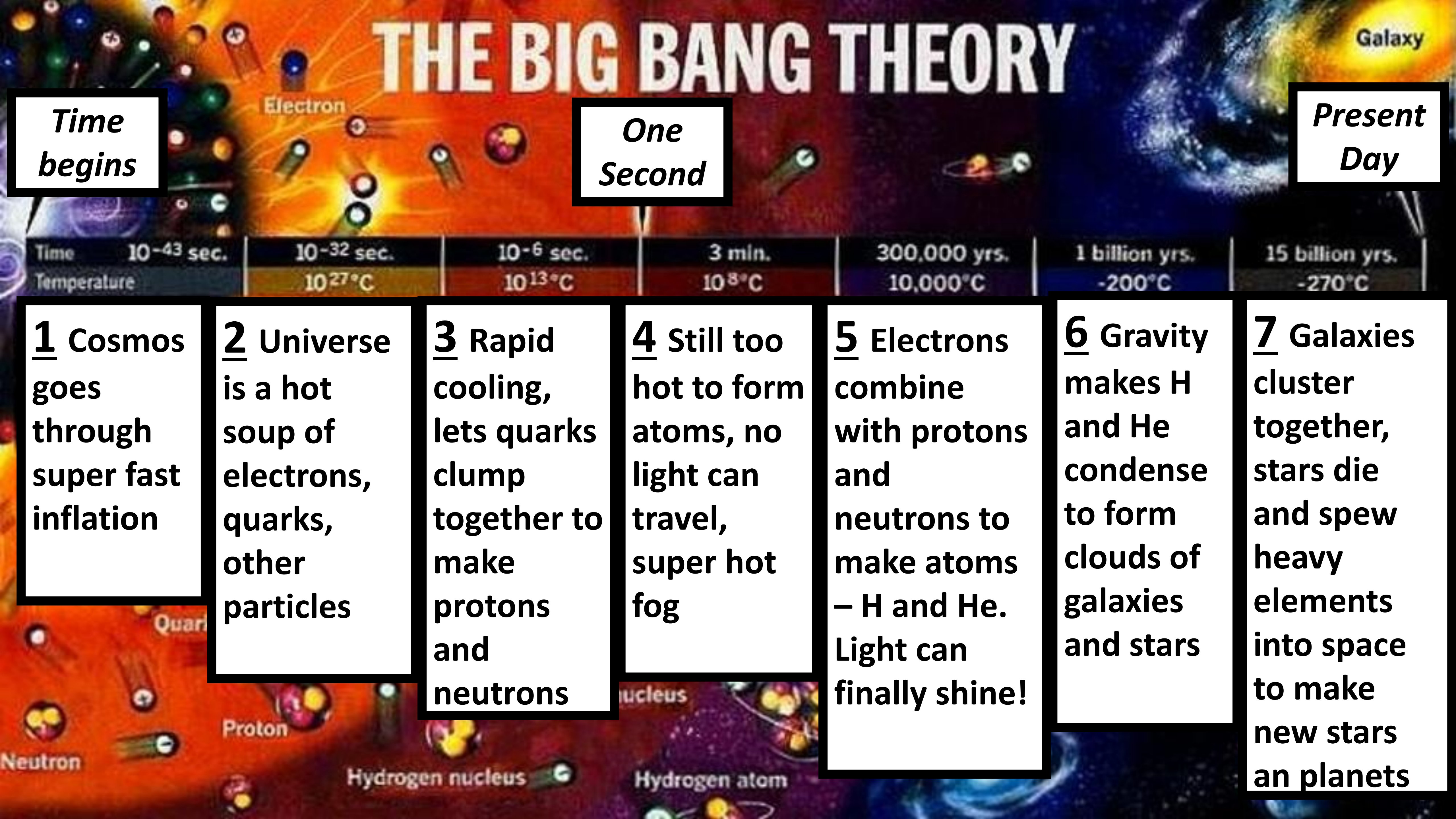
N-14 Atomic Absorption & Emission, Line Spectra and the Chemical Composition of Stars

Where did the elements come from?



Time begins

One Second

Present Day

Time	10^{-43} sec.	10^{-32} sec.	10^{-6} sec.	3 min.	300,000 yrs.	1 billion yrs.	15 billion yrs.
Temperature		10^{27}°C	10^{13}°C	10^{8}°C	10,000°C	-200°C	-270°C

<u>1</u> Cosmos goes through super fast inflation

<u>2</u> Universe is a hot soup of electrons, quarks, other particles

<u>3</u> Rapid cooling, lets quarks clump together to make protons and neutrons

<u>4</u> Still too hot to form atoms, no light can travel, super hot fog

<u>5</u> Electrons combine with protons and neutrons to make atoms – H and He. Light can finally shine!

<u>6</u> Gravity makes H and He condense to form clouds of galaxies and stars

<u>7</u> Galaxies cluster together, stars die and spew heavy elements into space to make new stars an planets

BIG BANG THEORY PHASES

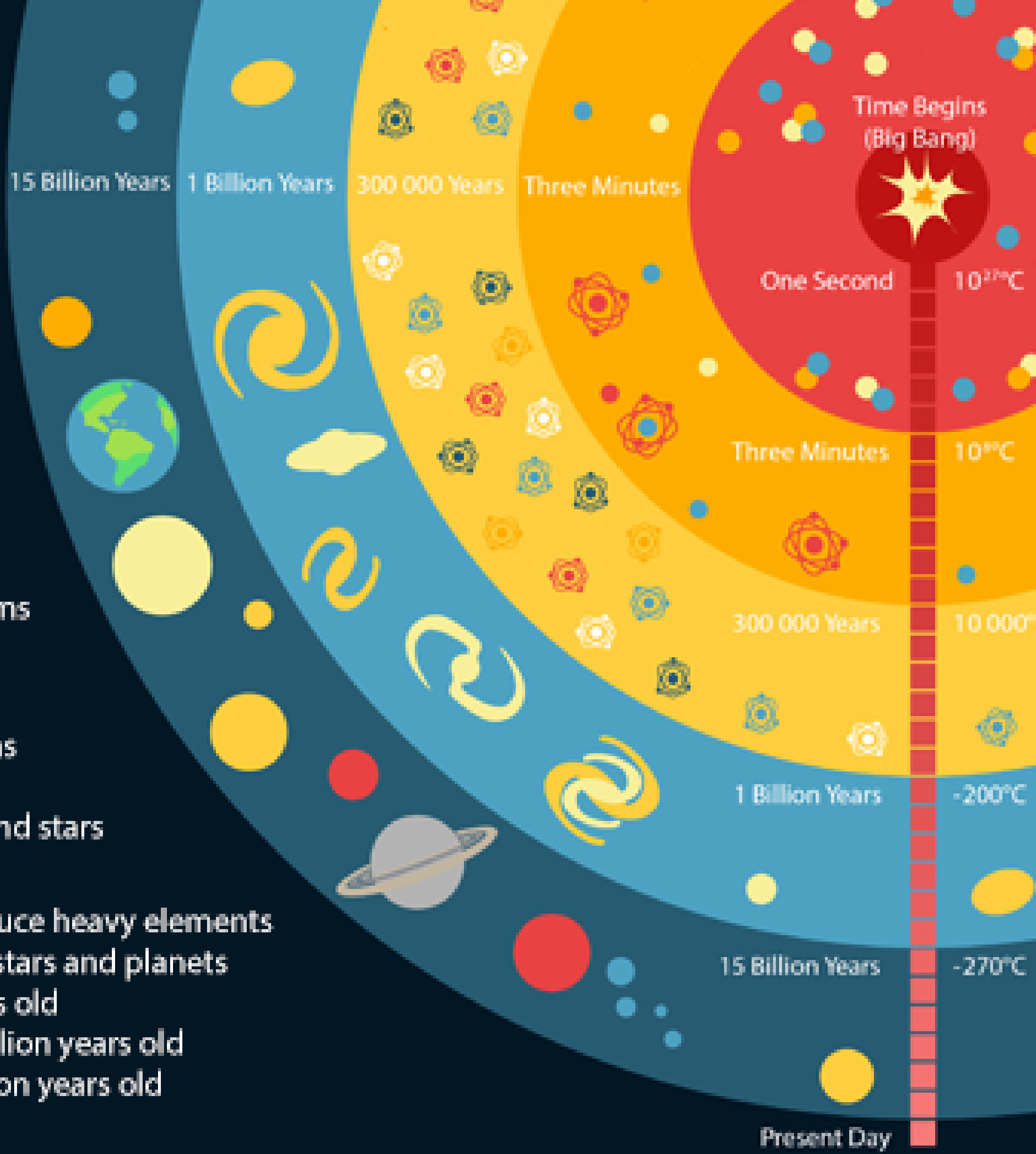
1 Boiling "soup" with electrons, quarks and other elementary particles. Space cools off rapidly. Quarks form protons and neutrons.

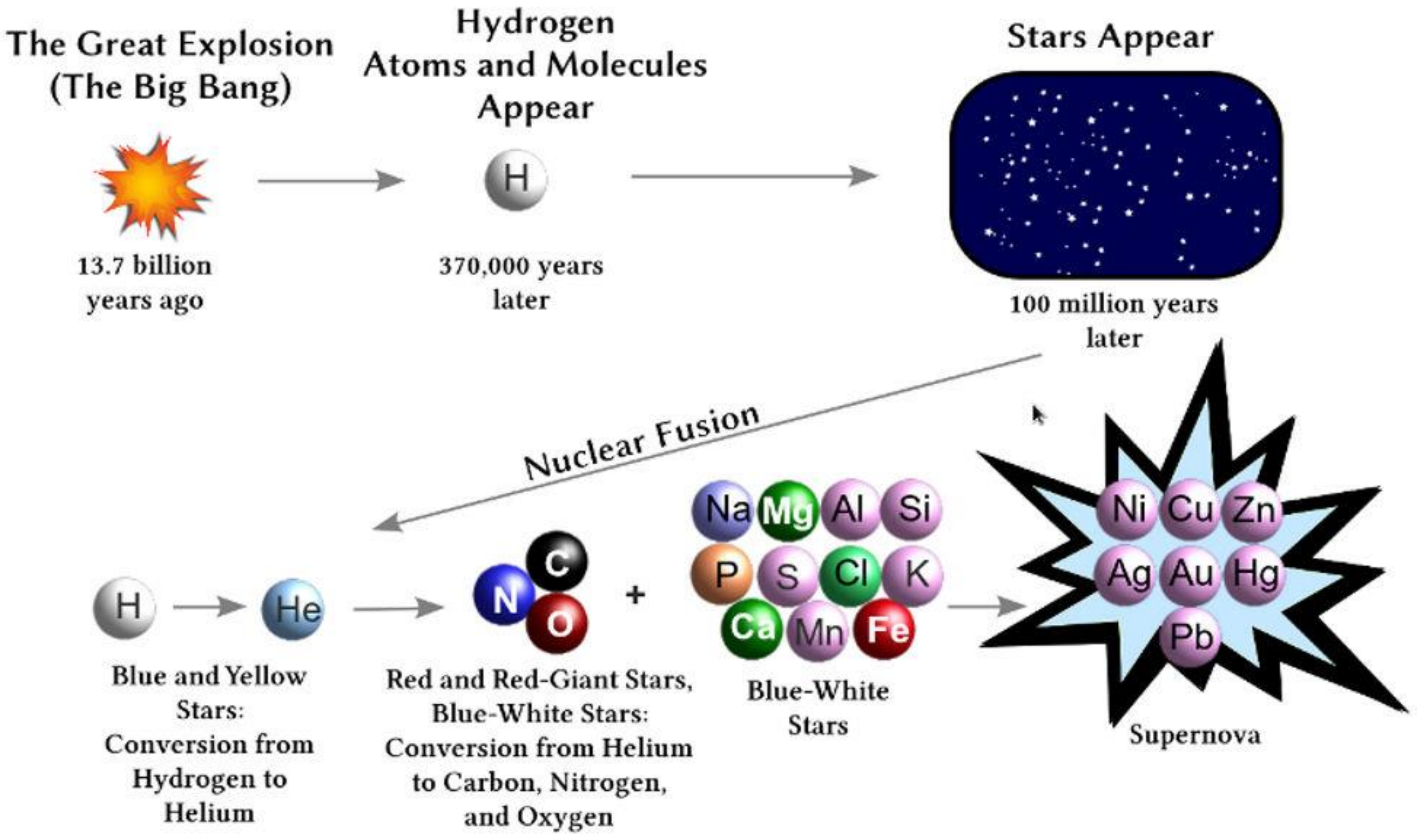
2 Universe - superhot fog. Heated protons and electrons hinder the emission of light. Light elements created like deuterium, lithium, helium.

3 Protons, electrons, neutrons combine and form atoms. Primarily hydrogen and helium atoms

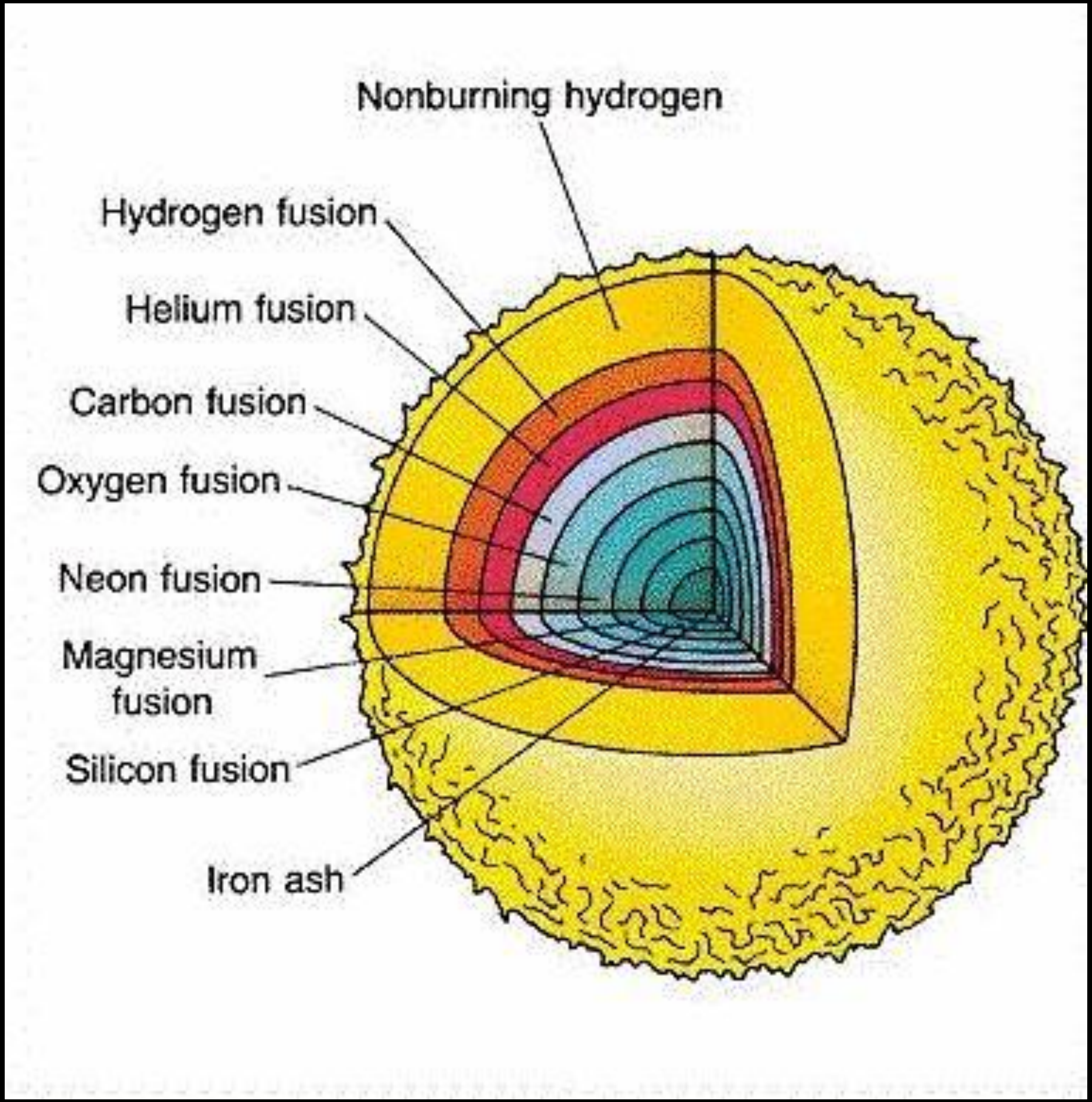
4 Galaxy formation era. Hydrogen and helium atoms begin to form giant clouds that will become galaxies and stars

5 First dying stars produce heavy elements which turn into new stars and planets
Sun ~ 4.6 billion years old
Solar System ~ 4.5 billion years old
Milky Way ~ 13.2 billion years old





The Great Explosion
(The Big Bang)
13.7 billion
years ago
Hydrogen
Atoms and Molecules
Appear
H
370,000 years
later
Stars Appear
100 million years
later
Nuclear Fusion
H
He
Blue and Yellow
Stars:
Conversion from
Hydrogen to
Helium
C
N
O
Red and Red-Giant Stars,
Blue-White Stars:
Conversion from Helium
to Carbon, Nitrogen,
and Oxygen
+
Na
Mg
Al
Si
P
S
Cl
K
Ca
Mn
Fe
Blue-White
Stars
Ni
Cu
Zn
Ag
Au
Hg
Pb
Supernova



Out of fuel

Implosion

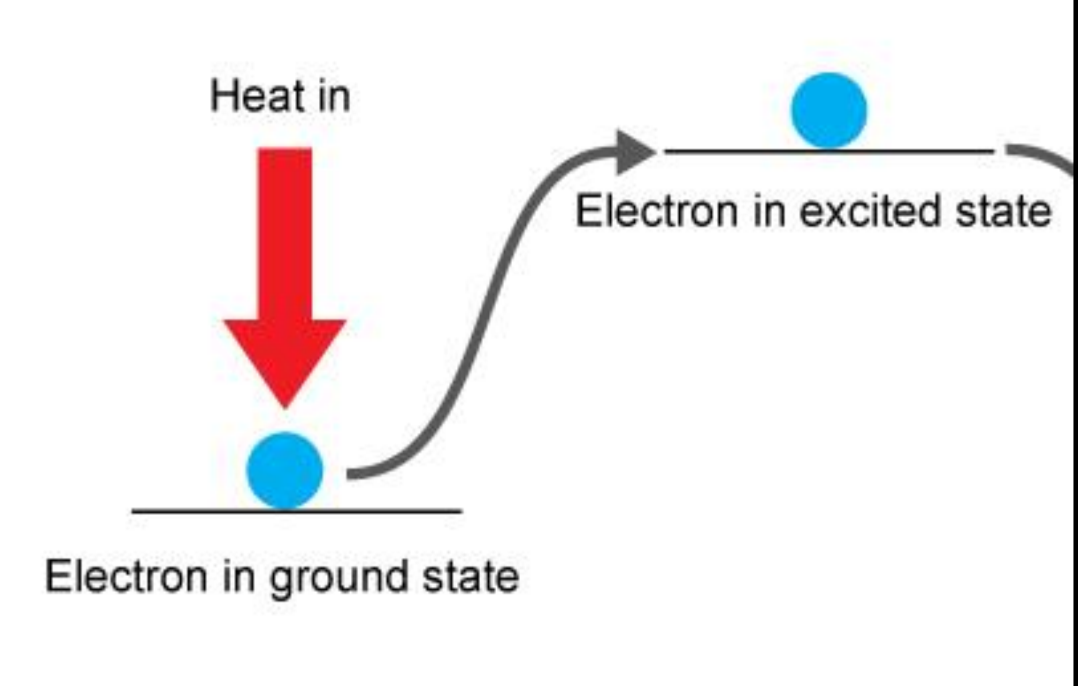
Forms nebula of elements

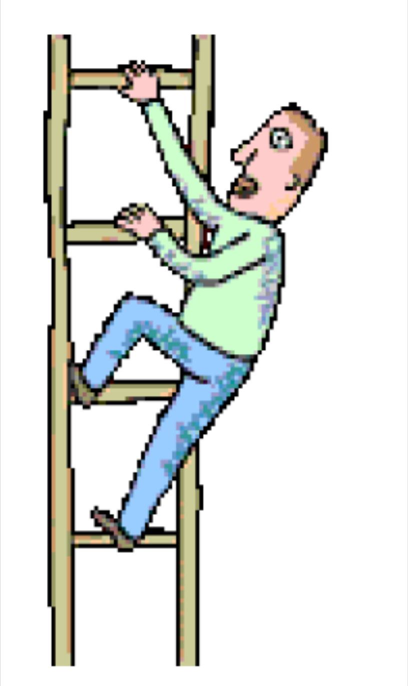
How do we know which stars have which elements?

We can analyze the wavelengths of light that are absorbed or released by the stars

ABSORPTION

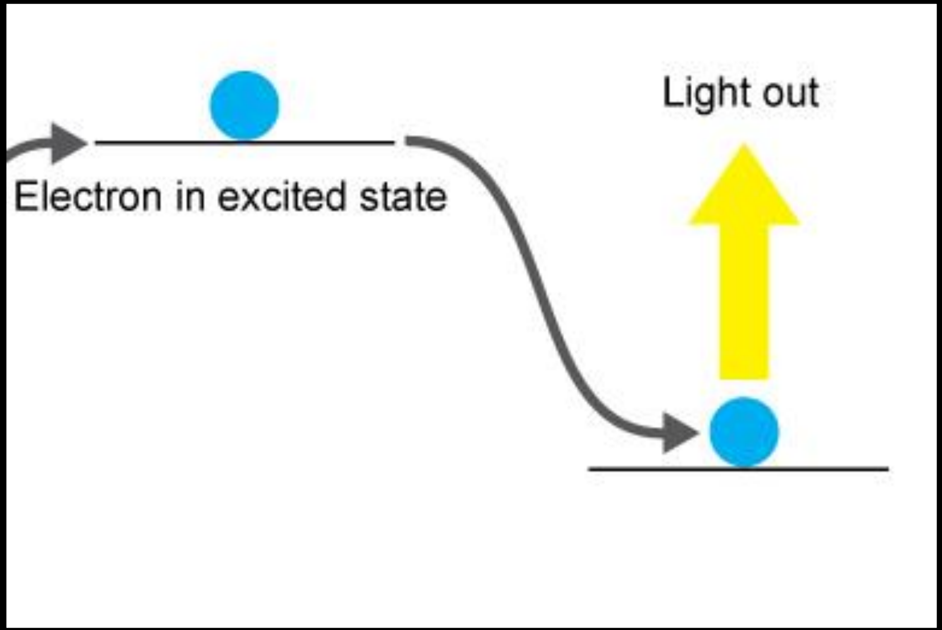
If you give an atom energy, the electron can be pushed up to a higher energy level

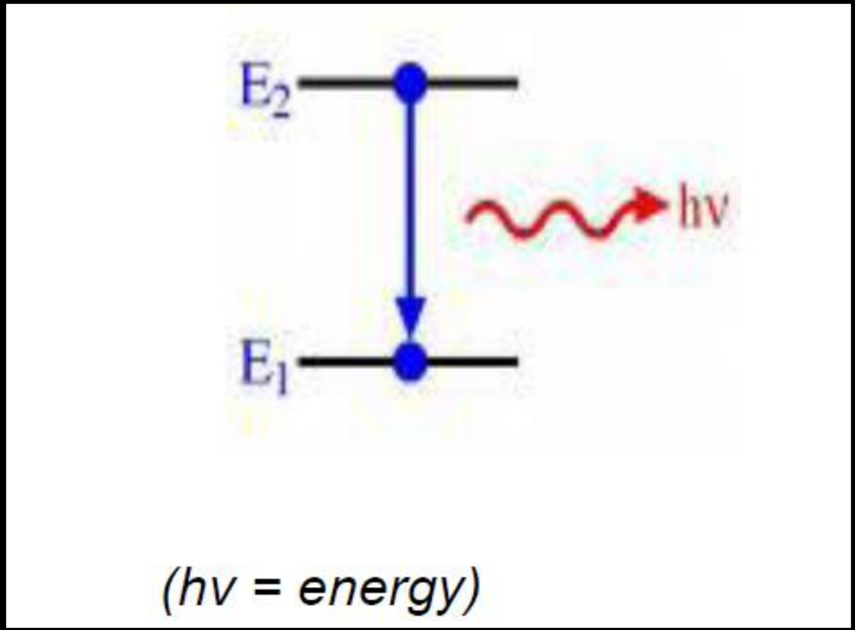




EMISSION

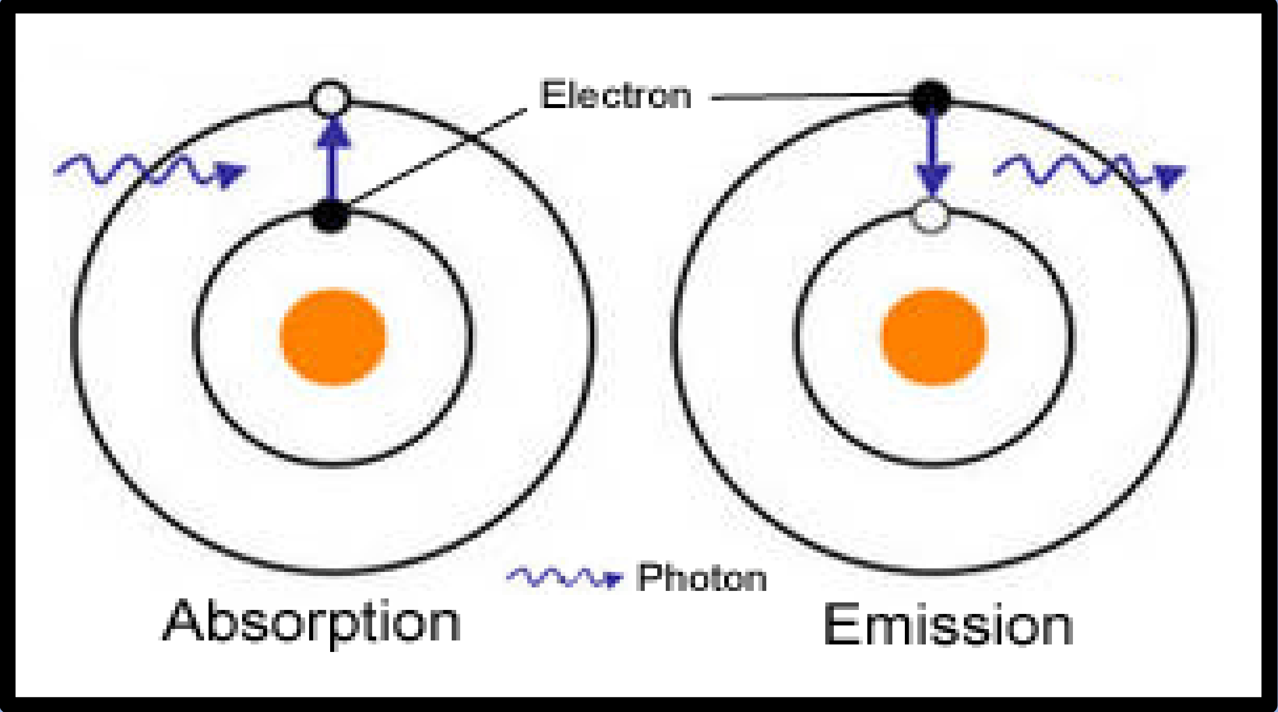
The electron does not want to stay at that higher level (Aufbau Principle!) so it will fall back down.

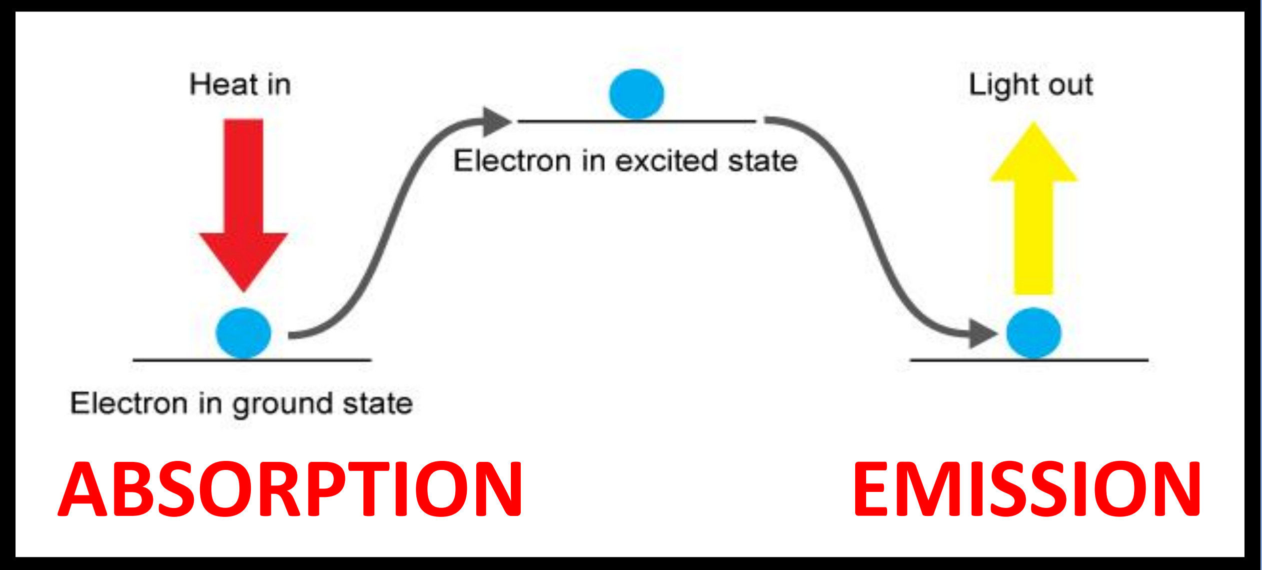




LOTS OF WAYS TO DRAW THIS

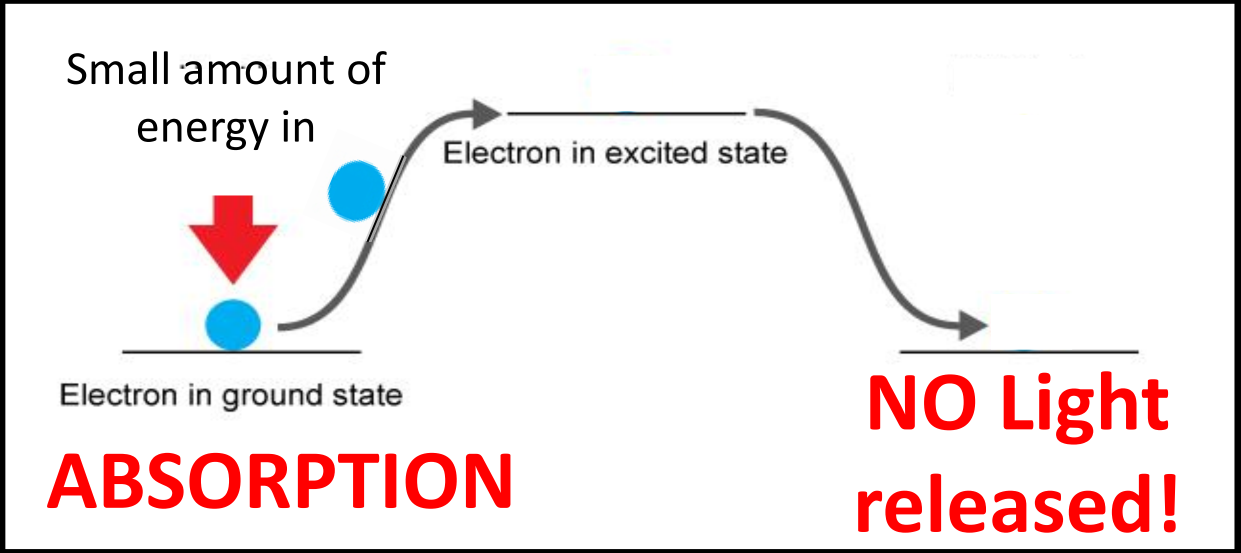
Make sure to show if energy is coming in or out, and which direction the electron is moving.





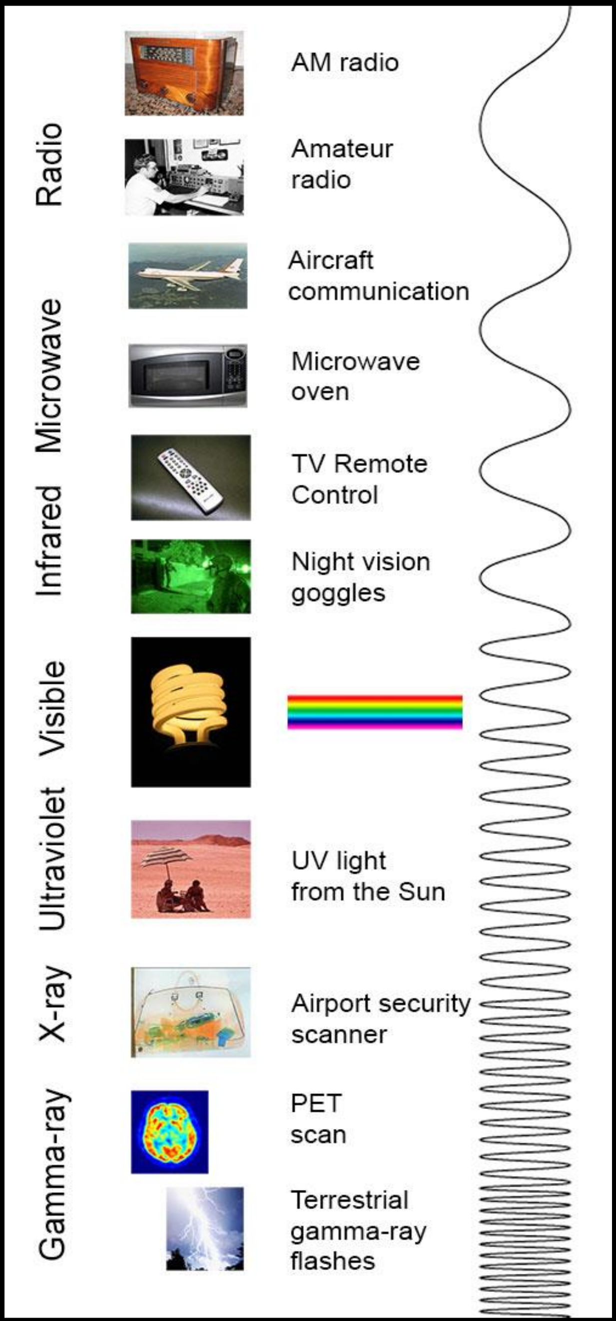
NEED THE RIGHT AMOUNG OF ENERGY!

If you don’t give the atom enough energy to get to the higher orbital, then nothing happens!

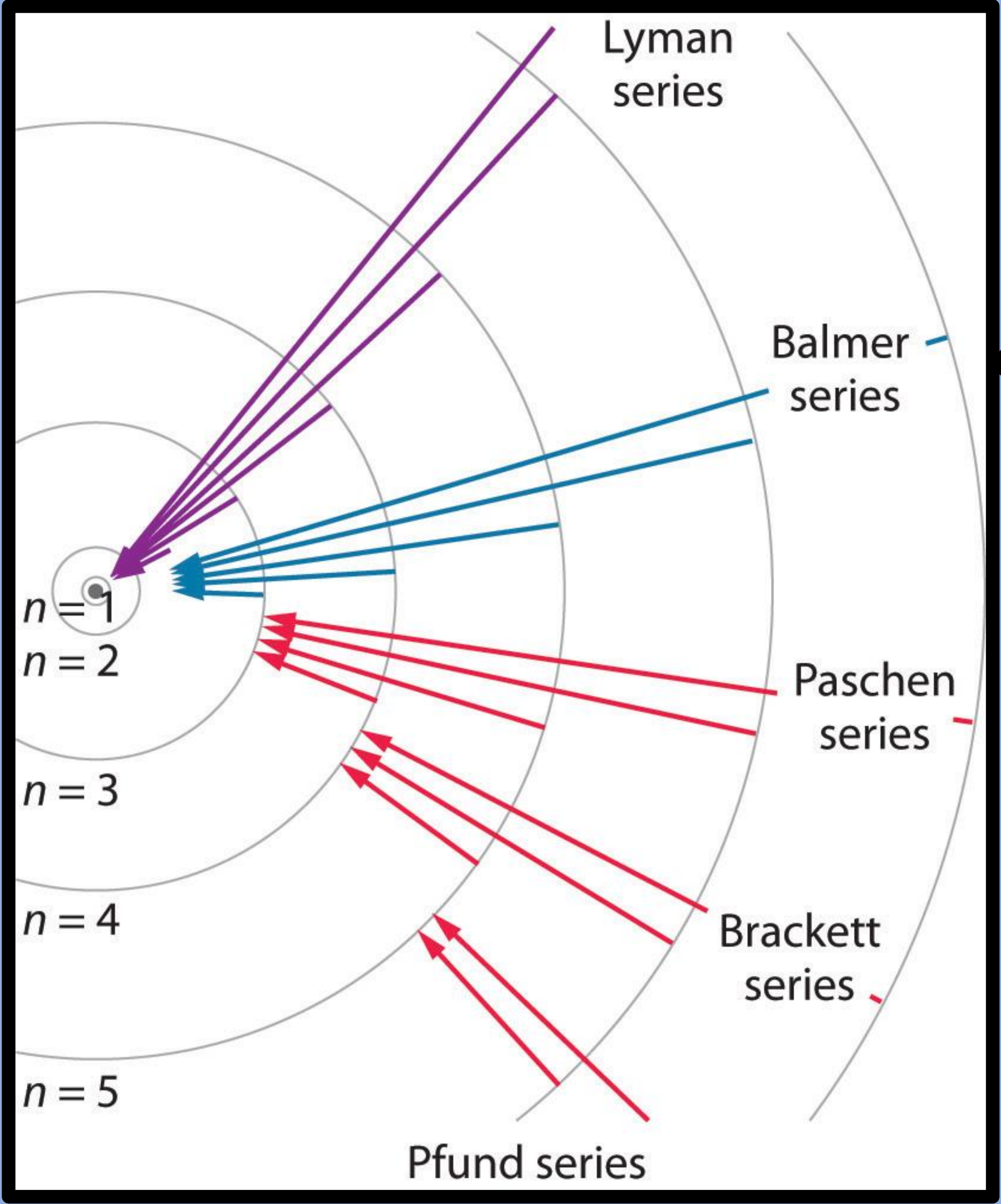


ENERGY RELEASED DURING EMISSION

Sometimes the released energy can be seen as LIGHT! The amount of energy given off depends on which energy levels the electron is falling from.



We can only see this little range here



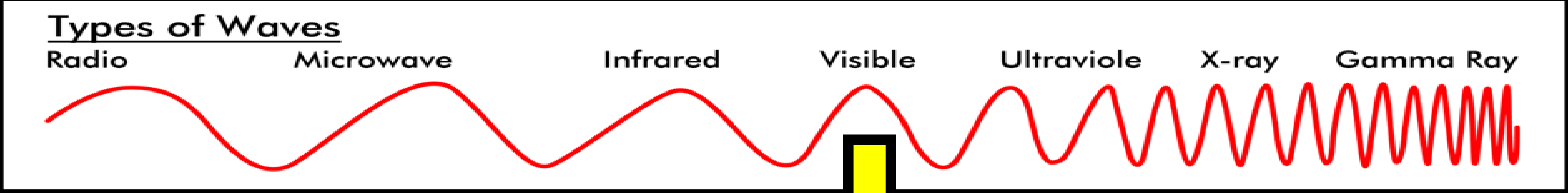
The Balmer Series of emissions are in the range we can see

The energy and color of light will change based on which element it is.

The amount of energy is different because the difference between energy levels is not the same for every element or every level

ENERGY SPECTRUM

You can measure the exact wavelength and it can tell you how big the energy gap was that the e- fell from



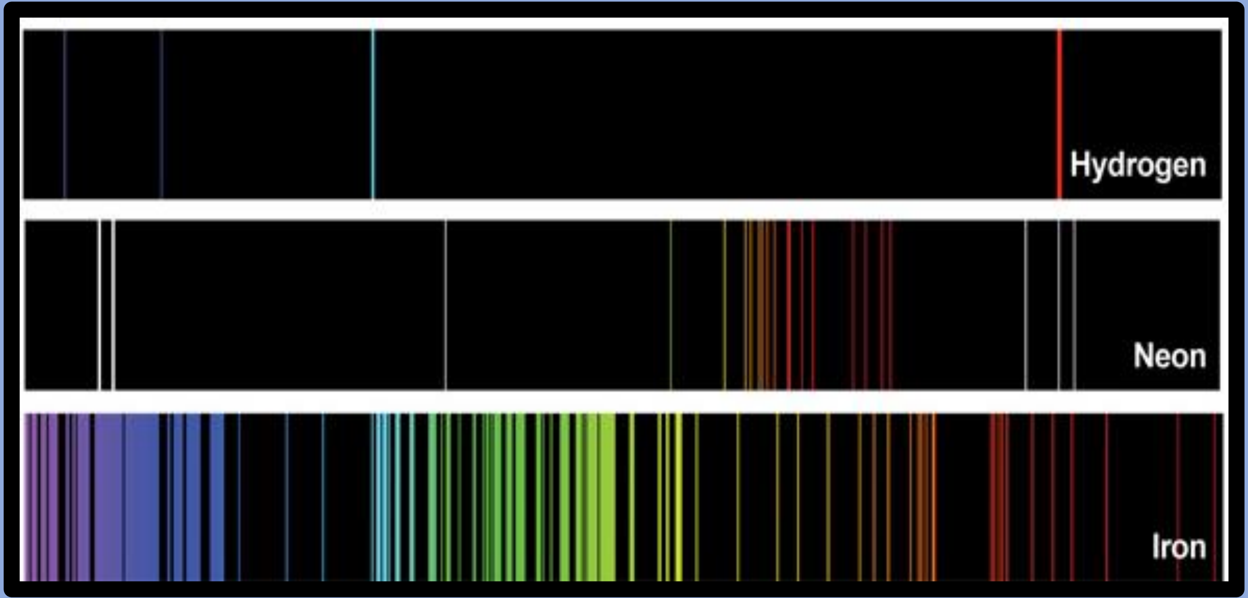
Red Orange Yellow Green Blue Purple

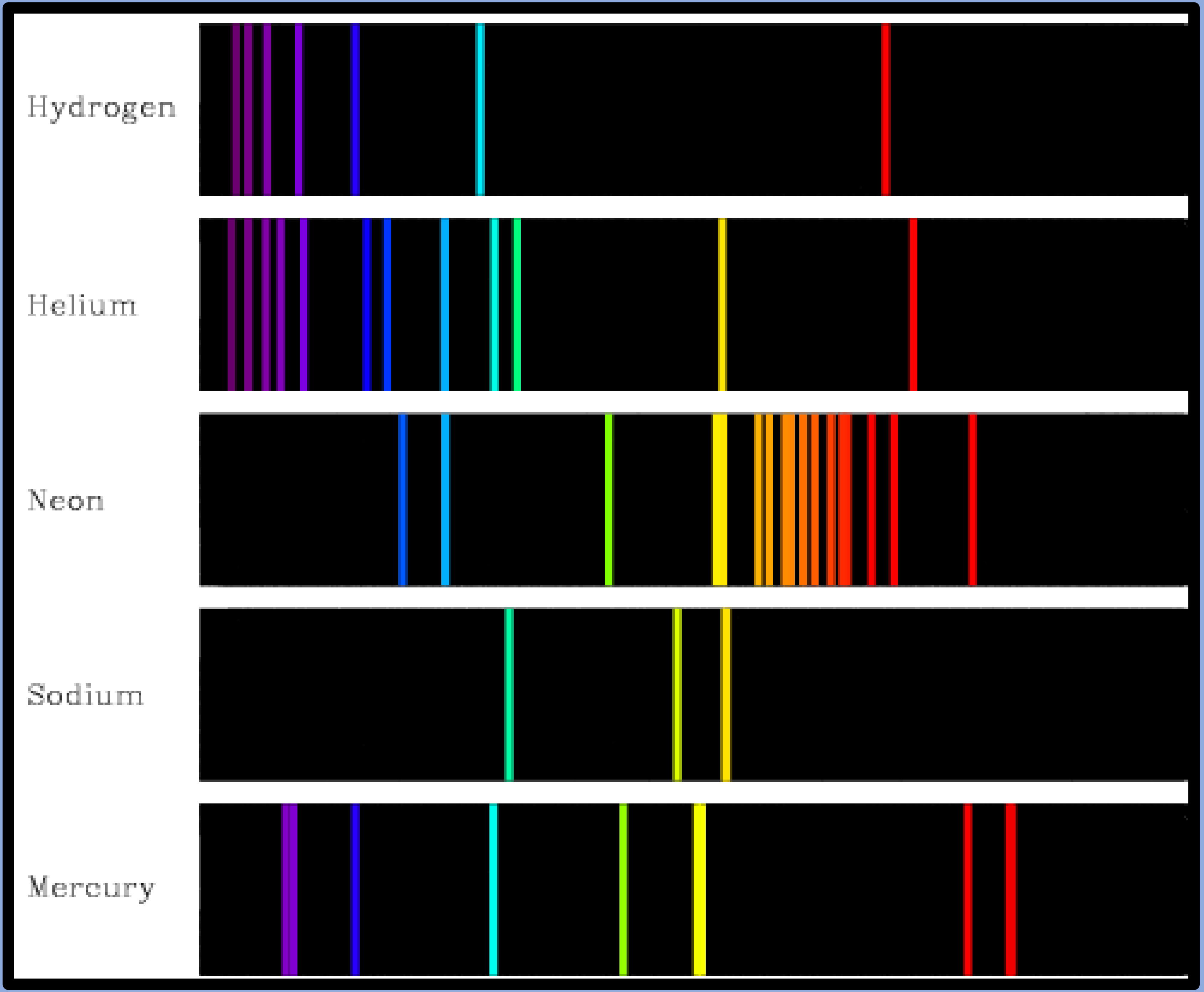
LOW energy

HIGH energy

UNIQUE LIKE A FINGERPRINT

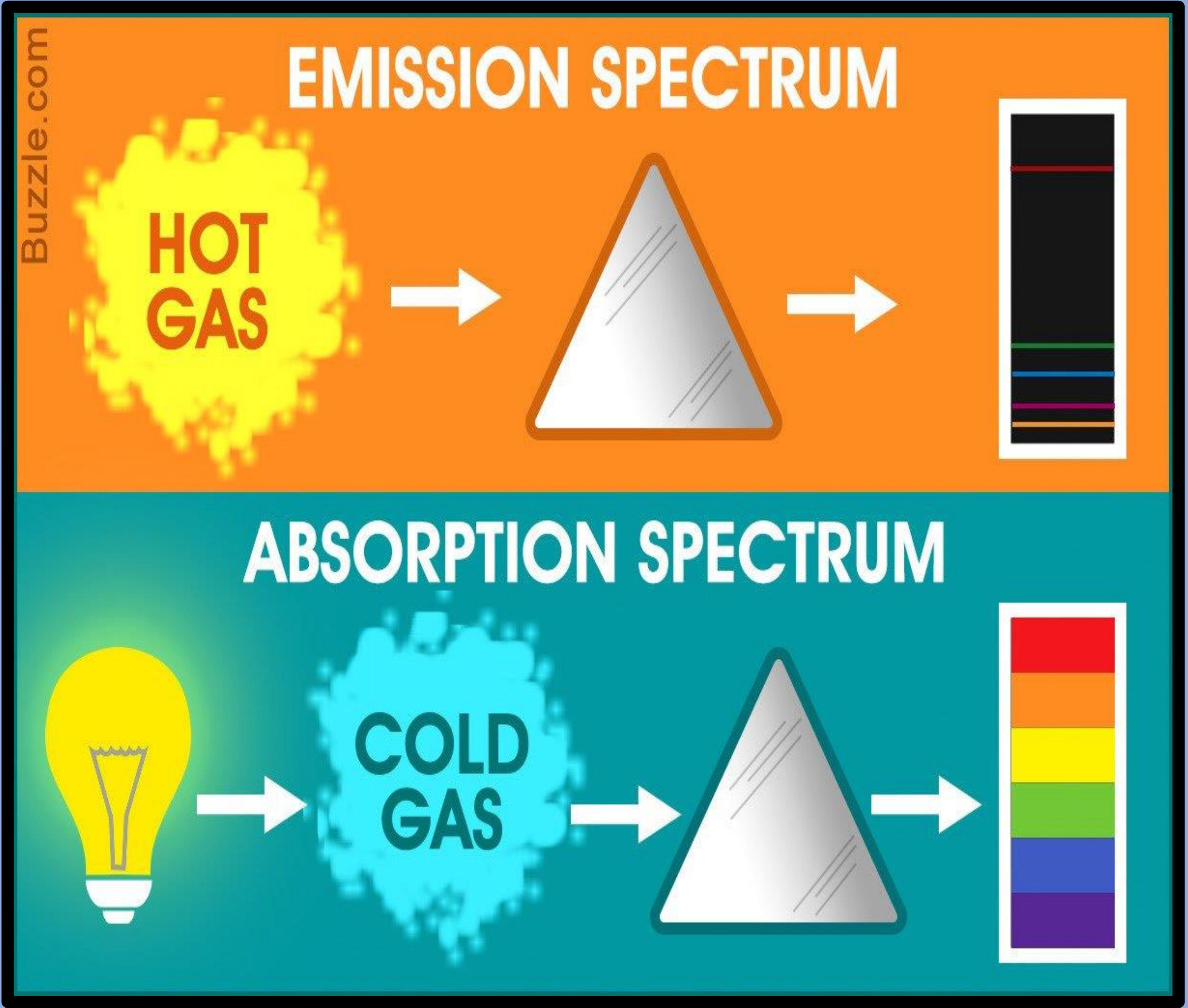
So just like people have unique finger prints, atoms have unique wavelengths they release (or absorb)




Hydrogen
Helium
Neon
Sodium
Mercury

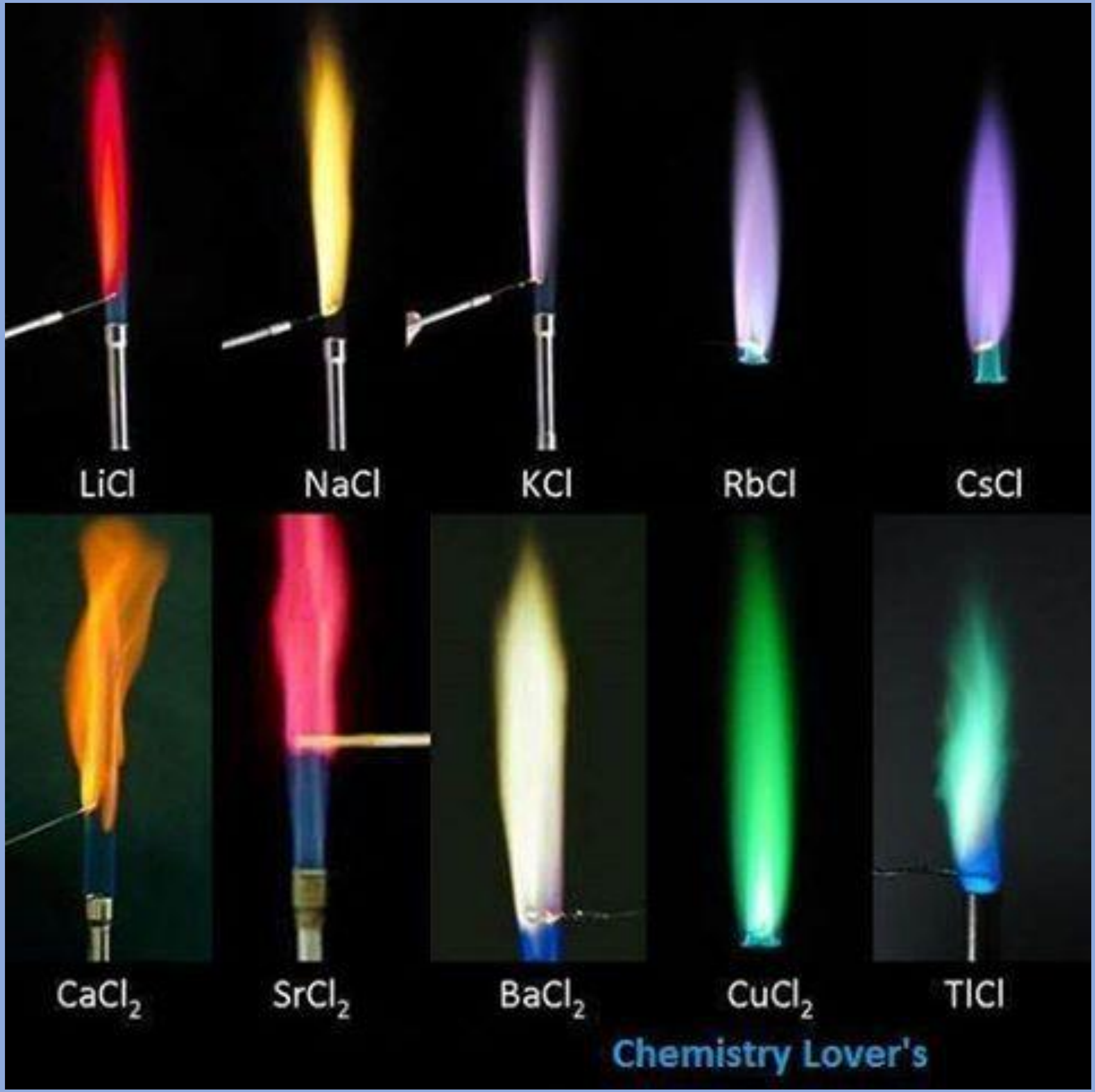
TWO WAYS TO DO THIS…

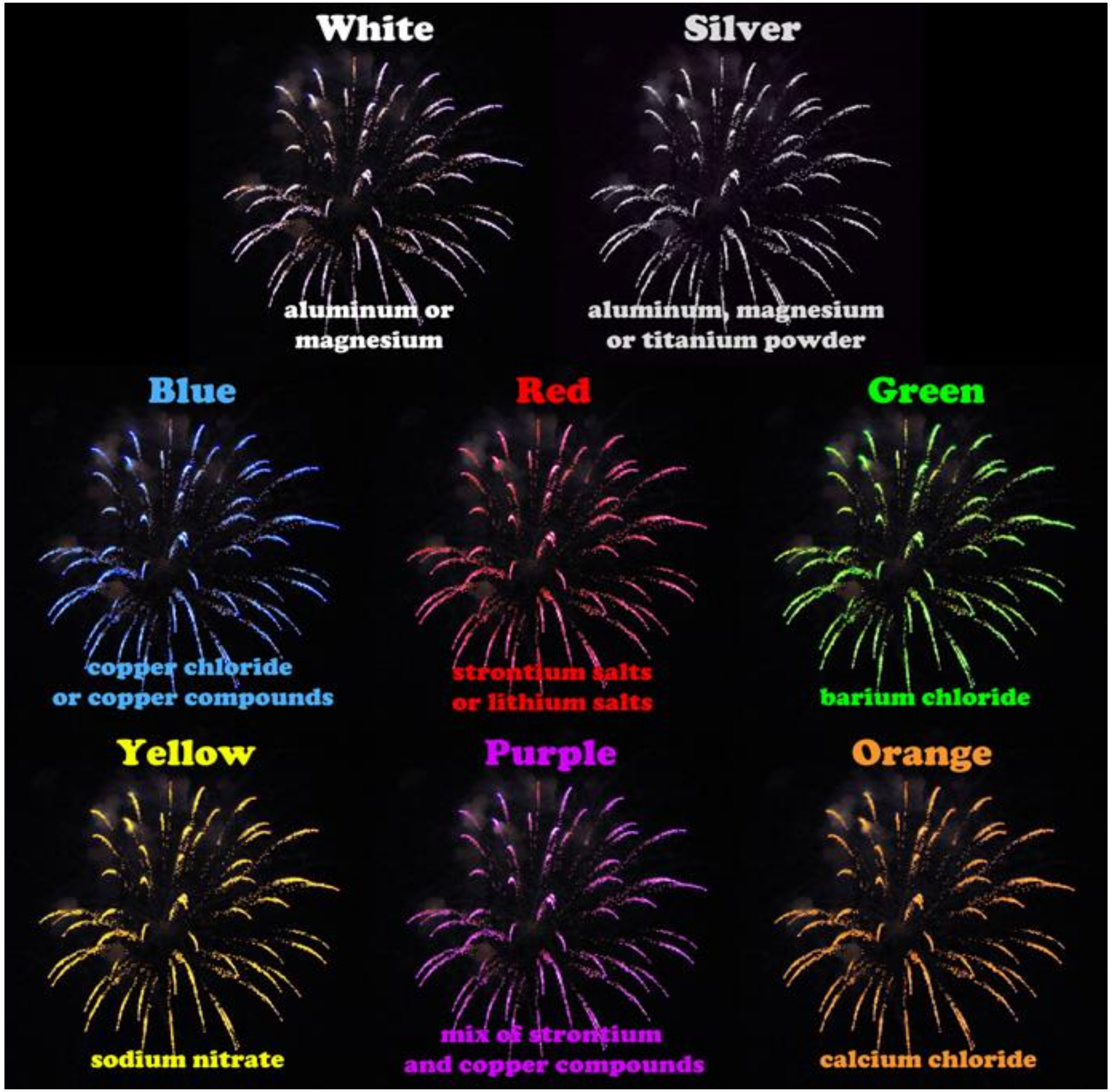
Which wavelengths does it give off, or which wavelengths does it absorb

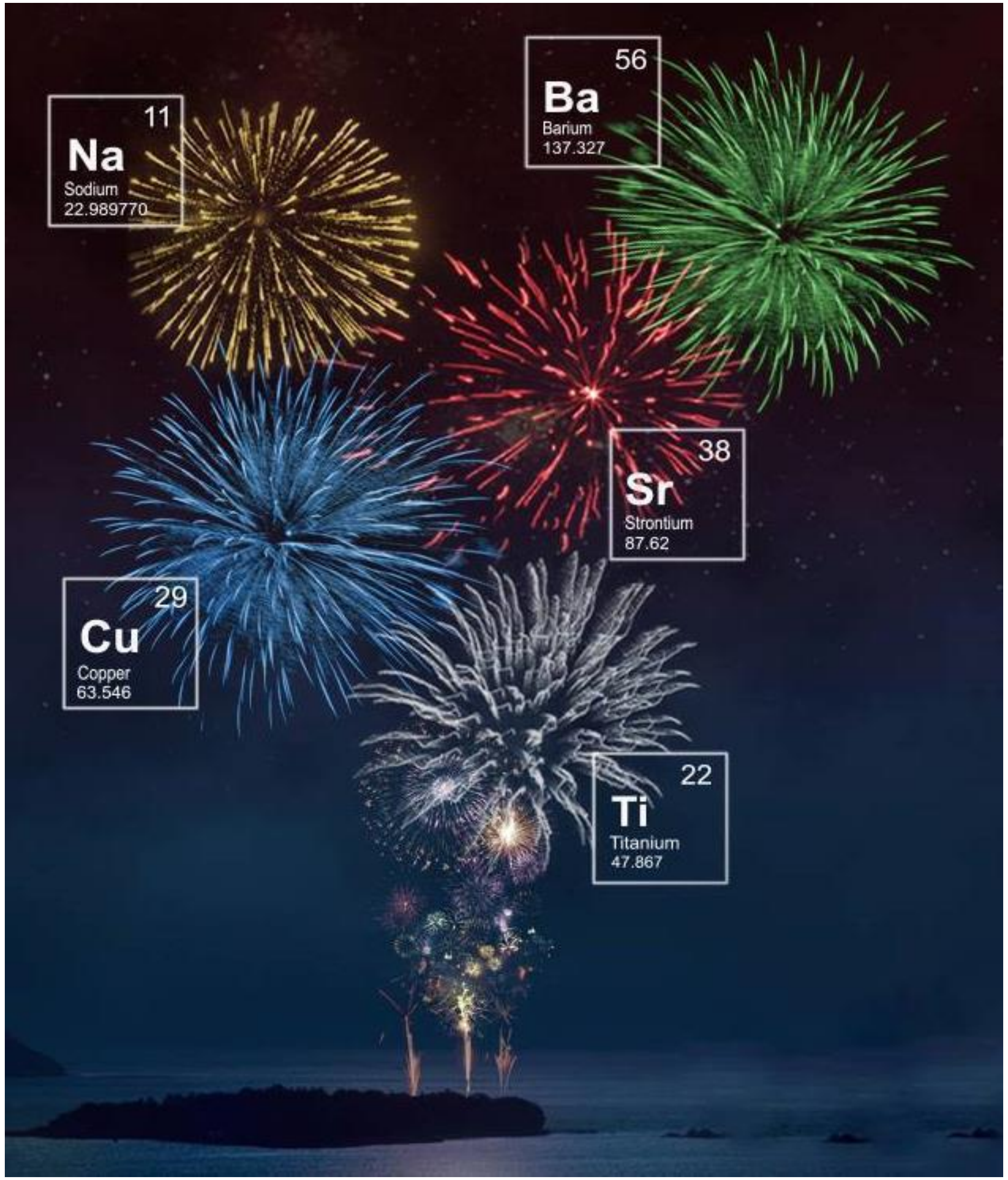


FLAME TESTS IN THE LAB

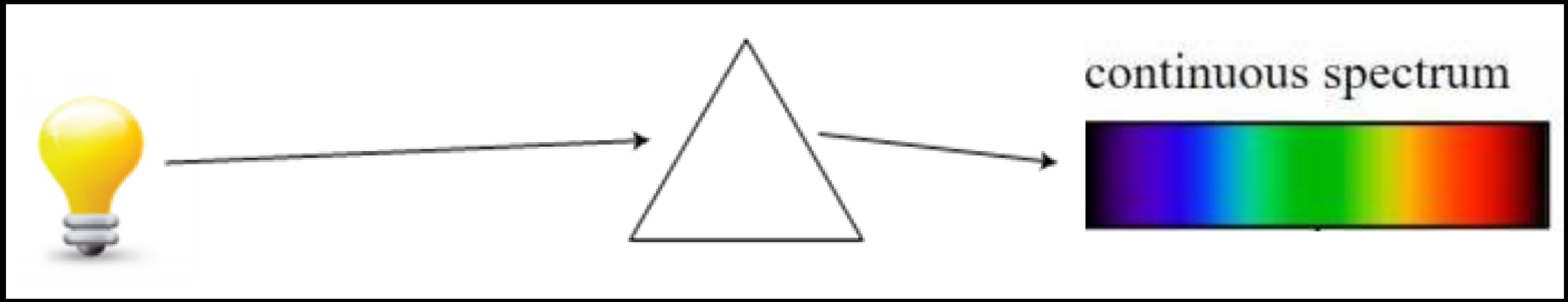
Compounds containing certain ions can be recognized by burning the compound and observing the colors produced




White
aluminum or magnesium
Silver
aluminum, magnesium or titanium powder
Blue
copper chloride or copper compounds
Red
strontium salts or lithium salts
Green
barium chloride
Yellow
sodium nitrate
Purple
mix of strontium and copper compounds
Orange
calcium chloride

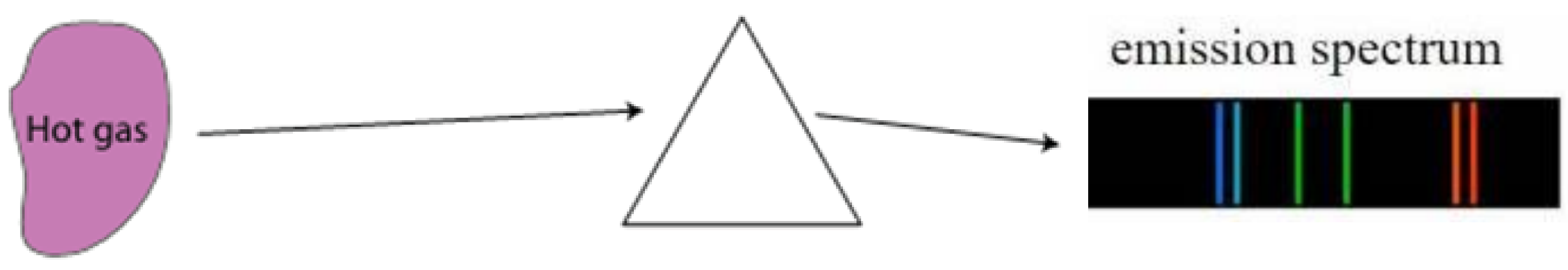

11 Na Sodium 22.989770
56 Ba Barium 137.327
38 Sr Strontium 87.62
29 Cu Copper 63.546
22 Ti Titanium 47.867

<u>Normally</u> – seeing continuous spectrum of wavelengths being released



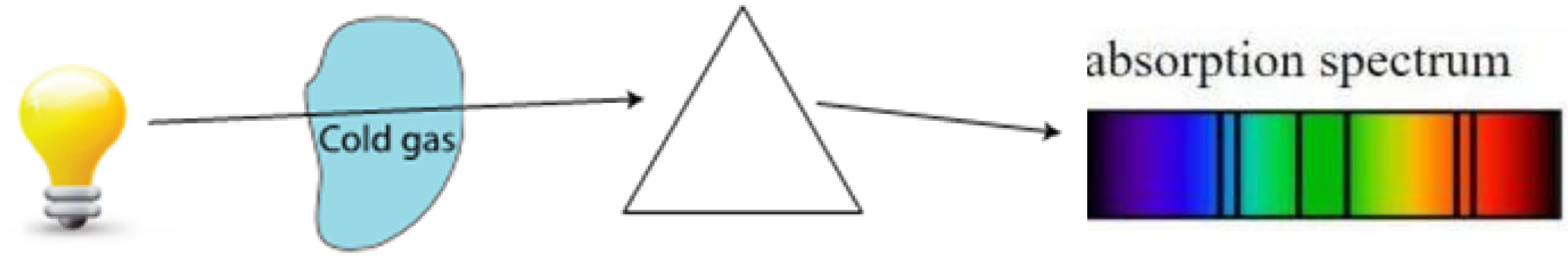
NORMAL

Emission – seeing wavelengths of energy RELEASED as excited electrons fall down to lower levels



IN LAB HEAT ATOMS

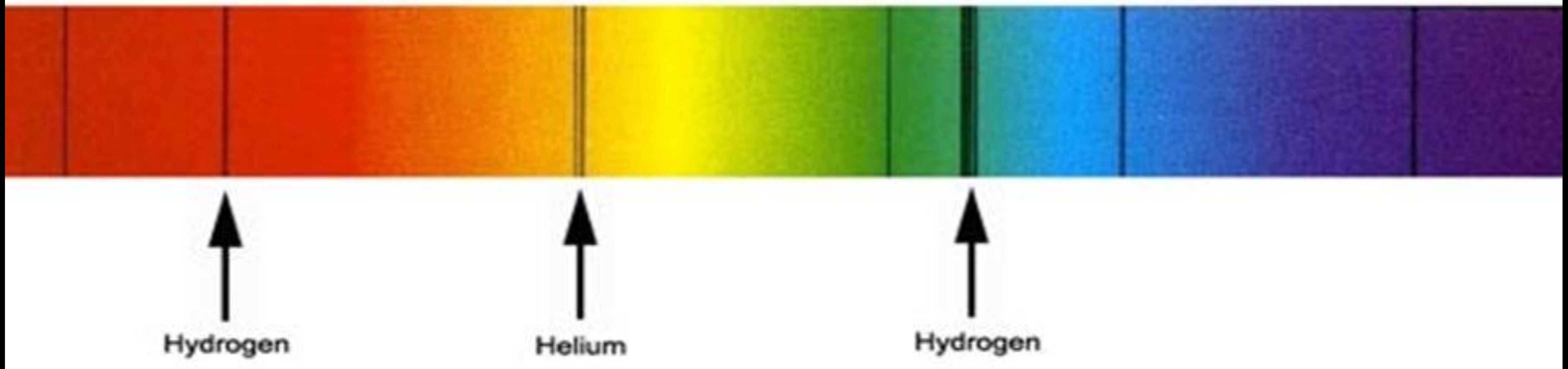
Absorption – seeing MISSING bands of energy being ABSORBED by a cold gas

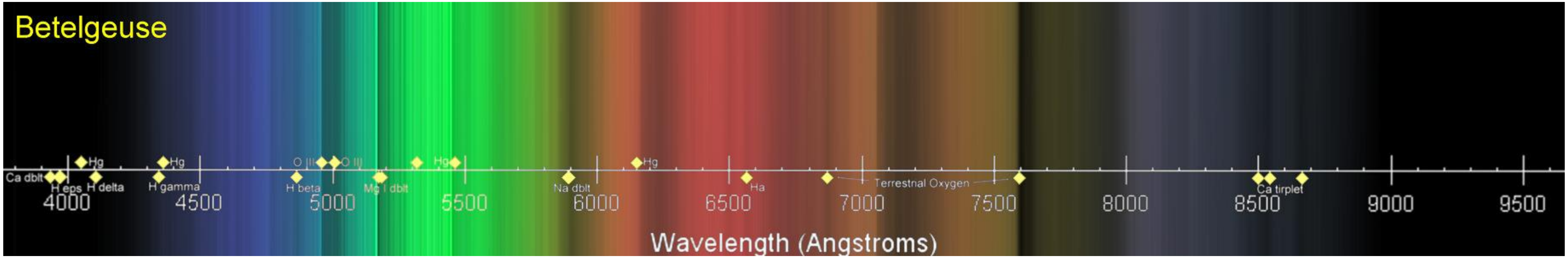


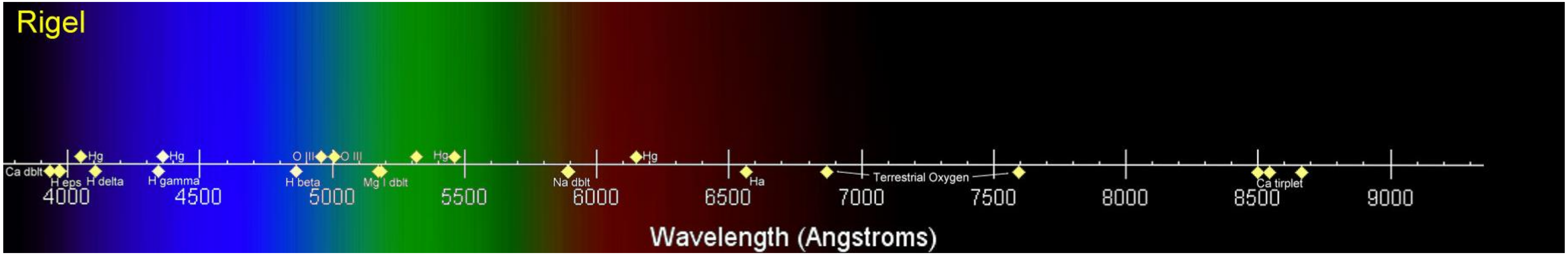
IN THE STARS

ABSORPTION LINES FOR STARS

The "colder" outer layers of the stars absorb the emission energy from the hotter inside of the star, so what we can see are absorption lines




Betelgeuse
Ca dblt
H eps
H delta
Hg
H gamma
O III
H beta
Mg I dblt
Na dblt
Ha
Terrestrial Oxygen
Ca tirplet
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
Wavelength (Angstroms)


Rigel
Ca dblt
H eps
H delta
Hg
H gamma
O III
H beta
Mg I dblt
Na dblt
Ha
Terrestrial Oxygen
Ca tirplet
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
Wavelength (Angstroms)