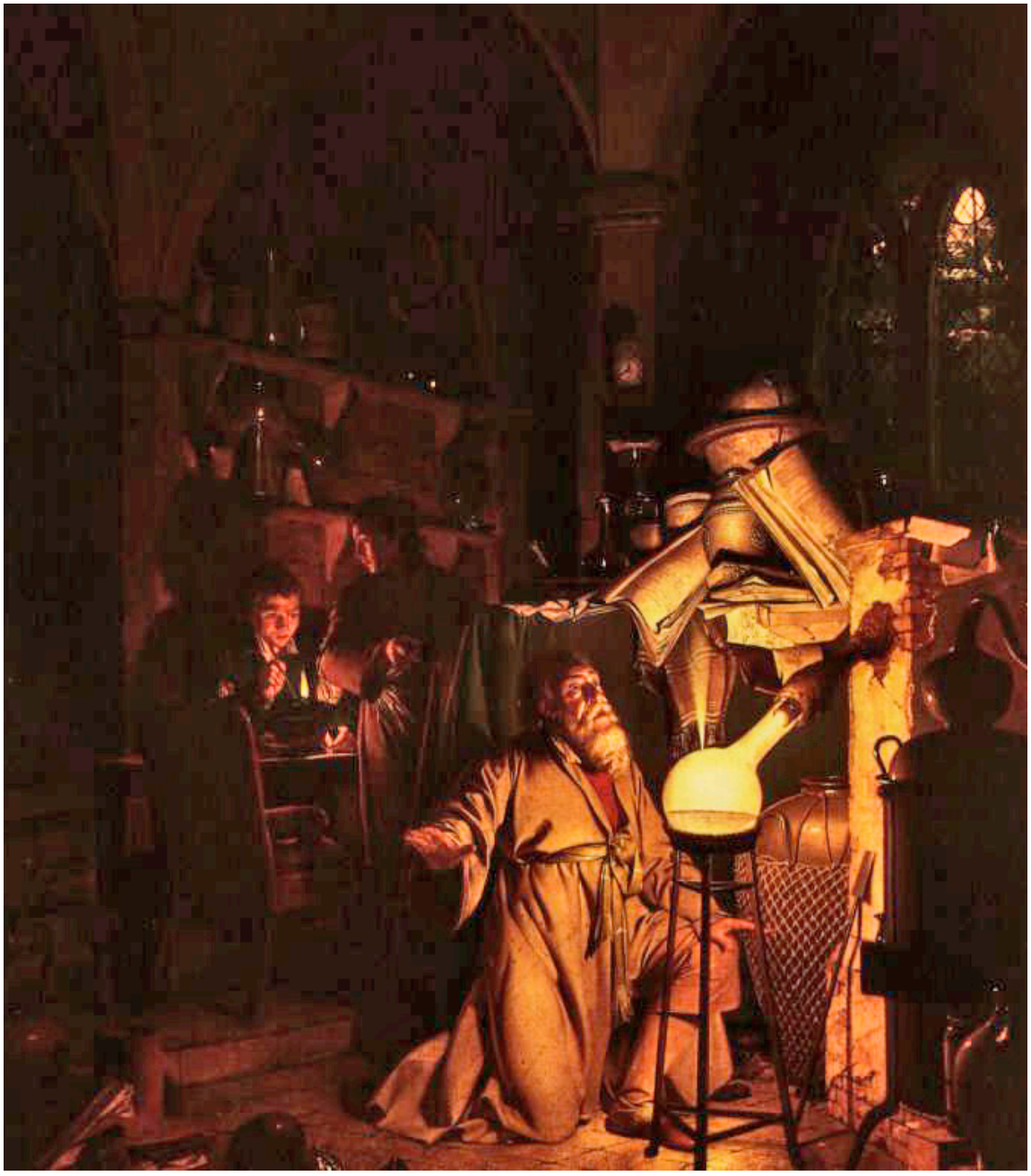
The Philosopher's Stone

Module 2 • i2P • La Ruta de Sal



'The Alchymist, In Search of the Philosophers' Stone by Joseph Wright of Derby, 1771.

By convention bitter, by convention sweet, but in reality atoms and void

- Democritus

A Chemical Expedition

To reach the Salar de Uyuni the i2P expedition team will be flying to Santiago Chile, and travelling northeast into the mountains of Bolivia by bus. Both the plane and bus will be powered by fossil fuels refined through a chemical process in an oil refinery, and both vehicles are equipped with rubber tires manufactured by mixing rubber with select chemicals. The i2P expedition team will be carrying with them a medication to prevent altitude sickness that was invented by chemists called Diamox, and has the chemical name N-(5-Sulfamoyl-1,3,4-thiadiazol-2-yl)-acetamide. i2P team members will be running on shoes that contain chemically manufactured plastic, and sleeping in tents made from synthetic materials designed by chemists to be light and waterproof. In fact virtually ever facet of the expedition involves materials or technology that required a deep knowledge of chemistry to develop.

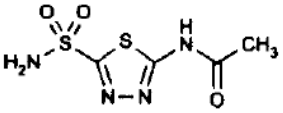


Figure 1: Chemical structure of Diamox

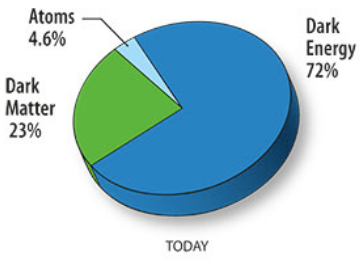
Knowledge of the chemical composition of matter has a profound influence on virtually all facets of our modern lifestyle. From the medicines that fight illness, to the buildings that shelter us; from the technology that allows us to communicate, to the equipment that transports us around the world; all these innovations depend upon knowledge of the chemistry of matter.

Today it is broadly accepted that 'everything in the world' is made of elementary particles called atoms. Beyond this common knowledge, the average person does not give much

Matter in Universe:

Only about 4 % of the total mass of the universe is represented by chemical elements, and is thus made up of atoms. This fraction is about 15% of the total matter, with the remainder of the matter (85%) being dark matter. Dark matter has a nature which is unknown, but it is not composed of atoms of chemical elements, because it contains no protons, neutrons, or electrons. (The remaining non-matter part of the mass of the universe is composed of the even more mysterious dark energy).

see: nasa



thought to chemistry. The journal Nature found that in Europe chemistry is losing its appeal as a subject to study (see: nature). Some say this drop in interest is due to the public perception that chemistry is a dull and obscure discipline (see: chemistry). Yet not only does knowledge of chemistry have practical value in our daily lives, the discipline of chemistry has a very colorful history.

What is the Matter?

Chemistry is defined as the science of matter; the branch of the natural sciences dealing with the composition of substances and the changes they undergo. In more blunt terms, chemistry is about "the stuff of the universe"; from inanimate rocks, to living breathing human beings, and everything in between.

Modern chemistry tells us that all matter is composed of microscopic elements called atoms. Hydrogen, oxygen, carbon, and nitrogen are four of the most recognizable of the one hundred and fifteen known elements. Different combinations and arrangements of atoms result in the creation of different compounds. Water is made of two hydrogen atoms and one oxygen atom, while salt is a compound prepared by mixing sodium and chloride atoms in equal parts. Larger objects are composed of complex combinations of atoms. A wooden chair is a lattice of glucose molecules that are made up of hydrogen, oxygen and carbon atoms that bind together to form wood.

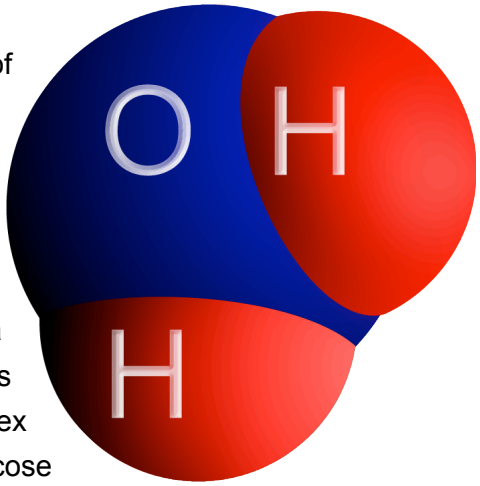


Figure 1: The water molecule (source: water)

The suggestion that matter is composed of elemental particles was first proposed by the Greek philosopher Democritus (460 BC - 370 BC) two thousand five hundred years ago. Although Democritus' theory has ultimately been proven correct, in his time it fell into disrepute. Rather it was the suggestion of the Greek philosopher Empodocles (490 - 430 BC) that gained a popular following. He proposed that all matter was composed of four elements: fire, air, water and earth. He reasoned that different ratios of these four elements accounted for different types of matter (Empodocles). According to this theory a rabbit was composed of fire and water, whereas a stone was made of earth. The influential Greek


Figure 2: The Greek Philosopher Democritus (source: Hendrik Bloemaert)

Did You Know?

The word "atom" is from the ancient Greek adjective atomos, meaning 'indivisible'

Did You Know?

A poem called De Rerum Natura (The Nature of Things) written by the Greek poet Lucretius, that praised the atomic theory of matter was one of the first texts set to print after the invention of the Guttenburg press in 1452

philosopher Aristotle (384 BC – 322 BC) endorsed this theory, giving it great credence for years to come. Indeed Aristotle's teachings about the four essential elements of matter were still taught in schools in Europe almost 2000 years after his death.

The Philosopher's Stone

For the next two thousand years the debate about the fundamental structure of matter lay dormant. Instead early chemists turned their attention to the study of chemical reactions. This lead to the birth of Alchemy, considered the precursor of modern chemistry.

Alchemists were not scientists in white lab coats working in laboratories. Rather Alchemy was a practice or philosophy that was driven by the belief that man could create gold from common metals such as lead through chemical processes. The process for changing metal in to gold is called transmutation. Great energy was dedicated to the quest for the philosopher's stone, a mythical metal that was said to be necessary to convert cheap metal into gold. The philosopher's stone was also thought to be capable of creating a chemical concoction called the 'elixir of life' that would confer immortality to any who drank it.

Definition: Transmutation

The changing of one element into another by radioactive decay, nuclear bombardment, or similar processes.

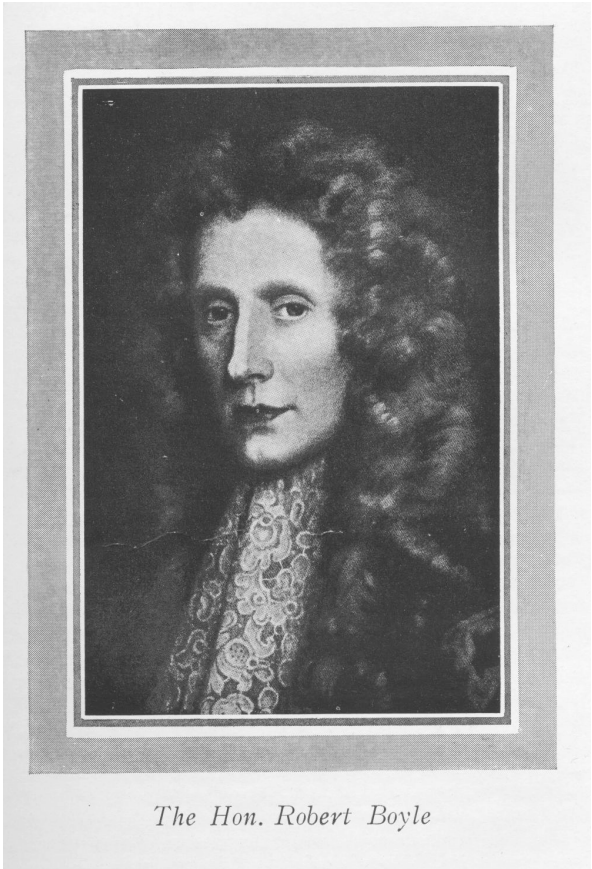
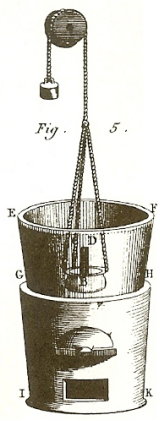


Figure 3: Robert Bolyle, author of the skeptical Chemist - published in 1661

Although today the quest to turn metal into gold and find the elixir of life are popularly known as the plot lines in a Harry Potter book, Alchemy was a serious and credible pursuit practiced widely around the world. Famous early scientists such as Sir Isaac Newton - considered the father of modern science - were practicing Alchemists. Alchemy was practiced in China, India, Europe and the Middles East.

Atomic Theory



A book called “The Skeptical Chemist”, published in 1661 by the Alchemist Robert Boyle precipitated the end of the practice of Alchemy. Boyle, who made dedicated attempts to transmute common metal into gold, is credited with reopening the debate on the nature of matter and re-popularizing Democritus’ particle theory of matter (see: Boyle). Following the publication of Boyle’s book a series of important discoveries helped discredit Aristotle’s four-element theory. Although the practice of Alchemy went out of favor, it seeded the practice of chemical experimentation that led to a series of important discoveries that laid the foundation of modern chemistry.

Definition: mass

Mass is the property which reflects the quantity of matter within a sample.

Antoine Lavoisier, a French Nobleman, is regarded as the father of modern chemistry. Among his many contributions to the science he named oxygen and hydrogen and put together the first extensive list of elements. Through careful experimentation he proved that although matter can change shape or form it always has the same mass. He demonstrated that the mass of water converted into a variety of forms (liquid and gas) always has an identical mass, provided that no material is lost during the experimentation (the system is isolated). Lavoisier’s Law is known today as the First Law of Thermodynamics - Law of the Conservation of Mass. Five years after publishing his law, Lavoisier died at the age of fifty when he was guillotined during the French Revolution (see: Lavoisier).

Figure 4: Antoine de Lavoisier’s laboratory, now a museum in Paris, France (source: Rama)

Did You Know? - Lavoisier’s Death

May 1794 the Tribunal of the French Revolution condemned Lavoisier to death. He had been accused of having plotted against the government and of having embezzled large sums of money which should have gone to the State. Both the accusations and the evidence against him were false.

Some of his friends intervened on his behalf, trying to impress on the judges his great merits and the advantages that his discoveries had gained for France. Any defense, however, was quite hopeless – the president of the Tribunal declared: "The Republic does not need any scientists!" – and Lavoisier was guillotined.

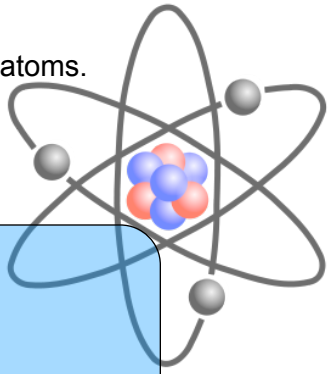
Figure 5: John Dalton

Not long after Lavoisier's death a second French chemist, Joseph Louis Proust, proposed another important principle of matter. Through careful analysis of copper carbonate Proust found that all pure samples had the same composition--that is, the same proportion of copper, carbon, and oxygen--no matter how they were produced. In analyses of other compounds, Proust obtained similar results.(see: Proust). Proust's law is called the Law of Proportions, and it is a fundamental principle of chemistry.

Modern Chemistry

The discoveries of John Dalton provided the first truly scientific theory of the atomic nature of matter. Dalton was a British chemist who conducted a series of experiments on the physical properties of gases that allowed him to isolate and weigh individual elements. Based on his experiments, Dalton published a paper called "New System of Chemical Philosophy" in which he concluded:

1. All matter is made of atoms. Atoms are indivisible and indestructible.
2. All atoms of a given element are identical in mass and properties
3. Compounds are formed by a combination of two or more different kinds of atoms.
4. A chemical reaction is a rearrangement of atoms (see: Dalton).



Did You Know?

Creation of New Atoms.

All the elements in the periodic table are the product of either fission or fusion reactions.

Scientists are now understand that atoms can be divided (fission) or combined (fusion) to form new atoms.

Fission, the division of atoms occurs in a nuclear power plant. It is the division of the atom that releases a great deal of energy that is harvested for power.

Fusion occurs in stars, such as our sun, where different atoms are combined to form a new atom. An example of this would be the combination of two hydrogen atoms to form helium.

It is fusion that is responsible for making the different atoms that are the elements that comprise the periodic table

With the acceptance of Dalton's atomic theory, any hope of the Alchemist's dream of synthesizing gold was finally laid to rest. It was now accepted that gold, and the other metals such as lead and iron were composed of indivisible atoms of their own category. As atoms were believed to be indivisible and indestructible, one metal could not be made from another.

Lets Make Gold

Although the essence of his atomic theory remains valid today we now know that some of Dalton's conclusions were incorrect. In the two hundred years since Dalton proposed his principles, it has been demonstrated that the atom is not the fundamental particle of matter but is composed of many subatomic particles, such as protons, neutrons, and electrons. It has also been established that atoms can be divided in a process called nuclear fission. Nuclear fission occurs when the nucleus of an atom is split, which releases a great deal of energy. The energy of nuclear fission can be released in a controlled manner, as seen in nuclear power plants, or an uncontrolled manner as in nuclear bombs.

When the nucleus of an atom is split, the resulting particles are not the same element, but rather two different atoms. Recall that the Alchemists where trying to change one substance (lead) into another (gold). It now has been demonstrated, through the process of fission - the splitting of atoms - that lead can indeed be converted into gold. In 1980 the American Nobel Laureate Glenn Seaborg used fission to convert a tiny amount of lead into gold (see: gold). Others have replicated this work. However the cost of this process far outstrips the value of the gold created, making the production uneconomical.

So we have come full circle in chemistry. The discredited Alchemists, although incorrect in believing matter to be the product of water, earth, fire and air, were correct in proclaiming that gold could be created from lead. In the end the very knowledge that spelled the end Alchemy - the atomic theory - has allowed the dream of transmuting gold to come true. The elixir of life on the other hand remains elusive, except by those of us at i2P who believe it to be found in exercise, learning and a strong sense of community.

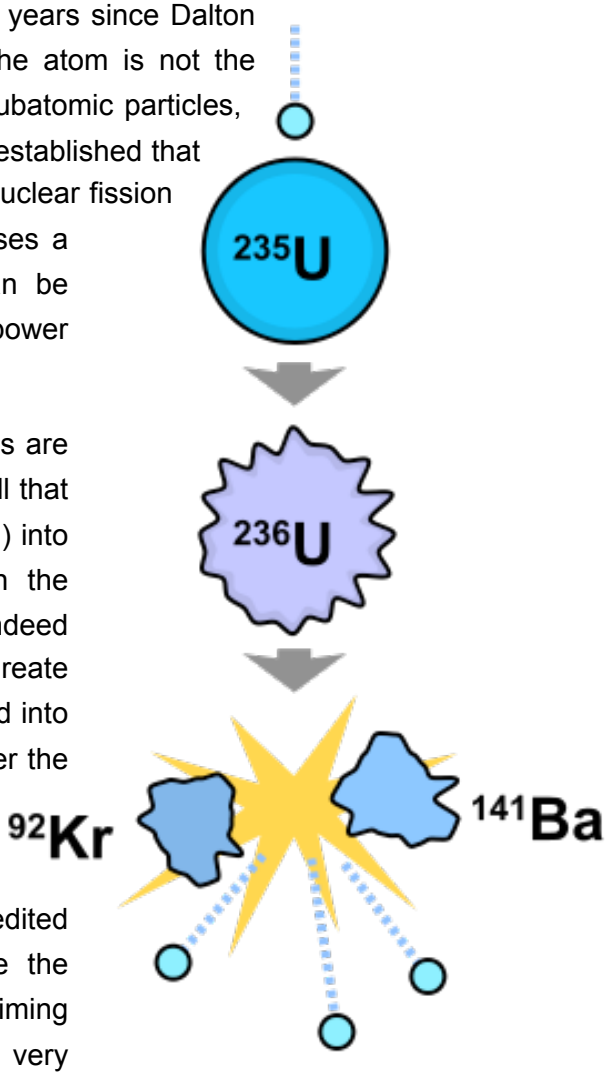


Figure 6: An example of nuclear fission in which one larger element is converted into two smaller elements. In this instance Uranium is broken into Krypton and Barium and three free neutrons. Gold can be made from lead in this manner.