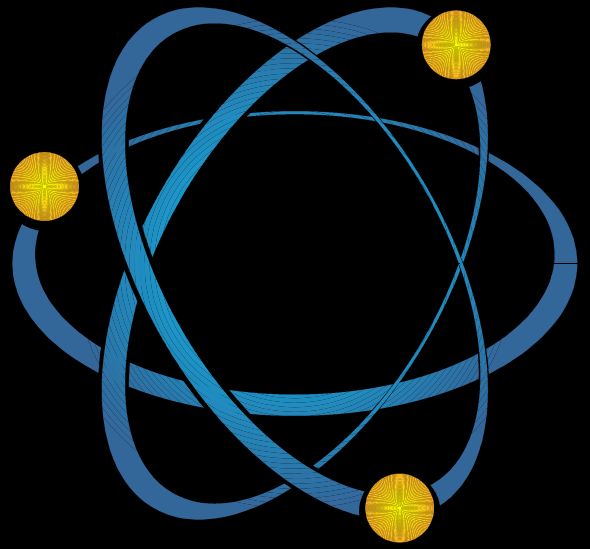
FALSE	There is only one model of the atom
FALSE	The electrons in an atom orbit its nucleus like planets in our solar system orbit the sun
FALSE	Electrons are larger than protons
TRUE	Each element is composed of a different atom
FALSE	Atoms can be seen with a microscope
FALSE	One thousand atoms can fit across a human hair 500K C Atoms!
FALSE	Electrons have no mass 9.1×10^{-31} kg 1/8636 a proton
TRUE	In a 150-pound human body, there are 6.5 octillion (6,500,000,000,000,000,000,000,000,000) atoms

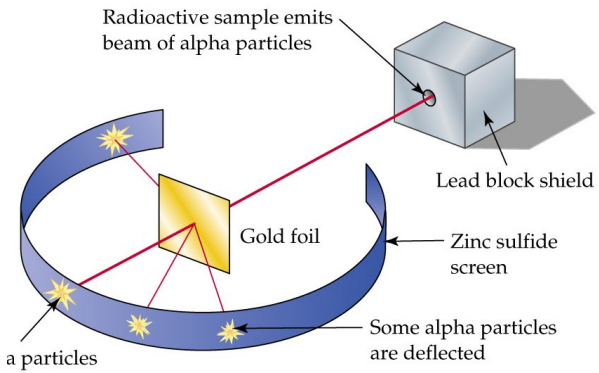
TRUE	Atoms were the creation of the Big Bang
TRUE	The earliest atoms were helium and hydrogen
TRUE	Protons and neutrons are in the nuclei Makes up 0.01% of volume, but 99.9% of mass
FALSE	As the number of protons increases, the size of the atom increases We will learn why in this unit!
TRUE	Humans can make atoms
TRUE	Humans replace 98% of atoms every year
TRUE	Adding a proton to an atom creates a new element

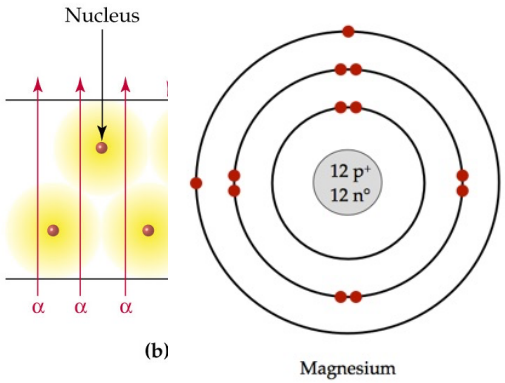


Early Models of the Atom

Scientists create models to….

1. Explain things that they cannot observe directly
2. Make predictions
3. Conduct experiments
4. Try to understand nature





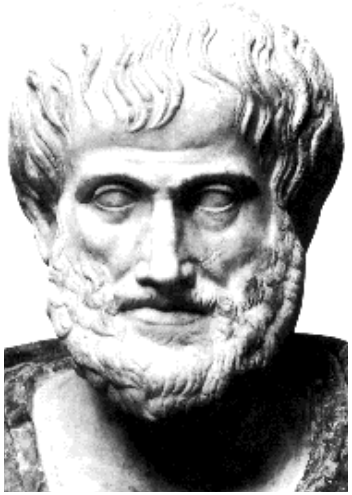
Atomos

2400 Search for the Atom

Early Greek Theories

- Democritus – 400 BC
  - Suggested that all matter was made up of tiny indivisible particles called "atoms" (Greek: atoma)

Democritus



Aristotle

- Aristotle – 350 BC
  - Modified an earlier theory that matter was made of four "elements": earth, fire, water, air
  - He was wrong but his theory persisted for 2000 years

Acharya Kanada

- Born in 600 BC in Eastern India
- Also known as Kashyapa
- Ancient Indian scientist and philosopher
- Formulated the theory of atoms by explaining the importance of individual grains of rice.

Acharya Kanada

Individual grain particles may not have any worth, but a collection of hundreds of grains can make up a person's meal, the collection of many such meals would serve an entire family and ultimately would feed the entire mankind. Therefore, even a single grain of rice is as important as all the valuable riches in this world.

John Dalton (1800s)

- 1800 – proposed a theory based on experimentation
- His ideas accounted for:
  - Law of Conservation of Mass
  - Law of Constant Composition

Dalton's Atomic Theory:

1. All matter is made up of atoms.
2. Atoms of an element are identical.
3. Each element has different atoms.
4. Atoms of different elements combine in constant ratios to form compounds
5. Atoms are rearranged in reactions.

- Billiard ball model:
  - all atoms are solid and indivisible.

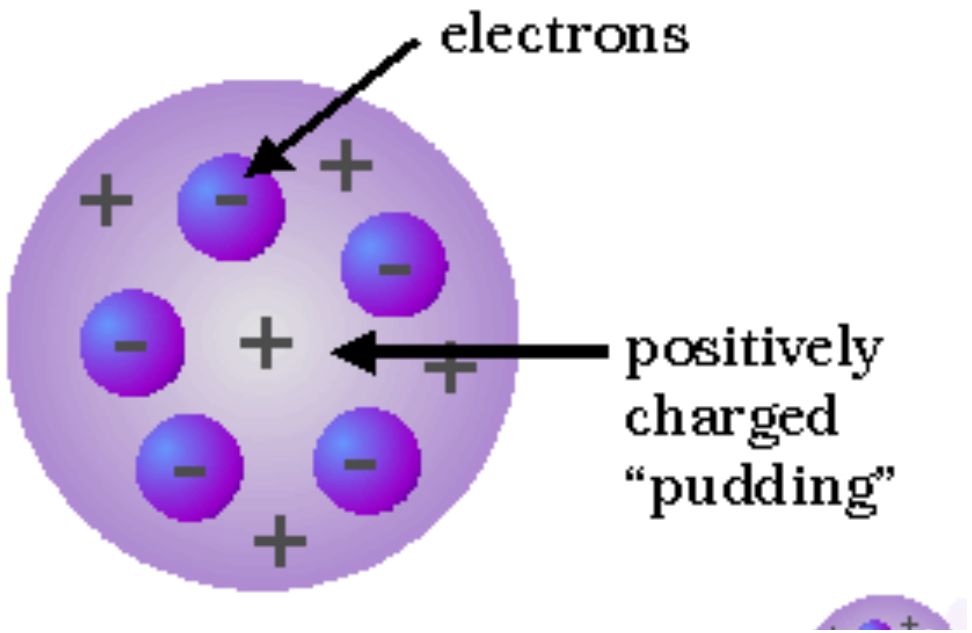
J.J. Thomson (1897)

- Using Crooke's Cathode Ray Tube (CRT), discovered the electron!

- Thomson's discovery of the subatomic particle disproved Dalton's previous Theory

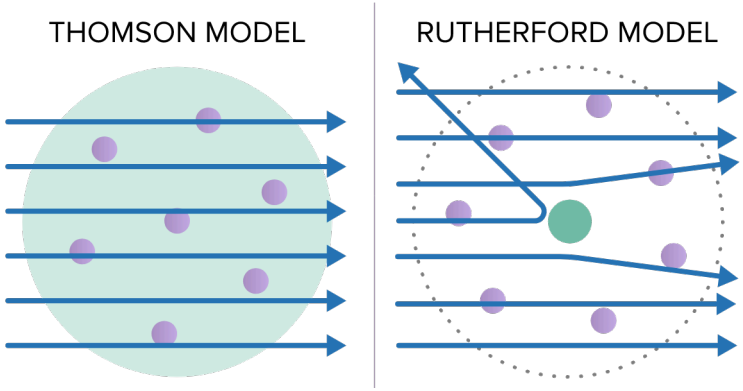
Thomson's Plum Pudding Model

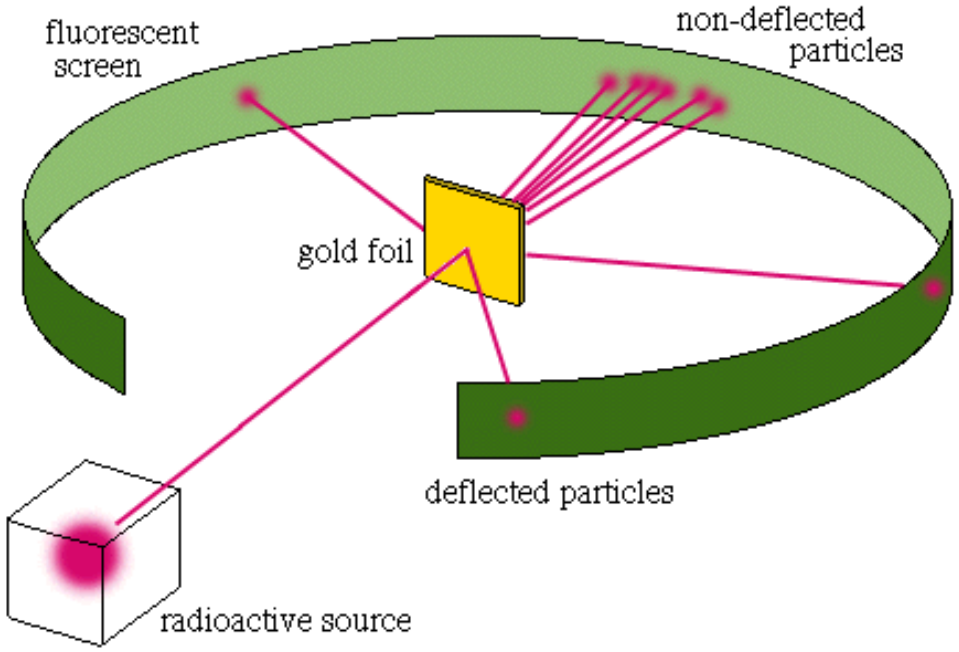
- Electron: -ve
- Protons: +ve



Ernest Rutherford (1911)

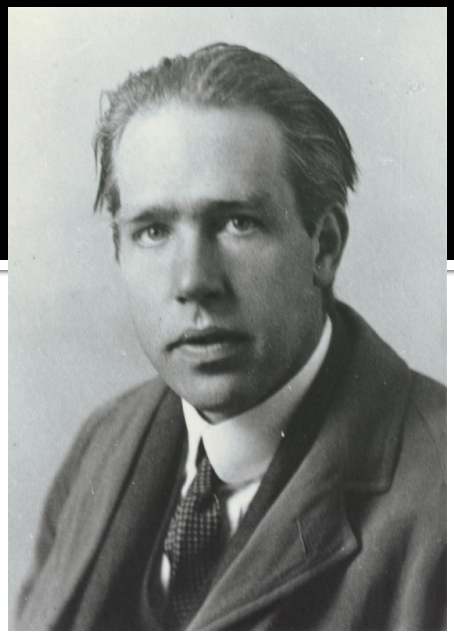
- Gold-foil experiment
- Discovery of the nucleus
  - Is positive
  - Holds most of atom's mass



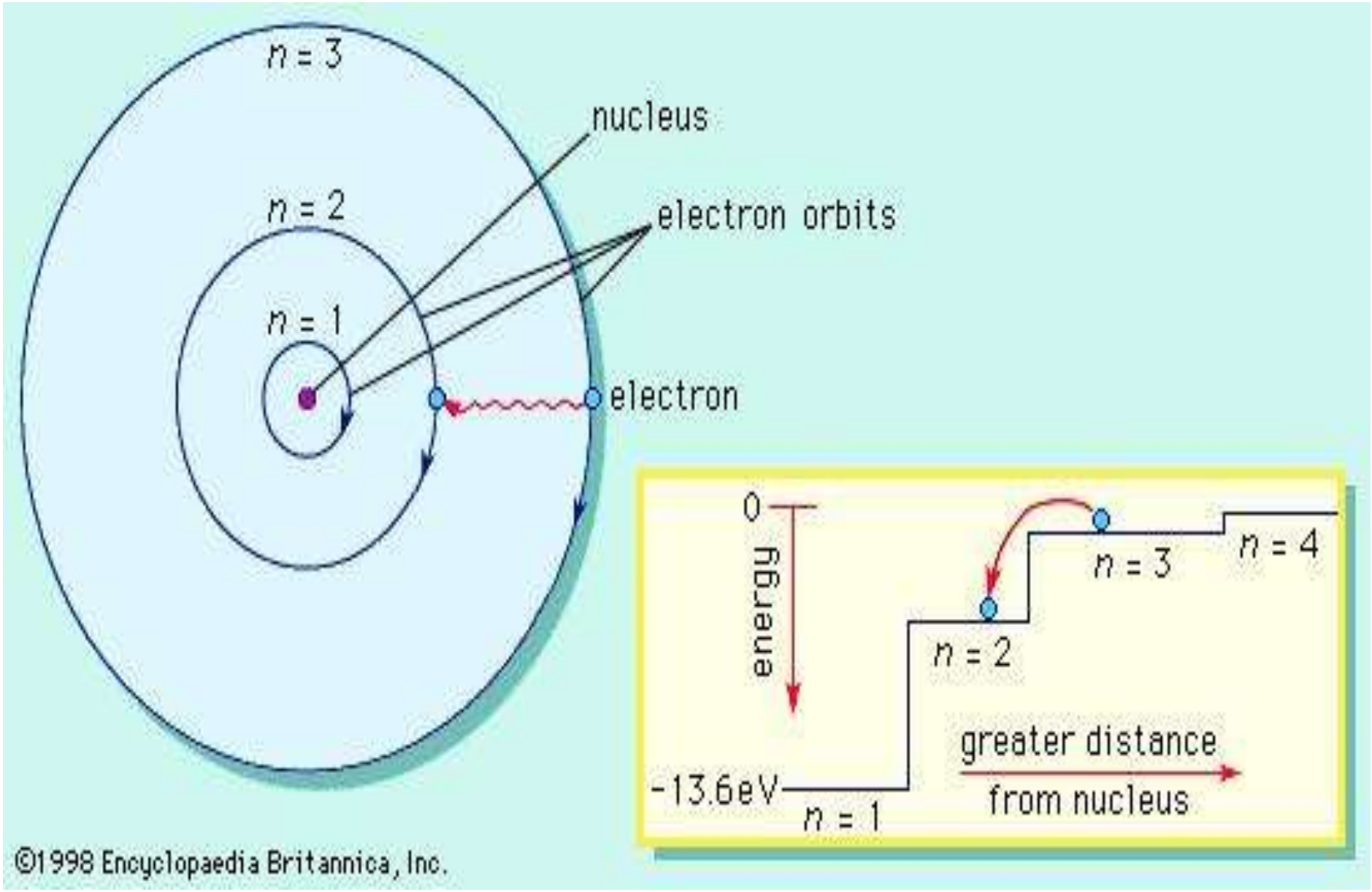


- **The flaw in Rutherford's model:**
  - **It could not explain why the electrons <u>didn't fall into the nucleus and destroy the atom</u>**

Niels Bohr (1913)



- Bohr pictured the hydrogen atom as having discrete energy "levels" which the electron could "inhabit".


n = 3
n = 2
n = 1
nucleus
electron orbits
electron
0
energy
-13.6eV
n = 1
n = 2
n = 3
n = 4
greater distance
from nucleus
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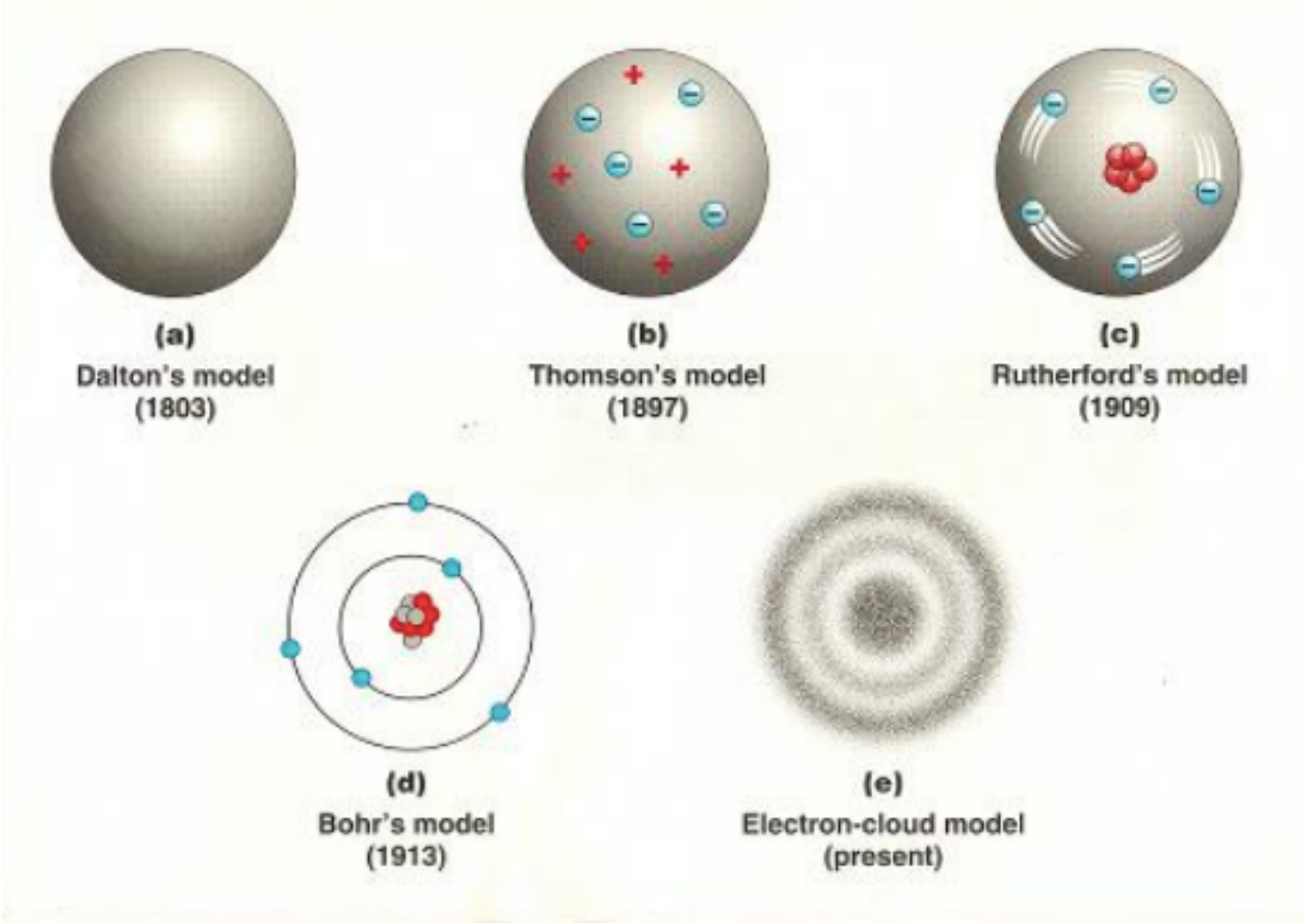
- When the atom was "excited" the electron could "jump" to a higher level.
- When the electron came back down, it released energy in the form of light.

Summary


(a)
Dalton's model
(1803)
(b)
Thomson's model
(1897)
(c)
Rutherford's model
(1909)
(d)
Bohr's model
(1913)
(e)
Electron-cloud model
(present)

Maria Goeppert Mayer (1949)

- Formulated the nuclear shell model that finally made it possible to understand how the nucleus of atoms work

Maria Goeppert Mayer

Periodic table (extended form)

Superheavy elements may not exist, and may not follow the order of this table even if they do exist

	1																	2
1	H																	He
2	3	4											5	6	7	8	9	10
	Li	Be											B	C	N	O	F	Ne
3	11	12											13	14	15	16	17	18
	Na	Mg											Al	Si	P	S	Cl	Ar
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Cs	Ba	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
	Fr	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo
8	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168
	Uue	Ubn	Ubu	Ubb	Ubt	Ubq	Ubp	Ubh	Ubs	Ubo	Ube	Utn	Utu	Utb	Utt	Utq	Utp	Uth	Uts	Uto	Ute	Uqn	Uqu	Uqb	Uqt	Uqq	Uqp	Uqh	Uqs	Uqo	Uqe	Upn	Upu	Upb	Upt	Upq	Upp	Uph	Ups	Upo	Upe	Uhn	Uhu	Uhb	Uht	Uhq	Uhp	Uhh	Uhs	Uho
9	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218
	Uhe	Usn	Usu	Usb	Ust	Usq	Usp	Ush	Uss	Uso	Use	Uon	Uou	Uob	Uot	Uoq	Uop	Uoh	Uos	Uoo	Uoe	Uen	Ueu	Ueb	Uet	Ueq	Uep	Ueh	Ues	Ueo	Uee	Bnn	Bnu	Bnb	Bnt	Bnq	Bnp	Bnh	Bns	Bno	Bne	Bun	Buu	Bub	But	Buq	Bup	Buh	Bus	Buo

Blocks of the periodic table

s-block p-block d-block f-block

Predicted elements are coloured in a lighter shade:

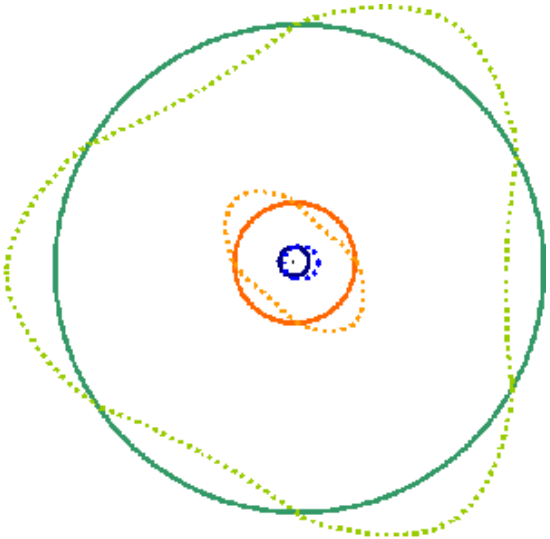
s-block p-block d-block f-block g-block

Other Significant Figures…

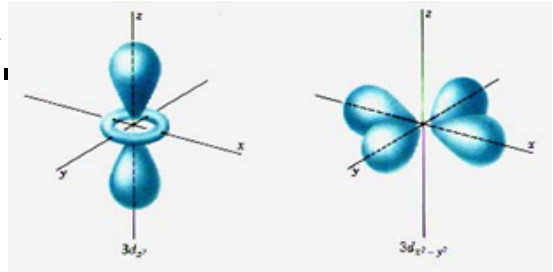
- **Louis De Broglie**
  - **Suggested that all particles have a "wave nature" and that things like light and electrons could be particles *or* waves!**

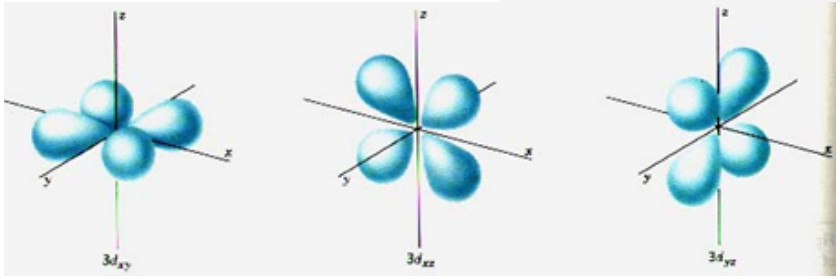
<u>De Broglie's model of the atom →</u>

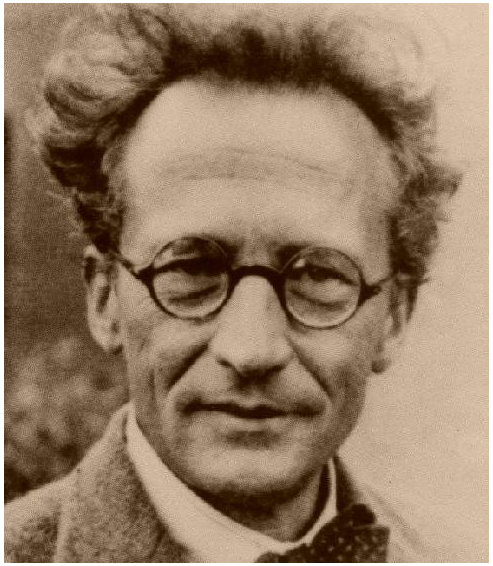
- **Electrons are like waves that go around the nucleus**



- Erwin Schrodinger
  - An orbital is a region in space where the probability of finding an electron is high. The denser the orbital, the higher the probability.







- **Wolfgang Pauli**
  - **Best known for "Pauli Exclusion Principle"**
    - **No two electrons in an atom can have identical quantum numbers**

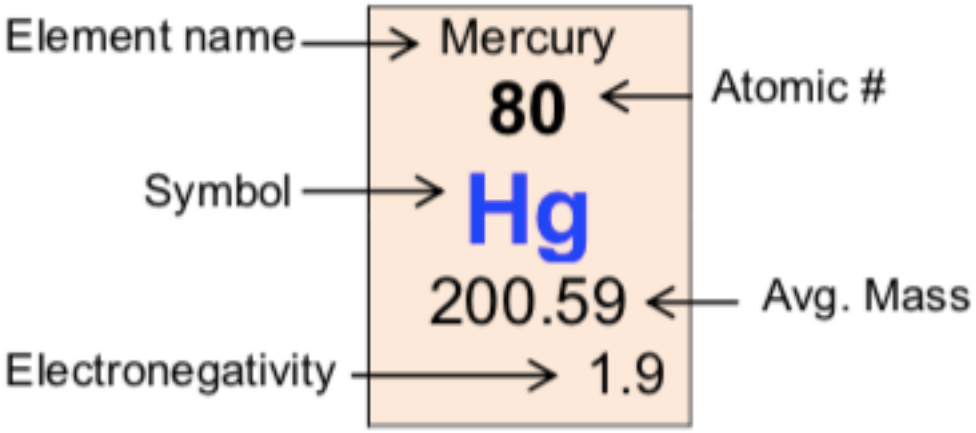
- **Friedrich Hund**
  - **Hund's Rule:**
    - **Each orbital is singly occupied before any orbital is doubly occupied**

Vocabulary

- **Atom:** the basic unit of a chemical element
- **Compound/Molecule:** a **group** of atoms bonded together
- **Ion:** a variant of an atom that has the same number of protons and neutrons, but a different number of **electrons** (a charged atom)
- **Isotope:** a variant of an atom that has the same number of protons and electrons, but a different number of **neutrons**

Atomic Structure

- Atomic Number: The number of **protons** in an element
- Mass Number: The number of **protons and neutrons** in an element



Calculations

1. Isotopes of Neon:
   a. Find Neon on the periodic table. How many protons does Neon have? **10**

-
   a. There are 3 isotopes of Neon: Neon-20, Neon-21 and Neon-22. For each isotope, determine the number of neutrons:

   Neon-20: **10** Neon-21: **11** Neon-22: **12**

   a. Each isotope exists in different proportions. Calculate the **average** atomic mass for neon if its abundance in nature is 90.5% Neon-20, 0.3% Neon-21, and 9.2% Neon-22. Compare the value calculated with the value in your Periodic Table.

   20.2 amu