Advanced Transition Metal Chemistry – Periodic Table
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Lecture – 3
It is all About the Periodic Table

Hello everyone, welcome to MSB lecture series on advanced transition metal chemistry. In my previous lecture, I did mention about the naming of the last element in the modern periodic table, that is, inert gas element with atomic number 118, named after Oganessian. So, let me continue from where I had stopped.

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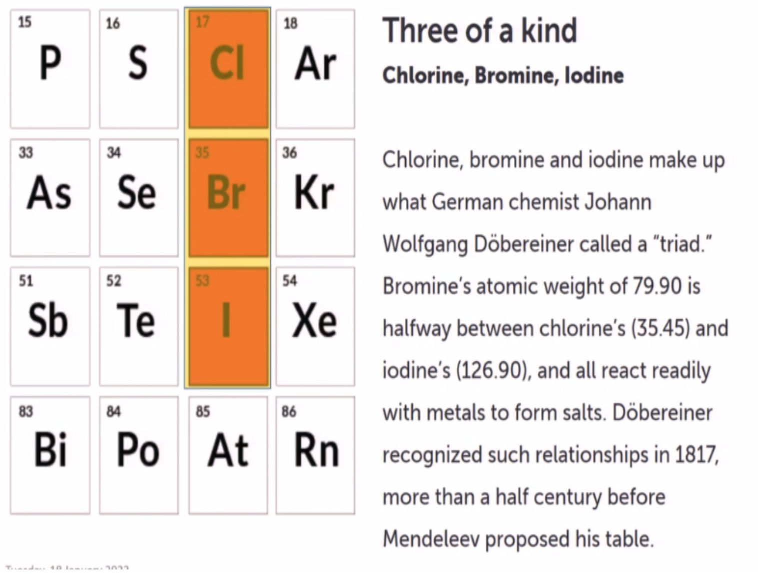

Please look into this slide here. Chlorine, bromine, iodine are shown here. In fact, German chemist Johann Wolfgang Dobereiner had called chlorine, bromine, iodine a triad and if you just look into the atomic weights here, the bromine's atomic weight of 79.90 is halfway between chlorine's 35.45 and iodine's 126.9 and all react readily with metals to form salts. In fact, Dobereiner recognized such relationship in 1817 that is almost 50 years before the modern periodic table was presented by Dmitri.

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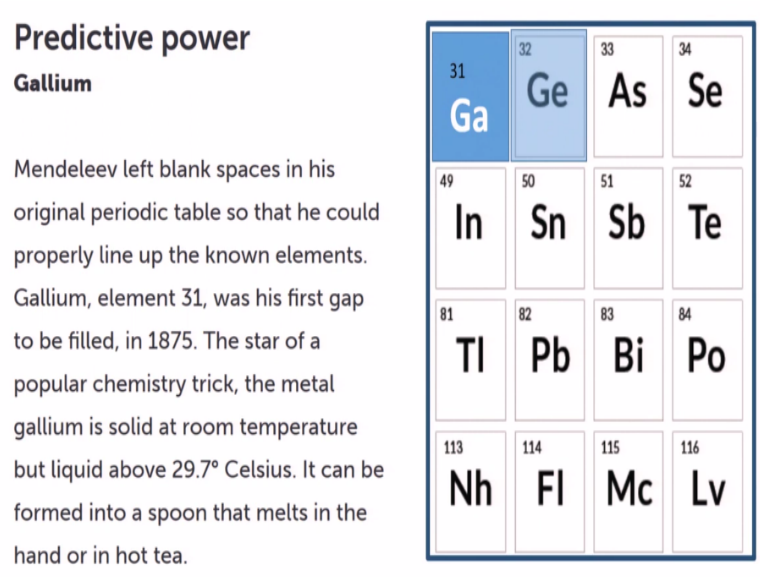

Another interesting thing is predicting power of Mendeleev's periodic table. So Mendeleev left blank spaces in his original table where elements were not known that time. For example, he left a gap below aluminum and silicon and called them aka aluminium and aka silicon and later gallium and germanium were discovered. So, the star of a popular trick, the **metal gallium** is solid at room temperature but liquid ~~at~~ above 29.7 Celsius.

When you look at gallium, it looks almost like mercury, but it has a melting point of 29.7 Celsius. It can be formed into a spoon that melts in the hand or in hot tea, commonly used by magicians to show you about melting spoon.

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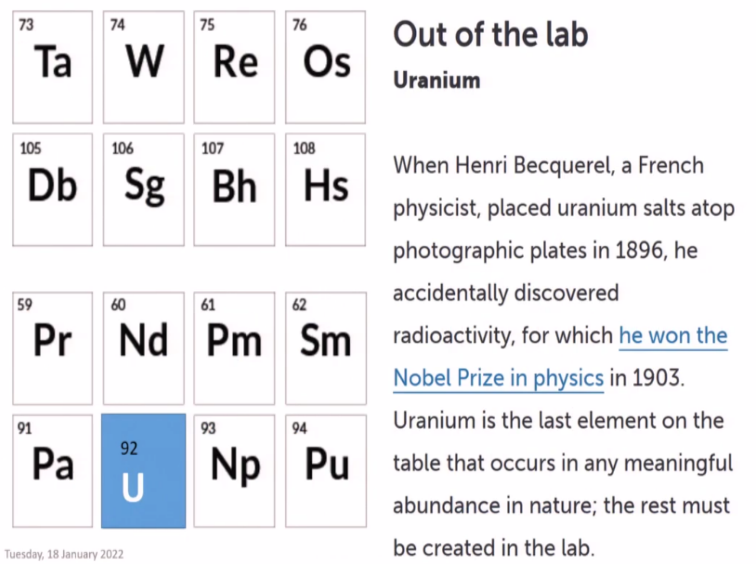

And about uranium: W~~w~~hen Henri Becquerel, a French physicist, placed uranium salts atop photographic plates, in 1896, he accidentally discovered radioactivity for which he won

Nobel Prize in Physics in 1903. Uranium is the last element on the table that occurs in any meaningful abundance in nature. That means uranium is the last element to be found in nature and the rest must be created in the lab, that is, post uranium are created in the laboratory.

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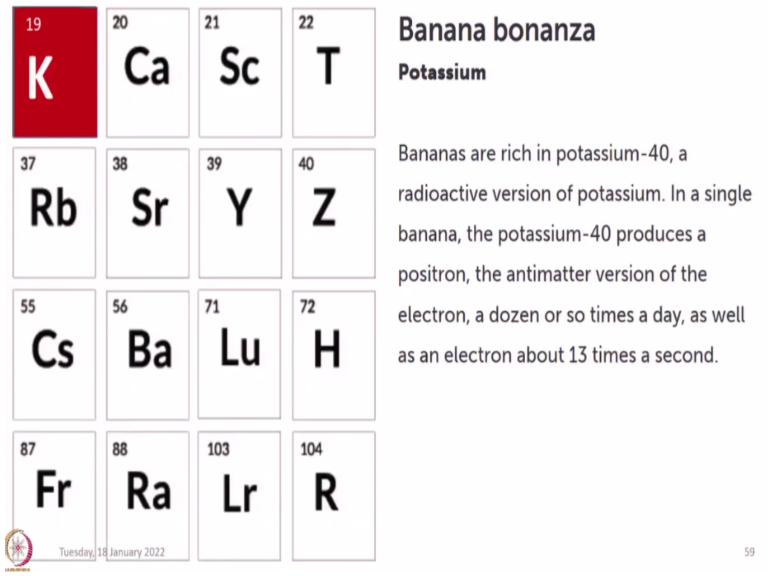

Let us look into some interesting aspects about potassium. Bananas are very rich in potassium-40, a radioactive version of potassium. In a single banana, the potassium-40 produces a positron, the antimatter version of the electron, a dozen or so times a day, as well as an electron about 13 times a second.

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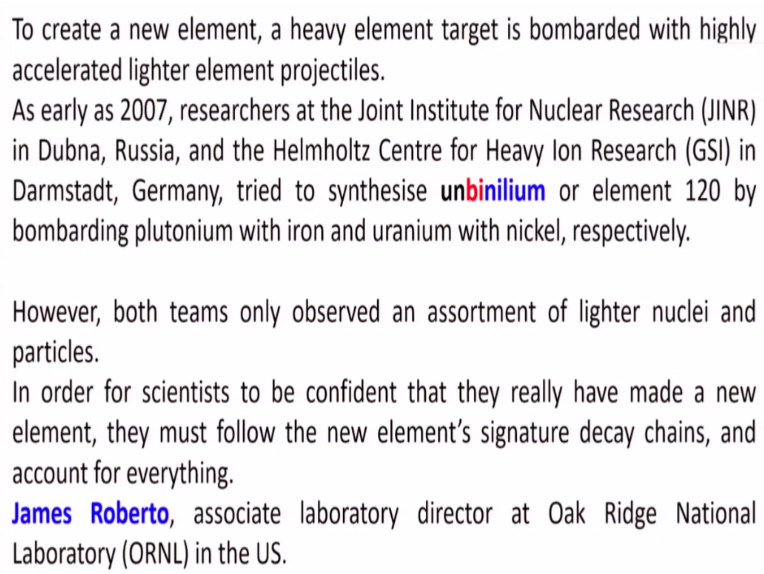

You may be interested to know how the post uranium elements were generated. So that means, to create a new element, a heavy element target is bombarded with highly accelerated lighter element projectiles. As early as 2007, researchers at the Joint Institute for Nuclear

Research in Dubna, Russia and the Helmholtz Centre for Heavy Ion Research in the Darmstadt, Germany, tried to synthesize element with atomic number 120, that with IUPAC, you can call it as unbinilium, by bombarding plutonium with iron, and uranium with nickel, respectively.

So, however both teams only observed an assortment of lighter nuclei and particles, so that indicates how difficult it is to make heavier elements in the laboratory. In order for scientists to be confident that they really have made a new element, they must follow the new element's signature decay chains and account for everything. James Roberto, associate laboratory director at Oak Ridge National Laboratory in the US did opine about these things.

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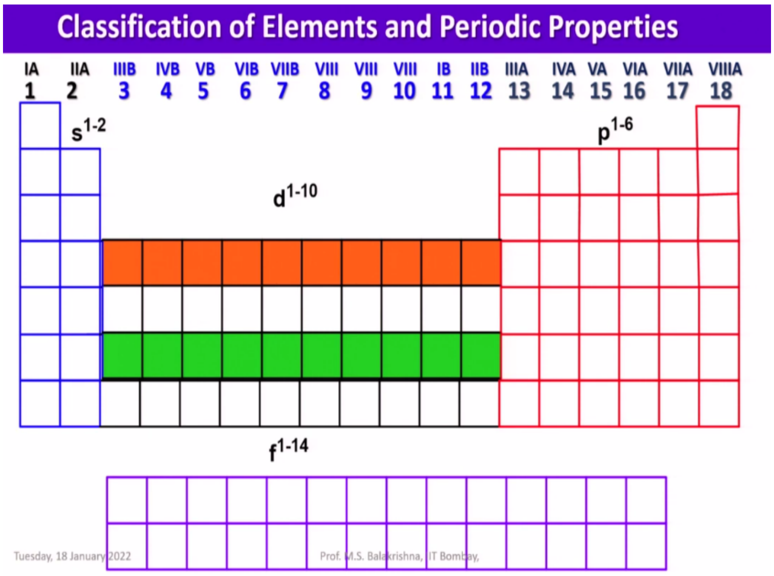

And of course, you know that this is the classical periodic table we see nowadays. You can clearly see the classification of elements in this periodic table. We have 2 s-block and 6 p-block elements. We call the s- and p-block elements altogether ~~we call them~~ as main group elements. And then we have here 3d, 4d, 5d series. We have 10 electrons starting from $nd^0 (n+1)\cancel{1}s^2$ to $nd^{10} (n+1)s^2$ and of course $nd^{10} (n+1)s^2$ falls to zinc group.

Since the zinc group has completely filled orbitals, they are not considered as transition elements. In fact, their chemistry is much similar to main group elements. As a result, most of the discussion that we are going to do on transition elements will be confined to only these 27 elements coming from 3d, 4d and 5d series starting from $nd^1 (n+1)s^2$ to $nd^9 (n+1)s^2$ electronic configuration.

That means having anywhere between d^1 to d^9 electrons in each group and each period. So, this is s-block, alkali metals and alkaline earth metals and then we have p-block starting from p^1 to p^6 including hydrogen and helium. And then we have this 3d, 4d, 5d series. And of course, we have the f block elements, f block elements are about 28. And then we have 27 d block elements together 55 elements are known as transition elements. So, our attention will be focused towards these 3d, 4d, 5d series in the next lectures to come.

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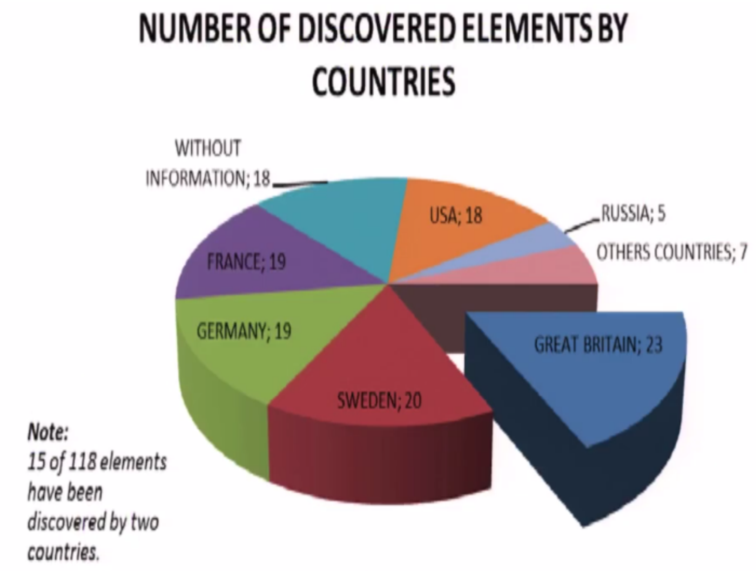

So, if you are curious to know about the number of countries that contributed in the discovery of ele~~fila~~ments, that you can see here, US contribution is 18, Russia 5 and then without information 18 elements. The ancient people knew about these elements and you cannot really tag these elements to any country, the old civilizations identified these 18 elements. And France contributed in identifying 19 or discovering 19 and Germany 19 and Sweden 20 and Great Britain 23. That means 15 out of 118 elements have been discovered by two countries.

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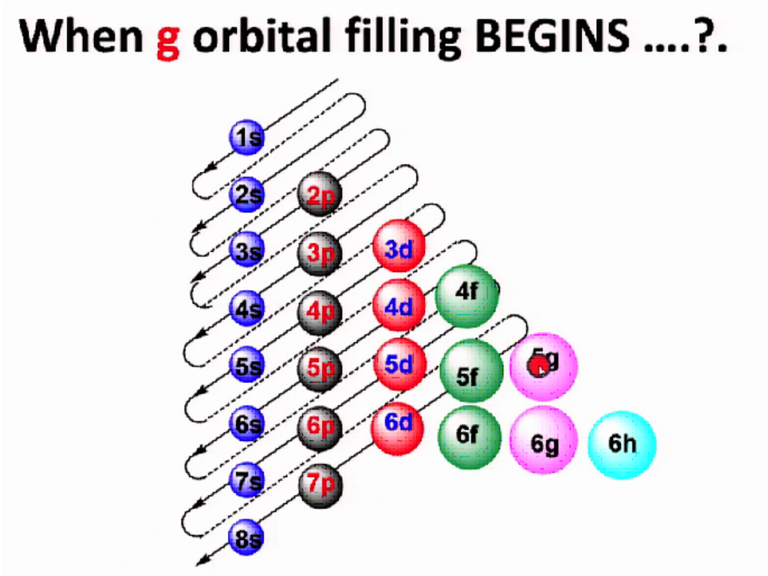

Let us look into some interesting facts. When the g orbital filling begins? If you look into Aufbau principal and Aufbau diagram, you can see electron filling model. There we come across s sorbitols with 2 electron capacity, p orbitals with 6 electron capacity and d orbitals with 10 electron capacity and if you go further f orbital is having capacity of 14 electrons and if you assume there is going to be a heavier element.

And if you have to use g orbital, then the capacity of g orbital will be, 9 orbitals and 18 electrons. So that means, for curiosity if we ask question when the g orbital filling begins, looking to this electron filling, so you can see, once after 6d and 5f is completed, we have to consider 5g.

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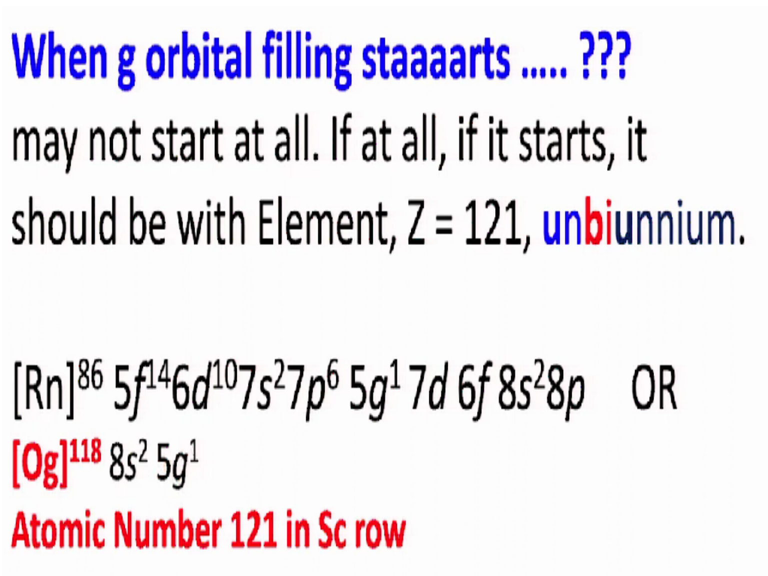

That means for your surprise, the g orbital filling may not start at all. The reason is, it is not very easy to make heavier elements because they readily disintegrate into nuclei of lower atomic number and some other particles. And if it starts in case, if an element is made for occupying electrons in g orbital that should begin with atomic number 121 According to IUPAC the name is unbiunium.

And for that one, one can write electron configuration starting from Radon atomic number 86 $5f^{14}$ $6d^{10}$ $7s^{2}$ $7p^{6}$ $5g^{1}$ and these are all empty valence orbitals or one can write [Oganesson -118] $8s^{2}$ $5g^{1}$. So that means if an element with atomic number 121 is discovered it will be below scandium having one electron in *g* orbital.

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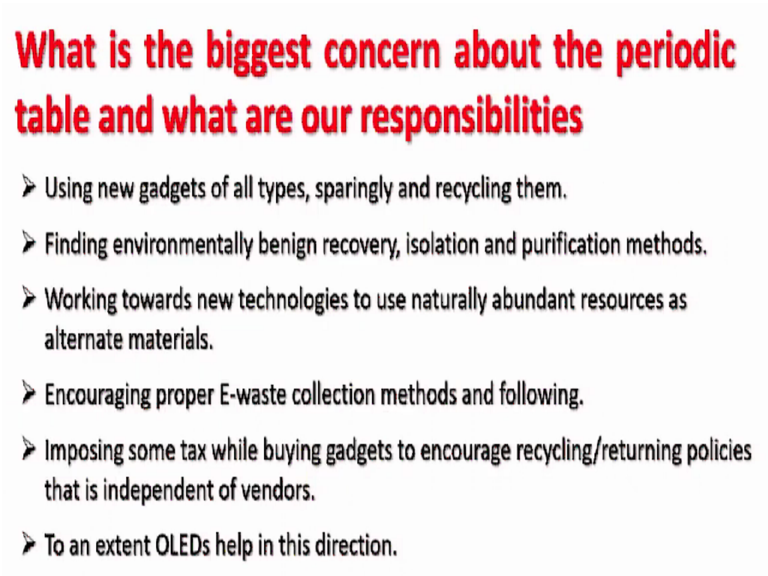

So what is the biggest concern about the periodic table and what are our responsibilities? It is very important. What we should do is: using new gadgets of all types sparingly and recycling them and finding environmentally benign recovery, isolation and purification methods. Working towards new technologies to use naturally abundant resources as alternate materials. So, we should find out new technologies where we can use most abundant elements for these new devices.

Encouraging proper E-waste collection method and following. So imposing some tax while buying gadgets to encourage recycling and returning policies that is independent of vendors. In this context OLEDs that means organic light emitting devices are helping greatly.

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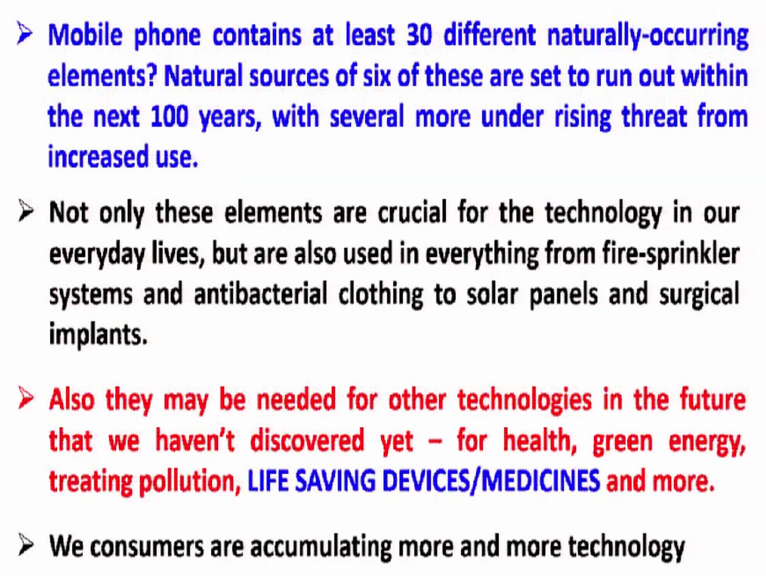

So, you will be surprised to know the fact that mobile phone contains at least 30 different naturally occurring elements. Natural sources of six of these are set to run out within next 100 years, that is a serious issue concern, with several more and the rising threat from increased use. Not only these elements are crucial for the technology in our everyday lives, but are also use it in everything from fire-sprinkler systems and antibacterial clothing to solar panels and surgical implants.

Also, they may be needed for other technologies in the future that we have not discovered yet, for example for health, green energy, treating pollution and also life saving devices and medicines and more. So, in this context we consumers should avoid accumulating more and more technology and use the existing one for a little longer time.

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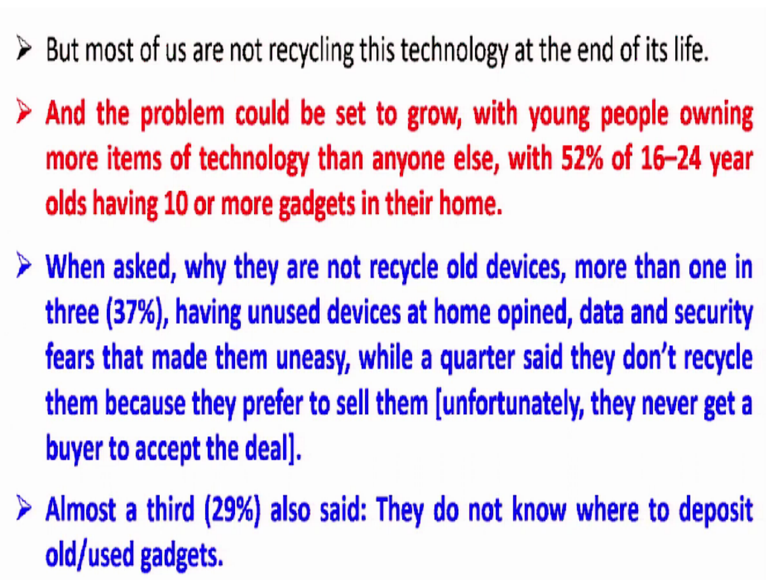

The sad part is most of us are not recycling this technology at the end of its life. And the problem could be set to grow with younger people owning more items of technology than anyone else, with 52% of younger people in the age group of 16 to 24 having 10 or more gadgets in their home. When asked why they have not recycled old devices, more than one in three that is 37% having unused devices at home opined that data and security fears that made them uneasy.

While a quarter said they do not recycle them because they prefer to sell them. Unfortunately, they never get a buyer to accept the deals that they are giving. So, almost a third about 29% also said: they do not know where to deposit old used gadgets.

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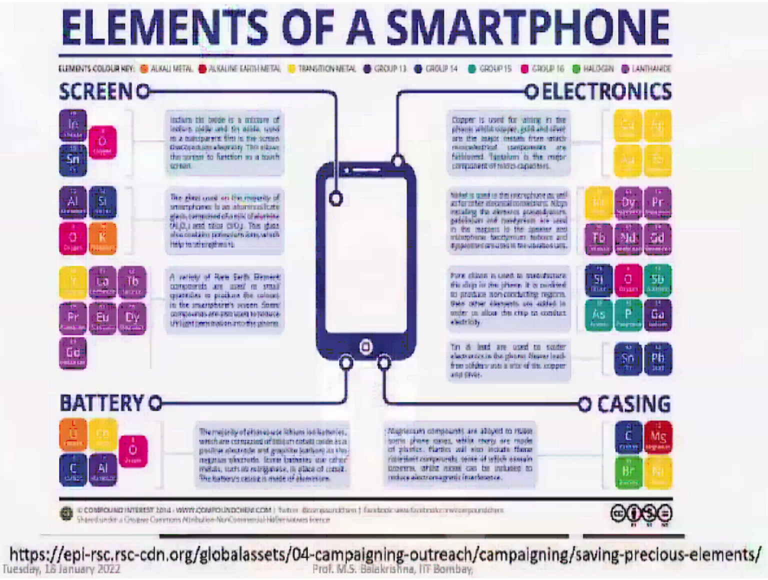

Just this slide will tell you how many elements are involved in devising a smartphone that we use today. You can see for various applications, for example screen; they are using this many and for battery, they are using these many elements and electronics, they are using these elements and for casing, they are using these elements. That means, if you just look into the number of smartphones in circulation and how many individuals have at home, you can see in what magnitude we are consuming some of these resources.

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Reduce – Postpone upgrading your phone for a year or more **after it suffers and suffocates for atleast four or more years in your hands.**

Reuse – **Pass your old phone to a relative, or donate to a charity.**

EVEN IF IT IS NOT WORKING

So, what is the solution? What is the remedy? Reduce, that means postpone upgrading your phone for a year or more after it suffers and suffocates for at least 4 more years in your hands. Let us try to reuse, pass your old phone to a relative or donate to a charity, even if it is not working.

So let me show you some monuments made in memory of the periodic table and also their discoverers.

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In front of the Faculty of Chemical and Food Technology of the Slovak University of Technology in Bratislava, Slovakia. The monument honors Dmitri Mendeleev. Date: 15 October 2006

So, in front of the Faculty of Chemical and Food Technology of Slovak University of Technology in Bratislava, Slovakia. So, this monument honours Dmitri Mendeleev.

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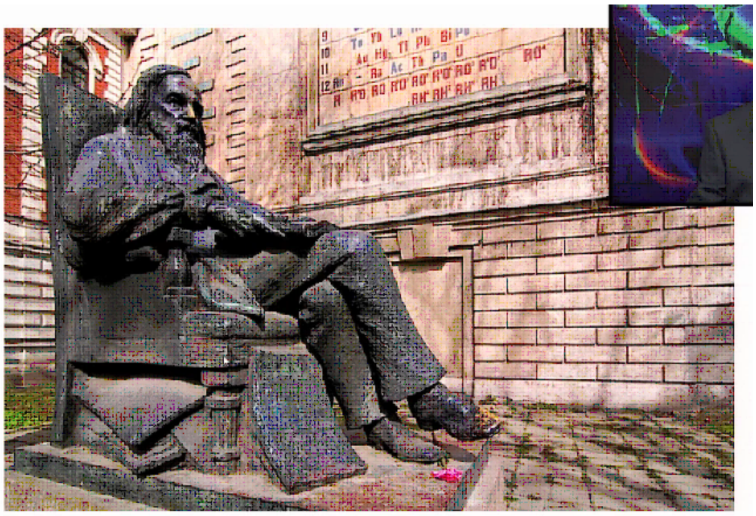

Near St. Petersburg Technological Institute, where Mendeleev gained his first professorship in 1864.

And near St. Petersburg Technological Institute where Mendeleev gained his first professorship in 1864, so they have put a statue of Mendeleev.

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Tower block decorated with Mendeleev's Periodic Table in Tobolsk, Siberia

Tower block decorated with Mendeleev's periodic table in Tobolsk, Siberia.

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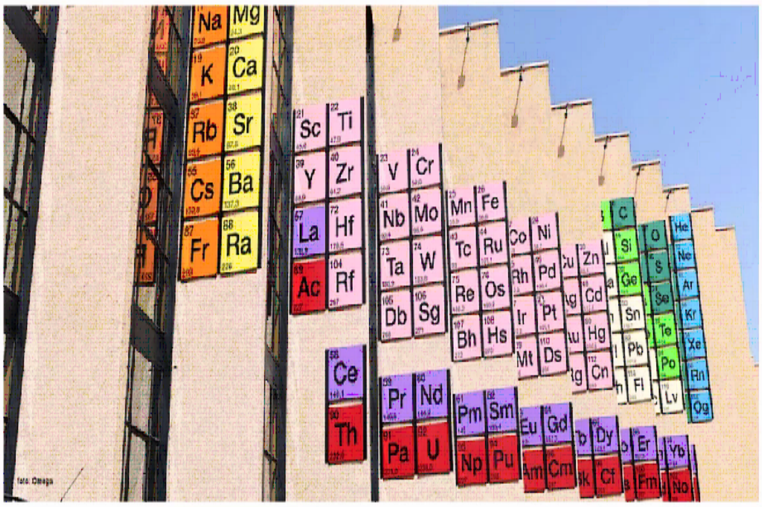

chemistry faculty building at the University of Murcia in Spain

Chemistry faculty building at the University of Murcia in Spain.

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Monumental periodic table on the chemistry faculty - UNAM MX

Monumental periodic table on the chemistry faculty University of Mexico in Mexico.

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Horizon community college Barnsley, UK have displayed a big periodic table.

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World's Largest Periodic Table on the Daley Center in Chicago 2006

The world's largest periodic table on Daley Centre in Chicago. So, it was built in 2006.

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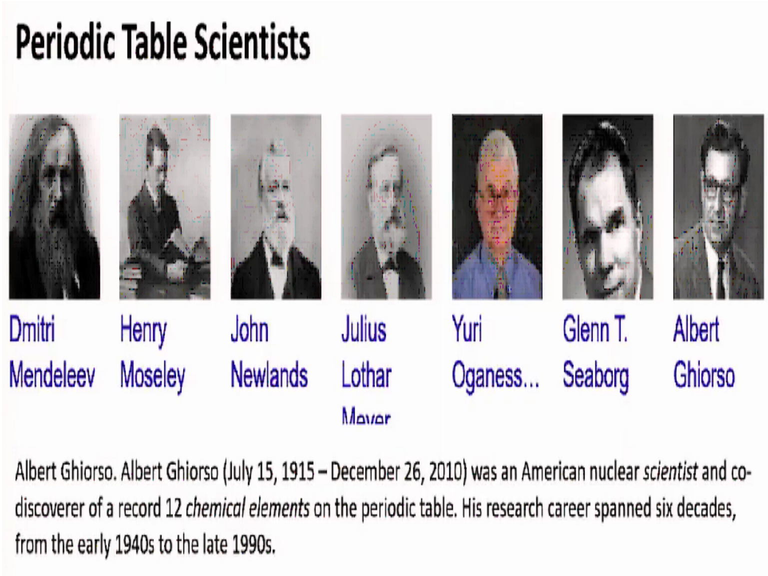

And these are the scientists who contributed to the presentation or formation of periodic table and of course I did mention about all these people. Dmitri Mendeleev, Henry Moseley, John Newlands, Julius Lothar Meyer, Yuri Oganessian, Glenn T. Seaborg. I did not mention about Albert Ghiorso. So, Albert Ghiorso was an American nuclear scientist and co-discoverer of a record chemical elements on the periodic table. His research career spanned 6 decades from the early 1940s to the late 1990s.

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Table of Elements in the Human Body by Mass

oxygen	43 kg	(61%, 2700 mol)	aluminum	60 mg	niobium	1.5 mg
carbon	16 kg	(23%, 1300 mol)	cadmium	50 mg	zirconium	1 mg
hydrogen	7 kg	(10%, 6900 mol)	cerium	40 mg	lanthanum	0.8 mg
nitrogen	1.8 kg	(2.5%, 129 mol)	barium	22 mg	gallium	0.7 mg
calcium	1.0 kg	(1.4%, 25 mol)	iodine	20 mg	tellurium	0.7 mg
phosphorus	780 g	(1.1%, 25 mol)	tin	20 mg	yttrium	0.6 mg
potassium	140 g	(0.20%, 3.6 mol)	titanium	20 mg	bismuth	0.5 mg
sulfur	140 g	(0.20%, 4.4 mol)	boron	18 mg	thallium	0.5 mg
sodium	100 g	(0.14%, 4.3 mol)	nickel	15 mg	indium	0.4 mg
chlorine	95 g	(0.14%, 2.7 mol)	selenium	15 mg	gold	0.2 mg
magnesium	19 g	(0.03%, 0.78 mol)	chromium	14 mg	scandium	0.2 mg
iron	4.2 g		manganese	12 mg	tantalum	0.2 mg
fluorine	2.6 g		arsenic	7 mg	vanadium	0.11 mg
zinc	2.3 g		lithium	7 mg	thorium	0.1 mg
silicon	1.0 g		cesium	6 mg	uranium	0.1 mg
rubidium	0.68 g		mercury	6 mg	samarium	50 μg
strontium	0.32 g		germanium	5 mg	beryllium	36 μg
bromine	0.26 g		molybdenum	5 mg	tungsten	20 μg
lead	0.12 g		cobalt	3 mg		
copper	72 mg		antimony	2 mg		
			silver	2 mg		

And then if you look into this table, it shows the elements found in human body by mass and of course whatever I have put here up to magnesium are in the blue colour they are very essential for human beings. And also I have given in what ratio they are present in our body. And apart from that one, we may find some of these in minute quantities in our body. And of course, some of these key elements which are really not needed to keep up good health are also there because of environment also, because of the condition in which we are living exposed to one or the other elements.

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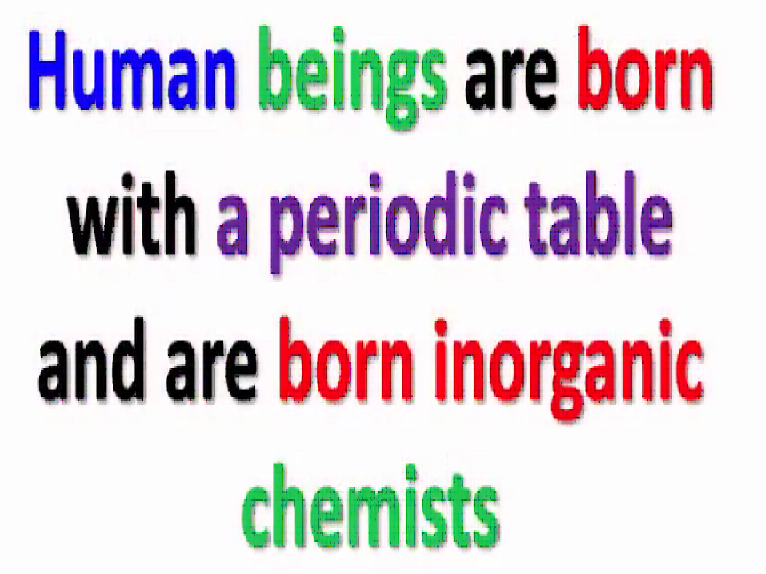

So, this indicates human beings are born with a periodic table and are born inorganic chemists.

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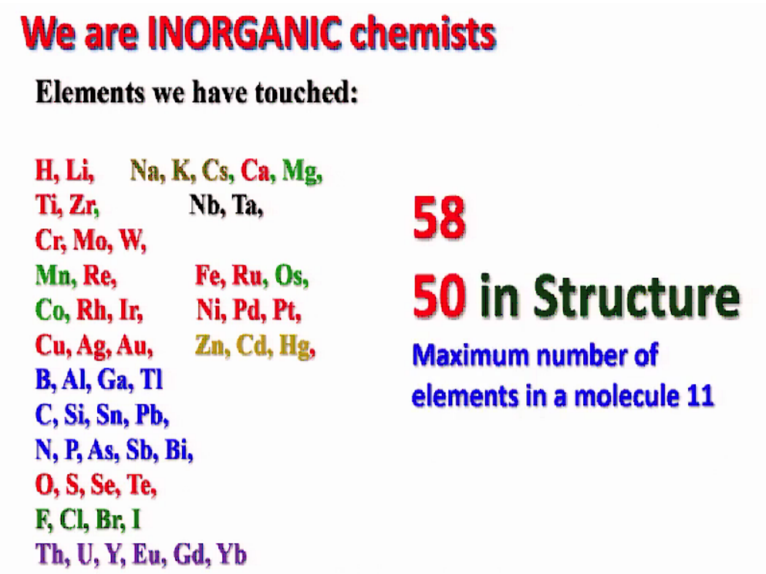

And if you see here, I have listed some elements here. These are the elements we have used in our laboratory while performing inorganic chemistry and out of 58 we have used 50 were found in the structure, we have determined using x-ray crystallography. And also we made compounds having a maximum number of elements in your molecule is 11, hopefully we will make in the years to come some molecules having as many as 14 or 15 elements in it.

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I am glad to inform you that I have the collection of most of the elements in the periodic table arranged in the same way, of course here I have only natural elements, not the radioactive ones. You can see here for example some of those things be empty because they are all highly corrosive; and alkali metals and alkaline earth metals are not there. And we have this argon gase ~~s are~~ kept ~~here~~ in small ampoules ~~small ampules~~ and similarly oxygen and nitrogen are also there.

You can recognize this one, this is copper. And then next to that we have silver and gold and this is gallium, this is selenium and this is antimony. So, most of the elements, I have here. If you happen to be in IIT Bombay, you are most welcome to come and have a look at it in my office. So, that ends about ~~a~~ history of periodic table. In my next lecture, I shall focus on chemistry of transition elements.