The teacher and the atoms

John Dalton was a happy man. He had always wanted to teach, although in the 18th century, this was somewhat unusual for someone from his social status. He was born as the son of a weaver who owned a small piece of land, and like many children of his era, John had to work from the very early age. However, he finally had made it: Since a couple of years, or, to be more precise, since the year 1793, he finally had a position as a lecturer of Mathematics and Natural Philosophy in the New College of Manchester. Shortly after his appointment, he also had become a member to the Manchester Literary and Philosophical Society, one of the eminent English scientific societies in the late 18th century. Dalton liked it to lecture, actually he had already begun to teach at the age of twelve in a local school. But he also loved science, and his new position offered him the opportunity to combine both his passions.

In particular, Dalton liked chemistry, standing in a laboratory and carrying out experiments where new substances were created and analyzed was one of those things where he was really good at, and where he was really happy.

Recently, chemistry had undergone significant changes, air had turned out to be a mixture of several gases instead of being an element, and the French Antoine Lavoisier had introduced a new chemical system, together with making experiments quantitative and using extremely sensitive balances in order to analyze chemical reactions not only in terms of substances that combine to new substances, but also in a quantitative manner. Even though a lot of chemists were still opposing this new system and this new approach, Dalton loved it. The combination of chemical manipulation and mathematical rigor was something that both met his interest and his competences. And from this new approach, Dalton had developed new insights that he was about to use in his teaching for the first time.

He straightened and opened the door to his classroom. As usual, there were the students sitting, and they raised when Dalton entered the room usual, there were chemicals and apparatuses on the table. However, this time things would be different.

Dalton started to talk, and he talked about the new, quantitative approach in chemistry: He stressed that there are always given relations between the masses of two substances which form in a chemical reaction a new substance. So from this point of view, chemistry was now turning into a mathematical science. The students did not seem to care that much, and Dalton felt some frustration raise, but then Smythe, a boy who was sitting in the first row and was one of the brightest and most interested students in his chemistry class, raised his arm:

“Sir, please, may I ask a question?”

“Go ahead”, replied Dalton, curious what might be questionable about these simple relations he was just talking about.

“Why are there these quantitative ratios between the elements in the chemical reactions?” asked Smythe.

“Why?” – this was a thought that had never come to Dalton’s mind. “Why?” Dalton started to think, and stood silent in the classroom. “Why?” None of the writings of the modern chemists was addressing this issue, and normally, they were not even mentioning these ratios. Chemical instructions were somewhat like cooking recipes, you follow them and get the intended results.

“Why?” In the end, Dalton straightened and smiled wearily at Smythe: “This is an excellent question, but the chemical theory is not yet at a point where we can answer such a question. Currently, we are collecting data, and it will be one of the future tasks to develop the understanding of the underlying truths that explain our empirical findings. You see, chemistry is not yet finished.” The boy did not seem to be too pleased with this response, however, he was smart enough to know that he would not get a better response.

However, when the lesson was over, Dalton was frustrated, and he could not stop himself from thinking “Why?” What was supposed to be a demonstration of the potential of the new chemistry of Lavoisier, of the powers of the

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quantitative approach had turned out to be a disappointment. “Why?” – Dalton felt that this was actually a question that required more thinking and would not to be answered easily.

Several years later, Dalton was still thinking about this episode, however, his perspective had changed from initial frustration to fascination. In the meantime he had quit his position at the New College of Manchester, he had become an independent chemist who earned his living by teaching children of wealthy Manchester industrialists – less teaching load, better payment, and more time for research. Currently, he was sitting in a coach to London where he was about to deliver a lecture to the prestigious Royal Institution, a lecture that condensed the findings of his researches of the last years, researches that were triggered by this question the schoolboy had asked him.

Dalton had been working a lot in the laboratory, but no longer focusing on the substances that could be composed (or produced by decomposing other substances). Instead, he was trying to find mathematical rules in the chemical reactions that went beyond the recipe approach. The easiest rule (and one that had already been known) had been that chemical substances always react in a certain mass ratio of the initial substances. Moreover, it was striking that there were more quantitative relations involved than one initially anticipated: 2g of Hydrogen react with 16g Oxygen, the same amount would also react with 32g Sulphur. 56g of Iron would also react with 16g Oxygen, the same amount would also react with 32g Sulphur. Moreover, there were two substances that could be formed from Sulphur and Oxygen – one consisted of 2g Sulphur and 3g Oxygen, the other of 2g Sulphur and 3g Oxygen. There were other chemical substances where similar ratios could be found, and Dalton had had the feeling that there had to be a hidden truth in Nature that could serve as an explanation of these ratios. Why did these chemical substances combine according to fixed numbers, and why did these numbers have a certain ratio with each other?

Going through the works of ancient chemists had not been that fruitful – Lavoisier was certainly the master who had laid the foundation to the manner how modern chemistry should be executed. Yet, in his writings was no explanation for this behavior. And then, one day, glancing through some old books in the library, he came across an argument of Aristotle who criticized another Greek philosopher, a man called Democritus who had envisioned atoms, smallest, inseparable particles that should form all matter. When reading through this, things became immediately crystal clear to Dalton – this was it, this was the explanation. If there are atoms, then this would explain the quantitative behavior. In the next couple of months, Dalton was rethinking this explanation again and again, was redoing experiments and reexamining evidences, and refining his interpretation. In the end, Dalton had been able to formulate some simple truths that would explain all his chemical findings:

1. Atoms cannot be made or destroyed.

2. All atoms of the same element are identical.

3. Different elements have different types of atoms.

4. Chemical reactions occur when atoms are rearranged.

5. Compounds are formed from atoms of the constituent elements.

These five sentences should form the basis of his new chemical theory, and he was going once again through the manuscript of the paper he was to deliver at the Royal Institution. Then, the coach finally arrived in London, and Dalton stepped on the road. Here he was ready to tell the chemists and everyone else who would attend his lecture about his findings.

The next day, Dalton stood in the lecture theatre of the Royal Institution – the seats were well occupied, there was a good audience. Dalton started to describe his first experiments, gave the numbers of the quantitative analysis, and finally drew his first conclusion: “Matter consists of atoms, small particles that cannot be destroyed or made.” He sensed some disturbance in the audience, but continued with his presentation. However, he had more and more the feeling that the discomfort of his audience increased. Finally, he drew his final conclusion: “Atoms are able to explain the chemical behavior of substances we know nowadays and are a valuable tool for the future research." There was mainly silence in the room, then an elderly scholarly looking man raised and asked a question that seemed to bother most persons in the audience: "Mr. Dalton, have you ever seen an atom?"

There was silence in the room, then Dalton answered: "Umm, well, no, certainly not, but …"

The man interrupted: "Well, Mr. Dalton, thank you very much for your … hypothesis, but you know, here in London, we strictly restrict our science to observable facts …"

Dalton felt the blood rushing into his head, and while he looked at the faces of the other attendees, he felt that the presentation he had put so many hopes in was a complete failure.

"Thank you, gentlemen, for your time and your attention" was all he could mutter, and then he left the lecture hall hastily.

Although Dalton's theory was adopted by several chemists very quickly, others rejected it. A key problem was the assumption that each element was formed by a different atom, as a result there were about thirty different atoms at the beginning of the 19th century, and their number was increasing. Thus, instead of simplifying the structure of matter, Dalton's atomic theory made nature more complex. For more than 60 years of Dalton's death the controversies about the validity his atomic structure continued.

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