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Elements of “Elements”

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ABSTRACT: The paper, though titled Elements of Elements, gives an exhaustive treatment on the topic. The search for elements by humans from time immemorial and by the Greeks ends up with the concept of the Big Bang and the Nucleosynthesis. Discovery of light and heavy elements and also transuranic elements up to the latest atom Oganesson of atomic number 118. Development of the periodic table by Mendeleev followed by the latest periodic table. Even though the paper is exhaustive, the author has dealt with only the discovery of elements and nothing about their physical or chemical properties. The paper ends with a conclusion.

KEYWORDS: Dark energy, Elements, Molecule, Nucleosynthesis, Periodic table, Quintessence, Scalar field, Transuranic elements.

I. INTRODUCTION

Before I begin my paper, I would like to mention what I exactly meant by the title, “Elements of ‘Elements’”. Two nouns in plural numbers joined by a preposition. The meaning of the first one is ‘elementary ideas’ or ‘basic principles’. The second noun refers to all the chemical elements such as Oxygen, Calcium, Potassium, etc. found in the universe. The title in no way means some material elements of some other material elements. I chose the title to make a rhythmic reading and I hope the readers will appreciate and as an element of surprise I would like to point out to the readers that contrary to the title, what I gave in the paper is exhaustive and in no way elementary.

The topic, ‘Elements’ is an ideal or probably may be the only topic that fits in both the subjects Physics and Chemistry. This paper (I request) should be read by both Physicists and Chemists even though they are at times at loggerheads.

The universe started with the Big Bang but the humans came to know of it much later. Man’s concept and search for elements started as soon as he appeared on the Earth. The search for elements started much before the Greeks followed by the classical Greek period and the period of late antiquity. Without numbering, the paper consists of three parts beginning with Thales of Miletus and ending with some work done by John Dalton. In the second part I have considered the discovery of both light and heavy elements by Nucleosynthesis followed by some idea of quintessence. In the third part I have dealt with the work of Mendeleev and Moseley in the formation of the periodic table. This is followed by discovery of transuranic elements without much description and the same fitted into the most modern periodic table.

I may warn the reader that other than just discovery and naming few elements, I have not given either their physical or chemical properties. As a picture speaks thousand words, I have included pictures of scientists almost at all places wherever a name appears deviating slightly from the research methodology leading this paper to an exhaustive article. The paper ends with a conclusion. The universe consists of elements and man being a part of it and hence I have included the elements present in the human body in the conclusion.

II. EARLY HISTORY

Much before the Greeks, sometime around 2000 BC in China and ancient India, the question was raised as to what the world is made of? It was the Greeks in the 5th century BC gave a satisfactory answer to the question and the concept of the answer remained for centuries thereafter. According to the Chinese, matter was composed of few basic elements such as *water, metal, wood, fire and earth*. For the Greeks and Indians they were *earth, air, fire and water*.

Thales of Miletus (640-546 BC) (Fig.1) is the first Greek philosopher supposed to have suggested that water was the basic material out of which everything was formed. According to the Greeks, particles of water might be viewed as

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spherical bodies that slipped over each other easily and that was the reason why one could pour water easily. Another philosopher, Anaximenes (570-528/500 BC) (Fig.2) thought it was *air*. Still another, Heraclitus (535-475 BC) (Fig.3) thought it was *fire* and so on. The Indians attributed these elements to divine mythology by assigning these elements to Gods or Goddess who have the power to produce and hold these elements together and maintain life on Earth. For example, the names in Sanskrit which is an ancient and original Indian language, Earth is *Bhoomi*, air is *Vayu*, fire is *Agni* and water is *Varun*. This idea still has not vanished from the minds of religious Indian philosophers.

The Greek philosopher, Empedocles (495-430 BC) (Fig.4) famous for originating the cosmogenic theory of the four classical elements supported the ideas of earlier thinkers and confirmed that the world was made of several different basic substances, *fire, water, air and earth*. To this, Aristotle (384-322 BC) (Fig.5) added *Aether* (from a Greek word for 'blazing') as a special substance out of which the luminous heavenly bodies were composed.

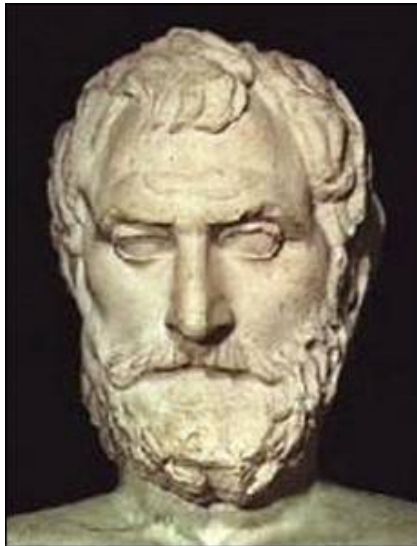


Fig.1.Thales of Miletus (640-546 BC)

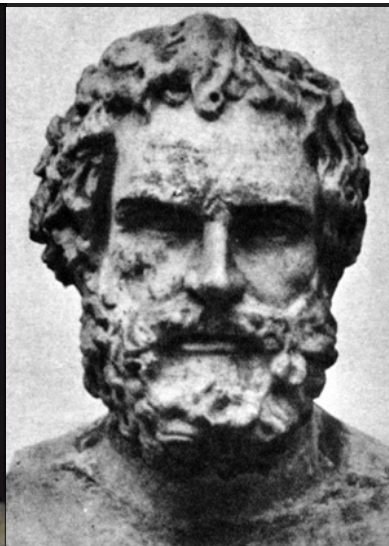


Fig.2. Anaximenes (585/570-528/500 BC)



Fig.3 Heraclitus (535-475 BC)

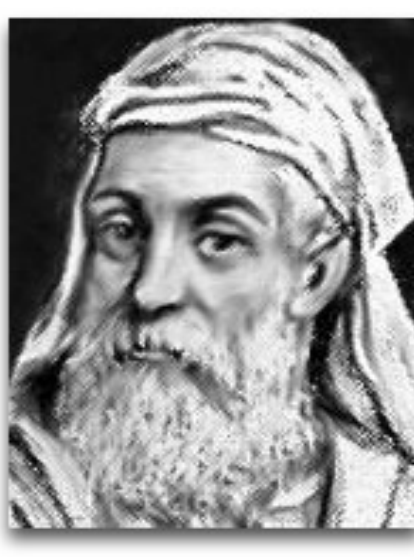


Fig.4 Empedocles (495-435/430BC)

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A link of these four elements, earth, air, fire and water is shown in the Fig.6 [8] which is an Italian wood-cut dating from 1496. An interesting illustration of these elements is given by the German painter and politician, Adolf Ziegler (1892-1959) (Fig.7) [1] which appeared as *Adolf Ziegler's (Circa 1937)* in the Time Magazine, New York dated 1 November 2010 is shown in

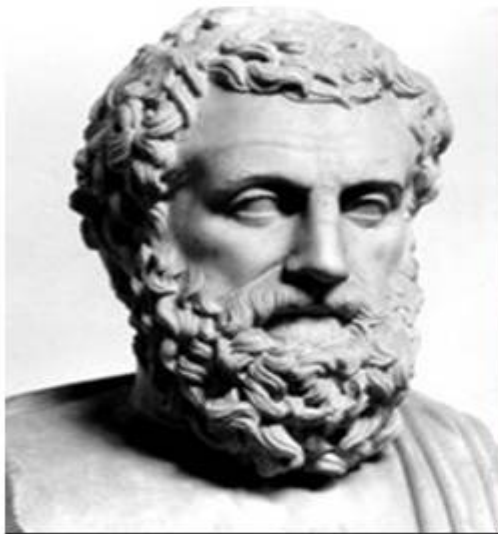
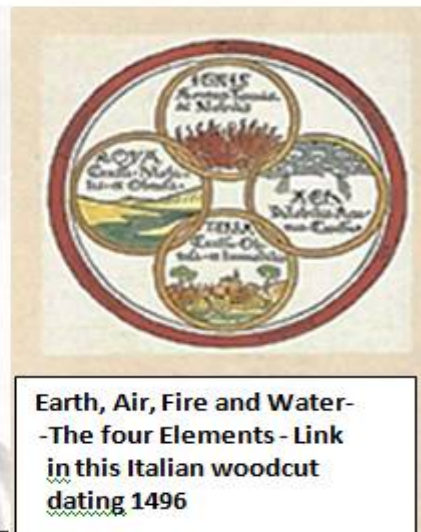


Fig.5 Aristotle (384-322 BC)



**Earth, Air, Fire and Water -
The four Elements - Link
in this Italian woodcut
dating 1496**

Fig.6 An Italian wood-cut depicting the four Elements[8]

Fig.8. These basic substances are called “elements”, a word derived from Latin. Even today we talk of the “raging of the elements”. As water pours down, air blows out and fire burns aslightening. To those



Fig.7 Adolf Ziegler 1892-1959) Fig.8 Adolf Ziegler's Circa 1937 depicting the four Elements:

which appeared in the “Time Magazine” New York Vol.176, No.18 dated 1 November 2010 [1]

people who accepted the notion of various elements, and who were atomists, it made sense to suppose that each element was composed of a different type of atom, so that the world consisted of four different types of atoms altogether, with a fifth type of heavenly aether. Even with only four types of atoms, it was possible to account for the

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great variety of objects on Earth. One only had to imagine that the various substances were made up of combinations of different numbers of different types of atoms in different arrangements.

However, the doctrine of the four or five elements began to vanish even as 'atomism' began to move ahead. In the year 1661 the philosopher, chemist and physicist, Robert Boyle (1627-1691) (Fig.9) wrote a book, "*The Sceptical Chemist*" in which he took up the position that it was useless to guess at what the basic substances of the world might be. One had to determine what they were by experiment.



Fig.9 Robert Boyle (1627-1691)



Fig.10 John Dalton (1766-1844)

According to him, any substance that could not be broken up by chemical manipulation into any simpler substance was an element. Any substance that could be broken down into simpler components was not an element. Thus, Boyle put the idea of element on a firm basis and starting with that for nearly three centuries scientists have been working to identify various elements. The elements identified were gold, silver, copper, iron, tin, aluminum, chromium, lead and mercury and among gases hydrogen, nitrogen and oxygen. The ancient Greek concept of air, earth, water and fire as elements was overthrown. As on today there are about 118 elements. About 90 of them occur naturally and the rest of them are created in laboratories. When there are 118 elements, there must be 118 different atoms.

John Dalton (1766-1844) (Fig.10) a science teacher in Manchester, England formulated the modern Atomic Theory and published the table of elements (Fig.11). In fact this is a starting point for the arrangement of elements in a tabular form which I will be showing in detail later. Dalton's first interest was Meteorology. His meteorological studies led him to the conclusion that atoms were physical entities and their relative weight and number were crucial in chemical combinations. Dalton's atomic theory of chemistry was published in "*A New System of Chemical Philosophy*" in 1808 and 1810. Briefly it has five parts:

- Elements are made of tiny particles called atoms that cannot be divided into smaller particles. nor can they be created or destroyed or changed into another kind of atom.
- All atoms of an element are identical. So, there are as many kinds of atoms as there are elements.
- The atoms of an element are different from those of any other element in that they have different weights.
- Atoms of one element can combine with atoms of another element to form a chemical compound (which we may call as the "Molecule", from Latin word meaning "a small mass") A compound always has the same relative numbers and kinds of atoms.
- In a chemical reaction, atoms are re-arranged among the compounds: they are neither lost nor gained.

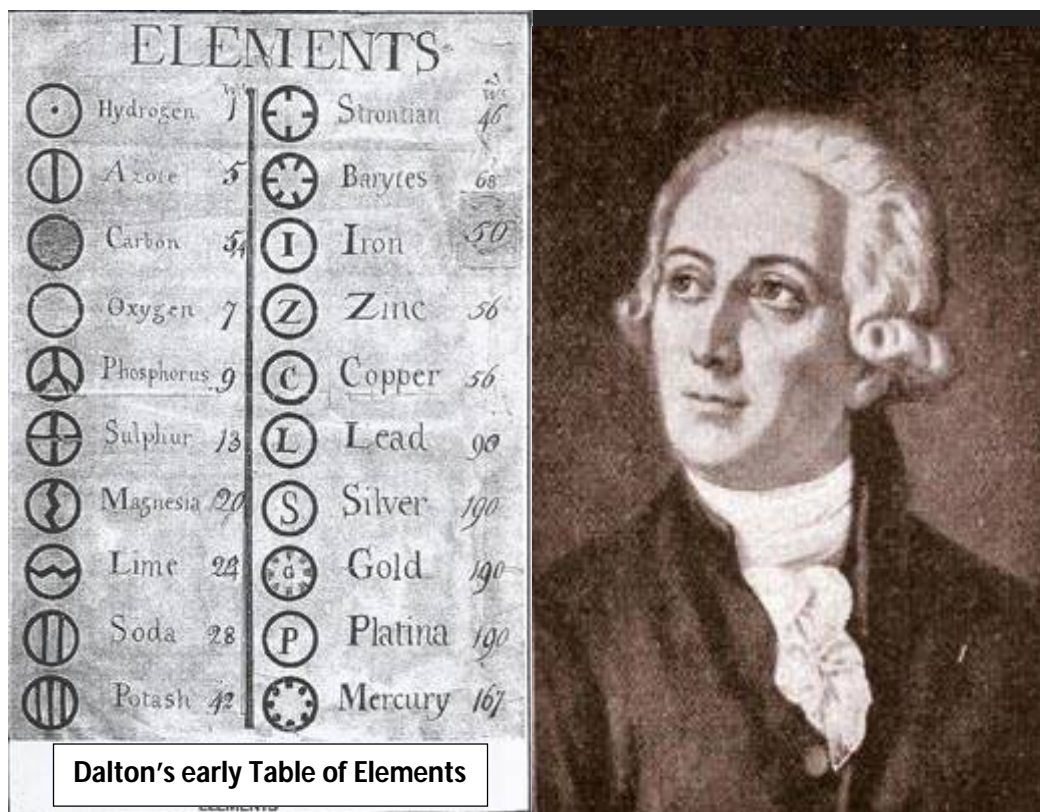
At the time of Dalton what was existent was the "*Caloric Theory of Heat*" introduced by Antoine Lavoisier (1743-1794) (Fig.12). Caloric is a self-repellent fluid which flows from hot bodies to cold ones and following this, according to Dalton, each particle of a gas is surrounded by an atmosphere of caloric. The particles are essentially at rest, their shells of caloric touching.

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Dalton's early Table of Elements

Fig.11 Dalton's Table of Elements [8]

Fig.12 Antoine Lavoisier (1743-1794)

An extract from Dalton's notebook [6] is shown in Fig.13. At the top of the figure two elementary atoms as they would exist in a gaseous mixture. The straight lines indicate the region of caloric around each mass. Below in the figure is shown a molecule of a compound, consisting of two atoms in close contact surrounded by a common, nearly spherical atmosphere of caloric. Dalton presented this knowing fully well that this goes against Newton's principle of "Action at a distance."

There are deviations in what was given by Dalton and a Swedish Chemist Jons Jakob Berzelius (1779-1848) modified some of them. He was the first to introduce chemical notation using one or two letters to represent an element in 1813. For water he used the notation, H²O instead of H₂O. Berzelius did much more. He published the first accurate list of weights of atoms.

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Fig.13 An extract from Dalton's Note book [6]



Fig.14 Jons Jacob Berzelius (1779 – 1848)

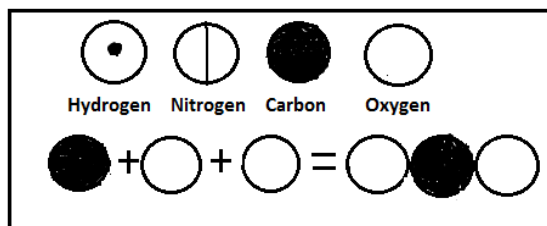


Fig.15 Dalton's illustration of a chemical Reaction

Dalton would represent a chemical reaction (carbon plus two oxygen to yield carbon dioxide) as shown in Fig. 15.

III. THE BIG BANGNUCLEOSYNTHESIS

3.1 Light Elements:[9]

The Origin of Chemical Elements based on the Big Bang theory and published in the Scientific American by Kelly Oakes states that when the universe started there were no elements at all. Only light elements such as hydrogen and helium were created by a process known as Big Bang Nucleosynthesis few minutes after the Big Bang. Earlier work on this was done by a large number of physicists, chemists and cosmologists. However the work done in 1948 by American theoretical cosmological physicist George Gamow (1904-1968) (Fig.16), the American cosmologist Ralph

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Asher Alpher (1921-2009)(Fig.17) and the American nuclear physicist Hans A Bethe (1906-2005) (Fig.18) is of importance.



Fig.16 George Gamow (1904-1968)

Fig.17 Ralph Asher Alpher

In a paper titled, “The Origin of Chemical Elements” and published on 1st April 1948 they have asserted that the elements in the universe originated “*as a consequence of continuous building-up process arrested by a rapid expansion and cooling of the primordial matter*”. In this process one nucleon gets added in the nucleus of an atom thereby making a new element till the universe got cooled. Alpher’s publication in the Washington Post with a heading “World began in five minutes – New Theory” is the starting for Big Bang Nucleosynthesis.

A time line of the expansion of the universe is shown Fig.19. The light elements were created at the far left of the figure at the beginning of the universe and became neutral atoms at a time around 380,000 year after the Big Bang The light elements were formed when the universe



Fig.18 Hans A Bethe (1906-2005)

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cooled from 10^{32}°C to 10^9°C . Elements such as Helium, Lithium and Beryllium were initially formed. The abundance of light elements at nucleosynthesis was predicted by an increase in the density of baryons which are particles made with 3 quarks such as protons and neutrons. It is found that more than 23% of the universe consisted of helium. During this process of nucleosynthesis, a peculiar radiation known as Cosmic Microwave Background (CMB) radiation (Fig.20) predicted by Alpher as early as 1940 was emitted. The CMB and its fluctuations as seen by Wilkinson Microwave Anisotropy Probe (WMAP), a

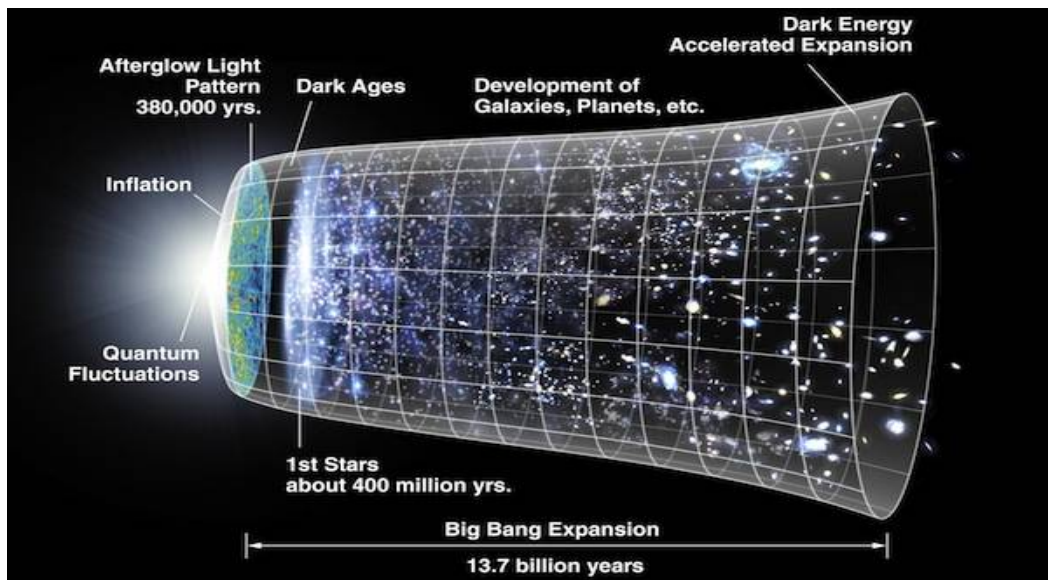


Fig.19 Timeline of the expansion of the universe (Credit Kelly Oakes [])

NASA Explorer mission launched in June 2001 to study cosmological measurements of the universe is shown Fig.20.

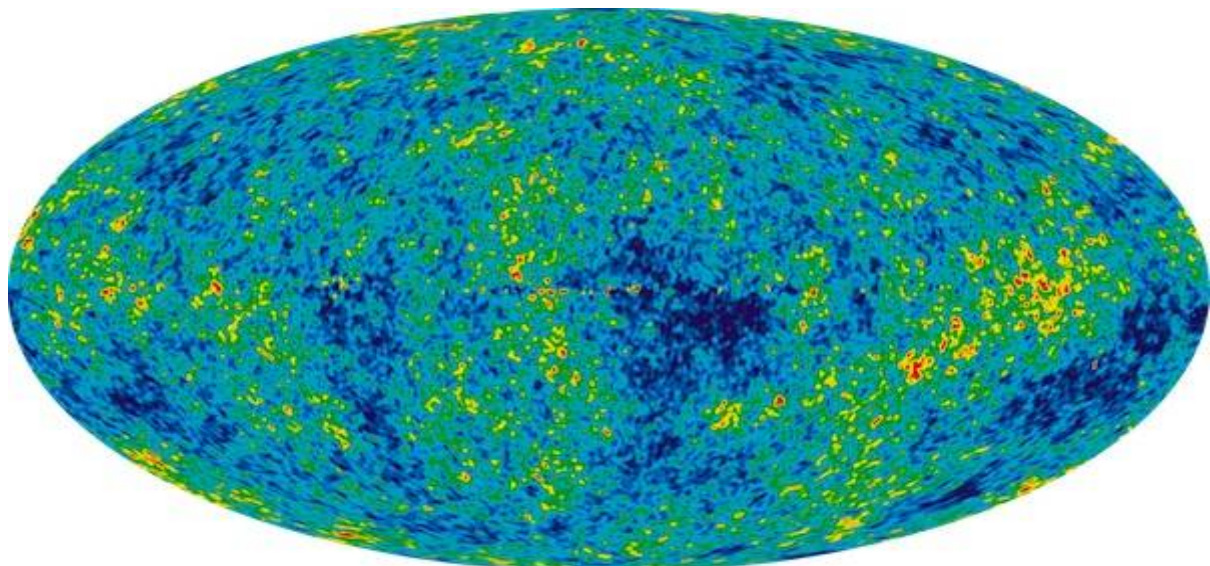


Fig.20 The CMB and its fluctuations as recorded by WMAP mission of NASA []

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3.2 Heavy Elements:[14]

Heavy elements were created from hydrogen and helium after the formation of stars by a process known as Stellar Nucleosynthesis, a process that continues even today. Some of the heavy elements such as magnesium, nickel and beyond were created within exploding stars by a process called Supernova Nuclear Synthesis. A plot of abundances of elements so far found on a logarithmic scale to the base 10 (ordinate) versus atomic number Z (abscissa) is displayed in the graph of Fig.21. Starting from the origin in the x-axis are shown elements such as hydrogen and helium within the paradigm of the Big Bang. The next 3 elements, Lithium (Li), Beryllium (Be) and Boron (B) are rare as they are poorly synthesized in the Big Bang and also in stars. There is an alternation in abundance as the atomic number increases and approaching heavy elements. But, however, a clear peak is seen for Iron (Fe) of atomic number 26 and Nickel (Ni) of atomic number 28. Fewer elements are seen with powers 2 and 6 having atomic number 100 ($\text{Log}_{10} 100$ being 2) and atomic number 1,000,000 ($\text{Log}_{10} 10^6$ being 6) respectively. The abundance of Silicon (Si) is normalized to 10^6 .

In fact, as on today, and put by Neil de Grasse Tyson [] “We are not simply in the universe, we are born from it”. This applies to every piece of matter in the universe including the humans.

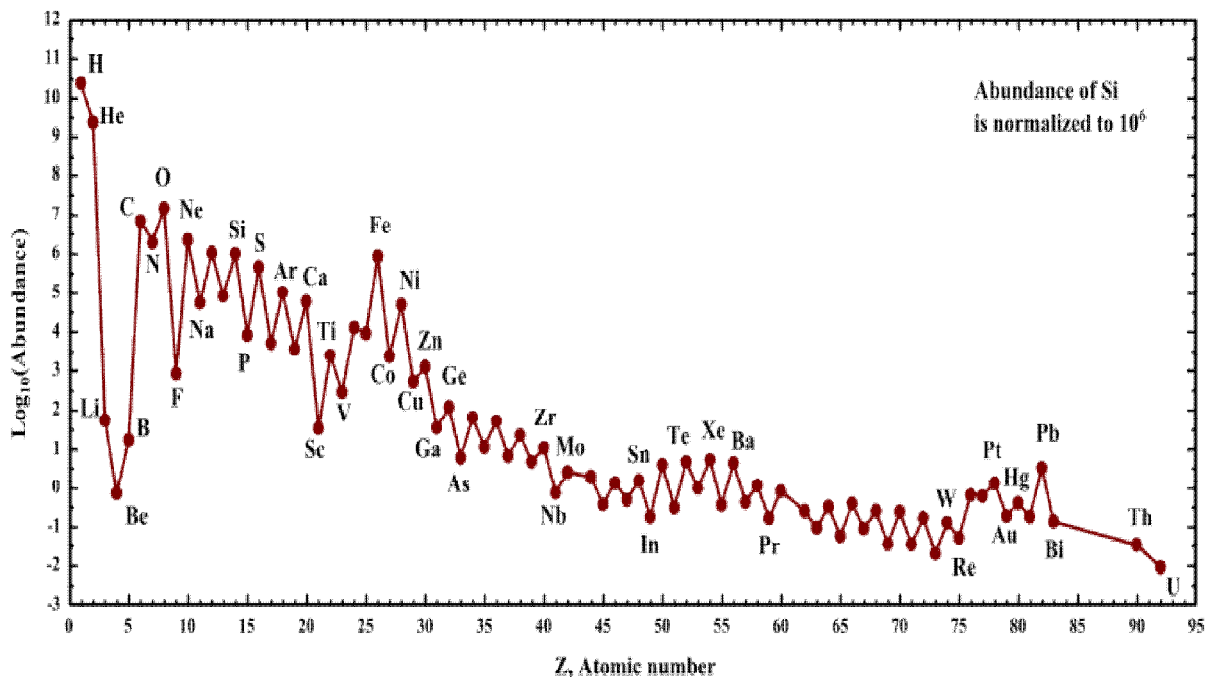


Fig.21 Abundances of chemical elements in the solar system(Graph Credit: 'Wikipedia')

3.3 Quintessence:

Quintessence (Aether) is the fifth element (Fig.22) that binds the four classical elements: Water, Fire, Earth and Air together. It is the strongest and most powerful element in the series, apart from the element of pure light which is bestowed upon Elyon, the God of Israelites in the Hebrew Bible. For a physicist this pure light is akin to photon and one of the most diverse regarding its effects.

Regarding quintessence Jean Tate [11] gives interesting synonyms. The word quintessence means the 5th essence the first 4 essences being Earth, Water, Fire and Air of the ancient Greeks. The 4 essences in modern Cosmology, however, being normal matter, radiation (photon), cold dark matter and neutrinos (which are hot dark matter). Dark matter is a hypothetical type of matter distinct from baryonic matter (ordinary matter such as protons and neutrons) which could explain many puzzling astronomical events. Unlike the gravitational field of Isaac Newton, quintessence is a complex scalar field such as the Higgs field of the Standard Model. According to Tate, a project seeking to measure the acceleration of the universe is **ESSENCE** (Equation of State SupEr Novae trace Cosmic Expansion)

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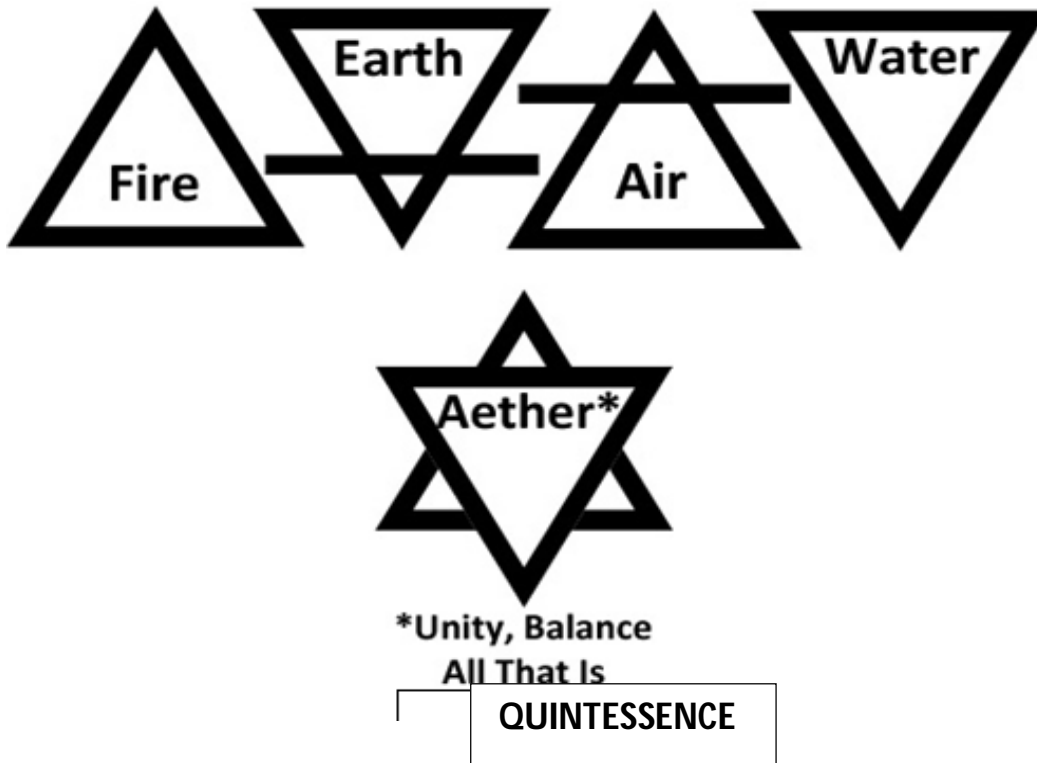


Fig.22 Symbolic illustration of the four elements and quintessence

The hypothetical form of dark energy which is precisely a scalar field postulated to explain accelerating universe was first proposed by Bharat Vishnu Ratra (Fig.23) and Phillip James Edwin Peebles (Fig.24) as early as 1988. I do not want to enter into the mathematical part of cosmology. The research paper I selected is such that it is much descriptive without any mathematics. Mathematics, in fact, is the language of Physics and I will be happy if I get some simple equation or at least some formulae.

In cosmology, the scalar field Q for a perfect fluid has an equation of state where w_q is the ratio of pressure p_q and density ρ_q is given by the potential energy $V(Q)$ and a kinetic term

$$w_q = \frac{p_q}{\rho_q} = \frac{\frac{1}{2}[\dot{Q}^2 - V(Q)]}{\frac{1}{2}[\dot{Q}^2 + V(Q)]}$$

is a dimensionless quantity Q is the scalar field and \dot{Q} is its first time derivative

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Fig.23 Bharat Ratra (b.1960)



Fig.24 Phillip James Edwin Peebles (b.1935-....)

Quintessence is dynamic and in general has a density ρ_q and w_q parameter which varies with time whereas a cosmological constant is static with value $w_q = -1$.

The equation of state for pressure can be written more precisely as

$$P = \rho_m RT = \rho_m C^2$$

where ρ_m is the mass density; R the universal gas constant; T the absolute temperature and $C^2 = RT$ the thermal velocity of the molecules. Thus,

$$w = \frac{p}{\rho} = \frac{\rho_m C^2}{\rho_m c^2} \approx 0 \quad \text{where } \rho = \rho_m c^2 \text{ and } C \ll c \text{ for a cold gas with } c \text{ as the velocity of light.}$$

Michael Brooks [10] gives the same thing put in a different way. The ancient Greeks, apart from the four basic elements earth, air, fire and water, also speculated a fifth component which they called 'quintessence'. They endowed it with a metaphysical purity – it was somehow a more 'elemental' element – but they never specified anything more about it. Present day physicists are in a similar position.

Observations of light from a distant supernova suggest that the expansion of the universe is accelerating. This means that some unknown mysterious force – known as Dark Energy – is in operation over cosmological scales. The source of dark energy lies in the energy fluctuations in the 'vacuum' of empty space, but the calculations led to negative results. Mathematically it was found the value for the accelerated expansion as 10120 times too big! .

It has been called the most embarrassing result in the history of Physics. One of the proposed solutions in this problem is that the acceleration is actually caused by an as yet undiscovered force that acts through the vacuum. Although physicists do not have much clue where that force might come from, they do at least have a name for it, "Quintessence"

IV. THE PERIODIC TABLE: [], [] & []

4.1 Earlier Work:

With the formation of the planets including the Earth and the rapid growth of civilization from time immemorial the search for elements started by the humans right from the classical Greece period (~400 BC) and the following period of Late Antiquity (~300 AD). The primitive man with a belief of flat Earth had no idea of either the Big Bang or the Nucleosynthesis. Elsewhere in this paper I have already dealt with a brief idea of elements and ended with the Dalton's atomic theory wherein is shown Dalton's table of elements (Fig.11). It is more a list rather than a table. In order to form a table there has to be sufficient number of elements, Gold, Silver, Tin, Copper, Lead and Mercury have been

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Fig.25 Hennig Brand (1630 – 1710)

Fig.26 Johann Wolfgang Dobereiner (1780 – 1849)

known since antiquity as they are found in their native form and are relatively simple to mine with primitive tools. Starting from the 17th century, important discoveries were done during the 19th and 20th centuries. In the 17th century in 1649, a German merchant and alchemist Hennig Brand (1630 – 1710) while searching for Philosopher's Stone accidentally discovered Phosphorus. He kept his discovery secret until 1680 when Robert Boyle (Fig.9) actually manufactured phosphorus and published his findings in 1689. Hence both Hennig Brand and Robert Boyle are given the credit for the discovery of Phosphorus. Antoine Lavoisier (Fig.12) identified elements such as Oxygen Nitrogen, Hydrogen, Phosphorus, Mercury, Zinc and Sulfur. He could only classify the elements as metals and non-metals. 18th and 19th centuries were crucial and to be exact in 1869 about 63 elements and their related compounds were discovered.

In the year 1817, Johann Wolfgang Dobereiner (1780-1849) (Fig.26) was one of the first to formulate and classify elements. He formulated a law known as the "Triad Law" according to which: "The chemically analogous elements arranged in increasing order of their atomic weights formed well marked groups of three which he called them Triads in which the atomic weight of the middle element was found in general the arithmetic mean of the atomic weight of the other two elements in the triad". The examples of the triad are: [Chlorine, Bromine and Iodine], [Calcium, Strontium and Barium], [Sulfur, Selenium and Tellurium] and [Lithium, Sodium, and Potassium].

Between the year 1829 and 1858 a large number of scientists found that the type of chemical relationships should be extended beyond the Triads. Hence in the year 1862 a French geologist, Alexandre-Emile Beguyer de Chancourtois (1820 – 1886) (Fig.27) noticed the periodicity of the elements when they are ordered in terms of their atomic weights. In the year 1862 he devised an early form of the periodic table which he named *Vis telluric* meaning the 'Telluric Helix' after the element Tellurium which fell at the center of his table. He arranged the elements in a spiral on a cylinder. As he included some compounds also in the cylindrical arrangement, scientists gave little attention to it. In the year 1864 John Newlands (Fig.28) an English chemist classified 62 known elements into 8 groups based on their physical properties. He noted that many pairs of similar elements existed which differed by some multiple of eight and hence he called it the "The Law of Octaves" and introduced the idea of "Periodicity" and "Atomic Number". But, however, the periodicity of eight similar to a musical scale was not accepted. In the same year a German chemist, Julius Lothar Meyer (Fig.29) noted that when the atomic weights were plotted as ordinates and the atomic volumes as abscissae, the resultant curve had a number of maxima and minima the maxima corresponding to the electropositive

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elements in the order of their atomic weights. His results were not published and next came the genius Dmitri Ivanovich Mendeleev (1834-1907) (Fig.30)

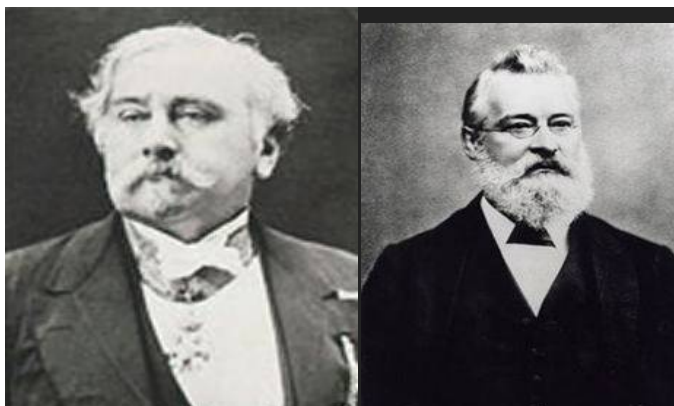


Fig.27 Alexandre-Emile Beguyer de Chancourtois (1820 – 1886)

Fig.28 John Newlands (1837 – 1898)

and one may call him both a chemist and a physicist and I would more appropriately call him a chemo physicist befitting what I mentioned in the Introduction.

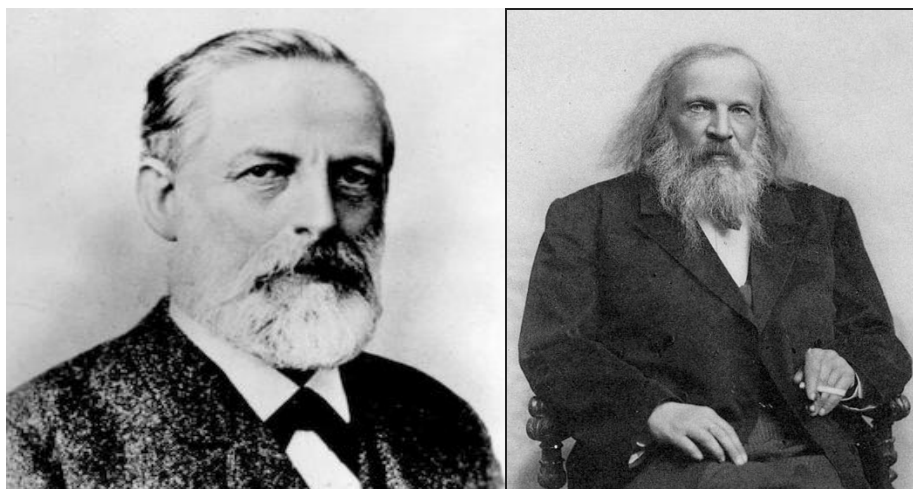


Fig.29 Julius Lothar Meyer (1830-1895)

Fig.30 Dmitri Ivanovich Mendeleev (1834-1907)

In 1869 just 5 years after John Newlands put forward the law of octaves, Mendeleev published a periodic table by arranging the elements known at his time in order of relative atomic mass and he did some more things that made his table well acceptable. Mendeleev, as quoted by Inostrantzev [7] says that there were almost 65 elements to be arranged and Mendeleev saw a table in a dream where all elements fell into a place except one as required and on waking up he immediately wrote it down on a piece of paper. The Royal Society of Chemistry has produced a stamp collector's miniature sheet (Fig.31) showing some of Mendeleev's original notes dated 17 February 1869.

The Russian version of his table first brought out is shown Fig.32. Mendeleev realized that the physical and chemical properties of elements were related to their atomic masses in a 'periodic' way and arranged them so that groups of elements with similar

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properties fell into vertical columns in his table. He left gaps in the table for elements still to be discovered in future and also could work out their atomic masses.

A German chemist, Julius Lothar Meyer (1830-1895) (Fig.29) by taking into consideration of the valence of about 28 elements independently prepared a periodic table in 1864 which almost tallied with that of Mendeleev but Meyer did not give any chance for the entry of future elements in his table.

4.2 Work after Mendeleev:

Mendeleev's table was not able to predict the existence of noble gases, but later on when they were discovered by a British chemist, Sir William Ramsay (1852-1915) (Fig.33), he (Ramsay) could fit them into Mendeleev's table by assigning Group 0 without disturbing the originality of the table.

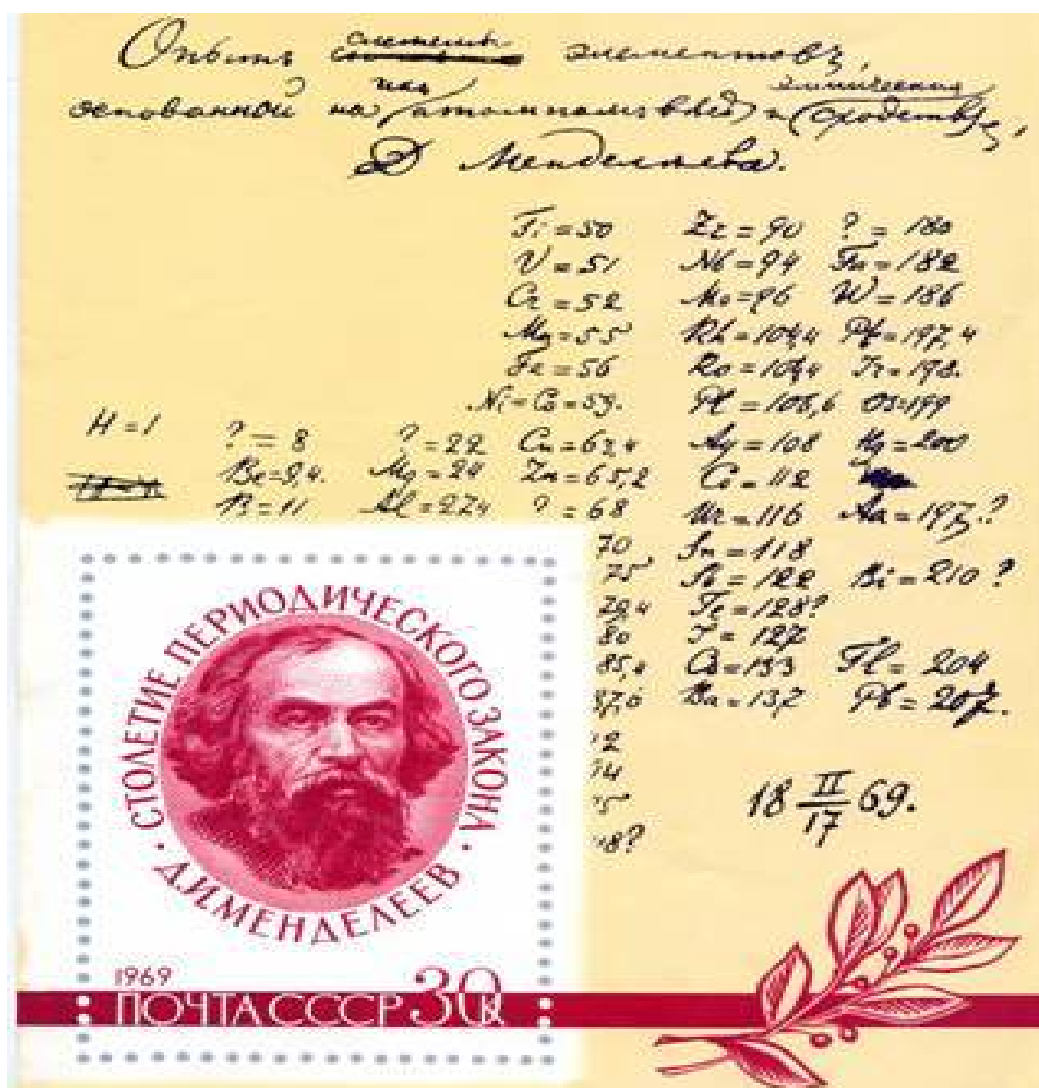


Fig.31 A commemorative stamp collector's minaturesheet showing some of Mendeleev's original notes. Horizontal lines like Cr, Mo and W (in the third row down) correspond to today's groups. Note the date, 17 February 1869. (Credit: Royal Society of Chemistry)

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The frame work of the Periodic Table was almost over by the end of the 19th century and completed by the British physicist, Henry Moseley (Fig.34). Eric R. Scerri [5] professor at the University of California at Los Angeles calls Moseley “*The Master of Missing Elements*” and the same titled in a research paper published in the “*American Scientist*” (Sep.-Oct.2014). Scerri speaks volumes of the scientist and his works regarding the elements and the periodic table. According to the author, Moseley’s discoveries sorted out the periodic table and transformed how scientists look for new forms of the most basic substances. Moseley’s methods showed the logic of the standard ordering of the periodic table. The discovery of X-rays by Wilhelm Rontgen further facilitated Moseley’s research. He found a relationship between the X-ray wavelength of an element and its atomic number. With the introduction of nuclear charge by Rutherford, Moseley was then able to re-sequence the periodic table by nuclear charge rather than by atomic weight. Antonius Johannes Van der Broek (1870-1926) a Dutch amateur physicist notable

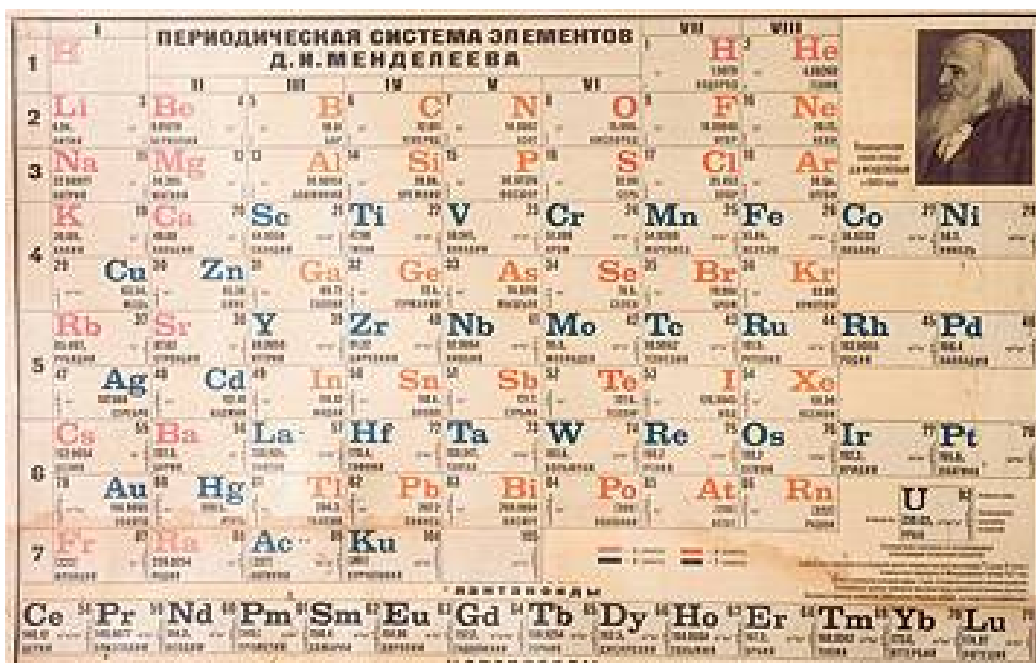


Fig.32 A Russian periodic table based on Dmitri Mendeleev’s original table of 1869.

for being the first who realized that the number of an element in the periodic table corresponds to the charge of its atomic nucleus, a hypothesis which was later confirmed by Moseley. His research helped to settle many debates and disputes about the number of elements remained to be discovered and incorporate in the periodic table

Glenn T. Seaborg (1912-1999) (Fig.35) in the isolation of the transuranic elements Americium and Curium brought out a change in the periodic table by assigning a series known as actinide series comprising of elements from actinium to lawrencium. Seaborg’s actinide concept paved the path for super heavy elements from 104 to 121 and a super actinide series from 122 to 153.

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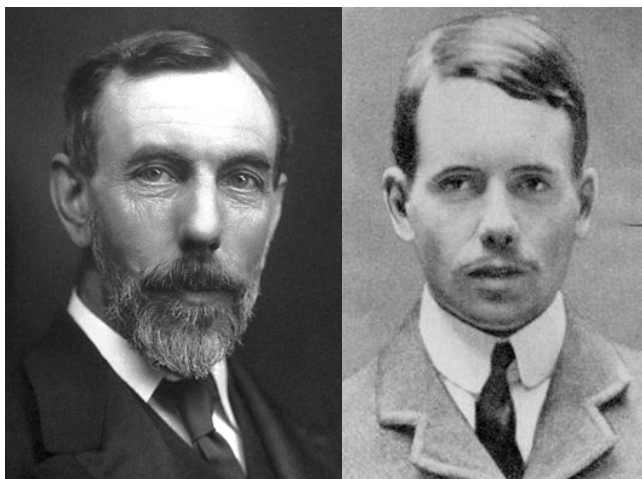


Fig.33 Sir William Ramsay (1852-1916) Fig.34 Henry Moseley (1887-1915)

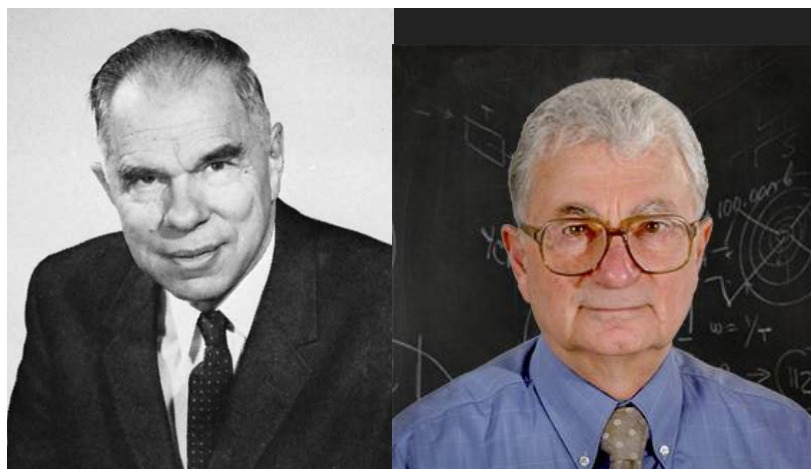


Fig.35 Glenn T. Seaborg (1912-1999) Fig.36 Yuri Oganessian (b. 1933-....)

4.3 Transuranic Elements:

The Manhattan project, the research leading to the nuclear explosions at Hiroshima and Nagasaki and the following half a century of research brought the scientists to the dawn of the 21st century and as on today there are 26 elements beyond uranium of atomic number 92 and atomic weight 238. Uranium the last element before the final entries in the periodic table, was discovered in the year 1789 by Martin Heinrich Kalproth and isolated and identified a century later by Henri Becquere in 1896. Elements after uranium are called transuranic elements and the first transuranic element to enter the periodic table is Neptunium of atomic number 93 and atomic weight 237. Even though its discovery was disputed and claimed by many, the official discovery went to Edwin McMillan and Philip H. Abelson in the year 1940. In the following table is shown a list of transuranic elements up to the latest one Ununoctium of atomic number 118 and atomic weight 294 (In Latin 'un' means one, 'oct' means eight and hence 'ununoct' means one one eight). It was discovered in the year 2006 by the lead Russian nuclear physicist and a pioneer in the discovery of synthetic elements, Yuri Oganessian (b.1933-...) (Fig.36) and hence known as Oganesson (Og). The elements being of recent origin it is of interest to know their lives, the year of discovery and the location where they are discovered and hence the same are shown in the table. []. The structure of Oganesson is shown Fig.37.[16]

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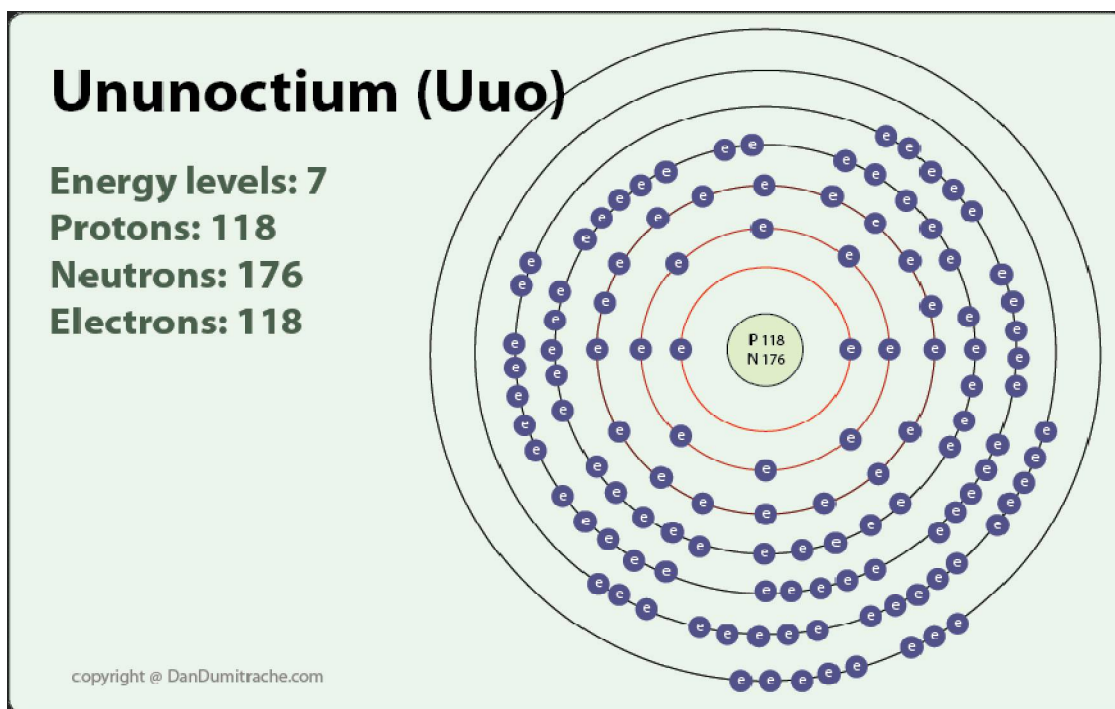


Fig. 37 The Structure of Element 118 (Credit: DanDumi trache.com)

Table []

Atomic Number	Symbol	Name	Longest-lived Isotope	Year of Discovery	* Location
93	Np	Neptunium	$^{237}_{\text{Np}}$ 2.1×10^6 y	1940	Berkeley
94	Pu	Plutonium	$^{244}_{\text{Pu}}$ 8.0×10^7 y	1940	Berkeley
95	Am	Americium	$^{243}_{\text{Am}}$ 7370 y	1944	Berkeley
96	Cm	Curium	$^{247}_{\text{Cm}}$ 1.6×10^7 y	1944	Berkeley
97	Bk	Berkelium	$^{247}_{\text{Bk}}$ 1380 y	1949	Berkeley
98	Cf	Californium	$^{251}_{\text{Cf}}$ 808 y	1950	Berkeley
99	Es	Einsteinium	$^{252}_{\text{Es}}$ 742 d	1952	Berkeley
100	Fm	Fermium	$^{257}_{\text{Fm}}$ 101 d	1952	Berkeley
101	Md	Mendelevium	$^{258}_{\text{Md}}$ 52 d	1955	Berkeley
102	No	Nobelium	$^{257}_{\text{No}}$ 58 m	1956	Dubna
103	Lr	Lawrencium	$^{262}_{\text{Lr}}$ 3.6 h	1962	Dubna/ Berkeley
104	Rf	Rutherfordium	$^{267}_{\text{Rf}}$ 1.3 h	1966	Dubna/ Berkeley
105	Db	Dubium	$^{268}_{\text{Db}}$ 28 h	1968	Dubna/ Berkeley
106	Sg	Seaborgium	$^{271}_{\text{Sg}}$ 1.9 m	1985	Dubna/ GSI

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107	Bh	Bohrium	270_{Bh} 61 s	1981	GSI
108	Hs	Hassium	269_{Hs} 10 s	1984	GSI
109	Mt	Meitnerium	278_{Mt} 8 s	1982	GSI
110	Ds	Darmstadtium	281_{Ds} 10 s	1994	GSI
111	Rg	Rontgenium	281_{Rg} 20 s	1994	GSI
112	Cn	Copernicium	285_{Cn} 30 s	1996	GSI

Atomic Number	Symbol	Name	Longest-lived Isotope	Year of Discovery	* Location
113	Uut	Ununtrium	286_{Uut} 20 s	2003	Dubna/ Berkeley
114	Uuq	Ununquadium	289_{Uuq} 2.6 s	1999	Dubna
115	Uup	Ununpentium	289_{Uup} 0.22 s	2004	Dubna/ Berkeley
116	Uuh	Ununhexium	293_{Uuh} 0.060 s	2000	Dubna
117	Uus	Ununseptium	294_{Uus} 0.036 s	2010	Dubna
118	Uuo	Ununoctium	294_{Uuo} 0.89 ms	2002	Dubna

*[Berkeley → University of California at Berkeley, Lawrence Radiation Laboratory, Lawrence Livermore Laboratory.

GSI → Heavy Ion Accelerator at Darmstadt, Germany.

Dubna → Joint Institute for Nuclear Research, Dubna (near Moscow) Russia]

Elements 113 to 118 shown separately in the table above have been given the temporary names existed earlier. In the most recent version of the periodic table released by the International Union of Pure and Applied Chemistry (IUPAC) on 28 November 2016. The new names with their symbols, however, are: Element 113 → Nihonium (Nh), 114 → Flerovium (Fl), 115 → Moscovium (Mc), 116 → Livermorium (Lv), 117 → Tennessine (Ts) and 118 → Oganesson (Og).

4.4 The Latest Periodic Table:

A periodic table following the schemes incorporated by both Mendeleev and Moseley, ideal and acceptable and free of shortcomings is shown in Fig. 38. The table is an arrangement in order of their atomic numbers such that elements with similar chemical properties appear in the same vertical

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Group→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓Period																		
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La *	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac **	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
Lanthanide Series	*			58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
Actinide Series	**			90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Fig.38 The latest Periodic Table (Credit: Wikipedia, edited on 5th July 2017)

column or ‘**Group**’. Atomic number of each element is shown above its respective symbol. The horizontal row of the periodic table is called the ‘**Period**’. There are 7 periods with each one beginning at far left. Period 1 has only 2 elements (Hydrogen, H and Helium, He) whereas periods 2 and 3 have 8 elements. Periods 4 and 5 have 18 elements. Periods 6 and 7 have 32 elements. This is because the two bottom rows separated from the rest of the table belong to these periods. They are purposely separated to make the table concise and fit into a single page. As suggested by Glenn T Seaborg, the Lanthanide series and Actinide series are also shown.

4.5 The Extended Periodic Table: [Credit: Wikipedia]

An extended periodic table theorized about elements beyond Oganesson (beyond period 7). Currently 7 periods in the periodic table of chemical elements are known and proven, culminating with atomic number 118 to even 172 and they are omitted here to maintain brevity of this paper.

V. CONCLUSION

The “Elements of Elements” have been brought to an end. I have dealt with only the discovery of few elements and the material, I believe, should be useful for students of both Physics and Chemistry. Without adding anything further, I cannot ignore the humans and as mentioned elsewhere in this paper that universe is full of elements and man is a part of the universe and hence as an Epilogue, I would like to finally end the paper by giving something about the elements present in the human body.

[2] has given an illustrative and self-explanatory diagram showing various elements with which the human body is made of and the same is shown in Fig.39

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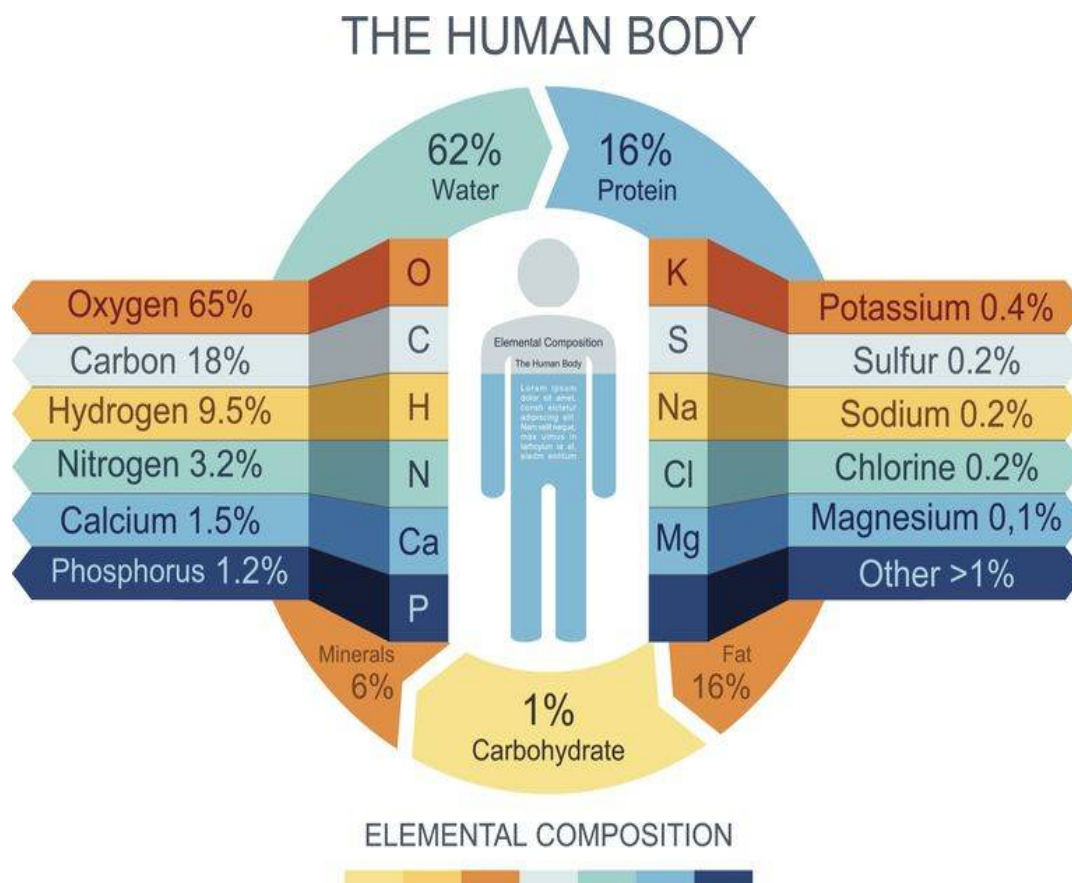


Fig.39. Percentage elemental composition of the human body []

The information collected by Ed Uthman, M.D [4] from a well known book, “The Elements” by Emsley John, 3rd edition, Clarendon Press, Oxford, 1998 is more vivid. He has mentioned about 59 elements present in an average person weighing 70 kg. Starting the weight in terms of kilogram and ending with an element in gram, the values are:

Oxygen : 43 kg; Carbon : 16 kg; Hydrogen : 7 kg; Nitrogen : 1.8 kg; Calcium : 1 kg;

Phosphorus : 780 g; Potassium : 140 g; Sulfur : 140g; Sodium : 100 g.

Other elements present are less than 100 g and in traces.

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BIOGRAPHY



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