

Dmitri's Periodic Dream

It was July 12, 1849 in Tobolsk, Siberia. Excitedly, the fifteen-year-old Dmitri Mendeleev clutched his high-school graduation certificate. As he studied the document together with his proud mother, Maria, he noticed a discrepancy: it read, "Age: 16 years old." His mother nodded, knowingly: "Yes, the regulations do not allow anyone to graduate before age 16, so, rather than holding you back, they changed it—it was my suggestion." Dmitri smiled, "It will allow me to enter university earlier, as well." Dmitri had his hopes set on entering university and building a successful and prosperous life for himself.

He was partly motivated by the hard times his family had suffered all his life, beginning with his father's blindness and death and the loss of most of their income when Dmitri was only an infant. His chances for serious studies looked bleak, with few resources and the closest university almost 2,000 kilometers away, in Moscow; however, that is where Dmitri's wealthy uncle, Vasili, lived. So, despite the hardship and expense, Maria set out on the long journey with Dmitri and his sister, Liza. When they finally arrived in Moscow, Dmitri immediately applied to Moscow University for admission. His eagerness was met with great disappointment, for the university only accepted students who had obtained their high-school diploma in Moscow.

Nothing was to stop Dmitri's mother, though, who promptly came up with another idea, "Why not try another major university, the one in St. Petersburg?" Uncle Vasili indicated his willingness to help out with the expenses for the 650-kilometer trip, so, the trio made the train trip to St. Petersburg, where Dmitri applied to the University for admission. Once again, he faced disappointment, for the policy there was to accept only students who had attended high school in St. Petersburg, resulting in another rejection.

But Dmitri's resourceful mother had another idea: Dmitri's father had attended the main teacher-training college in St. Petersburg in order to become a teacher, and she recalled that one of her late husband's classmates, Chizhov by last name, had become a professor, there. Perhaps, Professor Chizhov could help Dmitri gain admission to his father's former school. Fortuitously, they were able to locate Professor Chizhov, who fondly remembered Dmitri's father. "Of course, I will help you!" said the professor.

With Professor Chizhov's positive reference, Dmitri was allowed to write the admission examination in 1850, which he passed with a mark high enough to gain him a full scholarship. It certainly

was a major breakthrough for Dmitri. His fortune, however, was short lived. He had just begun his studies when calamity struck. Dmitri's mother became ill and died the very next month, and, less than two years after, his sister, Liza, also became ill and died. The entire ordeal was too much for Dmitri, who succumbed to a severe cough and lung condition, so much so that he had to be hospitalized. His doctor thought that the young man would not survive. Gradually, however, Dmitri began to improve. He was permitted to leave the hospital and resume his studies. On account of all his setbacks, he had to spend two years finishing his first year of university, placing nearly last in his class of 28 students. Being an extremely hard worker, he was soon able to catch up with his studies and graduate from teachers' training, receiving the Gold Medal in Excellence. Dmitri Mendeleev was 21.

Obligated to teach for two years after graduating—a condition of his scholarship—he dutifully took on a teaching position, but, at the earliest opportunity, applied to enter a Master's program at St. Petersburg University. He was, in reality, aspiring to a university teaching position, which, at that time, required two Master's degrees. Dmitri was able to meet the requirement and began to teach at his alma mater. Dissatisfied with his junior position there, he sought to improve his education once more. Only two years after he began teaching, the University agreed to send him on a study trip abroad. The twenty-five-year-old Mendeleev travelled to Heidelberg, Germany, where he joined the research group of the famous Chemist, Robert Bunsen. That following year was one of the best years of Mendeleev's life—he formed many friendships and learned a vast amount. In the next year, he was able to attend the first international Chemistry Congress in Karlsruhe, Germany. One of the talks given there affected him for life. The Italian Chemist, Canizzaro, presented his new system of calculating atomic weights, which greatly impressed Mendeleev. These experiences

abroad set the stage for him to be able to obtain his doctorate and, subsequently, the Professor of General Chemistry position at St. Petersburg University in 1867 at the age of 33.

In the fall, the new Professor Mendeleev took on new teaching duties, which included introductory inorganic chemistry. His first task was to look for a suitable textbook. Unable to find any textbook that he could recommend to his students, he set out to write his own. It kept him extremely busy, and he was constantly on a deadline, both with his students and with his publisher. By February of 1869, he had finished the first volume of the book, in which he had only been able to deal with eight of the then known 63 chemical elements. As he began writing the second volume, he thought more and more about a way to organize the elements so as to provide a structure for writing the rest of the textbook.

At the same time, he maintained his diverse interests outside of Chemistry, one of which was agricultural methods. He had joined the Free Economic Society for Agriculture and served as a scientific consultant. In February of 1869, the Society commissioned Mendeleev to tour cheese-making farms in the area.

It was February 17, 1869, and Mendeleev was in his office. Papers were strewn across his desk and in the middle was an official-looking letter. Mendeleev stared at it: "You are cordially invited to attend a tour of the cheese-making farms in the area on February 17th, 1869." It was all too much. The deadline for his next textbook chapter was approaching, and he still did not have a scheme for arranging the chemical elements. He had hardly slept at all for the past two days. Pondering the puzzle, he was startled by a brisk knock at the door. "Come in."

The unwelcome visitor, a coach driver, dressed in a warm winter coat, announced, "Sir, the coach is waiting to take you to the train station."

Mendeleev was ready to tear out his hair. "I don't have time to go today—send a message to the Society that I am delayed for a few days."

"Right, sir—as you say." The coachman turned and left, shutting the door behind him firmly.

Mendeleev looked at the papers on his desk. There was the letter. Beside it was a sheet of paper with one line written across the top: "The properties of Lithium." Where to go from here? Mendeleev realized that he needed some relief from this nervous tension. Usually, he would play the card game soli-

taire for that purpose. Reaching into his top desk drawer, he retrieved a deck of cards. Briskly, he shuffled the deck and took three cards, arranging them in order on his desk. He paused thoughtfully. His eyes began to glaze over and his head began to nod. The sleepless nights were surely catching up with the professor as his head sank to his chest and he succumbed to the fatigue, finally placing his head on the desk. The only sound that could be heard in the office was the rhythmic tick-tock of the pendulum clock on the wall and the occasional soft snore. Perhaps, 15 minutes passed. Mendeleev jerked and pulled himself upright, rubbing his eyes. "I think I see it, I think I see it," he said, shuffling through the pile on his desk to grab his writing tablet. Not finding it at the moment, he reached for the nearest object, the letter, and turned it over. On the back he began to write: "Li = 7, Na = 23, K = 39, Rb = 85."

Mendeleev had just had a dream in which he had seen the entire organizational structure for the chemical elements. He could remember some parts but not all of it. He glanced at the incomplete set of cards from his interrupted game of solitaire. A flash of inspiration crossed his mind. He opened his desk drawer and found a stack of blank white index cards. He counted the cards until he reached 63. "There, I have enough," he said to himself. On each one of the cards, Mendeleev wrote the name of an element, its symbol, its atomic weight, and its physical and chemical properties. His knowledge about the elements was impressive, indeed, as he completed the entire set, remembering every detail of each element. Then he began his game of chemical solitaire—arranging the cards of elements with similar properties in rows with ascending atomic weight. He puzzled and worked at it for hours. What bothered him was that he could not fill some spots on the grid of cards. The spots corresponding to atomic weights of 45, 68, and 70 were blank. "These must correspond to elements that we have not yet discovered," Mendeleev mused. A look of satisfaction crossed his face, and he quickly began scribbling the completed system on the back of the invitation letter so that he would not forget it. It all looked so familiar. "Of course! This is what I saw in my dream!" he exclaimed.

To be sure, thereafter, Mendeleev had no difficulty completing his textbook. As soon as possible, he published his new organizational system for the elements. At first, the other chemists would not be-

lieve in his discovery. Then, in 1875, the element with atomic weight 68 was discovered. It was named Gallium. Soon, elements to fill the spots 45 and 70 were also discovered. Mendeleev came to the realization that the system he had made was actually a law of nature. He was certain that it would make him famous one day, and he was right. His newly discovered law became known as the periodic table. Of course, as new elements and properties were discovered, the table was modified; however, Mendeleev's basic idea withstood the test of time.

Mendeleev was not the only scientist to make the discovery of the periodic table. The German chemist, Lothar Meyer, independently published a similar scheme, and so did the English chemist, William Odling. The one thing that distinguished Mendeleev's system, however, was that it contained scientific predictions, and that is why the invention of the periodic table is usually attributed to Mendeleev.

References

- Babaev, E. V. (2009). Dmitriy Mendeleev: A Short CV, and A Story of Life. *Mendeleev Communications*.
<http://www.mendcomm.org/Mendeleev.aspx>.
- Bensaude-Vincent, B. (1986). Mendeleev's periodic system of chemical elements. *British Journal for the History of Science*, 19, 3–17.

- Cassebaum, H. & Kauffman, G. B. (1971). The periodic system of the elements: The search for its discoverer. *Isis*, 62(3), 314–327.
- Gordin, M. D. (2004). *A well-ordered thing: Dmitrii Mendeleev and the shadow of the periodic table*. New York: Basic Books.
- Kaji, M. (2003). Mendeleev's discovery of the periodic law: The origin and the reception. *Foundations of Chemistry*, 5, 189–214.
- Scerri, E. (2007). *The periodic table: Its story and significance*. New York: Oxford University Press.
- Strathern, P. (2000). *Mendeleev's Dream*. New York: Thomas Dunne Books.

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