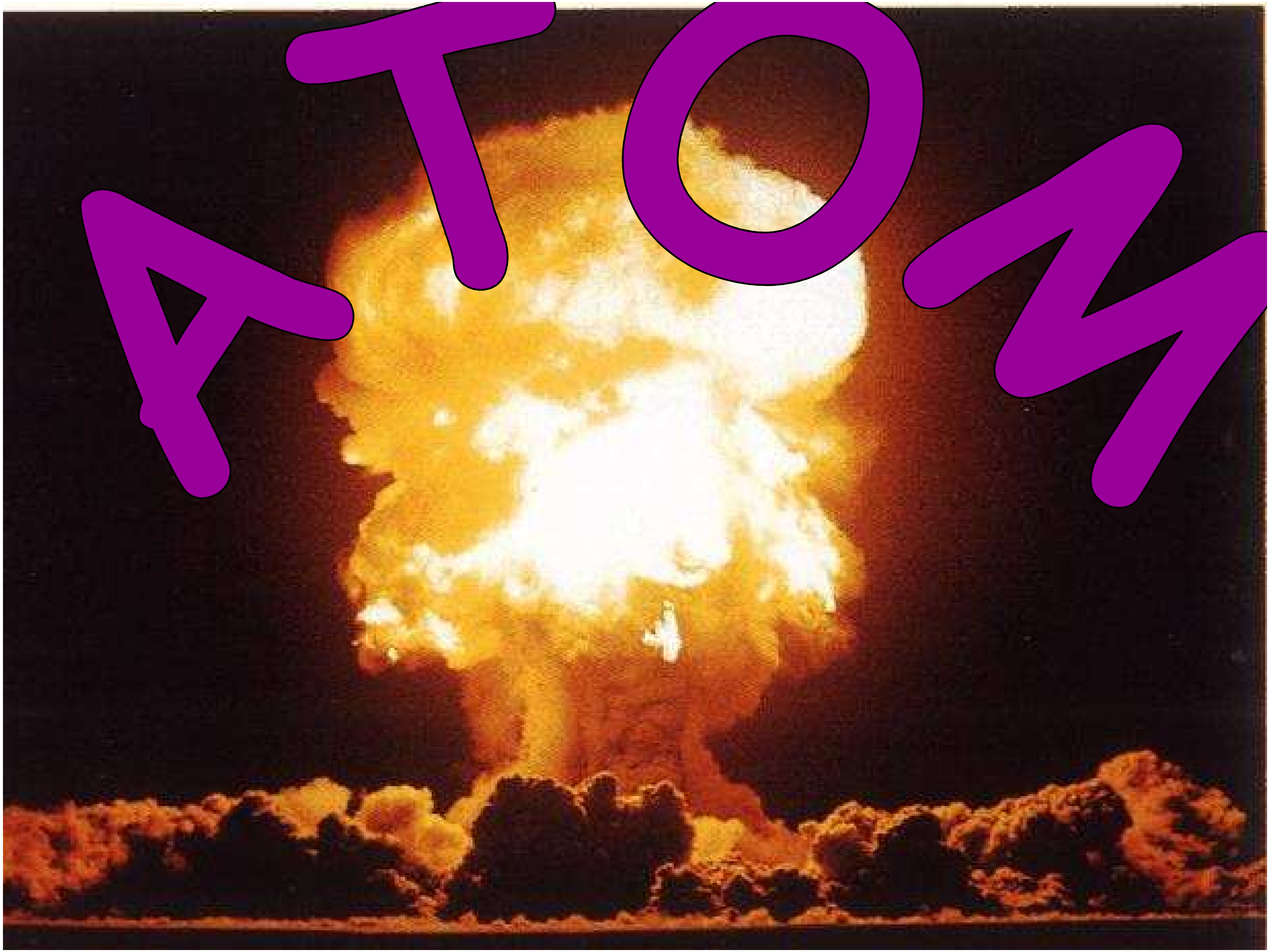
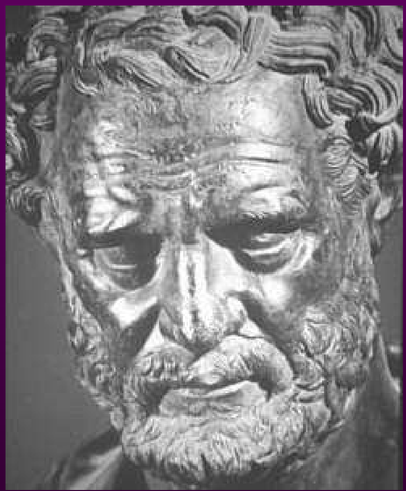

ATOM

What is the World Made of?

- Ancient times – 4 elements
- 19th century – atoms
- Early 20th century – electrons, protons, neutrons
- Today – quarks and leptons

HISTORY OF THE ATOM

460 BC Democritus develops the idea of atoms



he pounded up materials in his pestle and mortar until he had reduced them to smaller and smaller particles which he called

ATOMA

(*greek for indivisible*)

Dificulties in clasic physics

- Discreate matter properties
- Discreate electricity properties
- Discreate wave radiation properties

HISTORY OF THE ATOM

1808 John Dalton

suggested that all matter was made up of tiny spheres that were able to bounce around with perfect elasticity and called them

ATOMS

HISTORY OF THE ATOM

1898 Joseph John Thompson

found that atoms could sometimes eject a far smaller negative particle which he called an

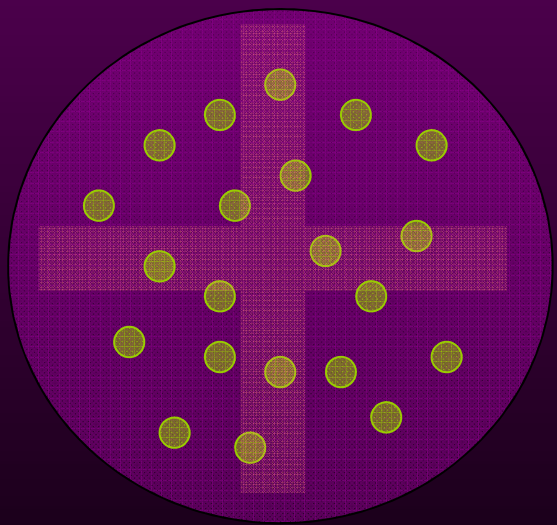
ELECTRON

HISTORY OF THE ATOM

1904

Thompson develops the idea that an atom was made up of electrons scattered unevenly within an elastic sphere surrounded by a soup of positive charge to balance the electron's charge

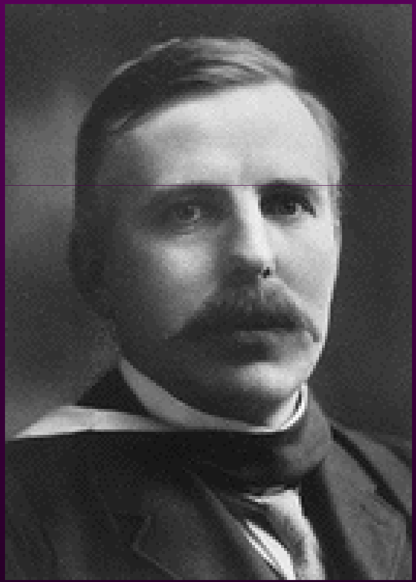
like plums surrounded by pudding.



PLUM PUDDING MODEL

HISTORY OF THE ATOM

1910 Ernest Rutherford

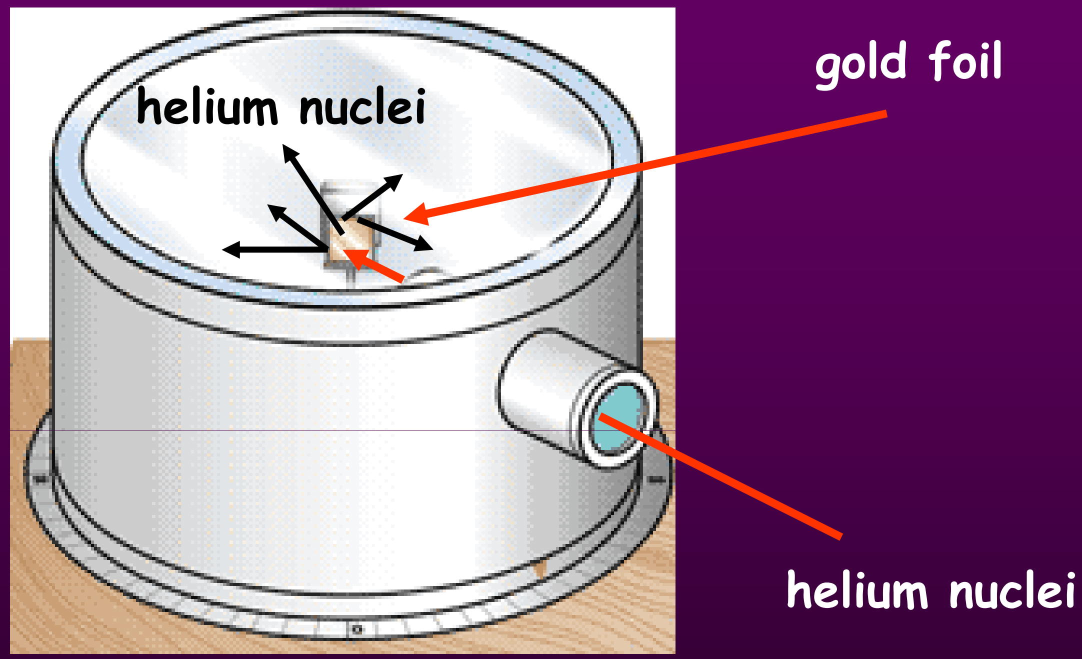


oversaw Geiger and Marsden carrying out his famous experiment.

they fired Helium nuclei at a piece of gold foil which was only a few atoms thick.

they found that although most of them passed through. About 1 in 10,000 hit

HISTORY OF THE ATOM



They found that while most of the helium nuclei passed through the foil, a small number were deflected and, to their surprise, some helium nuclei bounced straight back.

HISTORY OF THE ATOM

Rutherford's new evidence allowed him to propose a more detailed model with a **central nucleus**.

He suggested that the **positive charge** was all in a central nucleus. With this holding the electrons in place by electrical attraction

However, this was not the end of the story.

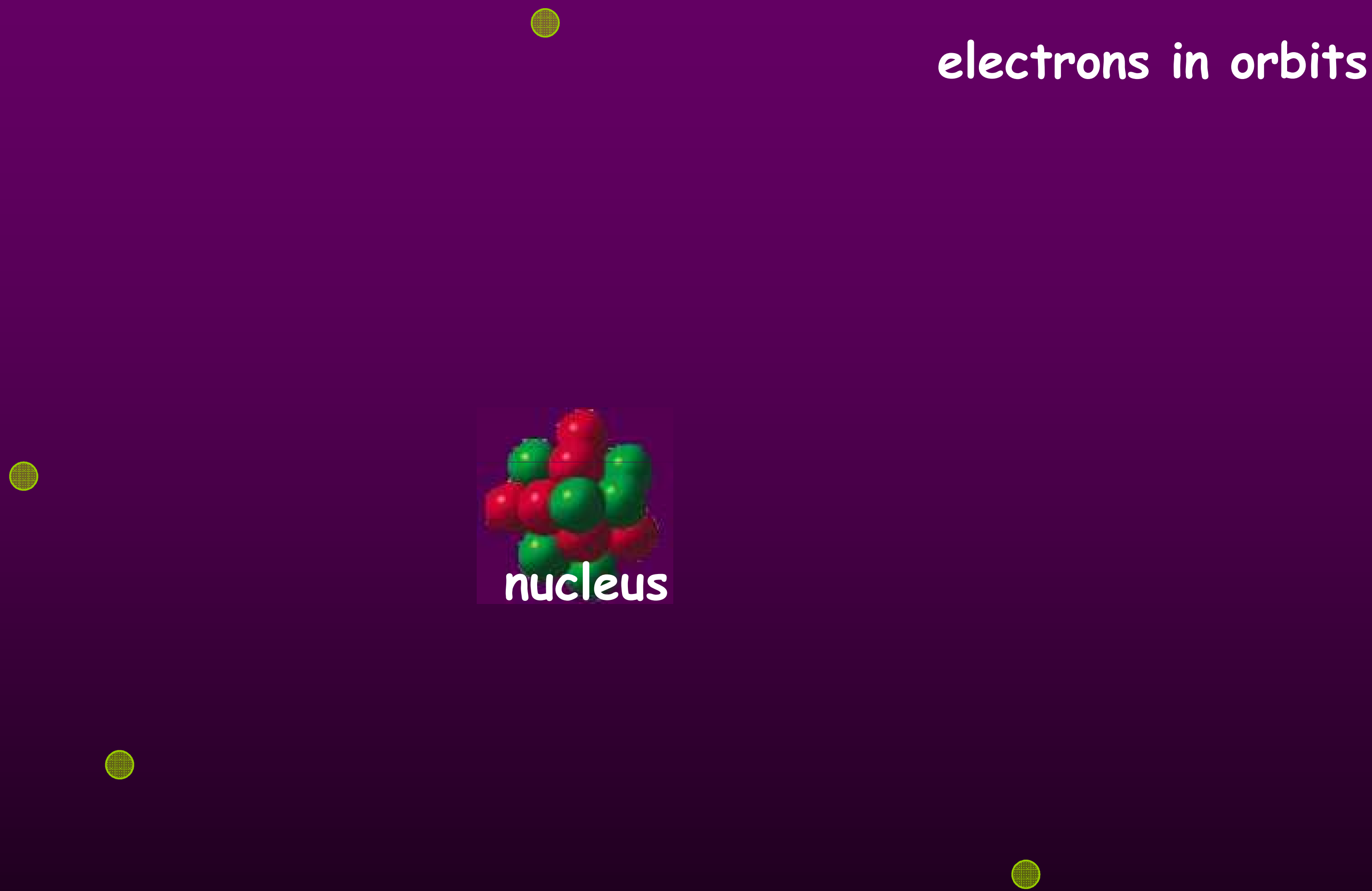
HISTORY OF THE ATOM

1913 Niels Bohr

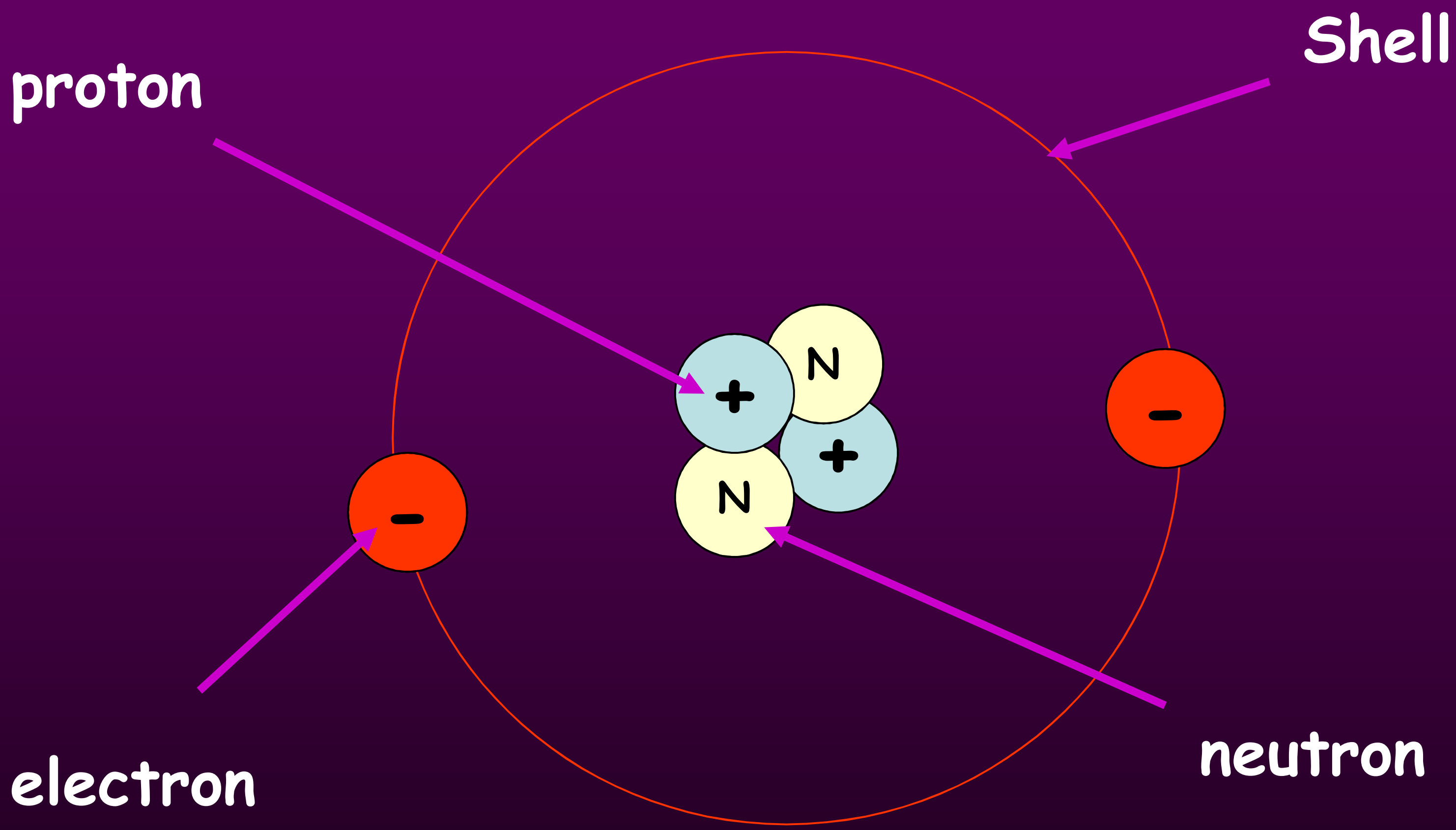
studied under Rutherford at the Victoria University in Manchester.

Bohr refined Rutherford's idea by adding that the electrons were in **orbits**. Rather like planets orbiting the sun. With each orbit only able to contain a set number of electrons.

Bohr's Atom



HELIUM ATOM



What do these particles consist of?

ATOMIC STRUCTURE

Particle	Charge	Mass
proton	+ ve charge	1
neutron	No charge	1
electron	-ve charge	nil

ATOMIC STRUCTURE

He

2 <u>Atomic number</u>

the number of protons in an atom

4 <u>Atomic mass</u>

the number of protons and neutrons in an atom

number of electrons = number of protons

ATOMIC STRUCTURE

Electrons are arranged in Energy Levels or Shells around the nucleus of an atom.

- first shell → a maximum of 2 electrons
- second shell → a maximum of 8 electrons
- third shell → a maximum of 8 electrons

ATOMIC STRUCTURE

There are two ways to represent the atomic structure of an element or compound;

1. Electronic Configuration

2. Dot & Cross Diagrams

ELECTRONIC CONFIGURATION

With electronic configuration elements are represented **numerically** by the number of electrons in their shells and number of shells. For example;

Nitrogen → configuration = 2 , 5

2 in 1st shell

5 in 2nd shell

2 + 5 = 7 → N^{7}_{14}

Since Democritus, much work was done that led to the understanding that the “atom” was actually composed of three smaller particles (electrons, protons, and neutrons).

As late as the 1930s these subatomic particles were thought to be indivisible, elementary (“having no smaller constituent parts”) or structureless.

Since the 1930s, it was determined that the proton and neutron, along with 100+ other particles, are composed of yet smaller particles known as quarks/antiquarks. These particles composed of the new quarks/antiquarks are collectively called hadrons.

Electrons, part of a larger group collectively known as leptons, continue to appear structureless/fundamental or elementary in nature.

Currently, the leptons and quarks appear to qualify as the true fundamental/elementary particles; meaning without structure.

FERMIONS

matter constituents
spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2

Flavor		Mass GeV/c²	Electric charge
ν_e	electron neutrino	$<1\times10^{-8}$	0
e	electron	0.000511	–1
ν_μ	muon neutrino	<0.0002	0
μ	muon	0.106	–1
ν_τ	tau neutrino	<0.02	0
τ	tau	1.7771	–1

Quarks spin = 1/2

Flavor		Approx. Mass GeV/c²	Electric charge
u	up	0.003	2/3
d	down	0.006	–1/3
c	charm	1.3	2/3
s	strange	0.1	–1/3
t	top	175	2/3
b	bottom	4.3	–1/3

Matter and Antimatter

- For every particle ever found, there is a corresponding antimatter particle or antiparticle
- They look just like matter but have the opposite charge
- Particles are created or destroyed in pairs

All matter particles of the Standard Model also have corresponding antimatter particles. These particles breakdown into groups of quarks (up, down, strange, charm, top, and bottom) and leptons (electron, muon, tau, and corresponding neutrinos).

Quarks and leptons are further grouped into sets known as generations.

Quarks carry color charges (red, blue, or green) so they participate in strong interactions.

The up, charm, and top quarks carry the electric charge (+2/3).

The down, strange, and bottom quarks carry the electric charge (-1/3).

This allows the quarks to participate in electromagnetic interaction.

Leptons are color neutral and do not participate in strong interaction.

The electron, muon, and tau particles carry the electric charge (-1) and participate electromagnetic interaction.

Neutrinos have no electric charge and do not participate in electromagnetic interactions.

Quarks and leptons carry flavor charges and participate in weak nuclear interactions.

Particles can decay

- Particles may decay, i.e. transform from one to another
- Most are unstable
- Proton and electron are stable
- Neutron can decay to electron and a proton
- Energy appears to be missing. It is carried off by a neutrino