QUESTION FROM THE CLASSROOM

By Bob Becker

Q Was it easy for people to accept the idea that matter is made of atoms when this idea was first introduced in the early 19th century? How did this idea appear anyway?

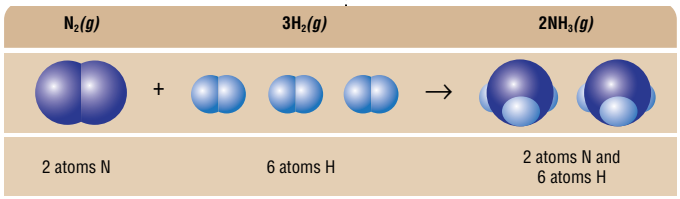
A The idea that matter is made of very small units that cannot be divided further first appeared in Greece in the 5th century B.C. Philosophers named Leucippus and Democritus were the first to propose that matter was made of small indivisible particles called atoms. But their idea was not studied scientifically until the early 19th century.

In 1805, an English chemist and physicist named John Dalton did scientific experiments that led him to suggest that matter was made of atoms. He revived an idea lost through the centuries and came up with what is known as the atomic theory. It was not widely accepted at first, and there were serious objections to it from some very learned and well-respected scientists. This theory stated the following:

- All matter is made up of tiny atoms—way too small to be seen, but there nonetheless.
- All atoms of a given element are identical in every way—size, mass, and other properties.
- Atoms cannot be created or destroyed, or even broken into smaller pieces.
- Different atoms combine in various ratios to form compounds.
- In a chemical reaction, atoms are simply separated, combined, and rearranged into new compounds.

To come up with the atomic theory, Dalton relied on two laws: (1) the law of conservation of mass, and (2) the law of definite proportions. These laws may have seemed counterintuitive at the time, but they are obvious to people who are familiar with the atomic theory.

The law of conservation of mass, formulated in 1789 by a French chemist named Antoine Lavoisier, states that in a chemical reaction, the total mass of all the reactants is the same as the total mass of all the products.



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Anyone who has ever built a fire in a fireplace or wood-burning stove knows that the ashes left over weigh a lot less than the logs you put in. Imagine being told that this observation was false and that if the fire was allowed to burn in a completely sealed-off container, the content of that container would weigh the same before and after being burned. You would think that was absurd.

But when viewed from the point of view of the atomic theory, the reasoning is obvious: No atoms entered or left the container, and no atoms were created or destroyed by the reaction. The atoms that were there in the beginning were simply rearranged into new molecules; so, of course, the mass would not change. But without the atomic theory, there is no reason why the mass of a system should stay constant.

The same concept applies to the law of definite proportions. This law, first established in 1799 by the French chemist Joseph Louis Proust, states that if a substance is broken down into its constituent elements, then the masses of the constituents always have the same proportions.

That any sample of a given compound is made up of the same elements in the same ratio of masses seems obvious to people who know that water's formula is H_2O or that the structure of table salt is NaCl. If it takes two atoms of hydrogen and one atom of oxygen to make a molecule of water, then it would take 200 atoms of hydrogen and 100 atoms of oxygen to make 100 molecules of water. So, their combining masses would always be in a fixed ratio.

At the time, compounds were considered like mixtures. Various elements could be put together

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to form compounds in the same way that various ingredients, such as flour, sugar, butter, and eggs could be put together to form cookies. So, imagine that the recipe also calls for 2 cups of flour and 1 cup of sugar. You decide to make a batch of these cookies using all the same proportions, but with 2 cups of flour and 1 ½ cups of sugar.

After letting them bake for 10 minutes, you open the oven door, expecting to find sweeter cookies. Imagine your surprise when, instead, you find a batch of cookies and a half-cup of sugar piled in a corner of the cookie sheet. Preposterous, right? How can the ingredients themselves possibly *know* the recipe that they are supposed to follow? Yet, that is exactly what the law of definite proportions claims for chemical elements.

Indeed, it would be nearly impossible to explain either of these two laws without using words such as "atoms" or "molecules." The atomic theory was, and still is, *huge*. It completely reshaped our perspective on the world and every change that has taken place within it.