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HISTORY of the ORIGIN of the CHEMICAL ELEMENTS and THEIR DISCOVERERS

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Note – this is an updated revision (with all 118 chemical elements), for the 100th anniversary of the International Union of Pure and Applied Chemistry's (IUPAC) creation, of the BNL-NCS-68350-01/10-REV paper presented at the 41st IUPAC General Assembly in Brisbane, Australia, June 29th – July 8th, 2001.

INTRODUCTION

What do we mean by a chemical element? Lavoisier defined a chemical element as a substance which (as far as we know) cannot be decomposed into simpler substances by ordinary chemical means. Atoms of all chemical elements are composed of positively charged particles called protons, an equal number of negatively charged particles called electrons and electrically neutral particles called neutrons. The number of protons in each atom is its atomic number, symbol *Z*, and determines the chemical element; for example, for hydrogen atoms, Z = 1 and for gold atoms, Z = 79. The number of neutrons, symbol N, in an atom of a given element may vary. The total number of protons and neutrons (Z + N) in a specific atom is the mass number, symbol A, where A = Z + N. A nuclide is an atom with a specific number of protons and a specific number of neutrons; that is a specific atomic number and a specific mass number. The terms nickel-64 and ^{64}Ni both refer to a nuclide of the element nickel with a mass number of 64. Nuclides of a given element that have different numbers of neutrons, but the same number of protons are called isotopic nuclides or isotopes. The term "isotope" is commonly used in discussions of atomic properties of an atom and "nuclide" is used for discussions of nuclear properties. For any element, only certain isotopes are stable. ^{64}Ni, with 28 protons and 36 neutrons is stable, whereas ^{65}Ni with 37 neutrons is unstable. A stable isotope is defined as an isotope for which no radioactive decay has been experimentally detected. An unstable isotope (also called a radioactive isotope or radioisotope) is energetically unstable and will decay (disintegrate) over time to another isotope of the same element or to a nuclide of a different element. The time it takes for one half of the atoms of a given unstable isotope in a sample to decay is called the half-life, $t_{1/2}$, of that isotope. The term isotope applies to both stable and radioactive isotopes.

As we will see in the following elemental review, the origin of the chemical elements display a wide diversity with some elements having an origin in antiquity, other elements having been discovered in

the past few hundred years and still others have been synthesized within the past seventy-five years via nuclear reactions on heavy elements because these elements are unstable and radioactive and do not exist in nature.

The names of the various chemical elements come from many sources including mythological concepts or characters; places, areas or countries; properties of the element or its compounds, such as color, smell or its inability to combine; and the names of scientists (both living and dead). There are also some miscellaneous names as well as some obscure names.

The basis for claim of discovery of an element has varied over the centuries. The method of discovery in the late 18th and early 19th centuries used the properties of the new substances, their separability, the color of their compounds, the shapes of their crystals and their reactivity to determine the existence of new elements. In those early days, atomic weight values were not available and there was no spectral analysis that would later be supplied by arc, spark, absorption, phosphorescent or x-ray spectra. At the time, there were many claims, e.g., the discovery of certain rare earth elements of the lanthanide series, which involved the discovery of a mineral ore, from which an element was later extracted. The honor of discovery has often been accorded not to the person who first isolated the element but to the person who discovered the mineral, even when the mineral ore was a mixture contained more than one element. The reason for this is that in the cases of these rare earth elements, the 'earth' now refers to oxides of a metal, not to the metal itself. This fact was not realized at the time of their discovery, until the English chemist Humphrey Davy showed that earths were compounds of oxygen and metals in 1808.

Although the atomic weight of an element and spectral analysis of that element were not available in the early days, both these elemental properties would be required before discovery of the element would be accepted by the latter part of the 19th century. In general, the requirements for discovery claims have tightened through the years and claims that were previously accepted would no longer meet the minimum constraints now imposed. There are also cases where the honor of discovery is not given to the first person to discover the element but to the first person to claim the discovery in print. If a publication was delayed, the discoverer has often historically been 'scooped' by another scientist.

This leads to the question of who should be considered the ultimate discoverer of a chemical element? Should it be the first person to describe the initial properties, the one who found the oxide or the metal, the one who separated the element or the first one to publish their results? As for publication, the Swedish chemist, Jons Jacob Berzelius, published an annual review (equivalent to our present abstract service) during the early 19th century. Berzelius usually cited articles published in other journals, but he also reported on the work in his laboratory which had not yet been published. This enabled his assistant Carl-Gustav Mosander to receive early credit for work that Mosander chose not to publish until many years later after he had worked out all the details. In the element review, we shall see that the answer to the above questions would be any of the above criteria could qualify for discovery of an element.

DETERMINING THE NAMES OF THE CHEMICAL ELEMENTS

Names of the chemical elements are also determined by the acceptance of the chemical community, the priority of the discoverer not with-standing. We shall see long-standing disputes among some elements.

For some elements, this involved both national pride and rivalry between French and German scientists for some of the older elements and Russian and American scientists in more recent times.

At the beginning of the 20th century, the International Committee on Atomic Weights (ICAW) was formed. Although ICAW did not set internationally approved names, a name with an atomic weight value in their table lent support for the adoption of that name by the chemical community. 20 years later, the ICAW became a part of the International Union of Pure and Applied Chemistry (IUPAC) when it was formed. IUPAC was called the International Union of Chemistry (IUC) in the years between 1930 and 1950. When the IUPAC Commission on Atoms was disbanded in 1949, the responsibility for acceptance of the name of a chemical element was given by IUPAC to its Commission on Nomenclature of Inorganic Chemistry (CNIC). When IUPAC dissolved almost all Commissions in 2001, responsibility for the names was passed to CNIC's parent organization, the Inorganic Chemistry Division Committee (ICDC).

ICDC does not deny the right of a discoverer to propose a name for a new chemical element. However, the approved name of elements should differ as little as possible in different languages; the names should be based on practicality and prevailing usage and finally the choice of the name carries no implication about priority of discovery. Examples of this last point will be seen in the element review.

SPECIAL DIFFICULTIES WITH THE RARE EARTH ELEMENTS

Discovery of the rare earth elements provide a long history of almost 200 years of trial and error in the claims of element discovery starting before the time of Dalton's theory of the atom and determination of atomic weight values, Mendeleev's Periodic Table, the advent of optical spectroscopy, Bohr's theory of electronic structure of atoms and Moseley's x-ray detection method for determination of atomic number. The fact that the similarity in the chemical properties of rare earth elements make them especially difficult to chemically isolate led to a situation where many mixtures of elements were being mistaken for elemental species. As a result, atomic weight values were not nearly as useful because the lack of separation meant that additional elements would still be present within an oxide and lead to inaccurate atomic weight values. Very pure rare earth samples did not become a reality until the mid to latter half of the 20th century.

Prior to the proposal of the Periodic Table, there was no information available on how many chemical elements could possibly exist. Even after the appearance of numerous periodic tables of chemical elements, the rare earth elements were an especially difficult case because they could not be properly arranged into any of the tables. Until the 20th century, fractional crystallization was the only method of purification of elements. In most cases, this required thousands of recrystallizations involving months of work. As a result, there is a long list of various false claims among the rare earth elements, some of which are detailed below.

Some of the erroneous element names proposed in the past include junonium, thorine, vestium, sirium, didymium, doarium, wasmium, mosandium, philippium, decipium, ytterbium, columbium, rogerium, austrium, russium, masrium, demonium, metacerium, damarium, lucium, kosmium, neokosmium, glaucodymium, monium, victorium, euxenium, carolinium, berzelium, incognitium, ionium, celtium, denebium, dubhium, eurosamarium, weisium, nipponium and moseleyum.

Of course, mistaken elements are not restricted to the rare earth elements alone. Other elemental errors produced such names as polonium, ilmenium, neptunium, pelopium and davyum.

It should be noted that the ytterbium listed above was a mixture discovered in the mineral erbia by de Marignac in 1878 and not the neoytterbium/aidebaranium element renamed ytterbium that was found in the mineral ytterbia. The columbium was a mixture found in the mineral samarskite and was not the present-day columbium/niobium. The ionium listed above was a mixture of terbium and gadolinium that was found in the mineral yttria and does not refer to the isotope ^{230}Th. Finally, the neptunium refers to material found in niobium/tantalum minerals and does not refer to the 1940 discovery of the trans-uranium element with atomic number 93 produced via a neutron capture reaction on a uranium sample.

CONTROVERSIAL HEAVY ELEMENTS

During the last half of the 20th century, there were many opposing claims, which took on a nationalistic rivalry and a fight over when and where an element was 'actually discovered' and who has the right to name that element. As mentioned above, IUPAC has taken the position that the name IUPAC proposes for an element carries no implication regarding the priority of the discovery but is merely related to the general usage of the name in the literature. Elements exist, where the accepted name was proposed, based on a discovery that was erroneous but widespread usage has dictated the continued use of the original name, even after the error was discovered (see nobelium in the element list). Historically, new elements have been proposed and accepted in the past that was based on evidence that would not meet the criteria of today.

Some 20 years ago, the 30-year old controversy about the first synthesis of new chemical elements in the trans-uranium region was resolved by a joint IUPAC and IUPAP (International Union of Pure and Applied Physics) committee's review and recommendation. The resulting IUPAC assigned names have been internationally accepted. Since that time, all recent elements up to Z = 118 have been reviewed and recommendations accepted via this joint IUPAC/IUPAP committee.

INDIVIDUAL ELEMENT NAMES AND HISTORY

The following list is given alphabetically by element name and provides the origin of the elements and information on their discoverers.

Actinium - the atomic number is 89 and the chemical symbol is Ac. This element has 32 unstable isotopes/nuclides known at present. The name derives from the Greek, aktis or akinis for "beam or ray" because in equilibrium with its decay products, actinium is a powerful source of alpha radiation. The discovery has been credited to the French chemist, Andre-Louis Debierne in 1899. It was independently discovered by the German chemist, Friedrich Oskar Giesel, in 1902, who called it emanium. It is thought that Debierne's original preparation consisted of two thorium isotopes, ^{227}Th and ^{230}Th, but there was confusion in those early discoveries in radioactivity and Debierne's claim prevailed and his name of

actinium has been retained to this day. The longest half-life associated with this unstable element is 21.77-year ^{227}Ac.

Aluminium – the atomic number is 13 and the chemical symbol is Al. This element has 1 stable and 22 unstable isotopes/nuclides known at present. The name was originally called aluminum. It was later changed to aluminium because all other languages retained the "i". Internationally, the element is referred to as aluminium to conform with the ending "ium" of most metallic elements. The name derives from the Latin, alum and alumen for "stringent", since the early Romans called any substance with a stringent taste, alum. The element was known in prehistoric times. In 1825, the Danish physicist, Hans Christian Oersted, isolated impure aluminium. The pure metal was first isolated by the German chemist, Friedrich Wohler in 1827.

Americium – the atomic number is 95 and the chemical symbol is Am. This element has 22 unstable isotopes/nuclides known at present. The name derives from "America" where it was first synthesized in a series of successive neutron capture reactions in the element plutonium, ^{239}Pu, in a nuclear reactor in 1944 by American scientists under Glenn T. Seaborg at the University of California lab in Berkeley, California, using the reaction ^{239}Pu (n, ɤ) ^{240}Pu (n, ɤ) ^{241}Pu -> β^- + ^{241}Am. Americium is the sixth element in the Actinide series of elements and is named in analogy to Europium, which is the sixth element in the Lanthanide series of elements. The longest half-life associated with this unstable element is 7370-year, ^{243}Am.

Antimony – the atomic number is 51 and the chemical symbol is Sb. This element has 2 stable and 36 unstable isotopes/nuclides known at present. The name derives from the Greek, anti + monos for "not alone or no one" because it was found in many compounds. The chemical symbol, Sb, comes from the original name, stibium, which is derived from the Greek, stibi for "mark", since it was used for blackening eyebrows and eyelashes. The name was changed from stibium to antimonium to antimony. The minerals stibnite (Sb_2S_3) and stibine (SbH_3) are two of the more than one hundred mineral species which were known in the ancient world.

Argon – the atomic number is 18 and the chemical symbol was originally just "A", but this symbol was changed to "Ar" in 1957. This element has 3 stable and 22 unstable isotopes/nuclides known at present. The name is derived from the Greek argos for "lazy or inactive" because it did not combine with other elements. It was discovered in 1895 by the Scottish chemist William Ramsay and the English physicist Robert John Strutt (Lord Rayleigh) in liquified atmospheric air. Rayleigh's initial interest was generated when he followed up a problem posed by the English physicist, Henry Cavendish, in 1785, i.e., when oxygen and nitrogen were removed from air, there was an unknown residual remaining.

Arsenic – the atomic number is 33 and the chemical symbol is As. This element has 1 stable and 32 unstable isotopes/nuclides known at present. The name derives from the Latin arsenicium and the Greek arsenikos for the arsenic ore "yellow orpiment" (As_2S_3), an ancient dye stuff and sounds similar to the Greek arsenikon for "male or potent", perhaps referring to its poison properties. The term orpiment is perhaps a corruption of auripigmentum meaning gold color. Arsenic was also known in prehistoric times for its poisonous sulfides. German scientist and philosopher, Albert von Bollstadt (Albert the Great/Albertus Magnus) is thought to have obtained the metal around 1250 but this is uncertain.

Astatine – the atomic number is 85 and the chemical symbol is At. This element has 40 unstable isotopes/nuclides known at present. The name derives from the Greek astatos for "unstable" since it is

an unstable element. It was first thought to have been discovered in nature in 1931 and was named alabamine. When it was determined that there are no stable nuclides of this element in nature, that claim was discarded. It was later shown that astatine had been synthesized by the physicists Dale R. Corson, Kenneth R. Mackenzie and Emilio Segre at the University of California lab in Berkeley, California in 1940, who bombarded bismuth with alpha particles, in the reaction ^{209}Bi (^{4}He, 2n) ^{211}At. Independently a claim about finding some x-ray lines of astatine was the basis for claiming discovery of an element helvetium which was made in Bern, Switzerland. However, the very short half-life precluded any chemical separation and identification. The longest half-life associated with this unstable element is 8.1-hour ^{210}At.

Barium – the atomic number is 56 and the chemical symbol is Ba. This element has 5 stable and 36 unstable isotopes/nuclides known at present. The name is derived from the Greek barys for "heavy" since it was found in the mineral heavy spar ($BaSO_4$). It was discovered by the Swedish pharmacist and chemist Carl Wilhelm Scheele in 1774 and it was first isolated by the British chemist Humphry Davy in 1808.

Berkelium – the atomic number is 97 and the chemical symbol is Bk. This element has 22 unstable isotopes/nuclides known at present. The name is derived from Berkeley, the town in California where the element was first synthesized in 1949 by the American scientific team under the American chemist Glenn T. Seaborg using the nuclear reaction ^{241}Am (^{4}He, 2n) ^{243}Bk. It is the eighth element in the actinide series of elements and was named in analogy with terbium (for Ytterby the town in Sweden whose mine produced the ore), which is the eighth element in the lanthanide series of elements. The longest half-life associated with this unstable element is 1400-year ^{247}Bk.

Beryllium – the atomic number is 4 and the chemical symbol is Be. This element has 1 stable and 11 unstable isotopes/nuclides known at present. The name derives from the Greek word berryllos for "beryl" ($3BeO.Al_2O_3.6SiO_2$) the gemstone in which it is found. It was discovered by the French chemist and pharmacist Nicholas-Louis Vauquelin in beryl and emerald in 1797. The element was first separated in 1828 by the French chemist Antoine-Alexandre-Brutus Bussy and independently by the German chemist Friedrich Wohler. Since the salts of beryllium have a sweet taste, the element was also known for many years by the symbol Gl and the name glucinium from the Greek glykys for "sweet". Since the priority of discovery could not be settled unambiguously, IUPAC's CNIC selected the name beryllium in 1949 based on considerations of prevailing usage.

Bismuth – the atomic number is 83 and the chemical symbol is Bi. This element has 41 unstable isotopes/nuclids known at present. The name derives from the German weisse masse for "white mass" (the name later altered to wismuth and bisemutum) from the color of its oxides. The ancients did not distinguish bismuth from lead. The French chemist Claude-Francois Geoffroy (the younger) showed that bismuth was distinct from lead in 1753.

Bohrium – the atomic number is 107 and the chemical symbol is Bh. This element has 10 unstable isotopes known at present. The name derives from the Danish physicist Niels Bohr who developed the theory of the electronic structure of the atom. The first synthesis of this element is credited to the laboratory of the GSI (Center for Heavy-Ion Research) under the leadership of the German scientists Peter Armbruster and Gunther Münzenberg in Darmstadt, Germany in 1981, using the cold fusion-evaporation reaction ^{209}Bi (^{54}Cr, n) ^{262}Bh. The longest half-life associated with this unstable element is the ~ 1-minute ^{270}Bh.

Boron – the atomic number is 5 and the chemical symbol is B. This element has 2 stable and 13 unstable isotopes/nuclides known at present. The name derives from the Arabic burqa for "white". Although is compounds were well known for thousands of years, it was not isolated until 1808, when the French chemists Louis-Joseph Gay-Lussac and Louis-Jacques Thenard obtained born in an impure state and the British chemist Humphrey Davy prepared pure boron by electrolysis.

Bromine – the atomic number is 35 and the chemical symbol is Br. This element has 2 stable and 30 unstable isotopes/nuclides known at present. The name derives from the Greek bromos for "stench or bad odor". It was first prepared by the German chemist Carl Lowig in 1825 but it was first publicly announced in 1826 by Ballard and so the discovery is credited to the French chemist and pharmacist Antoine-Jerome Ballard.

Cadmium – the atomic number is 48 and the chemical symbol is Cd. This element has 6 stable and 35 unstable isotopes/nuclides known at present. The name derives from the Greek kadmeia for "calamine (zinc carbonate)" with which it is found as an impurity in nature. Kadmeia was also the name of the fortress of Thebes, a city in the Boeottia region of central Greece. The fortress was named after its founder, Cadmus, who was the son of the Phoenician king, Agenor, and brother of Europ and would be a possible source for the name of the ore. The element was discovered and first isolated by the German physician Friedrich Stromeyer in 1817.

Caesium – the atomic number is 55 and the chemical symbol is Cs. This element has 1 stable and 39 unstable isotopes/nuclides known at present. The internationally accepted name is caesium because it is derived from caesius but the name is often given in English as cesium. The name caesium derives from the Latin caesius for "sky blue color", which was the color of the caesium line in the spectroscope. It was discovered by the German chemist Robert Wilhelm Bunsen and the German physicist Gustav Robert Kirchhoff in 1860. It was first isolated by the German chemist Carl Setterberg in 1882.

Calcium – the atomic number is 20 and the chemical symbol is Ca. This element has 5 stable and 22 unstable isotopes/nuclides known at present. The name derives from the Latin calx for "lime (CaO) or limestone ($CaCO_3$)" in which it was found. It was first isolated by the British chemist Humphrey Davy in 1808 with help from the Swedish chemist Jons Jacob Berzelius and the Swedish court physician M.M of Pontin, who prepared calcium amalgam.

Californium – the atomic number is 98 and the chemical symbol is Cf. This element has 20 unstable isotopes/nuclides known at present. The name derives from the state and the university of California, where the element was first synthesized. Although the earlier members of the actinide series were named in analogy with the names of the corresponding members of the lanthanide series, the only connection with the corresponding element dysprosium (Greek for hard to get at) that was offered by the discoverers was that searchers for another element (gold about a century before in 1849) found it difficult to get to California. An American scientific team at the University of California lab in Berkeley, California under Glenn T. Seaborg used the nuclear reaction ^{242}Cm (^{4}He, n) ^{245}Cf to first detect the element californium in 1950. The longest half-life associated with this unstable element is 900-year ^{251}Cf.

Carbon – the atomic number is 6 and the chemical symbol is C. This element has 2 stable and 13 unstable isotopes/nuclides known at present. The name derives from the Latin carbo for "charcoal". It was known in prehistoric times in the form of charcoal and soot. 1797, the English chemist Smithson Tennant proved that diamond is pure carbon.

Cerium – the atomic number is 58 and the chemical symbol is Ce. This element has 4 stable and 36 unstable isotopes/nuclides known at present. The name, which was originally cererium but was shortened to cerium, derives from the planetoid Ceres, the Roman goddess of agriculture. Two years later in 1803, the element was discovered by the German chemist Martin-Heinrich Klaproth, who called the element ochroite because of its yellow color. This rare-earth was independently discovered at the same time by the Swedish chemist Jons Jacob Berzelius and the Swedish mineralogist Wilhelm von Hisinger, who called it ceria. It was first isolated in 1875 by the American mineralogist and chemist William Frances Hillebrand and the American chemist Thomas H. Norton.

Chlorine – the atomic number is 17 and the chemical symbol is Cl. This element has 2 stable and 23 unstable isotopes/nuclides known at present. the name derives from the Greek klooris for "pale green or greenish yellow color" of the element. It was discovered by the Swedish pharmacist and chemist Carl-Wilhelm Scheele in 1774. In 1810, the English chemist Humphrey Davy proved it was an element and gave it the name chlorine.

Chromium – the atomic number is 24 and the chemical symbol is Cr. This element has 4 stable and 23 unstable isotopes/nuclides known at present. The name derives from the Greek chroma for "color" from the many-colored compounds of chromium. It was discovered in 1797 by the French chemist and pharmacist Nicolas-Louis Vauquelin, who also isolated chromium in 1798.

Cobalt – the atomic number is 27 and the chemical symbol is Co. This element has 1 stable and 31 unstable isotopes/nuclides known at present. The name derives from the German kobold for "evil spirits or goblins" who were superstitiously thought to cause trouble for miners, since the mineral contained arsenic which injured their health and the metallic ores did not yield metals when treated with the normal methods. The name could also be derived from the Greek kobalos for "mine". Cobalt was discovered in 1735 by the Swedish chemist Georg Brandt.

Copernicium – the atomic number is 112 and the chemical symbol is Cn. This element has 6 unstable isotopes/nuclides known at present. The name derives from the Polish astronomer Nicolaus Copernicus, who suggested the heliocentric theory of the planetary system. The element was first synthesized by a multi-national team of scientists working at the GSI (Heavy Ion Research Center) under Sigurd Hofmann in Darmstadt, Germany in 1996, using the fusion-evaporation reaction ^{208}Pb (^{70}Zn, n) ^{277}Cn. The observed alpha decays led to the known nuclide, ^{269}Sg. The scientific team included GSI, Darmstadt, the Joint Institute for Nuclear Research (JINR), in Dubna, Russia, Comenius University in Bratislava, Slovakia and the University of Jyvaskyia, Finland. There was later confirmation of the ^{277}Cn decay from the Research Group for Super-heavy Elements at the RIKEN Nishina Center for Accelerator Based Science, Saitama, Japan under Kosuke Morita. The longest half-life associated with this unstable element is ~ 0.5-minute ^{285}Cn.

Copper – the atomic number is 29 and the chemical symbol is Cu. This element has 2 stable and 30 unstable isotopes/nuclides known at present. The name derives from the Latin Cuprum foe "Cyprus", the island where the Romans first obtained copper. The chemical symbol, Cu, also comes from the Latin cuprum. The element has been known since prehistoric times.

Curium – the atomic number is 96 and the chemical symbol is Cm. This element has 0 stable and 21 unstable isotopes/nuclides known at present. The name derives from "Pierre and Maria Curie", the French physicist and Polish-born French chemist, who discovered radium and polonium. It was first

synthesized in 1944 by the American scientists at the University of California lab in Berkeley, California under the American chemist Glenn T. Seaborg, using the nuclear reaction ^{239}Pu (^{4}He, n) ^{242}Cm. Since it is the ninth member of the actinide series, curium was named in analogy with its homologue the ninth member of the lanthanide series, gadolinium, which had been named after the Finnish rare earth chemist Johan Gadolin. The longest half-life associated with this unstable element is 15.6-year ^{247}Cm.

Darmstadtium – the atomic number is 110 and the chemical symbol is Ds. This element has 10 unstable isotopes/nuclides known at present. The name derives from Darmstadt, Germany, the region where the Heavy Ion Research Center, GSI, is located. The element was first synthesized by a multi-national team of scientists working at GSI under Siguard Hofmann, using the fusion-evaporation reaction ^{208}Pb (^{62}Ni, n) ^{269}Ds. The scientific teams were from GSI, Darmstadt, the Joint Institute for Nuclear Research (JINR), in Dubna, Russia, Comenius University, Bratislava, Slovakia and the University of Jyvaskyia, Finland. The longest half-life associated with this unstable element is 14-second ^{281}Ds.

Dubnium – the atomic number is 105 and the chemical symbol is Db. This element has 13 unstable isotopes/nuclides known at present. The name derives from the location of the Russian research center, the Joint Institute for Nuclear Research (JINR) lab in "Dubna", Russia. The first synthesis of this element is jointly credited to the American scientific team at the University of California in Berkeley, California under Albert Ghiorso and the Russian scientific team at the JINR lab in Dubna, Russia, under Georgi N. Flerov in 1970. The longest half-life associated with this unstable element is 1.2-day **^{268}**Db.

Dysprosium – the atomic number is 66 and the chemical symbol is Dy. This element has 7 stable and 26 unstable isotopes/nuclides known at present. The name derives from the Greek dysprositos for "hard to get at", due to the difficulty in separating this rare earth element from a holmium mineral in which it is found. Discovery was first claimed by the Swiss chemist Marc Delafontaine in the mineral samarkite in 1878 and he called it philippia. Philippia was subsequently found to be a mixture of terbium and erbium. Dysprosium was later discovered in a holmium sample by the French chemist Paul-Emile Lecoq de Boisbaudron in 1886, who was then credited with the discovery. It was first isolated by the French chemist George Urbain in 1906.

Einsteinium – the atomic number is 99 and the chemical symbol is Es. This element has 18 unstable isotopes/nuclides known at present. The name derives from "Albert Einstein", the German born physicist who proposed the theory of relativity. A collaboration of American scientists from the Argonne National Laboratory near Chicago, Illinois, the Los Alamos Scientific Laboratory in Los Alamos, New Mexico and the University of California lab in Berkeley, California first found ^{252}Es in the debris of thermonuclear weapons in 1952. The longest half-life associated with this unstable element is 472-day ^{252}Es.

Erbium – the atomic number is 68 and the chemical symbol is Er. This element has 6 stable and 29 unstable isotopes/nuclides known at present. The name derives from the Swedish town of "Ytterby" (about 3 miles from Stockholm), where the ore gadolinite (in which it is found) was first mined. It was discovered by the Swedish surgeon and chemist Carl-Gustav Mosander in 1843 in an yttrium sample. He separated the yttrium into yttrium, a rose-colored salt he called terbium and a deep yellow peroxide that he called erbium. In 1860, an analysis of yttrium by the German chemist Berlin found only the yttrium and the rose-colored salt, which was now called erbium, not terbium. All subsequent workers followed Berlin in designating the rose-colored rare earth as erbium.

Europium – the atomic number is 63 and the chemical symbol is Eu. This element has 1 stable and 39 unstable isotopes/nuclides known at present. The name derives from the continent of "Europe". It was separated from the mineral samaria in magnesium-samarium nitrate by the French chemist Eugene-Anatole Demarcay in 1896. It was first isolated by Demarcay in 1901.

Fermium – the atomic number is 100 and the chemical symbol is Fm. This element has 20 unstable isotopes/nuclides known at present. The name derives from the Italian born physicist "Enrico Fermi", who built the first man made nuclear reactor. The nuclide ^{255}Fm was found in the debris of a thermonuclear weapon's explosion in 1952 by a collaboration of American scientists from the Argonne National Laboratory near Chicago, Illinois, the Los Alamos Scientific Laboratory in Los Alamos Laboratory in Los Alamos, New Mexico and he University of California lab in Berkeley, California. The longest half-life associated with this unstable element is 100-day ^{257}Fm.

Flerovium – the atomic number is 114 and the chemical symbol is Fl. This element has 5 unstable isotopes/nuclides known at present. The name derives from the Flerov Laboratory of Nuclear Reactions. This element was first synthesized in 1998 by a multi-national team of scientists working at the Joint Institute for Nuclear Reactions (JINR) in Dubna, Russia. The scientific teams were from JINR and the Lawrence Livermore National Laboratory in Livermore, California, USA. The teams used the fusion-evaporation reactions ^{244}Pu (^{48}Ca, 3n) ^{289}Fl; ^{242}Pu (^{48}Ca, 3n) ^{287}Fl; ^{245}Cm (^{48}Ca, 2n) ^{291}Lv -> ^{287}Fl + α. The longest half-life associated with this unstable element is ~ 1.9-second ^{289}Fl.

Fluorine – the atomic number is 9 and the chemical symbol is F. This element has 1 stable and 17 unstable isotopes/nuclides known at present. The name derives from the Latin fluere for "flow or flux" since fluorspar (CaF_2) was used as a flux in metallurgy because of its low melting point. It was discovered in hydrofluoric acid by the Swedish pharmacist and chemist Carl-Wilhelm Scheele in 1771 but was not isolated until 1886 by the French pharmacist and chemist Ferdinand-Frederic-Henri Moisson.

Francium – the atomic number is 87 and the chemical symbol is Fr. This element has 37 unstable isotopes/nuclides known at present. The name derives from the country "France", where the French physicist Marguerite Perey from the Curie Institute in Paris, France discovered it in 1939 in the alpha particle decay of actinium, ^{227}Ac -> ^{4}He + ^{223}Fr, which was known as actinium-K and has a half-life of 22 minutes. An earlier claim of discovery in 1930 with the element name virginium was determined to be incorrect. A similar claim for discovery of the element with atomic number 87 and named moldavium was also determined to be incorrect. The longest half-life associated with this unstable element is 22-minute ^{223}Fr.

Gadolinium – the atomic number is 64 and the chemical symbol is Gd. This element has 7 stable and 29 unstable isotopes/nuclides known at present. The name derives from the mineral gadolinite, which had been named for the Finnish rare earth chemist "Johan Gadolin". It was discovered by the Swiss chemist Jean-Charles Calissard de Marignac in 1886, who produced a white oxide he called Y_α in a samarskite mineral. In 1886, the French chemist Paul-Emile Lecoq de Boisbaudran gave the name gadolinium to Y_α.

Gallium – the atomic number is 31 and the chemical symbol is Ga. This element has 2 stable and 30 unstable isotopes/nuclides known at present. The name derives from the Latin gallia for "France" or perhaps from the Latin gallus for "le coq or cock", since it was discovered in zins blende by the French chemist Paul-Emile Lecoq de Boisbaudran in 1875. It was first isolated in 1878 by Lecoq de Boisbaudran

and the French chemist Emile-Clement Jungflesch. This element had previously been predicted as “eka-aluminum” by Mendeleev, along with its properties and its location in the Periodic Table.

Germanium – the atomic number is 32 and the chemical symbol is Ge. This element has 4 stable and 29 unstable isotopes/nuclides known at present. The name derives from the Latin gennania for “Germany”. It was discovered and isolated by the German Clemens-Alexander Winkler in 1886 in the mineral argyrodite ($GeS_2.4Ag_2S$). The element had previously been predicted as “eka-silicon” by Mendeleev, along with its properties and its location in the Periodic Table.

Gold – the atomic number is 79 and the chemical symbol is Au. This element has 1 stable and 40 unstable isotopes/nuclides known at present. The name derives from the Sanskit jval for “to shine”, the Teutonic word gulth for “shining metal” and the Anglo-Saxon gold of unknown origin. The chemical symbol Au derives from the Latin aurum, for “Aurora the goddess of dawn”. It was known and highly valued in prehistoric times.

Hafnium – the atomic number is 72 and the chemical symbol is Hf. This element has 5 stable and 33 unstable isotopes/nuclides known at present. The name derives from the Latin hafnia for “Copenhagen”. An element named celtium was erroneously claimed to have been discovered in 1911 by the French chemist George Urbain in rare earth samples, until the Danish physicist Niels Bohr predicted hafnium properties using his theory of electronic configuration of the elements. Bohr argued that hafnium would not be a rare earth element but would be found in zirconium ore. It was discovered shortly thereafter by the Dutch physicist Dirk Coster and the Hungarian physicist Georg von Hevesy in 1923, while working at Bohr’s institute in Copenhagen, Denmark.

Hassium – the atomic number is 108 and the chemical symbol is Hs. This element has 11 unstable isotopes/nuclides known at present. The name derives from the Latin Hesse for the German “state of Hesse”, whose former capital was Darmstadt. The element was first synthesized by German physicists at the Center for Heavy Ion Research lab (GSI) at Darmstadt, Germany in 1984, using the cold fusion-evaporation reaction ^{208}Pb (^{58}Fe, n) ^{265}Hs. The longest half-life associated with this unstable element is 0.5-minute ^{277}Hs.

Helium – the atomic number is 2 and the chemical symbol is He. This element has 2 stable and 6 unstable isotopes/nuclides known at present. The name derives from the Greek helios for “sun”. The element was discovered by spectroscopy during a solar eclipse in the sun’s chromosphere by the French astronomer Pierre-Jules-Cesar Janssen in 1868. It was independently discovered and named helium by the English astronomer Joseph Norman Lockyer. It was thought to be only a solar constituent until it was later found to be identical to the helium in the uranium ore cleveite by the Scottish chemist William Ramsay in 1895. Ramsay originally called his gas krypton, until it was identified as helium. The Swedish chemists Per Theodore Cleve and Nils Abraham Langet independently found helium in cleveite at about the same time.

Holmium – the atomic number is 67 and the chemical symbol is Ho. This element has 1 stable and 36 unstable isotopes/nuclides known at present. The name derives from the Latin holmia for “Stockholm”. It was discovered in erbia earth by the Swiss chemist J.L Soret in 1878, who referred to it as element X. It was later independently discovered by the Swedish chemist Per Theodor Cleve in 1879. It was first isolated in 1911 by Holmberg, who proposed the name holmium either to recognize the discoverer Per Cleve, who was from Stockholm or perhaps to establish his own name in history.

Hydrogen – the atomic number is 1 and the chemical symbol is H. This element has 2 stable and 5 unstable isotopes/nuclides known at present. The name derives from the Greek hydro for "water" and genes for "forming", since it burned in air to form water. It was discovered by the English physicist Henry Cavendish in 1766.

Indium – the atomic number is 49 and the chemical symbol is In. This element has 1 stable and 41 unstable isotopes/nuclides known at present. The name derives from indigo and for the indigo-blue line in the element's spark spectrum. It was discovered in 1863 by the German physicist Ferdinand Reich and the German metallurgist Hieronymus Theodore Richter, while examining zinc blende. They isolated indium in 1867.

Iodine – the atomic number is 53 and the chemical symbol is I. This element has 1 stable and 38 unstable isotopes/nuclides known at present. The name derives from the Greek ioeides for "violet colored" because of the violet vapors. It was discovered in sea-weed ash (kelp) by the French chemist Bernard Courtois in 1811. It was named iodine by the English chemist Humphrey Davy in 1813 and subsequently named iode by the French chemist Louis-Joseph Gay-Lussac, when he proved it was an element in 1814. Despite the priority rights dispute between Davy and Gay-Lussac, both acknowledged Courtois as the discoverer of the element.

Iridium – the atomic number is 77 and the chemical symbol is Ir. This element has 2 stable and 39 unstable isotopes/nuclides known at present. The name derives from the Latin Iris, the Greek goddess of rainbows because of the "variety of colors in the element's salt solutions". Iridium and osmium were both discovered in a crude platinum ore in 1803 by the English chemist Smithson Tennant. Indium was independently by the French chemist H.V. Collet-Descotils also in 1803. Descotils published one month before Tennant but Tennant is given credit for the discovery, perhaps because he alone found osmium in the ore.

Iron – the atomic number is 26 and the chemical symbol is Fe. This element has 4 stable and 27 unstable isotopes/nuclides known at present. The name derives from the Anglo-Saxon "iron" of unknown origin. The element has been known from prehistoric times. The chemical symbol Fe is derived from the Latin ferrum for "firmness".

Krypton – the atomic number is 36 and the chemical symbol is Kr. This element has 6 stable and 28 unstable isotopes/nuclides known at present. The name derives from the Greek "kryptos for concealed of hidden". It was discovered in liquified atmospheric air by the Scottish chemist William Ramsay and the English chemist Morris William Travers in 1898.

Lanthanum – the atomic number is 57 and the chemical symbol is La. This element has 1 stable and 38 unstable isotopes/nuclides known at present. The name derives from the Greek lanthanein for "to be hidden or to escape notice" because it hid in cerium ore and was difficult to separate from that rare earth mineral. It was discovered by the Swedish surgeon and chemist Carl-Gustav Mosander in 1839. In 1842, Mosander separated his lanthanum sample into two oxides, for one of these he retained the name lanthanum and for the other he gave the name didymium for twin.

Lawrencium – the atomic number is 103 and the chemical symbol is Lr. This element has 14 unstable isotopes/nuclides known at present. The original chemical symbol suggested was Lw but it was later changed because the letter "W" is an unusual occurrence in many languages. It is a cumbersome spoken

word. The name derives from the American physicist “Ernest O. Lawrence” who developed the cyclotron. Credit for the first synthesis of this element in 1971 is given jointly to American chemists from the University of California lab in Berkeley, California under Albert Ghiorso and the Russian scientific team at the JINR (Joint Institute for Nuclear Reactions) lab in Dubna, Russia under Goergi N. Flerov. The longest half-life associated with this unstable element is 3.6-hour ^{262}Lr.

Lead – the atomic number is 82 and the chemical symbol is Pb. This element has 4 stable and 39 unstable isotopes/nuclides known at present. The name derives from the Anglo-Saxon lead, which is of unknown origin. The element was known from prehistoric times. The chemical symbol Pb is derived from the Latin plumbum for “lead”.

Lithium – the atomic number is 3 and the chemical symbol is Li. This element has 2 stable and 8 unstable isotopes/nuclides known at present. The name derives from the Latin lithos for “stone” because lithium was thought to exist only in minerals at that time. It was discovered by the Swedish mineralogist Johan August Arfredson (student of Berzelius) in 1818 in the mineral petalite Li Al $(Si_4O_5)_2$. It was isolated in 1855 by the German chemist Robert Wilhelm Bunsen and Augustus Matthiessen.

Livermorium – the atomic number is 116 and the chemical symbol is Lv. This element has 4 unstable isotopes/nuclides known at present. The name derives from the Lawrence Livermore National lab in Livermore, California. This element was synthesized in 2004 and 2006 by a joint team under Yuri Oganessian at the JINR (Joint Institute for Nuclear Research) lab at Dubna, Russia and a scientific team from the Lawrence Livermore National lab in Livermore, California, using the fusion-evaporation reactions ^{245}Cm (^{48}Ca, 2n) ^{291}Lv and ^{245}Cm (^{48}Ca, 3n) ^{290}Lv. The ^{291}Lv decay chain passed through the ^{283}Cn nuclide, which serves as an established link to identify the atomic number of the members of the decay sequence with confidence. The longest half-life associated with this unstable element is 0.06-seconds ^{293}Lv.

Lutetium – the atomic number is 71 and the chemical symbol is Lu. This element has 1 stable and 38 unstable isotopes/nuclides known at present. The name was originally “lutecium” but in 1949, IUPAC’s CNIC changed the “c” to “t” since the name derives from “Lutetia” the ancient name for the city of Paris, rather than from its French equivalent “lutece”. The discovery is credited to the French chemist George Urbain in 1907, although it had been separated earlier and independently by the Austrian chemist Carl Auer von Weisbach from an ytterbium sample. Auer von Weisbach named the element cassiopeium for the constellation “Cassiopeia”. Although Auer von Weisbach’s paper appeared prior to Urbain’s paper, Urbain argued that he had sent his paper to the editor earlier. The International Committee on Atomic Weights (where Urbain was one of the four members) adopted Urbain’s name and his claim of priority. The German Atomic Weights Commission accepted Auer von Weisbach’s name of Cassiopeia for the element for the next forty years. Since the priority of discovery could not be settled unambiguously, Urbain’s name for the element was officially adopted by the IUPAC’s CNIC in 1949 based on consideration of prevailing usage, finally ending the controversy.

Magnesium – the atomic number is 12 and the chemical symbol is Mg. This element has 3 stable and 19 unstable isotopes/nuclides known at present. The name originally used was magnium and was later changed to magnesium, which is derived from Magnesia, a district in the northeastern region of Greece called Thessalia. The Scottish chemist Joseph Black recognized it as a separate element in 1755. In 1808, the English chemist Humphrey Davy obtained the pure metal and in 1831, the French pharmacist and chemist Antoine-Alexandre Brutus Bussy isolated the metal in the pure state.

Manganese – the atomic number is 25 and the chemical symbol is Mn. This element has 1 stable and 29 unstable isotopes/nuclides known at present. The name derives from the Latin magnes for "magnet", since pyrolusite (MnO_2) has magnetic properties. It was discovered by the Swedish pharmacist and chemist Carl-Wilhelm Scheele in 1774. Later in 1774, the Swedish chemist Johan Gottlieb Gahn first isolated the metal.

Meitnerium – the atomic number is 109 and the chemical symbol is Mt. This element has 9 unstable isotopes/nuclides known at present. The name derives from the Austrian physicist "Lise Meitner", who discovered the element protactinium. The first synthesis of the element meitnerium is credited to German physicists from the GSI (Center for Heavy Ion Research) lab in Darmstadt, Germany under Gunther Munzenberg in 1982, using the nuclear reaction ^{209}Bi (^{58}Fe, n) ^{266}Mt. The longest half-life associated with this unstable element is ~ 6-second ^{276}Mt.

Mendelevium – the atomic number is 101 and the chemical symbol is Md. This element has 17 unstable isotopes/nuclides known at present. The original symbol proposed was Mv but this was changed in 1955. The element name derives from the Russian chemist "Dimitri Mendeleev" who developed the Periodic Table of the chemical elements. Credit for the first synthesis of this element is given to American chemists at the University of California lab in Berkeley, California under Glenn T. Seaborg in 1958, who used the nuclear reaction ^{253}Es (^{4}He, 2n) ^{255}Md and the nuclear reaction ^{253}Es (^{4}He, n) ^{256}Md. The longest half-life associated with this unstable element is 51.5-day ^{258}Md.

Mercury – the atomic number is 80 and the chemical symbol is Hg. This element has 7 stable and 36 unstable isotopes/nuclides known at present. The name derives from the Roman god "mercury", the nimble messenger of the gods, since the ancients used that name for the element, which was known from prehistoric times. The chemical symbol, Hg, derives from the Greek hydragyrium for "liquid silver".

Molybdenum – the atomic number is 42 and the chemical symbol is Mo. This element has 6 stable and 32 unstable isotopes/nuclides known at present. The original name that was proposed was molydaenum but this was changed because of the prevailing usage of "e" rather than "ae" in English, American and French. Since the ending of the name was spelt "num" and not "nium" in most languages, this ending was not changed. The name derives from the Greek molybdos for "lead". The ancients used the term lead for any black mineral which leaves a mark on paper. It was discovered by the Swedish pharmacist and chemist Carl Wilhelm Scheele in 1778. It was first isolated by the Swedish chemist Peter-Jacob Hjelm in 1781.

Moscovium – the atomic number is 115 and the chemical symbol is Mc. This element has 4 unstable isotopes/nuclides known at present. The name derives from "Moscow oblast", or Moscow region, the location of Dubna, Russia. The element was synthesized by a joint scientific team from the JINR (Joint Institute for Nuclear Research) in Dubna, Russia and the Lawrence Livermore National lab in Livermore, California under Yuri Oganessian. They synthesized the element via the following fusion-evaporation reactions,^{243}Am (^{48}Ca, 4n) ^{287}Mc; ^{243}Am (^{48}Ca, 3n) ^{288}Mc; ^{243}Am (^{48}Ca, 2n) ^{289}Mc; ^{249}Bk (^{48}Ca, 4n) ^{293}Ts -> ^{289}Mc + α and ^{249}Bk (^{48}Ca, 3n) ^{294}Ts -> ^{290}Mc + α. The reproducibility of alpha chain energies and lifetimes of ^{289}Mc in cross reaction comparison is very convincing. The longest half-life associated with this unstable element is ~ 0.33-seconds ^{289}Mc.

Neodymium – the atomic number is 60 and the chemical symbol is Nd. This element has 5 stable and 34 unstable isotopes/nuclides known at present. The name was originally neodidymium and was later

shortened to neodymium, which is derived from the Greek neos for “new” and didymos for “twin”. It was discovered by the Swedish surgeon and chemist Carl Gustav Mosander in 1841, who called it didymium (or twin) because of its similarity to lanthanum which he had previously discovered two years earlier. In1885, the Austrian chemist Carl Auer von Weisbach separated didymium into two elements, one of which he called neodymium (or new twin).

Neon – the atomic number is 10 and the chemical symbol is Ne. This element has 3 stable and 17 unstable isotopes/nuclides known at present. The name derives from the Greek neos for “new”. It was discovered from its bright red spectral lines by the Scottish chemist William Ramsay and the English chemist Morris Travers in 1896 from a liquified air sample.

Neptunium – the atomic number is 93 and the chemical symbol is Np. This element has 23 unstable isotopes/nuclides known at present. The name derives from the planet “Neptune” (the Roman god of the sea), since it is the next out-most planet beyond the planet Uranus in the solar system and this element is the next beyond uranium in the periodic table. It was first synthesized by Edwin M McMillan and Philip H Aberson in 1940 via the nuclear reaction ^{238}U (n, ɤ) $^{239}U \rightarrow \beta^- + {}^{239}Np$. The longest half-life associated with this unstable element is 2.14 million-year ^{237}Np.

Nickel – the atomic number is 28 and the chemical symbol is Ni. This element has 5 stable and 30 unstable isotopes/nuclides known at present. The name derives from the German nickel for “deceptive little spirit” since miners called mineral niccolite (NiAs) by the name kupfernickel (false copper). Although the ore looks like copper, no copper was found in the ore. It was discovered by the Swedish metallurgist Alex-Fredrik Cronstedt in 1751.

Nihonium – the atomic number is 113 and the chemical symbol is Nh. This element has 6 unstable isotopes/nuclides known at present. The name derives from nihon a Japanese word for Japan, meaning “land of the rising sun”. It is the first element discovered and to be named by an Asian country in the history of the discovery of chemical elements. This element was synthesized by the Research Group for Super-heavy Elements in the RIKEN (Nishina Center for Accelerator-based Science) in Saitama, Japan under Kosuke Morita using the fusion-evaporation reaction ^{209}Bi (^{70}Zn, n) ^{278}Nh in 2004. The repeated reactions in 2007 and in 2012 are consistent. The longest half-life associated with this unstable element is ~ 13-seconds ^{286}Nh.

Niobium – the atomic number is 41 and the chemical symbol is Nb. This element has 1 stable and 34 unstable isotopes/nuclides known at present. The name derives from the Greek mythological character “Niobe”, who was the daughter of Tantalus (see the element Tantalum), since the elements niobium and tantalum were originally thought to be identical elements. Niobium was discovered in a black mineral from America called columbite by the British chemist and manufacturer Charles Hatchett in 1801 and he called the element columbium, since the mineral was discovered in America. A year later in 1802, the element tantalum was discovered. In 1809, the English chemist William Hyde Wollaston claimed that the elements columbium and tantalum were identical. Forty years later, the German chemist and pharmacist Heinrich Rose, determined from their acids that columbium and tantalum were two different elements in 1846 and gave the name niobium to columbium because it was so difficult to distinguish it from tantalum. Rose claimed that his niobium had a larger atomic weight than tantalum. Finally, in 1866, the Swiss chemist Jean-Charles Galissard de Marignac separated these elements. For more than a century, the name columbium continued to be used in America and niobium in Europe. Since the priority of discovery could not be settled unambiguously, IUPAC’s CNIC adopted the name niobium in

1949 based on consideration of prevailing usage. Niobium was first isolated by the chemist C.W. Blomstrand in 1846.

Nitrogen - the atomic number is 7 and the chemical symbol is N. This element has 2 stable and 14 unstable isotopes known at present. The name derives from the Latin nitrum and Greek nitrol for "native soda" and genes for "forming" because of nitrogen's presence in potassium nitrate (KNO), so called salpeter or nitre. It was discovered by the Scottish physician and chemist Daniel Rutherford in 1772.

Nobelium - the atomic number is 102 and the chemical symbol is No. This element has 16 unstable isotopes/nuclides known at present. The name derives from "Alfred Nobel", the discoverer of dynamite and the founder of the Nobel prizes. It was first synthesized in 1966 by the Russian scientists from the JINR (Joint Institute for Nuclear Research) lab in Dubna, Russia under Georgi Flerov. Earlier claims to have synthesized "Nobelium" beginning in 1957 were shown to be erroneous but the original name was retained because of its widespread use throughout the scientific literature. The longest half-life associated with this unstable element is 58-minute ^{259}No.

Oganesson – the atomic number is 118 and the chemical symbol is Og. This element has 1 unstable isotope/nuclide known at present. The name derives from "Yuri Oganessian", the head of heavy element research in Dubna, Russia. The element was synthesized in 2006 by a joint scientific team, working under Yuri Oganessian, from the JINR (Joint Institute for Nuclear Reactions) in Dubna, Russia and from the Lawrence Livermore National lab in Livermore California, using the fusion-evaporation reaction ^{249}Cf (^{48}Ca, 3n) ^{294}Og. This result was confirmed in 2012. Three other independent heavy element fusion studies served to identify and confirm the existence and decay properties of ^{294}Og descendants, ^{290}Lv and ^{286}Fl serving to link atomic numbers through cross bombardments. The longest half-life associated with this unstable element is 0.7-millisecond ^{294}Og.

Osmium - the atomic number is 76 and the chemical symbol is Os. This element has 5 stable and 38 unstable isotopes/nuclides known at present. The name derives from the Greek osme for "smell" because of the sharp odor of the volatile oxide. Both osmium and iridium were discovered simultaneously in a crude platinum ore by the English chemist Smithson Tennant in 1803.

Oxygen - the atomic number is 8 and the chemical symbol is O. This element has 3 stable and 14 unstable isotopes/nuclides known at present. The name derives from the Greek oxys for "acid" and genes for "forming", since the French chemist Antoine-Laurent Lavoisier originally thought oxygen was an acid producer because by burning phosphorus and sulfur and dissolving them in water, he was able to produce acids. Oxygen was discovered independently by the Swedish pharmacist and chemist Carl-Wilhelm Scheele in 1771 and the English clergyman and chemist Joseph Priestly in 1774. Scheele's "Chemical Treatise on Air and Fire" was delayed in publication until 1777, so Priestly is credited with the discovery, since he published first.

Palladium - the atomic number is 46 and the chemical symbol is Pd. This element has 6 stable and 34 unstable isotopes/nuclides known at present. The name derives from the second largest asteroid of the solar system Pallas (named after the goddess of wisdom and arts- Pallas Athene). The element was discovered by the English chemist and physicist William Hyde Wollaston in 1803, one year after the discovery of Pallas by the German astronomer H.W. Olbers in 1802. The discovery was originally

published anonymously by Wollaston to obtain priority, while not disclosing any details about his preparation.

Phosphorus - the atomic number is 15 and the chemical symbol is P. This element has 1 stable and 23 unstable isotopes/nuclides known at present. The name derives from the Greek phosphoros for "bringing light", since white phosphorus oxidizes spontaneously in air and glows in the dark. This was also the ancient name for the planet Venus, when it appears before sunrise. It was discovered by the German merchant Hennig Brand in 1669.

Platinum - the atomic number is 78 and the chemical symbol is Pt. This element has 5 stable and 38 unstable isotopes/nuclides known at present. The name derives from the Spanish platina for "silver". In 1735, the Spanish mathematician Don Antonio de Ulloa found platinum in Peru, South America. In 1741, the English metallurgist Charles Wood found platinum in Colombia, South America. In 1750, the English physician William Brownrigg prepared purified platinum metal.

Plutonium - the atomic number is 94 and the chemical symbol is Pu. This element has 20 unstable isotopes/nuclides known at present. The name derives from the planet Pluto, (the Roman god of the underworld). Pluto was selected because it is the next planet in the solar system beyond the planet Neptune and the element Plutonium is the next element in the periodic table beyond neptunium. Plutonium was first synthesized in 1940 by American chemists Glenn T. Seaborg, Edwin M. McMillan, Joseph W. Kennedy and Arthur C. Wahl in the nuclear reaction ^{238}U (^{2}H, 2n) $^{238}Np \rightarrow \beta^{-} + {}^{238}Pu$. The longest half-life associated with this unstable element is 80 million-year ^{244}Pu.

Polonium – the atomic number is 84 and the chemical symbol is Po. This element has 41 unstable isotopes/nuclides known at present. This radioactive metal was also known as radium-F. The name derives from "Poland", the native country of Marie Sklodowska Curie. It was discovered by Pierre and Marie Curie in 1898, from its radioactivity. It was independently found by the German chemist Willy Marckwald in 1902 and called radiotellurium. The longest half-life associated with this unstable element is 102-year ^{209}Po.

Potassium – the atomic number is 19 and the chemical symbol is K. This element has 2 stable and 24 unstable isotopes/nuclides known at present. The name derives from the English "potash or pot ashes" since it is found in caustic potash (KOH). The chemical symbol derives from the Latin kalium via the Arabic qali for alkali. It was first isolated by Humphrey Davy in 1807 from electrolysis of potash (KOH).

Praseodymium – the atomic number is 59 and the chemical symbol is Pr. This element has 1 stable and 39 unstable isotopes/nuclides known at present. The name was originally praseodidymium and was later shortened to praseodymium, which is derived from the Greek prasios for "green" and didymos for "twin" because of the pale green salts it forms. It was discovered by the Austrian chemist Carl Auer von Weisbach in 1885, who separated it and the element neodymium from a didymium sample. Didymium had previously been thought to be a separate element.

Promethium – the atomic number is 61 and the chemical symbol is Pm. This element has 36 unstable isotopes/nuclides known at present. The name promethium was preferred to prometheum because most metallic elements have names ending in "ium" and an "eum" ending would have caused problems. The name derives from "Prometheus" who stole fire from heaven and gave it to the humans, since it was found by the harnessing of nuclear energy, which also provides a dangerous threat of punishment.

In the USA and the element was named illinium. Subsequently another claim was made that element 61 had been discovered in Italy in 1924 but the manuscript had been secretly stored in a sealed envelope with Academia dei Lincei and the element had been named florentium. Both elements were supposedly found in natural materials. It was later shown that this element does not exist in nature and both claims were discarded. In 1941, neodymium and praseodymium were irradiated with neutrons, deuterons and alpha particles at Ohio State University in the USA and new activities were produced. Some of these activities are now associated with element 61. However, no chemical proof of element 61 was available because rare earth elements could not be separated from each other at that time. Promethium was first synthesized in fission products from the thermal neutron fission of ^{235}U at the Clinton (later Oak Ridge National Laboratory) lab by the American chemists, J.A. Marinsky, L.E. Glendenin and Charles D. Coryell in 1947, using chemical separation by ion exchange chromatography. The fission products ^{147}Pm and ^{149}Pm were also identified in the slow neutron activation of neodymium. The longest half-life associated with this unstable element is 17.7-year ^{145}Pm.

Protactinium – the atomic number is 91 and the chemical symbol is Pa. This element has 29 unstable isotopes/nuclides known at present. The name was originally protoactinium but in 1949 it was shortened to protactinium by IUPAC's CNIC. The name derives from the Greek protos for "first" and actinium since it was found to be the parent of actinium. An isotope of protactinium, ^{234}Pa, was first identified by the German chemists Kasimir Fajans and O.H. Göhring in 1913. They named the element "Brevium because of its short half-life. The long-lived isotope ^{231}Pa was identified by the German chemist Otto Hahn and the Austrian physicist Lise Meitner in 1918, while Hahn was away in military service. It was first isolated by the German chemist Aristid V. Grosse in 1927. Protactinium was accepted as the name for the element because it was preferred to use the name of the longer-lived isotope. The longest half-life associated with this unstable element is 32.5 thousand-year ^{231}Pa.

Radium – the atomic number is 88 and the chemical symbol is Ra. This element has 34 unstable isotopes/nuclides known at present. The name derives from the Latin radius for "beam or ray" because of its tremendous ray-emitting power. It was discovered by the French physicist Pierre Curie and the Polish born French chemist Marie Skiodowska Curie in 1898. It was independently discovered by the British chemists Frederick Soddy and John A. Cranston. It was first isolated in 1910 by Marie Curie and the French chemist Andre-Louis Debierne. The longest half-life associated with this unstable element is 1599-year ^{226}Ra.

Radon – the atomic number is 86 and the chemical symbol is Rn. This element has 40 unstable isotopes/nuclides known at present. The name indicates its origin from radium, and refers to the most stable isotope (^{222}Rn, half-life 3.82 days), which is emanation in the alpha decay of ^{226}Ra., which was first noticed by Friedrich Ernst Dorn in 1900. Dorn had followed the procedure of Ernest Rutherford, who earlier the same year had isolated and characterized "thoron" (^{220}Rn, half-life 55.6 seconds), the gas emanating from thorium. Hence, Rutherford should be considered the discoverer of radon. ^{222}Rn was isolated by the Scottish chemist William Ramsay and the English chemist Robert Whytlaw-Gray and determined the density of the gas and its atomic weight. They named the element "niton" (with chemical symbol Nt), which is Latin for "shining". The name was changed to radon in 1923. The longest half-life associated with this unstable element is 3.8-day ^{222}Rn.

Rhenium – the atomic number is 75 and the chemical symbol is Re. This element has 1 stable and 41 unstable isotopes/nuclides known at present. The name derives from the Latin rhenus for "the Rhine

river in Germany". It was discovered by x-ray spectroscopy in 1925 by the German chemists Walter Noddack, Ida Tacke and Otto Berg.

Rhodium – the atomic number is 45 and the chemical symbol is Rh. This element has 1 stable and 37 unstable isotopes/nuclides known at present. The name derives from the Greek rhodon for rose because of the "rose color of dilute solutions of its salts". It was discovered by the English chemist and physicist William Hyde Wollaston in 1803 in a crude platinum ore.

Roentgenium – the atomic number is 111 and the chemical symbol is Rg. This element has 7 unstable isotopes/nuclides known at present. The name derives from "Wilhelm Roentgen who discovered X-rays". This element was first synthesized in 1994 by a multi-national team of scientists working at the GSI (Heavy Ion Research Center) in Darmstadt, Germany. The scientific teams were from GSI, Darmstadt, Germany, JINR, Dubna, Russia, the Comenius University in Bratislava, Slovakia and the University of Jyvaskyia, Finland. They used the fusion-evaporation reaction ^{209}Bi (^{64}Ni, n) ^{272}Rg. The longest half-life associated with this unstable element is 1-minute ^{282}Rg.

Rubidium – the atomic number is 37 and the chemical symbol is Rb. This element has 1 stable and 37 unstable isotopes/nuclides known at present. The name derives from the Latin rubidus for deepest red because of the two "deep red lines" in its spectra. It was discovered in the mineral lepidolite by the German chemist Robert Wilhelm Bunsen and the German physicist Gustav-Robert Kirchoff in 1881. Bunsen isolated rubidium in 1863.

Ruthenium – the atomic number is 44 and the chemical symbol is Ru. This element has 7 stable and 33 unstable isotopes/nuclides known at present. The name derives from the Latin ruthenia for the "old name of Russia". It was discovered in a crude platinum ore by the Russian chemist Gottfried Wilhelm Osann in 1828. Osann thought that he had found three new metals in the sample, pluranium, ruthenium and polonium. He later withdrew his claim of discovery. In 1844 the Russian chemist Karl Karlovich Klaus was able to show that Osann's mistake was due to sample impurities but Klaus was able to isolate the ruthenium metal and he retained Osann's origin name of ruthenium.

Rutherfordium – the atomic number is 104 and the chemical symbol is Rf. This element has 13 unstable isotopes/nuclides known at present. The name derives from the English physicist "Ernest Rutherford" who won the Nobel prize for developing the theory of radioactive transformations. Credit for the first synthesis of this element is jointly shared by American scientists at the University of California lab in Berkeley, California under Albert Ghiorso and by Russian scientists at the JINR (Joint Institute for Nuclear Reactions) lab in Dubna, Russia under Georgi N. Flerov. The longest half-life associated with this unstable element is 10-minute ^{263}Rf.

Samarium – the atomic number is 62 and the chemical symbol is Sm. This element has 5 stable and 33 unstable isotopes/nuclides known at present. The name derived from mineral samarskite, in which it is found. It is named for "Colonel von Samarski", a Russian mine official. It was originally discovered in 1878 by the Swiss chemist Marc Delafontaine, who called it decipium. It was also discovered by the French chemist Paul-Emile Lecoq de Boisbaudran in 1879. In 1881, Delafontaine determined that his decipium could be resolved into two elements, one of which was identical to Boisbaudran's samarium. In 1901, the French chemist Eugene-Anatole Demarcay showed that this samarium earth also contained europium.

Scandium – the atomic number is 21 and the chemical symbol is Sc. This element has 1 stable and 26 unstable isotopes/nuclides known isotopes/nuclides known at present. The name derives from the Latin Scandia for "Scandinavia", where the mineral was found. It was discovered by the Swedish chemist Lars-Fredrik Nilson in 1879 from an ytterbium sample. In the same year, the Swedish chemist Per Theodore Cleve proved that scandium was Mendeleev's hypothetical element "ekaboron", whose properties and position in the Periodic Table Mendeleev had previously predicted.

Seaborgium – the atomic number is 106 and the chemical symbol is Sg. This element has 12 unstable isotopes/nuclides known at present. The name derives from the American chemist "Glenn Theodore Seaborg", who led a team that first synthesized many trans-uranium elements. The element Seaborgium was first synthesized by American scientists from the University of California lab in Berkeley, California under Albert Ghiorso, who used the fusion-evaporation reaction ^{249}Cf (^{18}O, 4n) ^{263}Sg. The longest half-life associated with this unstable element is 21-second ^{266}Sg.

Selenium – the atomic number is 34 and the chemical symbol is Se. This element has 5 stable and 28 unstable isotopes/nuclides known at present. The name derives from the Greek Selene, who was the Greek goddess of the moon because the element is found with tellurium (Tellus, the roman goddess of the earth). It was discovered by the Swedish chemist Jons Jacob Berzelium in 1817, while trying to isolate tellurium in an impure sample.

Silicon – the atomic number is 14 and the chemical symbol is Si. This element has 3 stable and 20 unstable isotopes/nuclides known at present. The name was originally silicium because it was thought to be a metal. When this was shown to be incorrect, the name was changed to silicon, which derives from the Latin silex and silicis for "flint". Amorphous silicon was discovered by the Swedish chemist Jons Jacob Berzelius in 1824. Crystalline silicon was first prepared by the French chemist Henri Sainte-Claire Deville in 1854.

Silver – the atomic number is 47 and the chemical symbol is Ag. This element has 2 stable and 39 unstable isotopes/nuclides known at present. The name derives from the Anglo-Saxon seofor and siolfur, which is of unknown origin. The chemical symbol, Ag, derives from the Latin argentum and Sanskrit argunas for "bright". The element was known in prehistoric times.

Sodium – the atomic number is 11 and the chemical symbol is Na. This element has 1 stable and 20 unstable isotopes/nuclides known at present. The name derives from the Latin natrium for "natron (soda in English)" It was discovered in 1807 by the English chemist Humphry Davy from electrolysis of caustic soda (NaOH).

Strontium – the atomic number is 38 and the chemical symbol is Sr. This element has 4 stable and 31 unstable isotopes/nuclides known at present. The name derives from Strontian, "a town in Scotland". The mineral strontianite is found in mines in Strontian. The element was first characterized by William Cruikshank in 1790 and fully characterized by the Scottish chemist and physician Thomas Charles Hope in 1792 observing the brilliant red flame color of strontium. It was first isolated by the English chemist Humphry Davy in 1808.

Sulfur – the atomic number is 16 and the chemical symbol is S. This element has 4 stable and 20 unstable isotopes/nuclides known at present. The American name sulfur was preferred to the English name Sulphur because many languages have a spelling using an "f" and the origin of the name is

obscure. The name derives from the Latin sulfurium or sulphurium and the Sanskrite sulveri. Sulfur was known as known as brenne stone for “combustible stone” from which brim stone is derived. It was known from prehistoric times and thought to contain hydrogen and oxygen. In 1809, the French chemists, Louis-Joseph Gay-Lussac and Louis-Jacques Thenard proved the elemental nature of sulfur.

Tantalum – theos” atomic number is 73 and the chemical symbol is Ta. This element has 2 stable and 38 unstable isotopes/nuclides known at present. The name derives from the Greek “Tantalos”, for the mythological character who was banned to Hades, the region of lost souls where he was placed up to his chin in water, which receded whenever he tried to drink it and under branches of fruit, which drew back whenever he tried to pick their fruit. This name was selected because of the insolubility of tantalum in acids, thus when placed in acids, it is incapable of taking any of them up. It was discovered by the Swedish chemist and mineralogist Anders-Gustav Ekeberg in 1802. (see niobium).

Technetium – the atomic number is 43 and the chemical symbol is Tc. This element has 37 unstable isotopes/nuclides known at present. The name derives from the Greek technetos for “artificial”. The claims of discovery of this element are extensive. It was first thought to be found in platinum ores in 1828 and was named polonium but is was impure indium. In 1846, an element ilmenium was claimed to be found in minerals and after further work, the author claimed another element neptunium (not to be confused with element 93). Ilmenium was determined to be impure niobium. In 1847, pelopium was claimed as a new element but it was also found to be impure niobium. In 1877, a new element davyium (in honor of Humphry Davy) was claimed in platinum ore but it was determined to be a mixture of indium, rhodium and iron. In 1896, a new element lucium was claimed to be found but it was determined to be yttrium. In 1909, the element nipponium was claimed to be isolated from various minerals but that claim was dismissed because of the argument that it element 75 (rhenium) and not element 43 (technetium). In 1925, the element masurium was claimed to be found in platinum ore by Ida Noddack-Tacke, Walter Noddack and Otto Berg. They were not able to isolate weighable amounts of the element, so their claim was also never verified. Technetium was first isolated and characterized in 1937 by Italian physicists Carlo Pernier and Emilio Segre from the Royal University of Palermo, Italy. The technetium was synthesized in a molybdenum sample, which had been bombarded at the University of California lab at Berkeley, California with deuterons (^{2}H) to produce ^{95m}Tc and ^{97m}Tc using the nuclear reactions ^{94}Mo (d, n) ^{95m}Tc and ^{96}Mo (d, n) ^{97m}Tc and Ernest Lawrence shipped it to Palermo. The longest half-life associated with this unstable element is 6.6 million-year ^{98}Tc.

Tellurium – the atomic number is 52 and the chemical symbol is Te. This element has 6 stable and 33 unstable isotopes/nuclides known at present. The name derives from the Latin Tellus, who was the “Roman goddess of the earth”. It was discovered by the Romanian mine director Franz Joseph Muller von Reichenstein in 1782 and overlooked for 16 years, until it was first isolated by German chemist Martin-Heinrich Klaproth in 1798. The Hungarian chemist Paul Kitaibel independently discovered tellurium in1789, prior to Klaproth’s work but after von Reichenstein.

Tennessine – the atomic number is 117 and the chemical symbol is Ts. This element has 2 unstable isotopes/nuclides known at present. The name tennessine recognizes the contribution of the Tennessee region, including Oak Ridge National Laboratory (ORNL), Vanderbilt University and the University of Tennessee at Knoxvile to super-heavy element research. Actinide materials from ORNL have contributed to the discovery and/or confirmation of nine super-heavy elements. The element was synthesized by a joint scientific team from JINR (Joint Institute for Nuclear Research) in Dubna, Russia and from the USA,

Lawrence Livermore National lab, in Livermore, California, Oak Ridge National lab, in Oak Ridge, Tennessee and Vanderbilt University, Nashville, Tennessee using the fusion-evaporation reactions, ^{249}Bk (^{48}Ca, 4n) ^{293}Ts and ^{249}Bk (^{48}Ca, 3n) ^{294}Ts in 2010. In 2012 the two reactions were repeated. Cross reactions producing ^{289}Mc and ^{285}Nh from both ^{249}Bk + ^{48}Ca and ^{243}Am + ^{48}Ca is convincing. The longest half-life associated with this unstable element is ~ 22 milli-second ^{293}Ts.

Terbium – the atomic number is 65 and the chemical symbol is Tb. This element has 1 stable and 35 unstable isotopes/nuclides known at present. The name derives from the "village of Ytterby" in Sweden, where the mineral ytterbite (the source of terbium) was first found. It was discovered by the Swedish surgeon and chemist Carl-Gustav Mosander in 1843 in an yttrium salt, which he resolved into three elements. He called one yttrium, a rose-colored salt he called terbium and a deep yellow peroxide he called erbium. The chemist Berlin detected only two earths in yttrium, i.e., yttrium and the rose-colored oxide, he called erbium. In 1862, the Swiss chemist Marc Delafontaine reexamined yttrium and found the yellow peroxide. Since the name erbium had now been assigned to the rose-colored oxide, he initially called the element mosandrum (after Mosander) but he later reintroduced the name terbium for the yellow peroxide. Thus, the original names are given to erbium and terbium are now switched. Since Bunsen spectroscopically examined Mosander's erbium (now terbium) sample and declared that it was a mixture, the question of who discovered terbium, Mosander or Delafontaine remains unresolved to this day.

Thallium – the atomic number is 81 and the chemical symbol is Tl. This element has 2 stable and 40 unstable isotopes/nuclides known at present. The name derives from the Greek thallos for "green shoot or twig" because of the bright green line in its spectrum. It was discovered by the English physicist and chemist William Crookes in 1861. The metal was first isolated by the French chemist Claude-Auguste Lamy in 1862.

Thorium – the atomic number is 90 and the chemical symbol is Th. This element has 31 unstable isotopes/nuclides known at present. The name derives from Thor, the "Scandanavian god of thunder". It was discovered in the mineral thorite ($ThSiO_4$) by the Swedish chemist Jons Jacob Berzelius, in 1828. It was first isolated by the chemists D. Lely Jr, and L. Hamburger in 1914.

Thulium – the atomic number is 69 and the chemical symbol is Tm. This element has 1 stable and 37 unstable isotopes/nuclides known at present. The name derives from Thule, the earliest name for the northern most part of the civilized world – "Scandanavia (Norway, Sweden and Iceland)". It was discovered in 1879 by the Swedish chemist Per Theodor Cleve in a sample of erbium mineral. It was first isolated in 1911 by the American chemist Charles James.

Tin – the atomic number is 50 and the chemical symbol is Sn. This element has 10 stable and 31 unstable isotopes/nuclides known at present. The name derives from the Anglo-Saxon tin (perhaps for the Etruscan supreme god of the sky, Tinia, also called Tin)). The symbol, Sn, is derived from the Latin stannum for alloys containing lead. The element was known in prehistoric times.

Titanium – the atomic number is 22 and the chemical symbol is Ti. This element has 5 stable and 22 unstable isotopes/nuclides known at present. The name derives from the Latin titans, who were the mythological "first sons of the earth". It was originally discovered by the English clergyman William Gregor in the mineral ilmenite ($FeTiO_3$) in 1791. He called this iron titanite menachanite for the Menachan parish where it was found and the element menachin. It was rediscovered in 1795 by the

German chemist Martin Heinrich Klaproth, who called it titanium because it had no characteristic properties to use as a name. Titanium metal was first isolated by the Swedish chemists Sven Otto Pettersson and Lars Fredrik Nilson.

Tungsten – the atomic number is 74 and the chemical symbol is W. This element has 4 stable and 38 unstable isotopes/nuclides known at present. The name derives from the Swedish tung sten for "heavy stone". The chemical symbol, W, is derived from the German wolfram, which was found with tin and interfered with the smelting of tin. It was said to eat up tin like a wolf eats up sheep. In 1949, IUPAC's CNIC officially adopted wolfram as the scientific name for the element and reserved tungsten for the commercial name, in a similar fashion to iron and steel. By 1951, the chemical community erroneously thought that the name tungsten had been eliminated. A world-wide protest resulted. The CNIC decided to change back to the name tungsten pending a further review, which has never occurred. The element was discovered by the Swedish pharmacist and chemist Carl-Wilhelm Scheele in 1781. Tungsten metal was first isolated by the Spanish chemists Don Fausto d'Elhuyar and his brother Don Juan Jose d'Elhuyar in 1783.

Uranium – the atomic number is 92 and the chemical symbol is U. This element has 27 unstable isotopes/nuclides known at present. The name derives from the planet Uranus, which in Roman mythology was "Father Heaven". The German chemist Martin Heinrich Klaproth discovered the element in 1789, following the German/English astronomer William Hershel's discovery of the planet in 1781. The metal was first isolated by the French chemist Eugene-Melchior Peligot in 1841.

Vanadium – the atomic number is 23 and the chemical symbol is V. This element has 1 stable and 27 unstable isotopes/nuclides known at present. The name derives from the "Scandanavian goddess of love and beauty", Freyja Vanadis, because of its many beautiful multicolored compounds. It was discovered by the Swedish physician and chemist Nils-Gabriel Sefstrom in 1830. It had originally been discovered by the Spanish mineralogist Andres Manuel del Rio y Fernadez in 1801, who named it erythronium, after the plant of that name whose flowers have many beautiful colors. Del Rio later decided that it was really chromium in his lead sample. However, his lead sample was later shown to have vanadium in it. (It might be mentioned that IUPAC's CNIC might have decided to change the name of vanadium to erythronium because of priority of discovery issues but decided this would be unreasonable because of prevailing usage. As a result, CNIC adopted the policy that priority should not be the only factor to be considered when choosing a name for an element). Vanadium metal was first isolated by the English chemist Henry Enfield Roscoe in 1869.

Xenon – the atomic number is 54 and the chemical symbol is Xe. This element has 8 stable and 32 unstable isotopes/nuclides known at present. The name derives from the Greek xenon for "the stranger". It was discovered by the Scottish chemist William Ramsay and the English chemist Morris William Travers in 1898 in a liquified air sample.

Ytterbium – the atomic number is 70 and the chemical symbol is Y. This element has 7 stable and 31 unstable isotopes/nuclides known at present. The name derives from the "Swedish village of Ytterby", where the mineral ytterbite (the source of ytterbium) was originally found. It was discovered by the Swiss chemist Jean-Charles Galissard de Marignac in 1878 in erbium nitrate from gadolinite (ytterbite renamed). In 1907, Carl Auer von Welsbach determined that ytterbium was two elements, which he named aldebaranium and cassiopeium. At the same time and independently, George Urbain obtained two elements from ytterbium, which he named neoytterbium and lutecium. Urbain's name of

neoytterbium was accepted over Auer von Welsbach's name of aldebaranium. The name was later shortened back to ytterbium. (See the discussion of the Urbain and Auer von Welsbach priority dispute under lutetium).

Yttrium – the atomic number is 39 and the chemical symbol is Y. This element has 1 stable and 33 unstable isotopes/nuclides known at present. The name of this element originally given by Gadolin was ytterbium and it was later shortened to yttrium by Anders Gustav Eckberg. The name derives from the "Swedish village of Ytterby", where the mineral gadolinite was found. In 1794, the Finnish chemist Johan Gadolin discovered yttrium in the mineral ytterbite (which was later named gadolinite for Gadoiln). Later another element was given the name ytterbium that Gadolin had proposed. The Swedish surgeon and chemist Carl-Gustav Mosander separated the element in 1843.

Zinc – the atomic number is 30 and the chemical symbol is Zn. This element has 5 stable and 27 unstable isotopes/nuclides known at present. The name derives from the German zink for "prong", referring to the antlers of a deer. Sublimed zinc collects in long "icicles" resembling such horns. This was observed in the mines (e.g., in Rammelsberg) in central Germany. It was first used in prehistoric times, where its compounds were used for healing wounds and sore eyes and for making brass. It was recognized as a metal as early as 1374.

Zirconium – the atomic number is 40 and the chemical symbol is Zr. This element has 4 stable and 32 unstable isotopes/nuclides known at present. The name derives from the Arabic zargun for "gold-like". It was discovered in zirconia by the German chemist Martin Heinrich Klaproth in 1789. Zirconium was first isolated by the Swedish chemist Jons Jacob Berzelius in 1824 in an impure state and finally by the chemists D Lely Jr. and L. Hamburger in a pure state in 1914.

DISCUSSION

The most recent IUPAC/IUPAP Joint Working Group (2017 version) under chairman, Sigurd Hofmann, has the task of establishing criteria for assigning the discovery of new elements beyond Z = 118. They estimate the possible experimental developments for the production and identification of new elements beyond the presently known ones. They present criteria and guidelines for establishing the priority of discovery of these potential new elements. Their report notes that "although the criteria are principally based on definite physical laws, it is presently not possible to generally establish definite criteria on those laws that could be applied for all conceivable cases that may occur in the future. Three reasons prevent such an initiative, which include the locations of regions of highest stability of prospective new elements are unknown; the optimum production reactions for new elements are unknown and stability significantly influences the production cross-sections due to a reduced fission probability of the generally excited newly produced nucleus; and finally, technical developments may considerably improve the methods for detection and identification of new elements in the future. Methods may be improved, which presently seem to be not applicable. The possibilities for synthesis of new elements may be broadened by higher beam intensities, radioactive beams, secondary reactions using fragments from induced fission, and applications of the heaviest beams up to uranium or even heavier with the use of more radioactive isotopes of actinide elements".

In the last eighteen years since the previous version of this history was presented, nine new chemical elements were discovered (synthesized), and officially named from darmstadtium to oganesson. At this point, a reasonable conclusion to draw might be that this rate of discovery of a new element every two years does not seem likely to continue over the next few years. However, only time will tell.

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