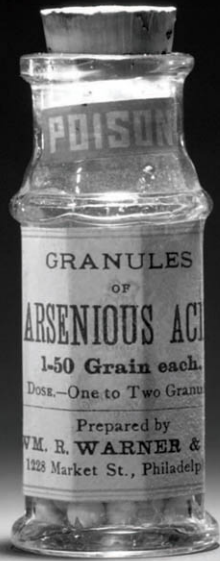


KING of POISONS

A HISTORY OF ARSENIC



JOHN PARASCANDOLA

*KING of
POISONS*

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A HISTORY OF ARSENIC

JOHN PARASCANDOLA



Potomac Books
Washington, D.C.

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*To my parents-in-law,
Roslyn and Daniel Weisberg*

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Acknowledgments

Years ago, while conducting research in the history of pharmacology and toxicology, I became fascinated with the history of arsenic. I have long wanted to write a book on the subject for a broad audience. This book is aimed more toward the general reader than to the specialist in the history of medicine and science, although scholars in these and related fields looking for an overview of the subject should find it useful as well.

The book is based on an extensive number and wide variety of secondary and primary sources. I am indebted to many previous authors on the subject. The works cited in the list of suggested further readings were especially useful. The sources for the images in the book are gratefully acknowledged in the captions.

Many people contributed suggestions or comments in connection with my research and writing, and I cannot list them all. However, I would like to acknowledge and thank several individuals who were especially helpful. My brother, Louis Parascandola, brought to my attention a number of literary works that featured arsenic as part of the story. My editor at Potomac Books, Elizabeth Demers, read the manuscript and made many useful suggestions for changes. I also wish to thank two other members of the Potomac Books staff, Amanda Irle, who guided me through the copyediting process, and Liz Norris, whose copyediting significantly improved the manuscript. Last, but certainly not least, I wish to express my appreciation to my wife, Randee, for her support and encouragement throughout this project.

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Introduction

The very name of arsenic conjures up images of murder and intrigue. It is in many ways the quintessential poison and was for centuries undoubtedly the most frequently used substance for the purpose of homicide. In the words of John Emsley, “Arsenic has a long and disreputable pedigree: its very name seems to condemn it as something unspeakable.” The word itself has a complicated history but ultimately seems to go back to the Greek word *arsenikon*, meaning “bold” or “potent.”

Arsenic trioxide, also called arsenic oxide, is the form in which the element was most commonly administered in cases of murder, and frequently it is this compound that people were actually describing when they referred to arsenic. The oxide is colorless, odorless, and tasteless, and dissolves readily in water and other liquids. It is thus not easy for the victim to detect that he or she is being poisoned. As it is a cumulative poison, small doses can be given over a long period of time, eventually killing someone without necessarily arousing suspicion. The prominent gastrointestinal effects of arsenic were easily mistaken for diseases that were common throughout much of history, such as cholera. Also, there weren't any good tests for detecting arsenic in body tissues until well into the nineteenth century.

Clearly, it is arsenic's poisonous properties that have most fascinated the public over time. However, even this part of the story goes well beyond arsenic's criminal uses. Countless individuals over the centuries have been the victims of unintentional poisoning with arsenic, especially in more modern times. Arsenic is much more than a poison used to dispatch one's enemies or those who get in one's way. Arsenic has had many commercial uses that made it a common substance in the workplace and the environment, especially

beginning in the nineteenth century. Arsenic's value as a green pigment, for example, led to its inclusion in wallpaper, paint, fabrics, and other common domestic items, exposing both the workers who produced these products and the consumers who purchased them to possible poisoning. Arsenic also had numerous other industrial uses, including as a pesticide and as a preservative. In addition, although it may seem odd given its poisonous reputation, arsenic has been used as a medicine since ancient times.

This book tells the fascinating story of arsenic in its many aspects. It begins by looking at arsenic's history as an intentional poison. Given its common use for this purpose throughout much of recorded history, arsenic has often been labeled the King of Poisons. The first chapter examines this murderous history. Not surprisingly, arsenic has been frequently used for homicidal purposes in fiction as well as in real life, and the second chapter will cover the history of arsenic in literature. The focus next turns to unintentional poisoning, looking first at arsenic poisoning in the workplace and then in the broader environment. The final chapter deals with the use of arsenic in medicine.

To begin with, however, some general information about arsenic is in order. Arsenic is an element with the symbol As, an atomic number of 33, and an atomic mass of 74.9. It is classified in Group 15 of the periodic table, along with nitrogen, phosphorous, antimony, and bismuth. The first two of these elements are nonmetals, and the last two are metals. Arsenic falls in the middle of this group and is considered a metalloid (i.e., it has properties of both metals and nonmetals, although it is frequently called a metal).

Estimates of arsenic's concentration in the Earth's crust range from about 1 to 5 parts per million, meaning that it is not one of the more abundant terrestrial elements. But it is concentrated in some parts of the Earth due to its close association with certain other metals and due to human activities such as mining and pesticide manufacture. It also occurs in air and water, generally in small amounts, but again can be concentrated in certain areas, creating toxicity problems. For example, the high arsenic content of drinking water in Bangladesh and West Bengal, India, is poisoning millions of people today. William Cullen has noted that "the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) ranks arsenic as No. 1 on its list of priority hazardous substances because of both its prevalence in contaminated environments and its toxicity. This ranking has not changed for many years."²

Arsenic is rarely found as an element in nature but usually occurs in the forms of the sulfide compounds orpiment (As_2S_3) and realgar (As_4S_4), or as the iron-sulfur compound arsenopyrite (FeAsS). When heated in air, it combines with oxygen to form arsenic trioxide (As_2O_3), which is the most toxic form of arsenic. Although arsenic exists in nature largely in the form of such inorganic compounds, the element can also bind to organic (i.e., carbon-containing) compounds. Many organic arsenic compounds have been synthesized and used as medicines and for other purposes. Organic arsenic compounds are generally less toxic than inorganic compounds of the element.

Some studies suggest that arsenic may be essential to animals and even humans, although the evidence is not definitive enough yet to establish this with certainty. Recently, controversy has also developed over a claim by a team of researchers led by Felisa Wolfe-Simon of the NASA Astrobiology Institute (NAI) that they had discovered a species of bacteria that substituted arsenic for the phosphorous usually used to build DNA, the basic genetic material of living organisms. The idea of arsenic-based life challenges the understanding of the basic requirements of life held by scientists in general, and the study has been criticized by some as being deficient and drawing unjustified conclusions. As this book was going to press, the journal *Science*, based on two new studies, stated that the original Wolfe-Simon paper that it had published was incorrect in some of its major findings and that arsenic did not substitute for phosphorous in the bacterium. Wolfe-Simon and her coworkers, however, defended their original conclusions.³

Arsenic thus remains a subject of controversy today, as it has throughout its history. Whether as a poison or a medicine, a pesticide or a preservative, or for whatever purpose it was used, arsenic has been viewed as a blessing and a curse. Of course, it is neither, merely a chemical element. How we use it determines whether it helps or harms. A doctor can use arsenic trioxide to cure someone suffering from acute promyelocytic leukemia (APL), or a murderer can slip it into someone's coffee. In this book, we shall examine essentially all aspects of the riveting history of this most famous of poisons. We shall explore the many purposes to which arsenic has been put over the ages and better understand why it is the King of Poisons.

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King of Poisons

Arsenic and Murder

Who discovered the poisonous properties of arsenic, and who first used it to murder a fellow human? The answers to these questions are lost to history. The naturally occurring arsenic sulfides realgar and orpiment were known in ancient times and were even used to some extent in medicine. The fact that they were toxic was certainly recognized, but they would not have been useful for homicidal purposes. These compounds are insoluble and colored, and so would have been difficult to administer to someone undetected. The form in which arsenic is generally used as a poison is arsenic trioxide, a white powder that has sometimes been called white arsenic. The trioxide dissolves readily in water and is colorless and tasteless, thus making it an ideal poison. The poisonous nature of arsenic trioxide and methods for making the compound, which does not occur in nature, were certainly known by the ancient Greeks and Romans. It is easily produced, for example, by the smelting of copper ores that contain arsenic as an impurity. Roasting orpiment would also produce a white compound that would have been largely arsenic trioxide. The sodium salt of the trioxide, which had similar properties to the trioxide, could be prepared readily by heating orpiment with natural sodium carbonate.

Some accounts argue that arsenic trioxide was the poison used by Agrippina the Younger and her son, Nero, to eliminate his rivals for emperor of Rome. The evidence for such a claim, however, is not definitive, and other substances, such as cyanide, are also possible candidates. Plants, such as hemlock and wolfsbane, were apparently the most widely used poisons in ancient Greece and Rome. Hemlock, of course, was the poison administered by the city-state of Athens to execute Socrates, and wolfsbane was actually so

frequently used as a poison that the emperor Trajan banned the growing of the plant in Roman domestic gardens.¹

It was not until the beginning of the fifteenth century that arsenic became popular as a poison. The most notorious name associated with poisoning in the Italian Renaissance period is the Borgia family, especially Rodrigo Borgia (who became Pope Alexander VI in 1492) and two of his children, Cesare and Lucrezia. It appears that Lucrezia has become unfairly associated with murder, however, as exemplified by the scene in Donizetti's opera *Lucrezia Borgia* where she poisons five people. In reality, Lucrezia was a pious woman who died at the age of 39, probably without poisoning anyone. There seems to be little doubt of the guilt of her father and brother, however. Cesare, in particular, probably poisoned dozens of people in the furtherance of political ends. Arsenic (probably the trioxide) was almost certainly the key ingredient in the Borgias' favorite poison, called La Cantarella.

Poisoning became a formal method of assassination in Italy. By the sixteenth century, there was a branch of the government of Venice that arranged for the elimination of enemies of the state. Professional poisoners worked for hire and charged fees. In Naples, beginning in the second half of the seventeenth century, a woman named Giulia Toffana (La Toffana) gained notoriety as a poisoner. Arsenic appears to have been the crucial ingredient in the poison she sold, which was frequently referred to as Aqua Toffana. When La Toffana was finally arrested and executed in 1709, she confessed (probably under torture, so the reliability of her information is questionable) to being responsible for the poisoning of some six hundred people. In the mid-sixteenth century, another woman named Hieronyma Spara (La Spara) sold an arsenic-based poison in Rome. La Spara even formed a society where she taught women how to get rid of their husbands with the use of poison.²

Catherine de Medici (who married Henry II, the future king of France, in 1533) often gets the credit for bringing the Italian art of poisoning to France and using it for political gain, although this view has not gone unchallenged.³ There was a widespread belief in France that Italians were a devious people who got rid of their enemies by covert means. Italians were deemed experts on poisons, possessing secret knowledge of powerful toxins.

The French were themselves making significant use of arsenic and other poisons for political or personal gain by the seventeenth century. Marie-

Madeleine-Margu rite d'Aubray, marquise de Brinvilliers, was notorious for murdering members of her family to gain wealth and property in the second half of the century. She reputedly tested out her poisonous concoctions (which included arsenic) on hapless patients in a hospital in Paris, mixing the poison in the gifts of food and drink that she brought for the sick, although most likely this story is a myth. Her crimes were eventually discovered, and she was beheaded in 1676.

Another famous French poisoner of that period was Catherine Deshayes Monvoisin (La Voisin). When her husband went bankrupt, La Voisin supported her family by carrying out abortions, performing witchcraft, and selling love potions and poisons. Arsenic appears to have been a main ingredient in one of her poisons. Convicted of involvement in poisoning and abortion, she was tortured and burned at the stake. Poisoning had become so common in the court of Louis XIV that the king, convinced he himself was in danger, established a special commission to investigate the matter. By the time the commission finished its work in 1682, its investigation had led to the trial of 104 persons, 34 of whom were executed, with others receiving sentences of banishment or imprisonment. A royal edict issued in that year decreed that anyone convicted of supplying poison for the purpose of murder, whether or not the act resulted in fatalities, would be subject to the death penalty.⁴

The British also tended to view poisoning as particularly associated with Italy. They even referred to the act of poisoning as "Italianation," but such crimes occurred in Britain as well. By the sixteenth century, court records reveal that trials involving poisoning were occurring regularly, if not frequently. One source recorded a dozen criminal poisonings between 1571 and 1598. Not surprisingly, arsenic was one of the weapons of choice for British poisoners. In 1712 servant Elizabeth Mason used arsenic in an attempt to murder the two women who employed her. One woman died, but the other survived, and the servant was hanged.⁵

The evidence suggests that poisoning probably reached a peak in England in the mid-nineteenth century (although poisoning was still much less frequent than other means of homicidal violence). By far the most common poison for homicide was arsenic. In a study of 540 English criminal poisoning cases between 1750 and 1914, Katherine Watson found that arsenic (in the

form of the oxide or the sulfides) was involved in 237 cases. The next most common poison, opium, was a distant second, involved in 52 cases. Watson commented, "The story of poisoning in England and Wales is in many ways a chronicle of the rise and fall of arsenic."⁶

Before 1851 there were no legal restrictions on the sale of poisons in England, so they were not difficult to obtain. It was especially easy to purchase arsenic. White arsenic was relatively cheap and was widely available, as it was commonly used to kill rats and other vermin. Arsenic was also used in medicine, such as in the popular medication known as Fowler's solution.⁷

Although the press tended to focus attention on high-profile poisoning cases involving people of higher social status, such as physicians and middle-class women, Watson has shown that, at least in England, poisoning was primarily a crime of the poor and underprivileged. People in unhappy or abusive marriages sometimes murdered their spouses because they were unable to get divorced if they were not wealthy. Parents might murder children because they could not afford to feed and care for them, and desperate or greedy individuals might poison a relative to reap the rewards of an insurance policy. The motives for murder were many and varied.⁸

Poison was typically viewed in the Victorian era as a woman's weapon. The poisoner was linked with characteristics stereotypically associated with women, such as secrecy and cunning. In the 540 poisoning cases studied by Watson, however, men and women were about equally represented (49 percent to 51 percent respectively) among the accused poisoners. Watson does go on to point out that these figures must be considered in light of the more general statistics concerning violent crime. Men comprised a substantial majority of those tried for murder in this period. Watson concludes, "Roughly speaking, then, men were three times more likely than women to commit murder, but women who did so were far more likely than men to choose poison as their weapon." Reviewing cases from England in the 1840s, Ian Burney found that in 60 percent of the cases, the accused party was a woman, 37 percent of whom were charged with poisoning their spouses. He also noted that in nearly 70 percent of these cases, the poison used was arsenic.⁹

Detection of Arsenic

The number of poisoning cases reported was no doubt significantly lower than the actual number of cases, at least up into the nineteenth century. There weren't any good chemical tests for most poisons, and the symptoms of poisoning were often confused with those of disease. Arsenic poisoning was particularly difficult to detect. Its symptoms were similar to those of cholera and dysentery, and there was no reliable chemical test for arsenic until the nineteenth century. Convictions of arsenic poisoning were generally based on confessions or circumstantial evidence (e.g., the accused was known to have purchased the poison and had the opportunity and motive to commit the crime).¹⁰

The first known case in which convincing scientific proof of poisoning was given in court took place in Oxford, England, in 1752. The accused was Mary Blandy, a thirty-one-year-old woman who was charged with poisoning her father with arsenic. Blandy had had an affair with a Scottish army officer named William Cranstoun. Mary's father learned that Cranstoun was married, although the latter denied it, and forbade her from seeing him. Cranstoun apparently believed that Mary was to inherit a large sum of money and was determined not to give her up. After returning to Scotland, he sent Mary a white powder to give to her father, telling her that it would make him more favorably disposed to their marriage. Mary administered the powder to her father in food and drink and he became seriously ill. Two maids who had eaten some of the same food also suffered some ill effects. When they noticed powder at the bottom of a pot of gruel, they turned the pot over to a local apothecary.

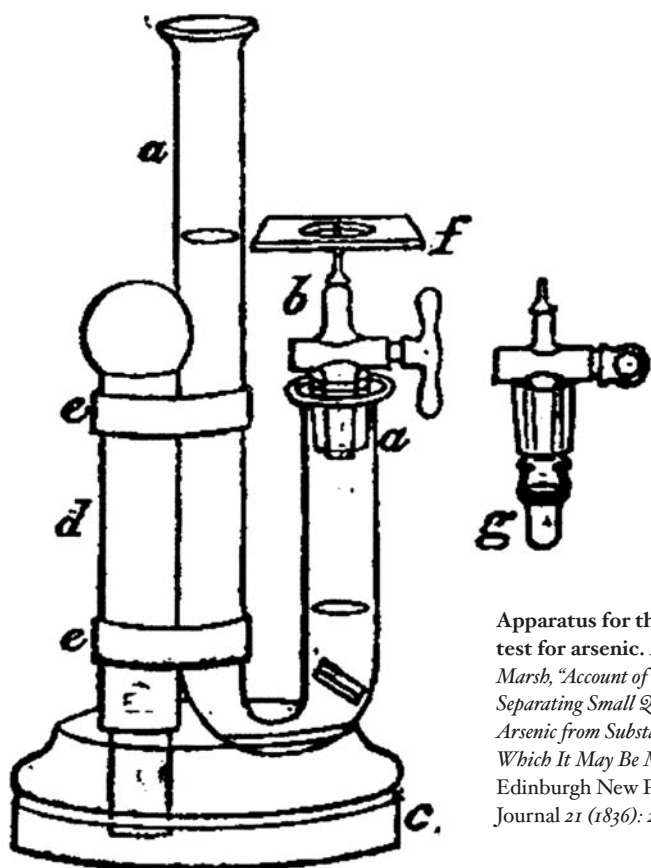
The physician called in to treat Blandy, Anthony Addington, suspected poisoning. Blandy informed the doctor that he became sick after eating the gruel. His symptoms included a painful burning in his mouth and intestinal tract, vomiting, and diarrhea, all consistent with arsenic poisoning. Addington and a chemist examined the powder from the pot that the maids had given to the apothecary. Addington testified at Mary's trial that he concluded that the white powder was arsenic on the basis of some chemical tests, which in reality were rather nonspecific. The powder had the following similar characteristics with white arsenic: it was milky white, it was gritty, the greater part of it sank to the bottom and remained undissolved in cold water, and it produced thick white fumes with a garlic smell when thrown onto a hot iron.

He added that it behaved the same way as arsenic did in a number of chemical tests involving the formation of precipitates.

Since Mary had confessed to putting the powder in her father's food, the main question for the jury was whether or not they believed her claim that she did not know it was poison. She indicated that she had accepted Cranstoun's explanation that the powder would simply make her father fonder of her lover. The jury obviously did not believe that she was telling the truth, since they quickly returned a verdict of guilty. Mary was hanged, but Cranstoun fled to France, where he died shortly thereafter.¹¹

The tests available to Addington were suggestive but did not provide conclusive evidence of the presence of arsenic in cases of suspected poisoning. A more positive identification required a better chemical test. This became clear to James Marsh, a chemist at the Royal Arsenal in Woolwich, England, when he was called upon in 1832 to test for arsenic in a case of suspected murder in Plumstead. The accused was charged with murdering his grandfather. Since the grandson was known to have purchased arsenic, supposedly as a rat poison, Marsh was asked to test some coffee (which had made several people in the household, including the deceased, sick) and the stomach contents of the dead man. Marsh was able to produce a yellow precipitate, characteristic of the presence of arsenic, in the coffee, but the jury was not sufficiently impressed by this demonstration. Furthermore, he was unable to demonstrate the presence of arsenic in the stomach contents. The jury acquitted the defendant, who later admitted his guilt.

Frustrated by the acquittal, Marsh was determined to invent a more definitive test for arsenic. The procedure he developed was based on the discovery by pharmacist-chemist Carl Scheele in 1775 that when arsenic acid reacts with zinc, it produces a gaseous compound of arsenic and hydrogen known as arsine. The gas is highly toxic and smells somewhat like garlic. Marsh found that the gas leaves a film of metallic arsenic when burned or sufficiently heated. The amount of arsenic could be roughly estimated from the size of the film. Marsh's test allowed him to separate small quantities of arsenic from organic matter and to clearly show the presence of the arsenic through the film deposited. Tests involving the formation of precipitates could confirm that the film was arsenic. The Marsh test was adopted quickly in both the laboratory and the courtroom. The sensitivity of the test was



Apparatus for the Marsh test for arsenic. From J. Marsh, "Account of a Method of Separating Small Quantities of Arsenic from Substances With Which It May Be Mixed," *Edinburgh New Philosophical Journal* 21 (1836): 229–36.

later improved so that it could detect even smaller amounts of arsenic. The Swedish chemist Jöns Jacob Berzelius developed a quantitative version of the test in 1837.¹²

The Marsh test, however, required significant skill to perform, or the results could be erroneous or misleading. The test also took hours to complete, and it was possible to contaminate the results through the introduction of arsenic from extraneous sources. The problems involved in using the test are illustrated in the notorious trial of Marie Lafarge in France in 1840. Her husband, Charles Lafarge, died under suspicious circumstances in January 1840, and Marie was arrested and charged with poisoning him when the

autopsy results suggested there was arsenic in his stomach (although the results were questionable because the test tube had exploded during the test). The world-renowned toxicologist Mathieu Orfila pointed out that there were problems with the test procedure. The court asked three chemists to repeat the test on the stomach contents and on Charles's vomit. They used the Marsh test and reported that they found no evidence of arsenic. Charles's body was exhumed and tested again, but still no arsenic was found.

The trial judge was still not satisfied, and he sent for Orfila from Paris. Convinced that Orfila's results would confirm the absence of arsenic, the defense had agreed to the reanalysis. Orfila and two of his colleagues performed the analysis and found about half a milligram of arsenic in the body and the stomach contents. In spite of the earlier results, and the relatively small amount of arsenic detected by Orfila, the jury found Marie guilty, and she was sentenced to hard labor for life (which was later commuted to just life imprisonment). She was released in 1852 after she became ill in prison.¹³

German chemist Hugo Reinsch developed a quicker and simpler test for arsenic in 1841. This test involved dipping copper foil in a boiling solution of the sample. If the sample contained arsenic, a grey material consisting of copper arsenide was deposited on the foil. When the copper arsenide was heated, it produced white crystals of arsenic trioxide that could be readily identified with the aid of a magnifying glass. Both the Marsh and the Reinsch tests became commonly used in inquests and trials involving suspected arsenic poisoning, making it harder for murderers to get away with their crimes.¹⁴

Efforts to Control the Availability of Arsenic

Although it became easier to detect the presence of arsenic in bodies and in the vehicles used to administer it by the middle of the nineteenth century, it still remained a popular choice for poisoners. For one thing, arsenic was readily available and inexpensive. The poisoner no doubt hoped that the crime would go undetected, with the symptoms being mistaken for those of an illness and no autopsy called for.

As early as 1819 in England, there was an effort to pass legislation establishing regulations for the sale of certain poisons and drugs, the focus being



Mathieu Orfila, pioneer toxicologist, about 1815.

Courtesy of the National Library of Medicine.

on arsenic, oxalic acid, and corrosive sublimate (mercuric chloride). Druggists were concerned that the bill would interfere with the dispensing of medicines, and so they opposed it, leading to its withdrawal. The perceived increase in reported cases of poisoning in the 1840s, especially involving arsenic, prompted Parliament to revisit the issue of controlling the sale of poisons. The bill introduced was limited only to arsenic because, as stated in the preamble, “the unrestricted sale of arsenic facilitates the commission of crime.” The poison was available not only in drugstores but also from grocers and other merchants.

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