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The Chemical Adventures of Sherlock Holmes: The Death Puzzle at 221B Baker Street

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The following story describes a chemical mystery with an emphasis on medicinal chemistry and qualitative analysis. This is the tenth article in a series presenting a scientific problem in mystery format in the context of the popular and beloved characters Sherlock Holmes and Dr. Watson (1, 2). There is a break in the story where readers (students and teachers) can ponder and solve the mystery. Sherlock Holmes provides his solution in the paragraphs following this break.

The Story

Around the first of the new year, on a day that was cold and clear, I remembered that I was happy. Thus it is in our lives, when the weather is the finest and our spirits soar, that we are least prepared for any possible loss. Indeed, I was ill-prepared for the shock that would confront me three fortnights hence as I faced the death of my friend and colleague Mr. Sherlock Holmes, the best and the wisest man I have ever known.

Returning from Chiselmhurst Station and the main postal building of London, I opened the door to our sitting room at 221B Baker Street and saw my esteemed friend seated by the fire with the *Times* spread across his lap and a collection of crime clippings on the floor beside his chair.

He was busily engaged, but he briefly glanced up at me. "I see you have a holiday gift with you, Watson. Shall I open your package, or shall I first tell you what it contains and for whom it is intended?"

"Surely Holmes," I replied, "since it is wrapped in plain brown paper, fastened securely with string, and has no distinguishing marks upon the paper save for the posting label, I am sure you will have to open it to determine that information."

"Rubbish, Watson. This is a trifling exercise, as should be obvious to you of all people. You have seen me deduce significant facts from trivial observations often enough. One simply needs to follow a rational train of thought, my dear fellow."

"All right, then," I said, a little annoyed but accepting his challenge, "what is this package and who is it for?"

He leaned forward in his chair, taking the box from me and holding it in his long fingers. "As to whom it is for, that is simple. You suggested I would have to open the package to determine its contents and you would hardly let me open a package intended for someone else. You also arrived with a bit of a sly grin on your face as if you had a secret or surprise to share."

"Well," I stammered, "I suppose that *was* rather obvious, but you certainly cannot know what is *in* the package."

"May I continue?" he inquired with a smile. "Referring to your days in India, you have spoken on more than one

occasion of the beautiful earthenware and porcelain made in the villages near the origin of the Bhima River. These villages happen to be outside Bombay and I noticed the package's postmark indicates its origin is Bombay, British India.

"Immediately before you flung open the door," he said as he motioned with his chin toward the door behind me, "I heard Mrs. Hudson's footsteps slowly coming up the stairs. Then I heard the door to the street open and I heard you run up the stairs. On the eleventh step, you stopped and so did Mrs. Hudson. Shortly thereafter, I heard Mrs. Hudson angrily stomp down the stairs, while you dashed up and appeared where you still stand. What may I deduce from these trivial facts?"

I started to speak, but he continued at a quickened pace after glancing at his watch.

"Since it is time for afternoon tea, I assume Mrs. Hudson was on her way up with the tea tray. You stopped her and sent her back down. Whereupon, her quiet, slow steps coming up were changed to the heavy, angry tread I heard going down. I have heard those often enough to recognize her mood. You enjoy afternoon tea as much as I. Therefore, you must have wanted her to repeat her preparations of the tea.

"When we put these facts together, I must conclude that you have had sent from India a new tea set for our flat. I would think a pot and two cups—one for each of us. I doubt their porcelain can compare to our British ware and since it came all the way from India, I would expect some earthenware with an exotic design. The native clays of that region of India are known for their—"

"Enough, Holmes, enough," I cried. "It is hardly worth the trouble to organize a surprise if you already know what it is. Your deductive powers can be annoying at times."

"Nonsense, Watson. Now, Mrs. Hudson should be along at any moment to fetch this down to the kitchen," said Sherlock Holmes as he reached down for his scissors. He cut the string, tore off the paper, and opened the box to reveal a carefully packed, intricately marbled red-and-white pot with two matching cups.

Mrs. Hudson knocked firmly on the door and entered our sitting room. "Well, where is this new tea set I am supposed to use? It is bad enough to have Mr. Holmes running off at all odd times of the day and night without a concern for my schedule, but now you've got me making tea and then making it again."

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"Mrs. Hudson," said Holmes, "I believe that Chinese tea we purchased from the new vendor around the corner and a few slices from that delicious supply of lemons you found at the market the other day would make an excellent brew in our new pot."

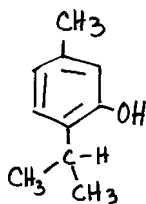
"Well, it's attractive enough," she said as she held up the pot to examine it more closely, "but you aren't changing any more pots, I hope."

After Mrs. Hudson departed, Holmes and I listened silently as she descended the stairs, her impatience abated.

The aroma in the room was quite pungent. In the fireplace behind Holmes, I noticed a collection of leafed branches burning slowly around the edge of the fire. And several of the same type smoldering branches rested in a metal bowl across the room from the fireplace and seemed to be the source of the odor. "What the devil are those branches for, Holmes?" I asked.

Holmes glanced over his shoulder. "Ah, yes, Watson, the branches do produce a rather strong odor when heated. As you know, our beloved 221B has become quite infested with mites. While I might be willing to share my quarters with them, Mrs. Hudson is desperate to have them out. It seems our former adversary Heilbron O'Malley has reformed and become a chemist since his stay in Woolthshrap prison. My brother Mycroft has obtained these branches from him. Seems O'Malley collected them on the continent and brought them back to London. He recommended the leaves to cure Mycroft's intestinal infection and also our mites. The plant is *Thymus vulgaris* and I've done a little study of an ingredient in the volatile oil (3, 4)."

Holmes tossed a lab notebook over to me and I immediately noticed the organic formula he had drawn on the open page:



"Think of it, Holmes," I said, "we sit at the center of the world. The lines of the British Empire lead to our great city. Here in London at our humble 221B we have cups from India, tea from China—" I hesitated while taking note of the increasingly foul odor, but then added, "—and medicinal branches from the continent."

Upon my mention of the European continent, Holmes brought up the subject of my forthcoming trip. I was planning a six-week excursion to see a bit more of the world and to learn some of the latest medical advances in Paris, Zurich, Berlin, and Heidelberg.

"No doubt your anticipated travel to the continent has elevated you to this exuberant New Year spirit. I, however, find it difficult to bring to the season the enthusiasm that you do."

"You should—" I had started, when he held up his hand.

"The criminal element takes no rest in this season, Watson. In fact, I have been alerted to an interesting case which I plan to address in the coming weeks. It seems that a banker named Stevenson is convinced that his wife and

an associate are trying to poison him. However, the clues are rather tenuous and he may be trying to use me to falsely incriminate them. I shall miss your companionship and assistance."

Mrs. Hudson brought in a tray with piping hot tea. She was setting the tray down, when I glanced at my watch and jumped up. "I have arranged for a hansom cab to take me to the train station. He must be waiting out front!"

"And shall I keep your tea hot for six weeks till you get back, sir?" asked Mrs. Hudson as she glared at me. "Your running about is getting as bad as Mr. Holmes'. No decent schedules in this household."

Holmes spoke up. "I shall be having tea, Mrs. Hudson, and I shall drink Watson's portion for him. It shall not go to waste."

"Hmfff," said Mrs. Hudson.

I grabbed the packed bags out of my bedroom and paused in the doorway. "I will miss you, Holmes, and you too, Mrs. Hudson."

When I stepped into the waiting cab, I called up to the driver, "Paddington Station." As we rattled over the cobblestone streets, I looked out at an unusually clear sky above our Great City. But my thoughts had drifted far away. I began to dream of a blue sky above the white, snow-capped mountains of Switzerland.

Six weeks later, as I pulled into the Paddington Train Station, a dark and menacing fog surrounded the train. Through the scattered light I was taken aback to see Mrs. Hudson and Sergeant Phelps standing under one of the dim gaslights on the loading dock.

After the train jolted to a halt, I grabbed my bags and stepped off the train. Mrs. Hudson ran toward me.

"Thank heavens you're here, sir. I knew you were due today, but I didn't know which train. I've been waiting all day. My telegrams didn't reach you?"

"I am afraid that my itinerary changed after I reached Zurich," I said.

"I didn't know what to do, Doctor," continued Mrs. Hudson, not pausing to catch her breath. "He's a stubborn man. Wouldn't go to a hospital. Wouldn't see a doctor. Said he wanted to see you. Finally, I contacted Scotland Yard. I thought maybe some of those awful criminals he's always chasing after had turned the tables on him. When he found out that LeStrade was in charge of his case, he turned whiter than a ghost. He said Scotland Yard was filled with more incompetent fools than the hospitals. You know how he is, sir."

I grabbed hold of her shoulders and faced her. "Mrs. Hudson, are you saying something is wrong with Holmes?"

"None other," she replied.

"What is it?" I shouted. "What is wrong?"

"Why, he's dying, sir."

I looked about at the fog surrounding me and felt suddenly disoriented. The scattered light of the gas lamps seemed to come from all around me. I lost my sense of direction. I turned around, not sure which way to go.

Sergeant Phelps strode up to Mrs. Hudson and me. "This way, Doctor. I've a carriage waiting. We've no time to lose."

I listened to the clattering hooves of the horse pulling our carriage through the fog-shrouded city. Although I was aware of the loss to Scotland Yard, to London, and to the British Empire if the World's Greatest Consulting Detective



should die, I did not think of those things. Rather, one thought and one thought alone filled my mind—Holmes needs me.

"All right now, Mrs. Hudson," I said, trying to calm myself. "I need the facts of this malady that has beset Sherlock Holmes."

She nodded.

"I need them clear and concise," I said, remembering Holmes' own methods.

She rubbed her hands together and looked down at her feet. "It was like this, Doctor. For about a week after you left, there was nothing unusual. He just ran about at all hours of the day and night after this criminal and that. Then he began to complain to me of my cooking, saying I must have got some bad beef. His stomach pained him more and more.

"I don't feel right talking about these things to anyone but a medical man, but at first he had diarrhea and then constipation," she mumbled in a low voice.

"Yes, I get the idea Mrs. Hudson, and—?"

"Then whenever I see him he is pushing on his stomach, rather bent over. He eats less and less until he is eating next to nothing. I try bread. I try soup. Finally, the only thing he'll take is tea with sugar and lemon. I kept him filled with that the best I could. And I kept putting those peculiar branches on the fire and placing smoldering ones in that metal bowl across the room to get rid of the mites. Then he takes to his bed and stays there. He's not one to complain, but I hear moaning at all hours of the night. It's awful. The pain is in his stomach. Then he's got pain in his legs and the back of his arms and his shoulders. He lies in bed too weak to get up, and hardly caring to try anymore."

When the carriage finally stopped in front of 221B Baker Street, I jumped out, dashed up the stairs, and plunged into our flat. Only the glow from the fireplace lit the sitting room.

A terrible odor like rotten eggs filled the apartment, but I did not have time to find its source. I stepped into Holmes' bedroom and saw his long figure stretched out in the bed. His emaciated face was ashen white and his arms were bone thin.

"I need to check you, Holmes," I said.

He nodded weakly and I proceeded. I lifted his upper lip and observed a dark line ringing his mouth near the edge of his gums. I lifted his right arm out straight and his wrist dropped. His fingers were trembling and he could not lift his wrist.

Suddenly I heard Sergeant Phelps call out, "Say, what are you doing here?"

I looked away from Holmes and toward the sitting room to see Mrs. Hudson and Sergeant Phelps with a ragged, ill-kept boy. The boy stepped out of the shadows near the table where Holmes keeps his chemistry equipment and chemical supplies. He carried a large flask filled with a dark liquid clouded by a black precipitate. Sergeant Phelps directed his lamp at the boy, whose eyes widened as the light fell upon his face.

The ill-kept boy mumbled, "He told me to do it. Whispered me the instructions. I only did like Mr. Holmes told me to."

"These ragamuffin street boys keep coming around here," said Mrs. Hudson. "I chase 'em away, but they keep coming back."

"The Baker Street Irregulars," I said to Sergeant Phelps. "Holmes from time to time employs these street urchins to be his eyes and ears around the city on special cases."

"What did you do, boy?" asked the sergeant.

"I boiled vinegar in this white and red teapot for half an hour. Then I poured the vinegar into this funny-shaped glass. He had me mix this stuff he called ferrous sulphide with that liquid." [The boy pointed to a bottle labeled "Acidum Hydrochloricum".] "It made a foul-smelling gas. I capped the bottle of the mixture with a rubber tube which carried this gas to the funny-shaped glass with the vinegar from the pot. Bubbles came out the rubber tube into the vinegar and the vinegar turned black as night." With trembling fingers Holmes motioned me down toward his face and whispered into my ear. I jerked upright with a start.

"Sergeant Phelps," I said, "the case is solved."

Stop Here and Solve the Mystery



You can solve this mystery by careful chemical deduction from the clues provided. Can you answer these questions?



What was the cause of Holmes illness?

Who was responsible for Holmes illness?

What was the purpose of the chemical test the boy performed?

The following pages contain Holmes' chemical solution to this mystery. Compare your solution to his.





The Solution

"Well, what do these smoking branches and rotten egg smells and this lad mixing chemicals all have to do with Mr. Holmes?" asked Sergeant Phelps. "Has the boy poisoned him?"

"No sergeant," I replied, "it was not the boy."

I walked across the room and picked up the red and white pot and the two matching cups. I looked at Holmes and he weakly nodded. I lifted the beautiful earthenware pot and hurled it into the fireplace. It shattered into pieces. The two cups quickly followed.

"Have you gone mad, Dr. Watson?" screamed Mrs. Hudson.

Startled, the boy looked around the room and then at Sergeant Phelps. Phelps nodded toward the door and the boy took off running.

"Now, just what is this all about, Doctor?" said Phelps.

"Plumbism," I said, shaking my head in distress.

"What?" said the policeman.

"Plumbism. Lead poisoning. Diarrhea. Constipation. Intense stomach pain. Then muscle and joint pain. The classic symptoms of lead poisoning are lead line—a dark line where the gums meet the teeth—and wristdrop, because of the weakness of the flexors in the arms" (5).

"And what about Mr. Holmes?" asked Mrs. Hudson.

"If we stop the source of the lead then he will recover. Holmes told me the pot and cups were the source of the lead."

"And who is responsible?" said Phelps.

"I am. I almost killed my best friend. I'm the guilty one."

A week later Holmes and I reclined in our chairs by the fire. He was only slowly regaining his strength, but his attitude was already back to normal.

"Really, Watson. You must stop blaming yourself. You are no more responsible than I am for drinking the tea or Mrs. Hudson for fixing it. The acid from the lemons no doubt helped pull additional lead from the pot and cups. And as I got sicker, I drank more and more of the brew. As you know, lead poisoning is cumulative and not acute."

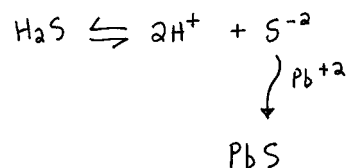
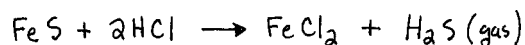
"I should have solved the problem much sooner, but as the illness progressed, I could not think clearly. That was even worse than the pain. To have one's mind so muddled. That explains why it took me so long to think of testing for the lead in the pot. As I look back on it now, it seems so obvious."

"I recognized the symptoms of lead poisoning," I said, "but what was the chemical test you had that young lad carry out?"

"I had him mix ferrous sulphide and hydrochloric acid. This produces hydrogen sulphide, which is a poisonous gas that has the smell of rotten eggs. Through the use of tubing, the hydrogen sulphide gas was bubbled into the Erlenmeyer flask. It contained vinegar which had been heated in the pot. The heat and acid served to coax the lead out of the pot" (6).

"Show me the equations," I said.

"Here, Watson," Holmes replied as he rapidly jotted a series of chemical equations in his notebook.



"A classic test for lead is the formation of a black precipitate in the presence of hydrogen sulphide," he said. "Sulphide ions occur when hydrogen sulphide is present in solution. Of course, the amount of the sulphide ions present is affected by the acidity of the solution. Lead ions and sulphide ions combine to form lead sulphide. If there are no lead ions then there is no black precipitate (6). A fact, Watson! A scientific fact upon which my life depended. Your diagnosis of plumbism confirmed my hypothesis."

"And another scientific fact," I said, "is that the lead line I observed in your mouth to confirm the diagnosis of lead poisoning must be formed by the very same chemistry. Tiny quantities of hydrogen sulphide produced in our mouths from food decay or digestive processes can combine with excess lead in our gums to produce a dark line just above our teeth (5).

"Excellent, Watson! Lead sulphide can precipitate in our gums. Our bodies are chemistry just as our surroundings are chemistry."

"I had been a bit suspicious of those burning branches, but once I observed the classic symptoms of lead poisoning that possibility was driven from my mind," I said. "But the pot and cups themselves. Why the lead?"

"Some other metal from the acid-insoluble sulphide group such as copper might be a possibility, but the white and red color of the tea set and my symptoms were entirely consistent with salts of lead [7]. It is a fact that some ceramics contain soluble lead salts. Lead silicates, as present in leaded glass, are harmless, but this is not true of other lead salts found in some glazes. I have written a letter to a certain company in Bombay to inform them of the danger. The temperature of curing could also be a factor. We know that many industries allow much too high an exposure to lead. A sad fact that perhaps one day will be rectified. Chemistry, our lives, and society are clearly intertwined."

"At least for our own benefit," I said, "let us hope our future chemical adventures are not quite so close to home."

"By the way, Watson," Holmes cheerily replied, "the



mites have departed! The herbs of the Chemist O'Malley have given up their active oils and have driven off our little visitors. I must remember to thank O'Malley and my brother Mycroft for bringing *Thymus vulgaris* to my attention. Ah, the Flora and Fauna—the chemistry of living things in our world is extraordinary wouldn't you say, Watson?

Before I could answer, Mrs. Hudson opened the door to our apartment and with a cheery voice, cried out, "Tea time, gentlemen."

Acknowledgment

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