Atoms, Elements, and the Periodic Table

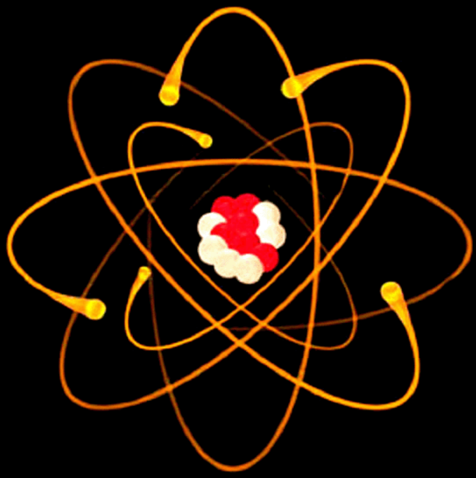
Part 1: The Atomic Model

Atomic Theory Timeline

The atomic model has changed over time.

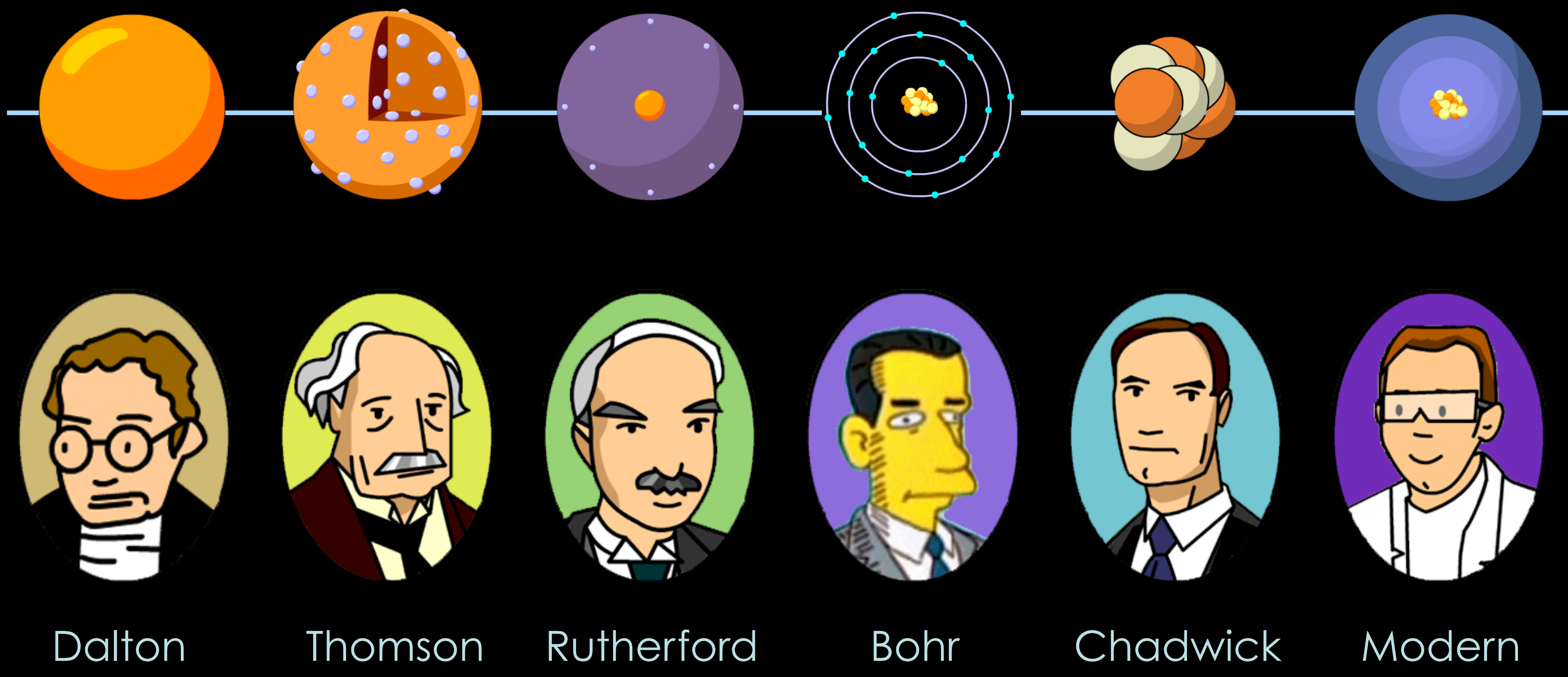
For over two centuries, scientists have created different models of the atom.

As scientists have learned more and more about atoms, the atomic model has changed.



Atomic Theory Timeline

Here is a timeline of some of the major ideas.



But First, Democritus!

Democritus was a Greek philosopher (470-380 B.C.) who is the father of modern atomic thought.

He proposed that matter could NOT be divided into smaller pieces forever.

He claimed that matter was made of small, hard particles that he called "atomos"

John Dalton - 1808

John Dalton created the very first atomic theory.

Dalton was an English school teacher who performed many experiments on atoms.

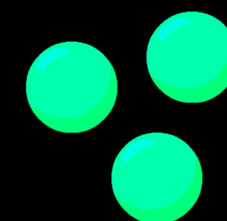
Dalton viewed atoms as tiny, solid balls.

His atomic theory had 4 statements…

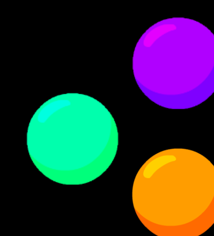
Dalton’s Theory

1. Atoms are tiny, invisible particles.

2. Atoms of one element are all the same.



3. Atoms of different elements are different.



4. Compounds form by combining atoms.

J.J. Thomson (1897)

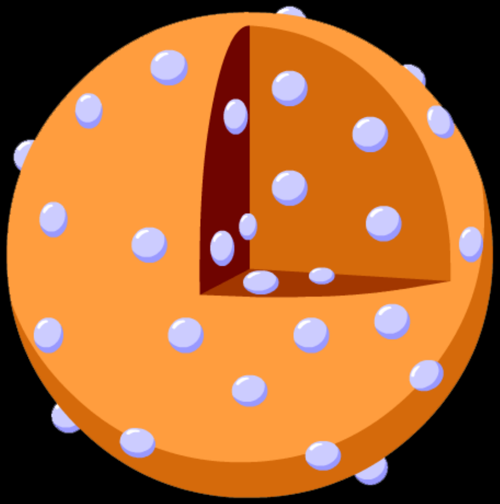
J.J. Thomson discovered electrons.

He was the first scientist to show that the atom was made of even smaller things.

He also proposed the existence of a (+) particle…

His atomic model was known as the “raisin bun model”…

Thomson’s Model



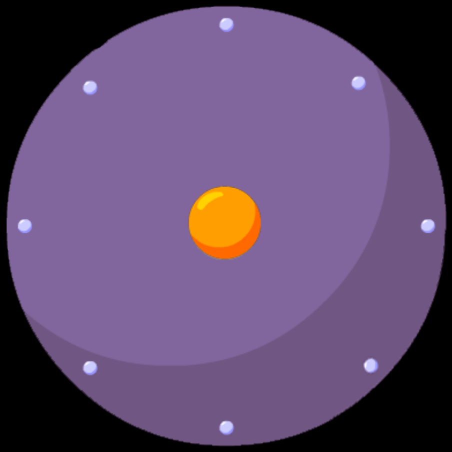
Atoms are made mostly out of (+) charged material, like dough in a bun.

The (-) charged electrons are found inside the (+) dough.

Ernest Rutherford (1911)

Rutherford discovered protons and the nucleus.

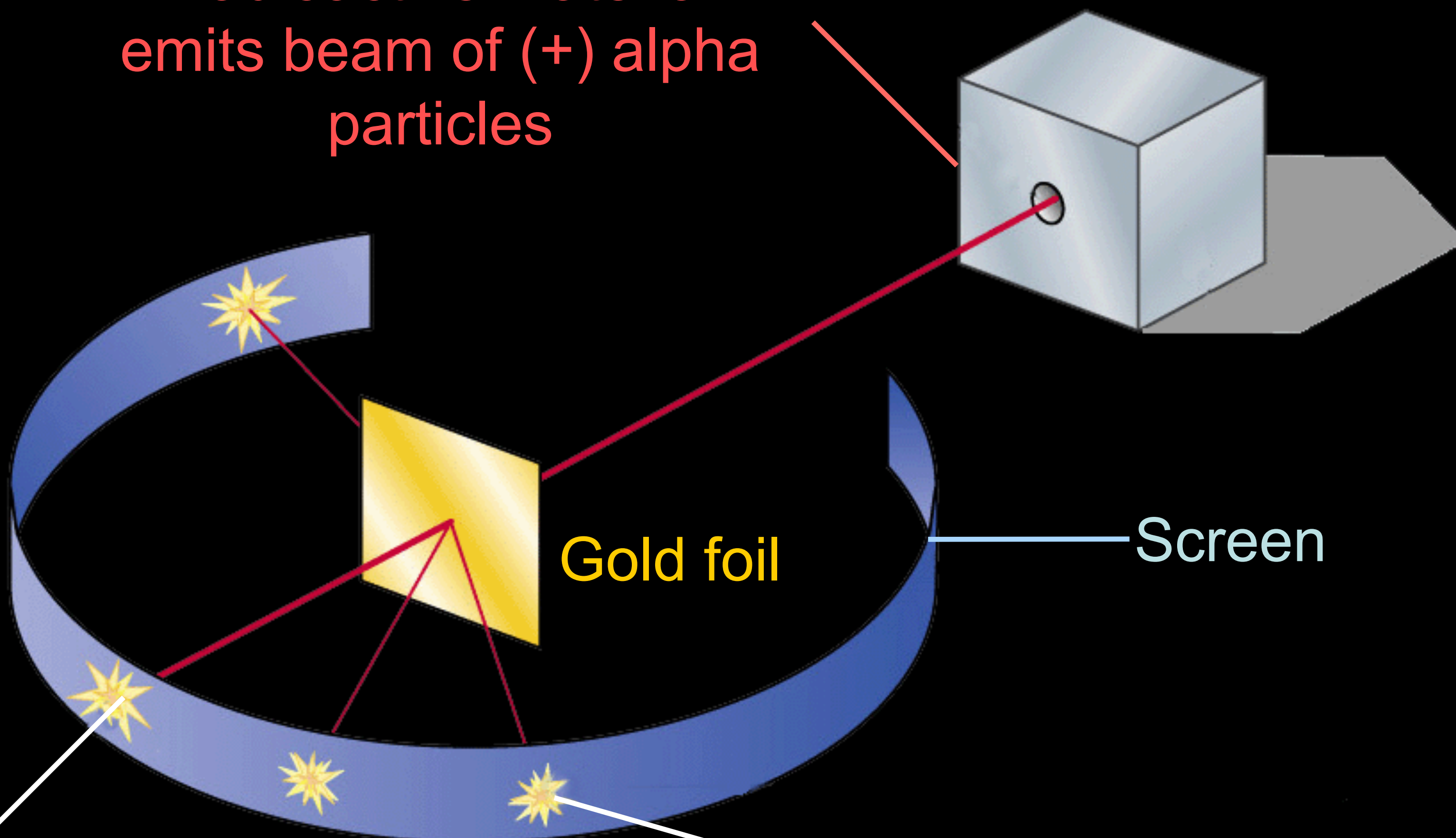
He showed that atoms have (+) particles in the center, and are mostly empty space.



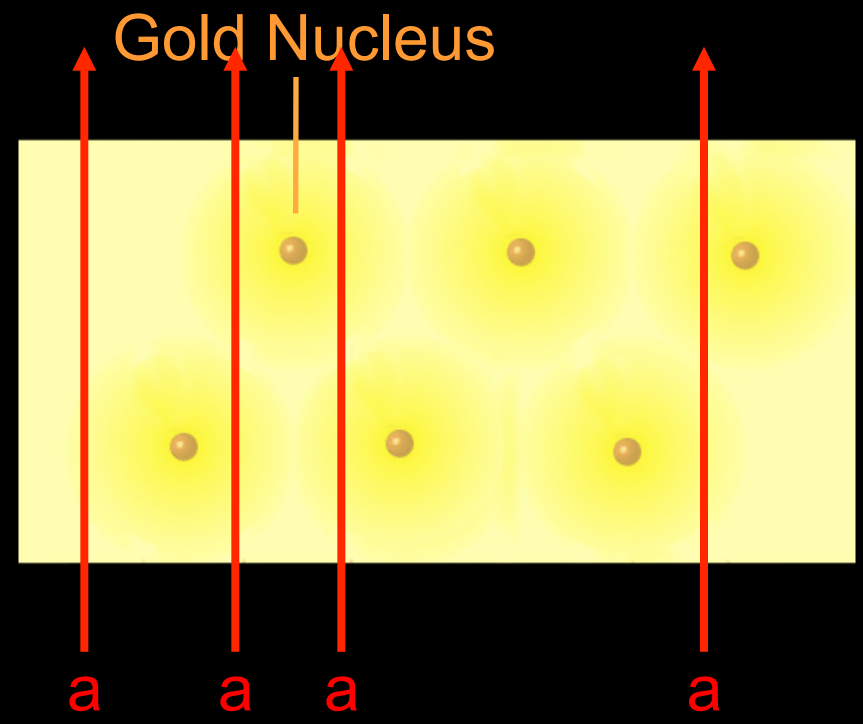
He called these (+) particles protons.

He called the center of atoms the nucleus.

Rutherford's Experiment

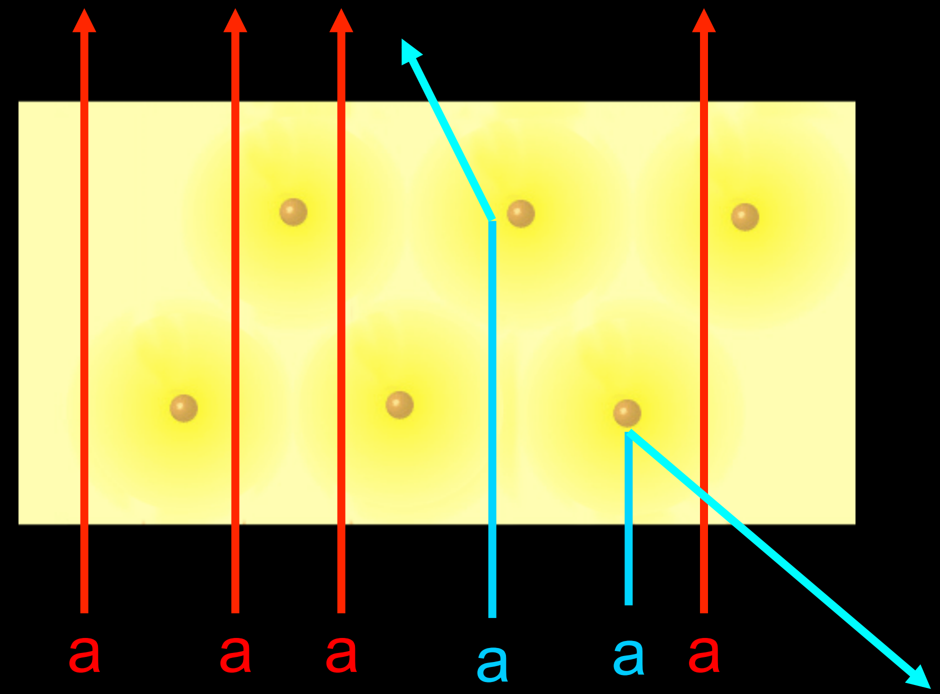


Rutherford's Experiment



Most α particles <u>went through</u> the gold.
The atom is mostly empty space.

Rutherford’s Experiment

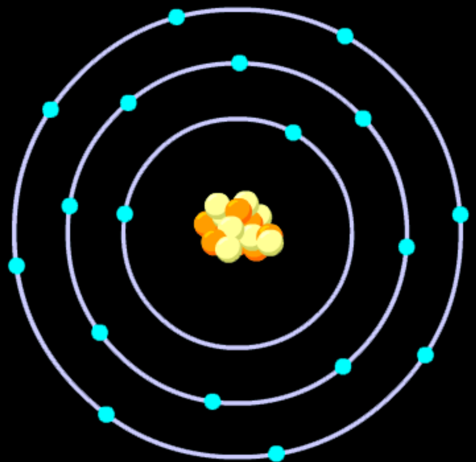


The atom had a very dense (+) center.
Rutherford called it the nucleus.

Niels Bohr (1913)

Niels Bohr improved on Rutherford's model.

He proposed that electrons move around the nucleus in specific layers, or shells.



Every atom has a specific number of electron shells.

James Chadwick (1932)

Chadwick discovered neutrons.

Working with Rutherford, he discovered particles with no charge.

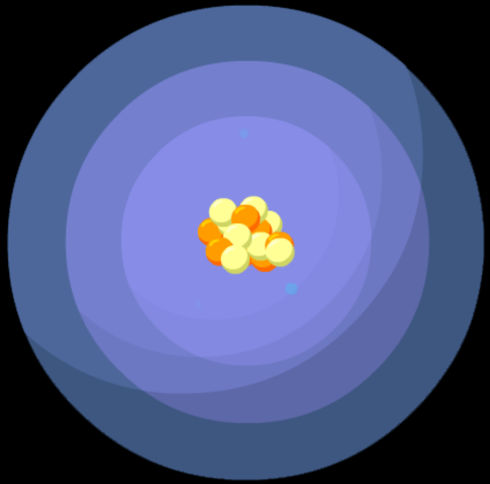
He called these particles neutrons.

Neutrons are also found in the nucleus.

The Modern Model (1932-)

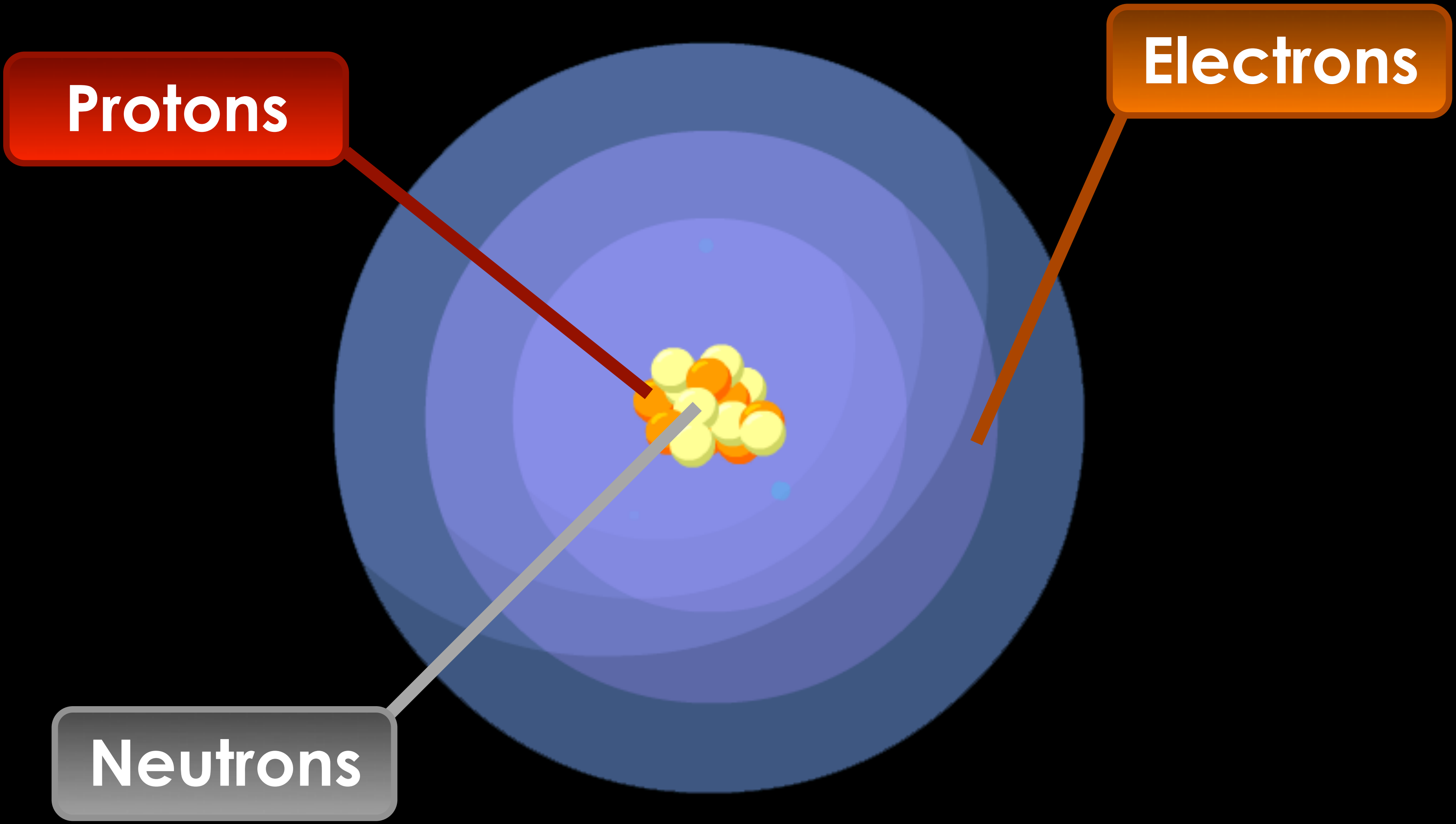
Work done since 1920 has changed the model.

The new atomic model has electrons moving around the nucleus in a cloud.

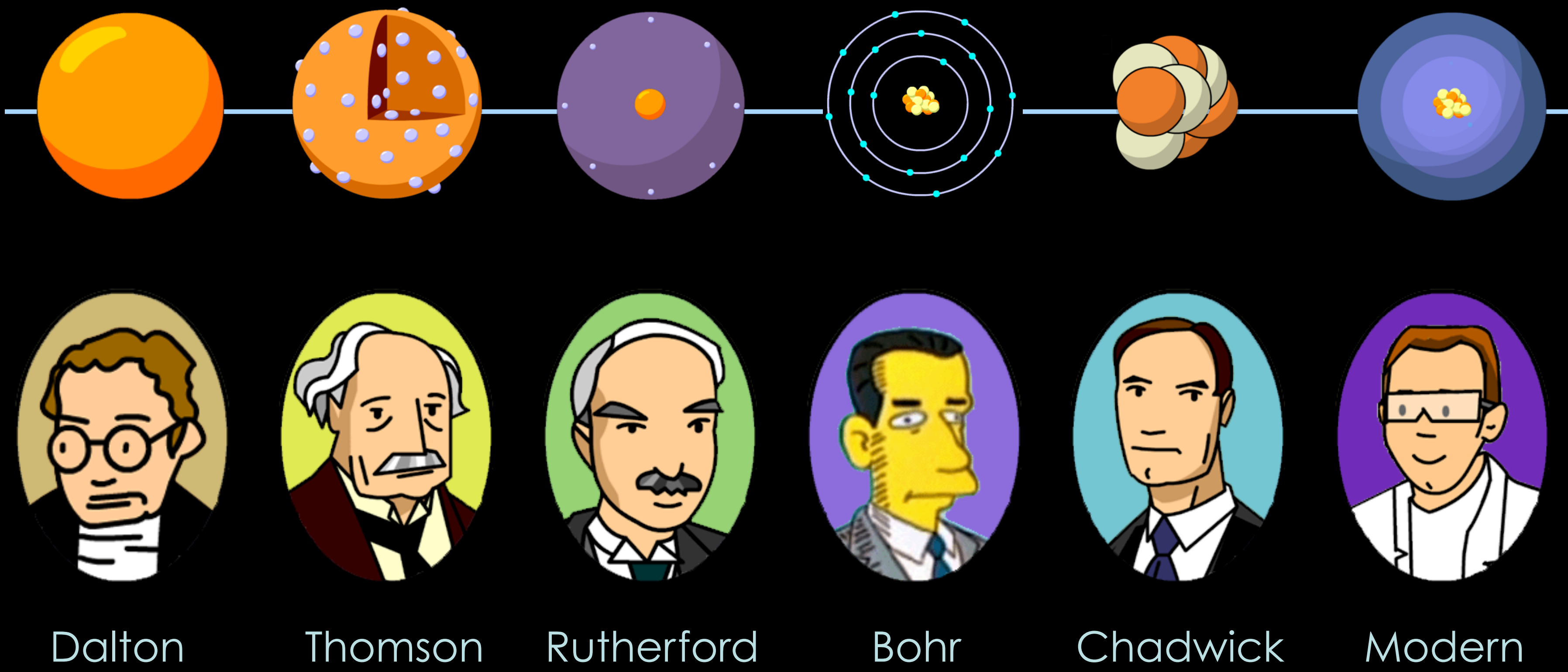


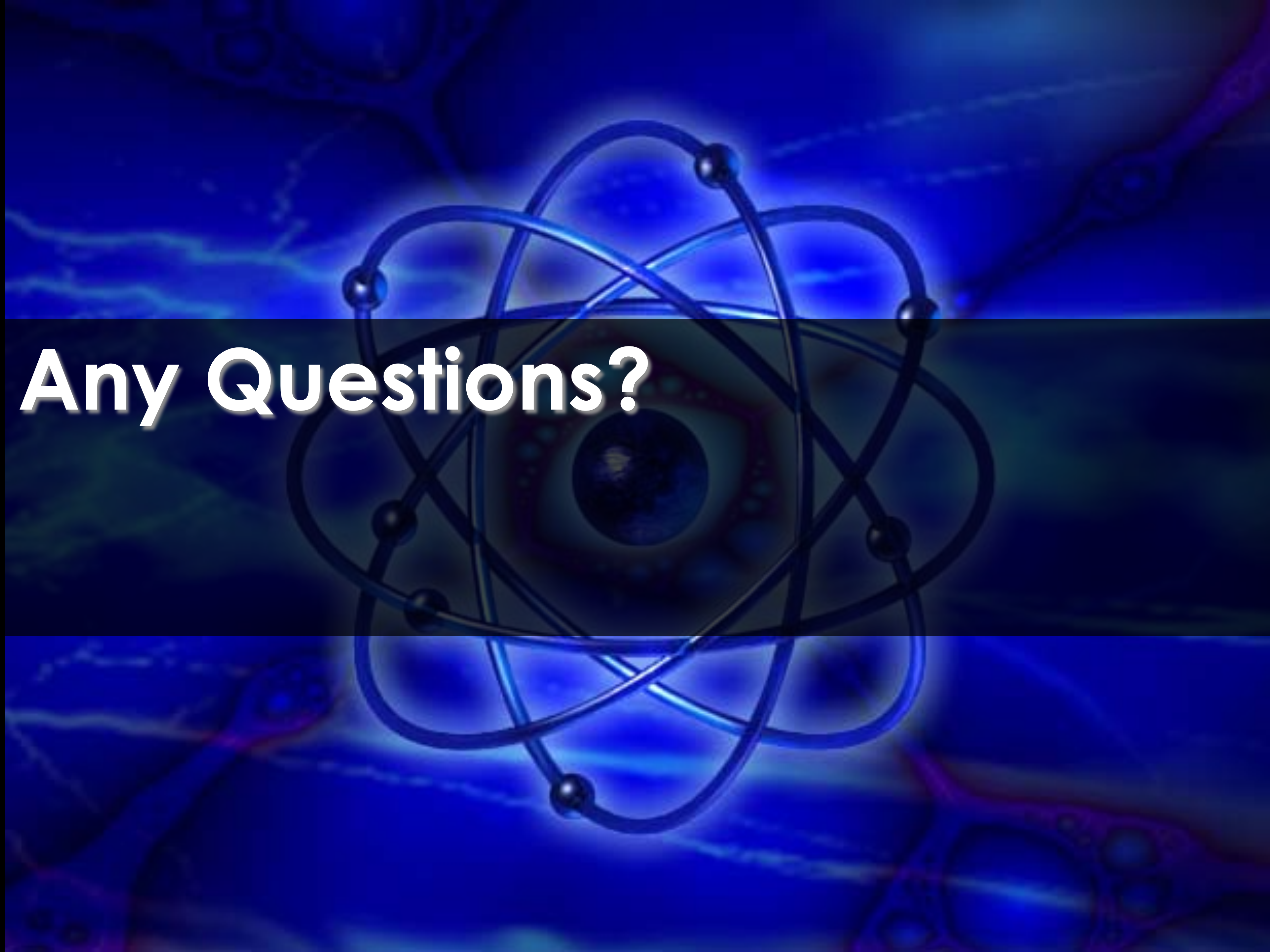
It is impossible to know where an electron is at any given time.

The Current Atomic Model



Atomic Theory Timeline




Any Questions?

Atoms, Elements, and the Periodic Table

Part 2: The Periodic Table

Periodic Table

There are ≈ 110 different elements in the universe.

The Periodic Table of Elements organizes these 110 elements in a simple way.

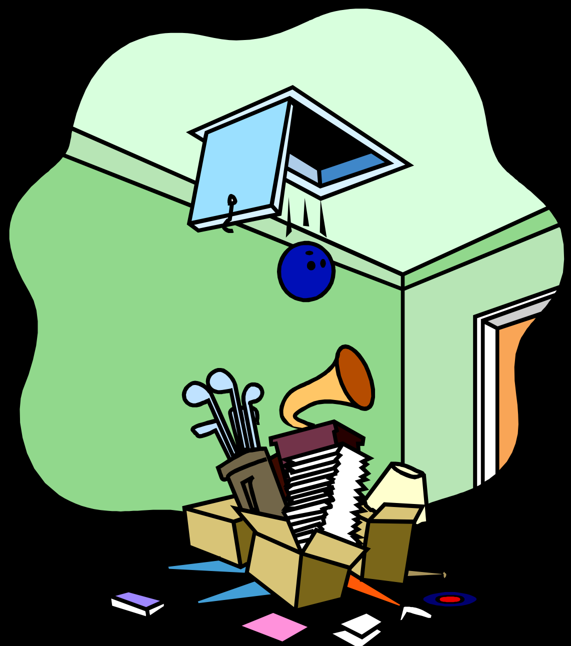
Remember!

Elements differ from each other by the # of protons, neutrons and electrons they have.

Before the Table

Before the Periodic Table was invented, the field of Chemistry was a gigantic mess!

The known elements were not organized in any way.



It was very difficult to find information on any element AND to predict how each element would react.

Before the Table

A Russian scientist named Dmitri Mendeleev discovered patterns in the properties of the elements.

I placed the elements in order of increasing atomic weight. When I did that, I noticed patterns in their properties and their reactivity.

Li 7	Be 9	B 11	C 12	N 14	O 16	F 19	

I put the first 7 known elements in a row by increasing atomic weight…

Li 7	Be 9	B 11	C 12	N 14	O 16	F 19	
Na 23	Mg 24	Al 27	Si 28	P 31	S 32	Cl 35.5	
K 39	Ca 40		Ti 48	V 51	Cr 52	Mn 55	Fe 56 Ni 59
Cu 63	Zn 65			As 75	Se 78	Br 80	
Rb 85	Sr 87		Zr 90	Nb 94	Mo 96		Pd 106

Then I put the next 7 in a new row, and filled rest of the table like that.

Li 7	Be 9	B 11	C 12	N 14	O 16	F 19	
Na 23	Mg 24	Al 27	Si 28	P 31	S 32	Cl 35.5	
K 39	Ca 40	? 44	Ti 48	V 51	Cr 52	Mn 55	Fe 56 Ni 59
Cu 63	Zn 65	? 68	? 72	As 75	Se 78	Br 80	
Rb 85	Sr 87	? 88	Zr 90	Nb 94	Mo 96	? 100	Pd 106

I left gaps for elements that I predicted would be discovered.

Li 7	Be 9	B 11	C 12	N 14	O 16	F 19	
Na 23	Mg 24	Al 27	Si 28	P 31	S 32	Cl 35.5	
K 39	Ca 40	? 44	Ti 48	V 51	Cr 52	Mn 55	Fe 56 Ni 59
Cu 63	Zn 65	? 68	? 72	As 75	Se 78	Br 80	
Rb 85	Sr 87	? 88	Zr 90	Nb 94	Mo 96	? 100	Pd 106

Elements in the same column share similar chemical properties.

Li 7	Be 9	B 11	C 12	N 14	O 16	F 19	
Na 23	Mg 24	Al 27	Si 28	P 31	S 32	Cl 35.5	
K 39	Ca 40	? 44	Ti 48	V 51	Cr 52	Mn 55	Fe 56 Ni 59
Cu 63	Zn 65	? 68	? 72	As 75	Se 78	Br 80	
Rb 85	Sr 87	? 88	Zr 90	Nb 94	Mo 96	? 100	Pd 106

This allowed me to even predict the properties of the <u>unknown</u> elements.

Li 7	Be 9	B 11	C 12	N 14	O 16	F 19	
Na 23	Mg 24	Al 27	Si 28	P 31	S 32	Cl 35.5	
K 39	Ca 40	Sc 44	Ti 48	V 51	Cr 52	Mn 55	Fe 56 Ni 59
Cu 63	Zn 65	Ga 68	Ge 72	As 75	Se 78	Br 80	
Rb 85	Sr 87	Y 88	Zr 90	Nb 94	Mo 96	Tc 100	Pd 106

The elements were soon found, and they matched my predictions!

Mendeleev's Table

Mendeleev was amazingly accurate with his table.

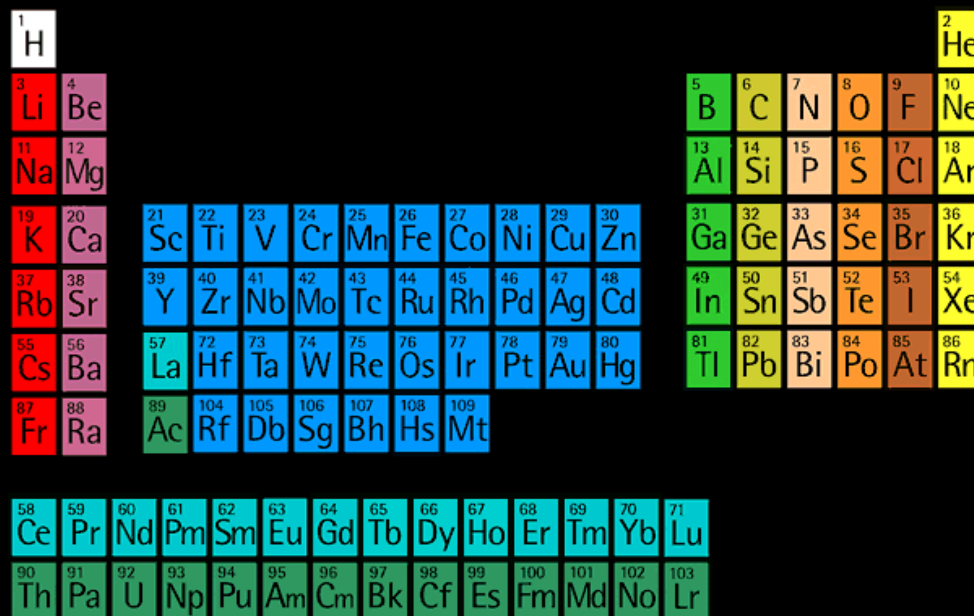
The Periodic Table has been updated since then with new elements and information.

Once protons were discovered, elements were rearranged by atomic number.

Some elements changed spots, making the pattern of properties even more regular.

The New Table

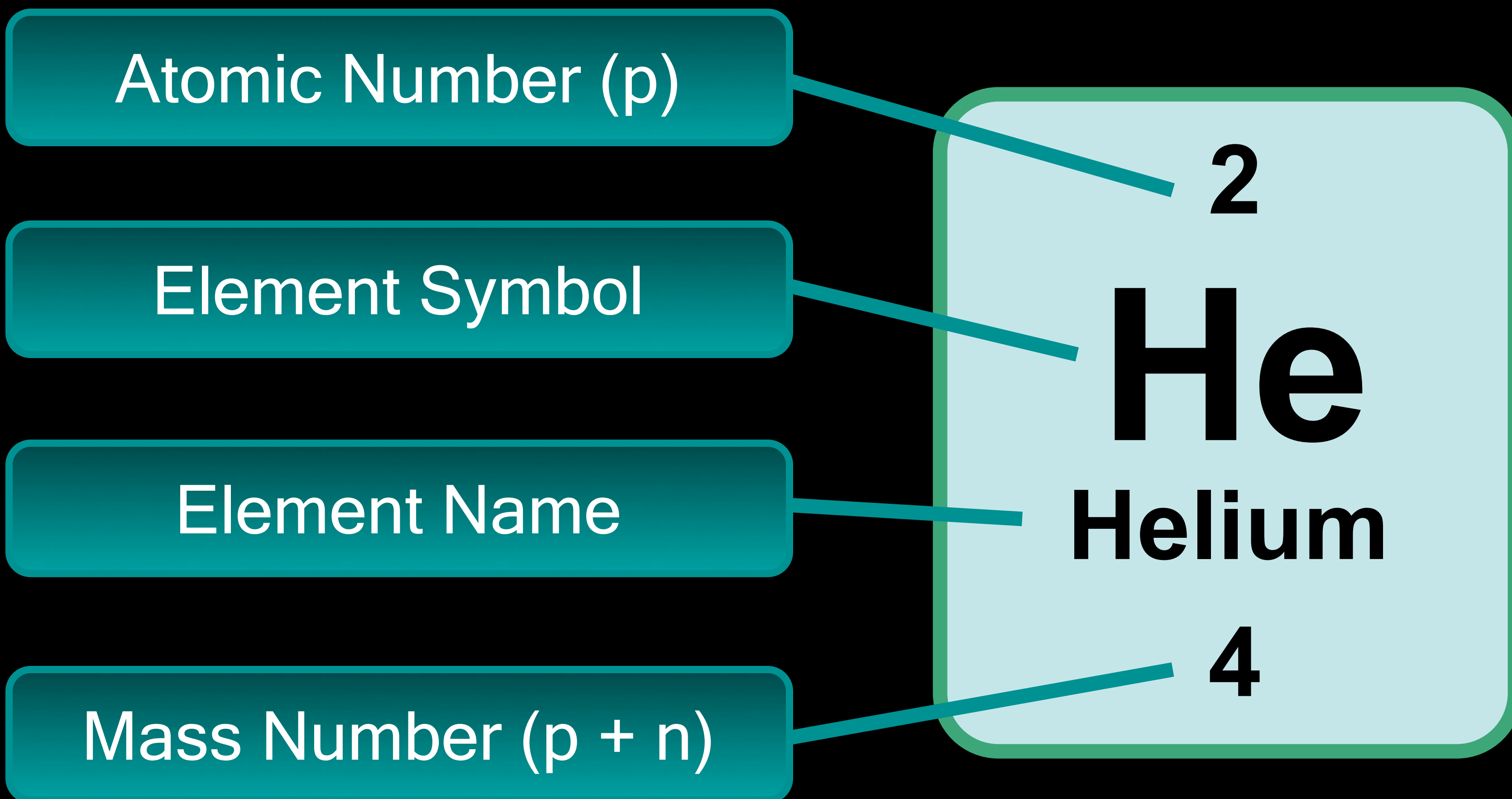
The new periodic table has over 100 squares.



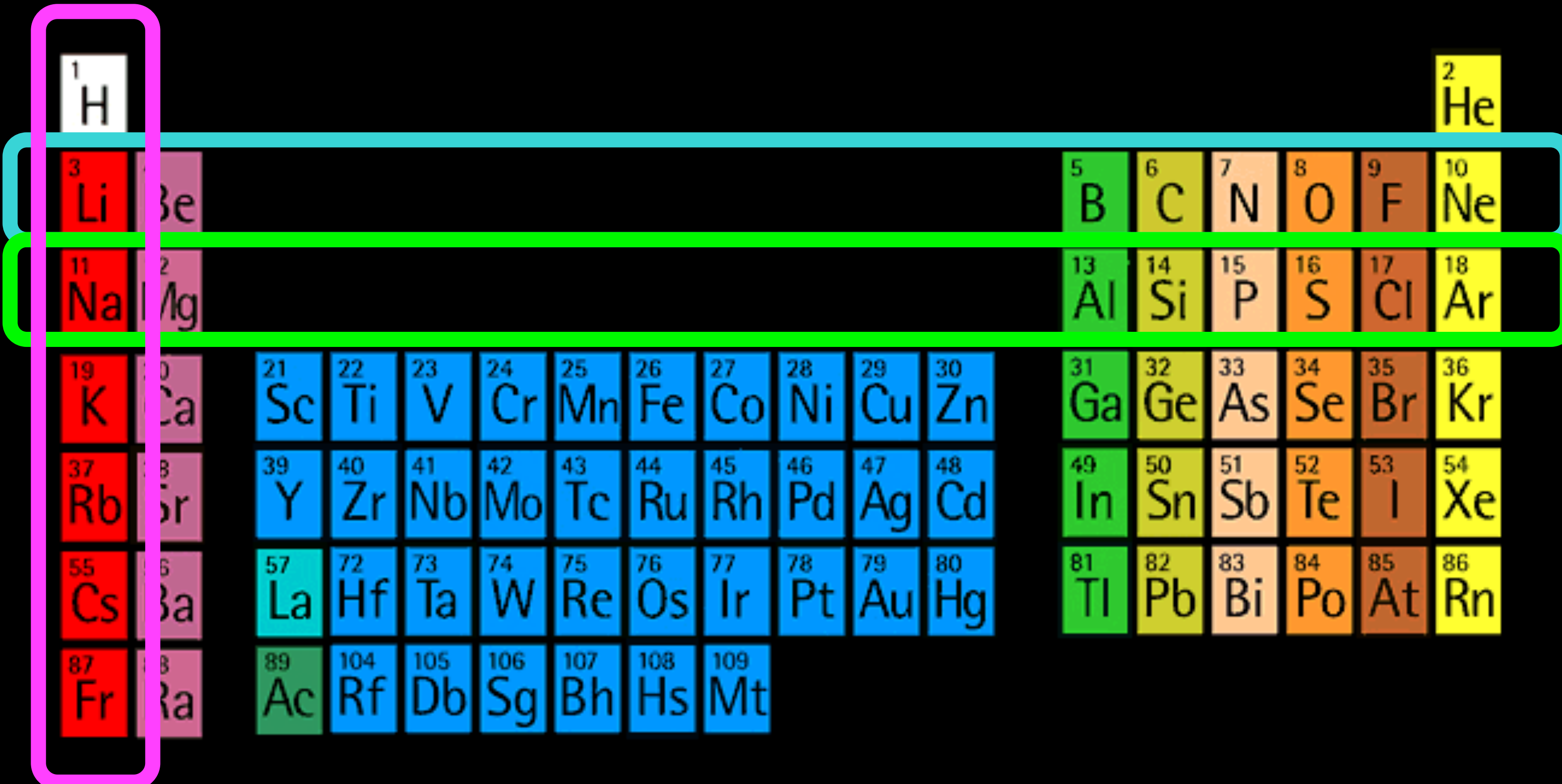
Each square shows the element’s name, symbol, atomic number and atomic mass…

Element Information

Take the element Helium, for example:

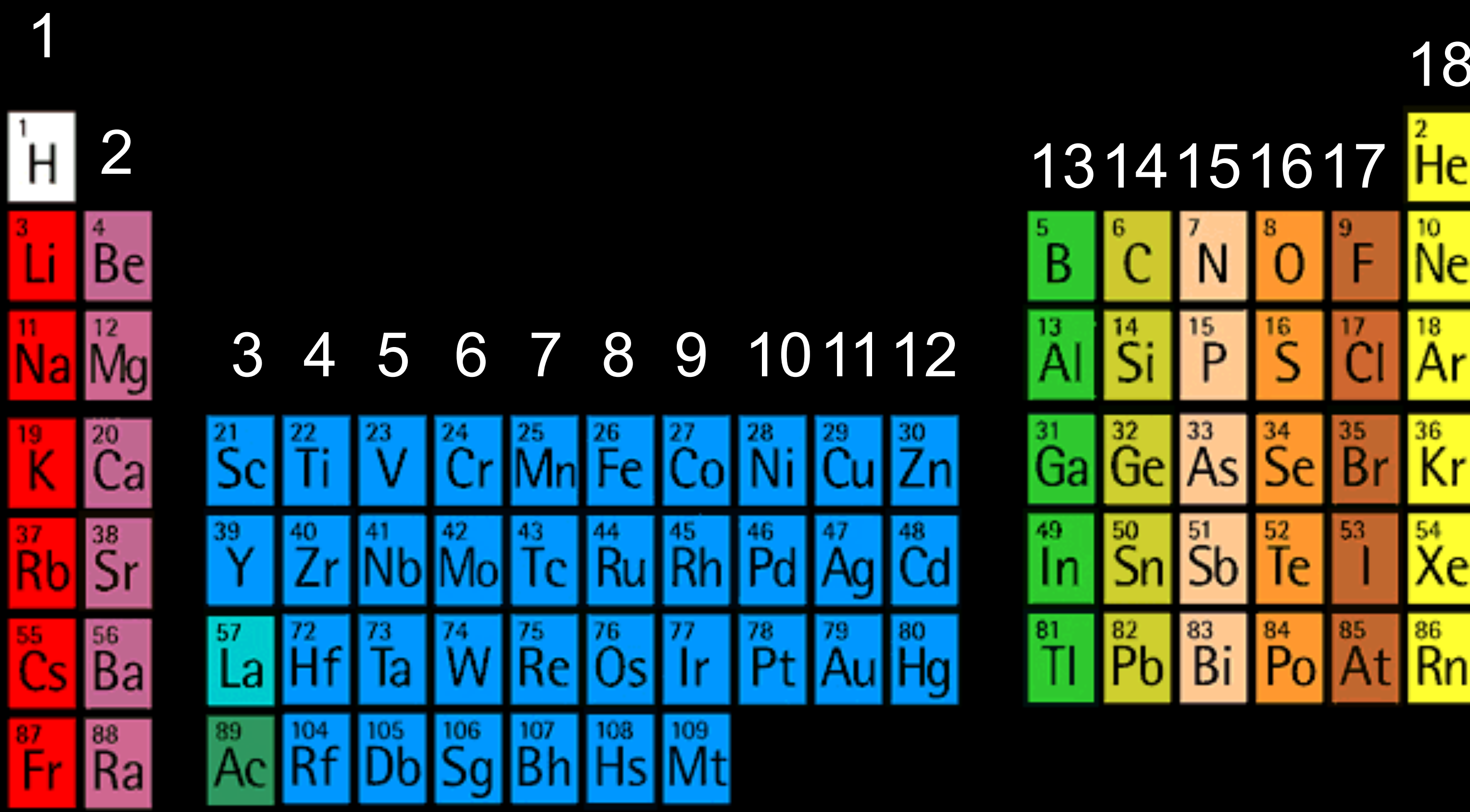


A row is called a “period”.



A column is called a “group”.

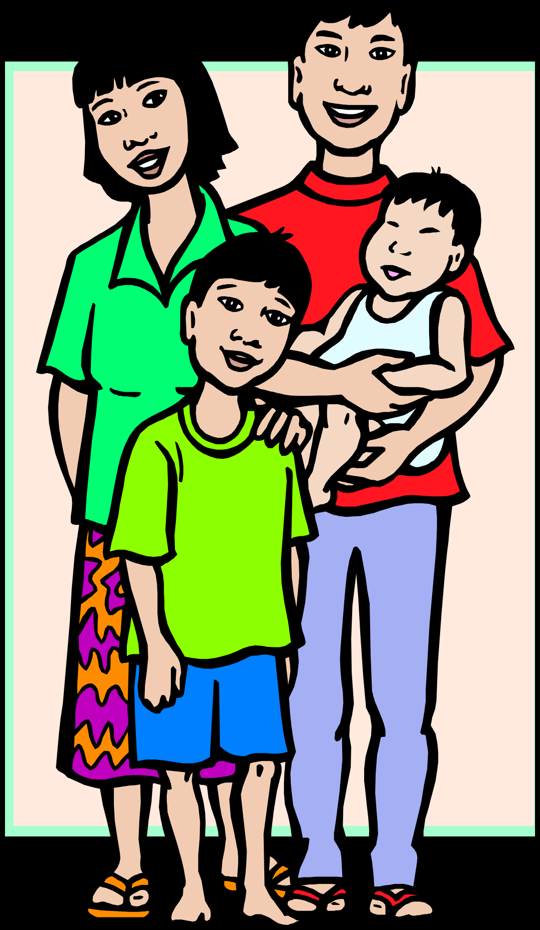
The groups are numbered from left to right.



Elements in the same group have similar properties.

Groups

Each group is also called a “family” of elements.

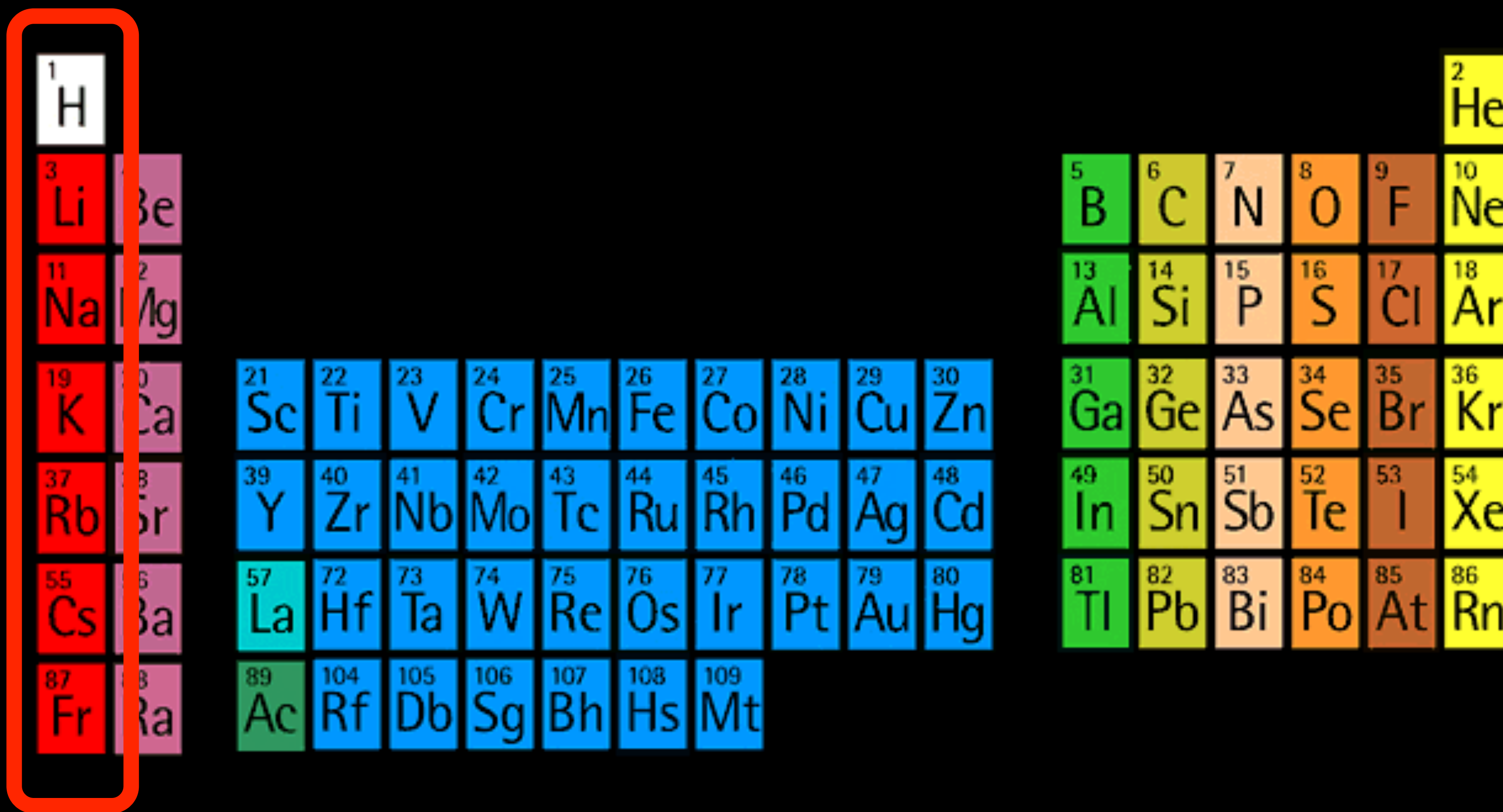


Just like members of the same family, they share similar characteristics.

Each element family has a unique name as well!

Let’s look at them now…

Groups



Gp 1 - Alkali Metals

Gp 1: Alkali Metals

HIGHLY reactive metals.

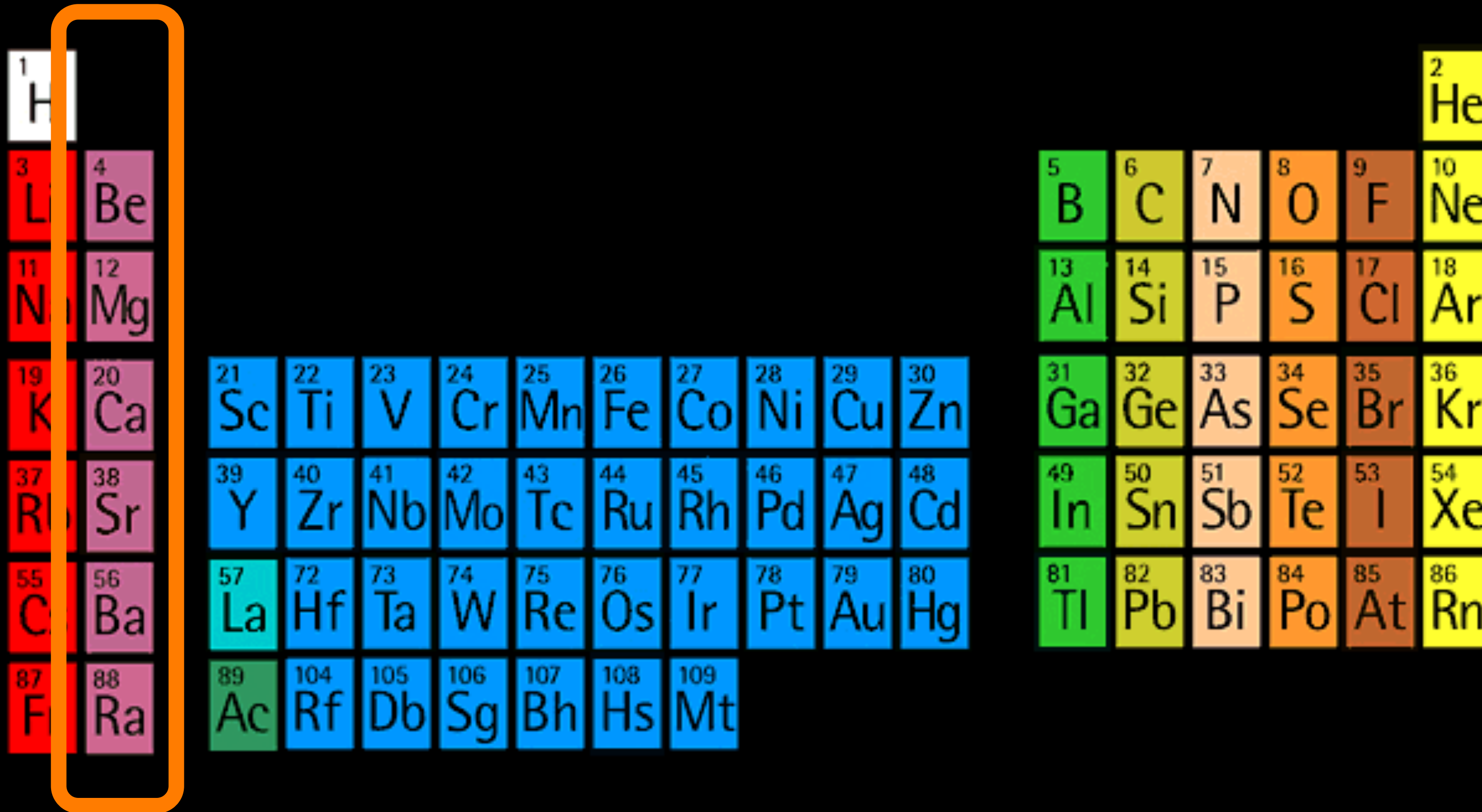
Sodium (Na)

They are so reactive that they are never found uncombined in nature.

Metals soft enough to be cut with a butter knife!

e.g. Li, Na, K

Groups



Gp 2 – Alkaline Earth Metals

Gp 2: Alkaline Earth Metals

Fairly reactive metals.

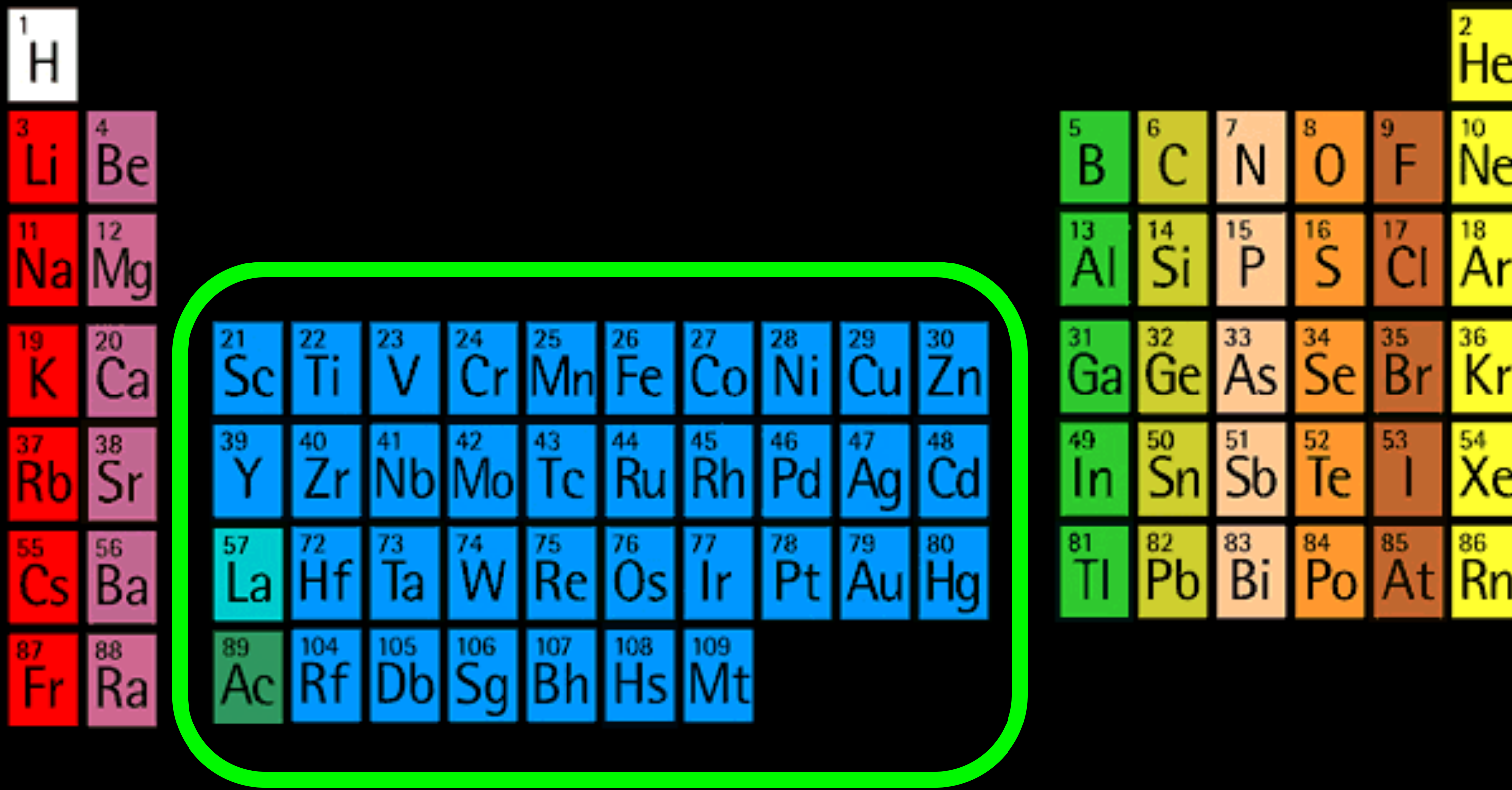
Not as reactive as the Alkali Metals, but still never found uncombined in nature.

Serve as important minerals for our body.

e.g. Be, Mg, Ca

Calcium (Ca)

Groups



Gps 3-12 – Transition Metals

Gp 3-12: Transition Metals

Less reactive metals.

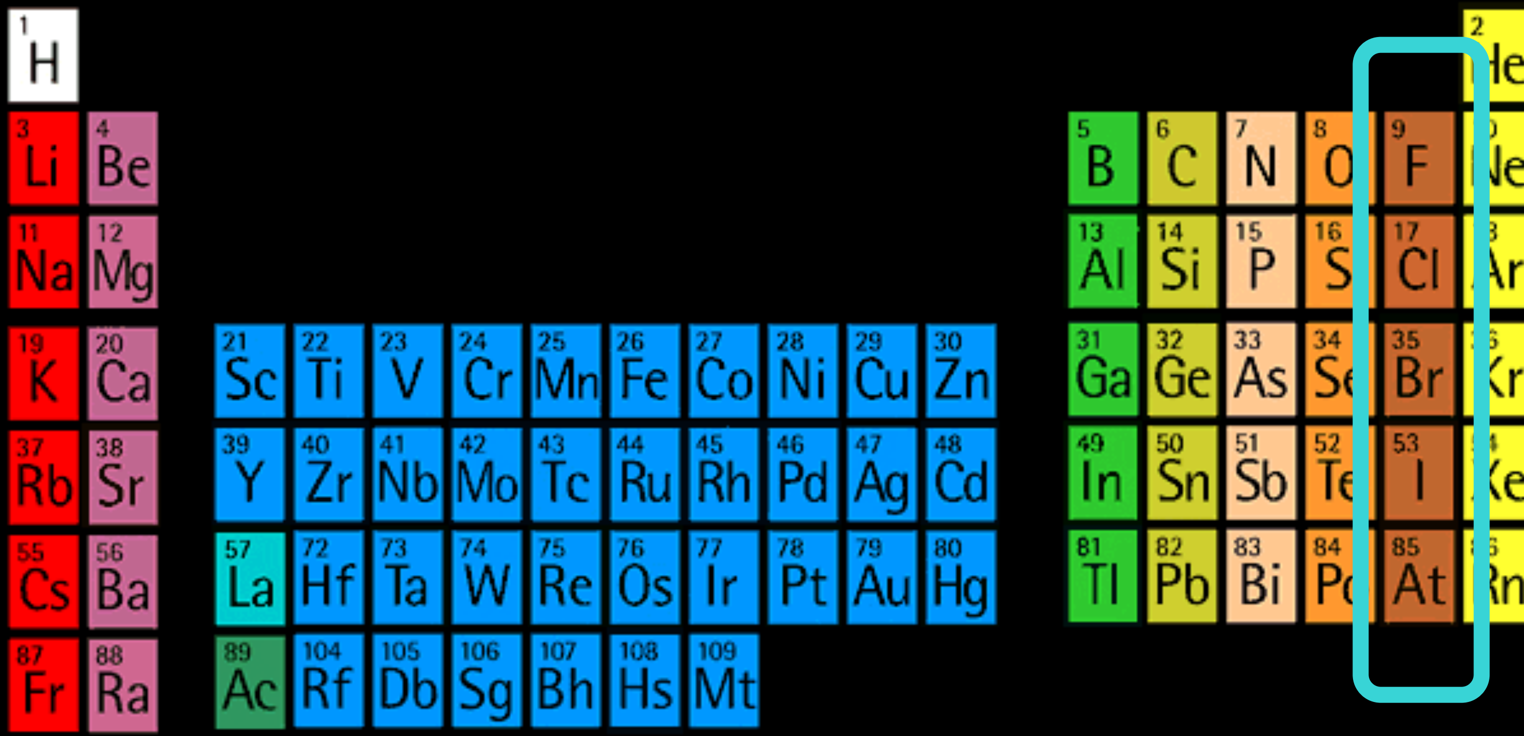
Nickel (Ni)
Gold (Au)

Hard, dense metals that are useful as building materials, jewellery and coins.

Also used as oxides to make paints and pigments.

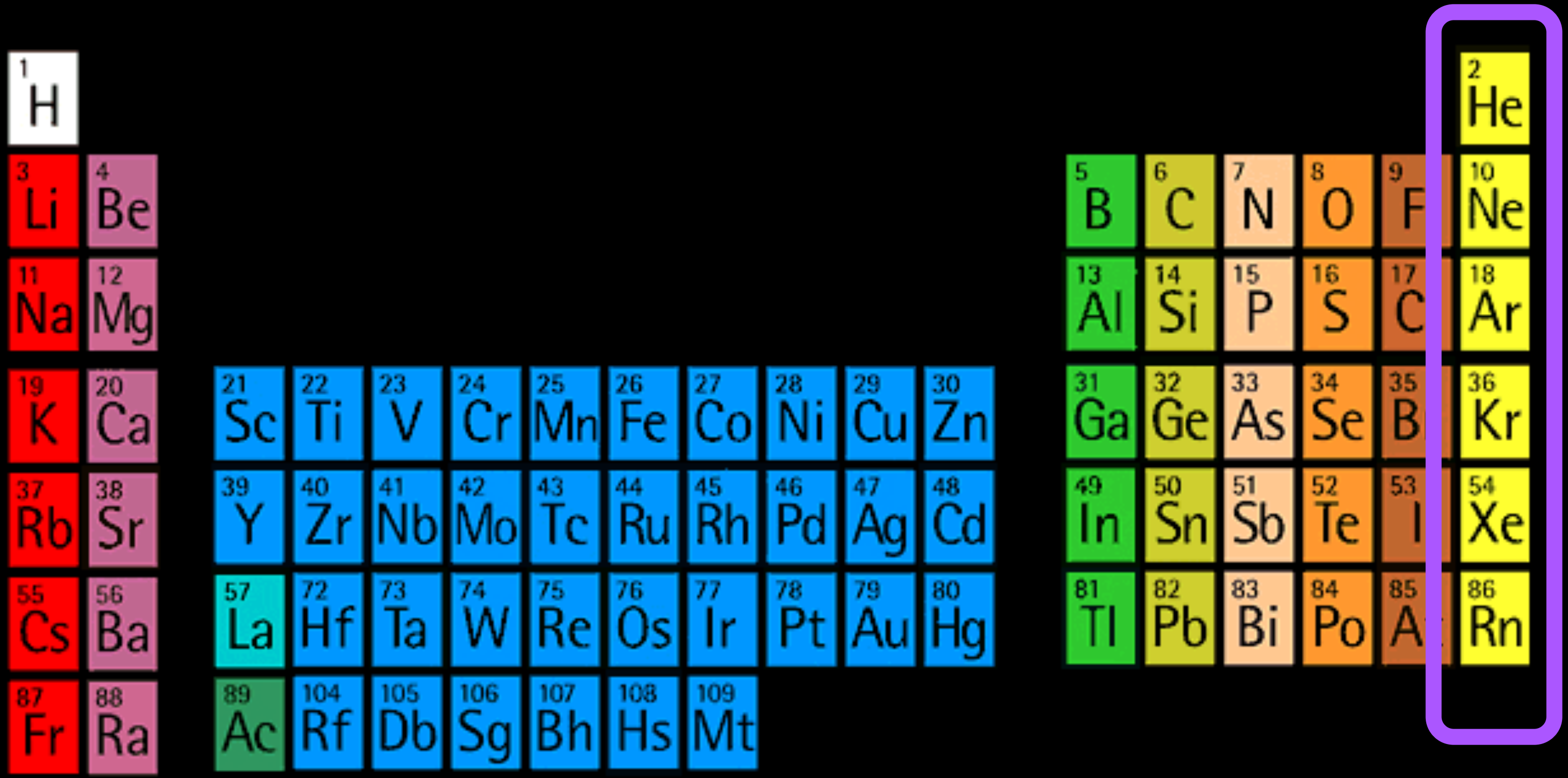
e.g. Fe, Cu, Au, Ag

Groups



Gp 17 - Halogens

Groups



Gp 18 - Noble Gases

Gp 18: Noble Gases

Unreactive gases.

Neon (Ne)

Do not react naturally - always found on their own in nature.

Used in “neon” signs, balloons and light bulbs.

e.g. He, Ne, Ar

Any Questions?

Atoms, Elements, and the Periodic Table

Part 3: Isotopes

Review

Each element has a unique # of **protons**.

Every single atom of that element must have the same number of protons.

So, each element has a unique **atomic number**.

Atomic Number (p)

6
C
Carbon
12

Isotopes

Atoms of one element must have the same # of protons, but can have a different # of neutrons.

__Isotopes__ are atoms with the same # of protons and a different # of neutrons.

This gives an isotope a different **__mass number__**.

Mass Number (p + n)

6	6
C	C
Carbon	Carbon
14	12

An Example

There are 3 isotopes of oxygen:

8	8	8
O	O	O
Oxygen	Oxygen	Oxygen
16	17	18

Each has 8 protons: that's why it's oxygen!

How many neutrons does each isotope have?

An Example

There are 3 isotopes of oxygen:

8	8	8
8 neutrons	9 neutrons	10 neutrons
16	17	18

Each has 8 protons: that's why it's oxygen!

How many neutrons does each isotope have?

A Second Example

There are 3 isotopes of carbon:

6	6	6
C	C	C
Carbon	Carbon	Carbon
12	13	14

How many neutrons does each isotope have?

A Second Example

There are 3 isotopes of carbon:

6	6	6
4 neutrons	5 neutrons	6 neutrons
12	13	14

How many neutrons does each isotope have?

Why Decimals?

Mass numbers are normally **decimals**.

6

C

Carbon

12.001

Why is this?

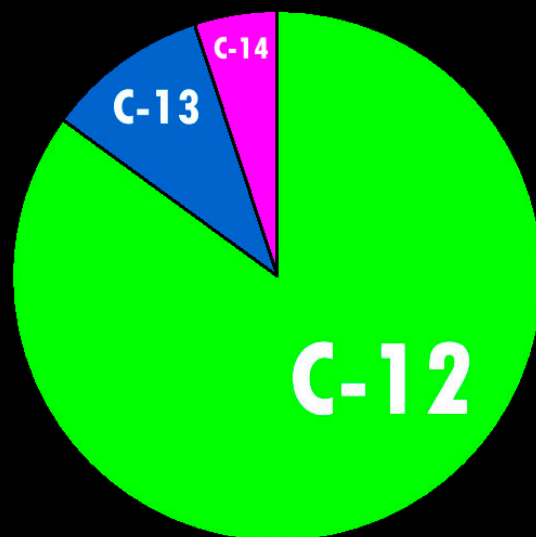
Mass numbers are decimals because some isotopes are <u>more common</u> than others.

Lets's look at an example….

Why Decimals?

In the universe, there is much more C-12 than C-13 and C-14 isotopes.

6
C
Carbon
12.001



The mass # is always closest to the <u>most common</u> isotope.

When you average out all of the masses, you get a number close to 12, but not exactly!

An Example

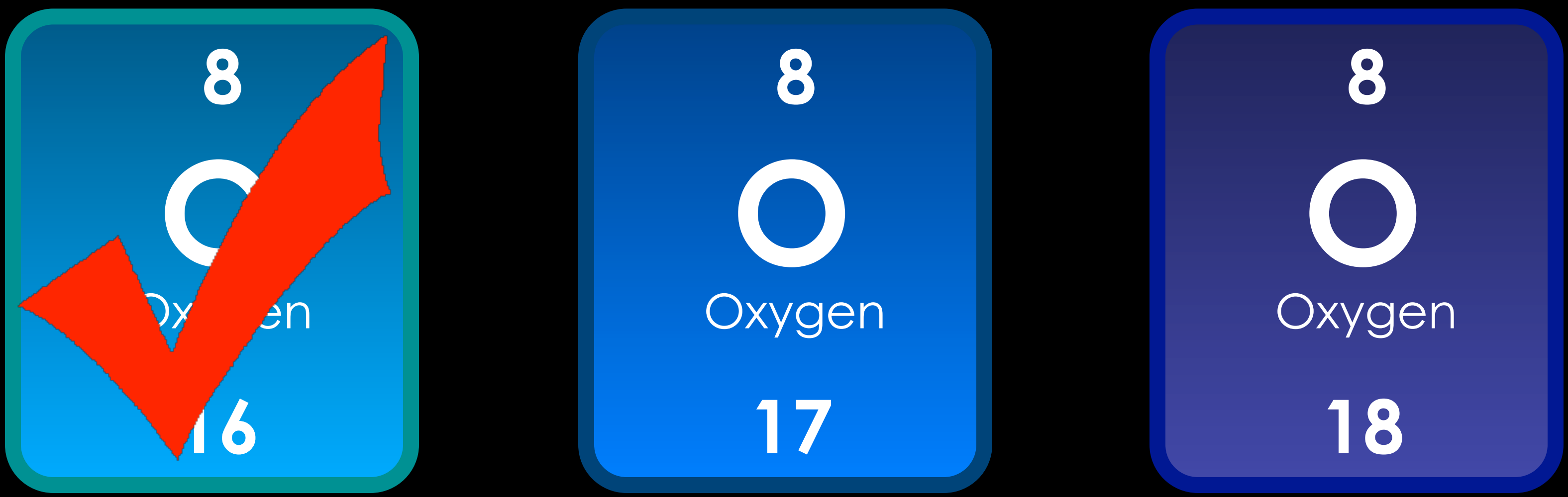
The mass number of oxygen is 15.999

8	8	8
O	O	O
Oxygen	Oxygen	Oxygen
16	17	18

What's the most common oxygen isotope?

An Example

The mass number of oxygen is 15.999



What's the most common oxygen isotope?

This is because 15.999 is closest to O-16.

Another Example

The mass number of chlorine <u>35.45</u>

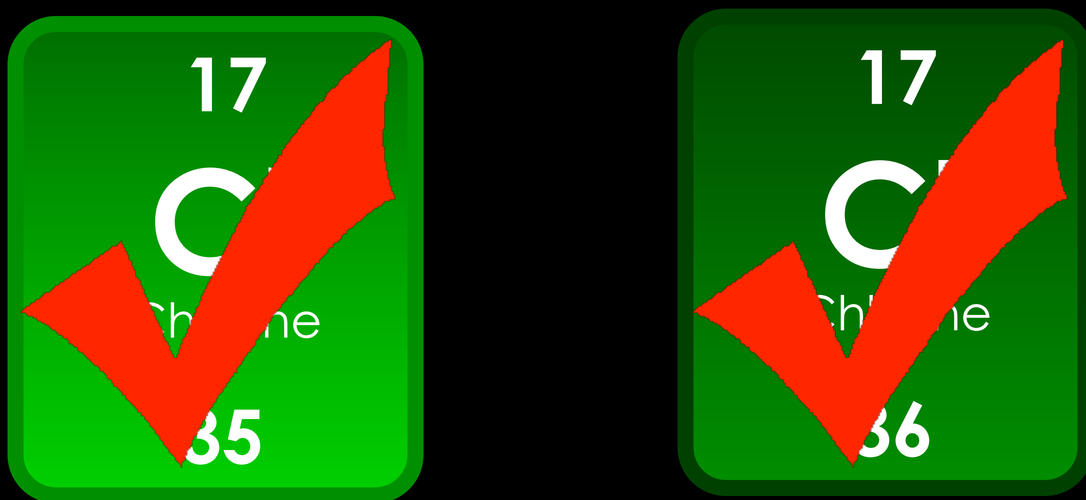
17
Cl
Chlorine
35

17
Cl
Chlorine
36

What is the most common chlorine isotope?

Another Example

The mass number of chlorine <u>35.45</u>



What is the most common chlorine isotope?

Chlorine is found in <u>roughly</u> equal amounts.

Any Questions?