

In 1963, Nobel Laureate Richard Feynman (1918-1988), one of the most accomplished and influential scientists of the 20th century, wrote:

"If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis (or the atomic fact, or whatever you wish to call it) that all things are made of atoms—little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling on being squeezed into one another. In that one sentence, you will see, there is an enormous amount of information about the world, if just a little imagination and thinking are applied." (Feynman 1963)



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**Q 1: What do you know about atoms?
(Make a list)**



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Q 2: Which has atoms in it?

- I. Heat
 - II. Cells
 - III. Air
 - IV. Gold
- A. All of them
 - B. II and IV
 - C. II III and IV
 - D. Only IV



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Q 3: Which is smaller?

- A. An atom
- B. A molecule
- C. A cell
- D. It depends



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Q 4: How big do you think an atom (H) is?

- A. About 0.1 centimeters (0.1×10^{-2} m)
- B. About 0.1 millimeter (0.1×10^{-3} m)
- C. About 0.1 micrometer (0.1×10^{-6} m)
- D. About 0.1 nanometer (0.1×10^{-9} m)
- E. About 0.1 picometer (0.1×10^{-12} m)



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Evidence for atoms



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How do you know atoms exist?

What is the evidence?



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Atomic Theory Development

- Where did the original idea of atoms come from?
- (the Greeks)
- Was this a Scientific Theory?



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Development of Atomic Theory

- Greeks: earliest atomic theory
 - Not based on experimental evidence – based on philosophy
 - Elements: Earth, fire, air, and water (and aether)
 - Atoms were thought to be in constant motion
 - based on watching the movement of dust motes in sunlight – and that there was nothing or a “void” between them (later called Brownian motion from Einstein)



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Questions

- What properties ascribed by the Greeks to atoms do we still consider to be valid?
- If atoms are in constant motion, what do you think keeps them moving?
- If “earth” had atoms that were cubic, what shape would you ascribe to the elements “air”, “water”, and “fire”?



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Elements

- Atom is smallest unit of an element
- 91 naturally occurring – ordered in the periodic table.



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Periodic Table																		He																			
1 H																		2 He																			
3 Li		4 Be																5 B		6 C		7 N		8 O		9 F		10 Ne									
11 Na		12 Mg																13 Al		14 Si		15 P		16 S		17 Cl		18 Ar									
19 K		20 Ca		21 Sc		22 Ti		23 V		24 Cr		25 Mn		26 Fe		27 Co		28 Ni		29 Cu		30 Zn		31 Ga		32 Ge		33 As		34 Se		35 Br		36 Kr			
37 Rb		38 Sr		39 Y		40 Zr		41 Nb		42 Mo		43 Tc		44 Ru		45 Rh		46 Pd		47 Ag		48 Cd		49 In		50 Sn		51 Sb		52 Te		53 I		54 Xe			
55 Cs		56 Ba		57-70 *		71 Lu		72 Hf		73 Ta		74 W		75 Re		76 Os		77 Ir		78 Pt		79 Au		80 Hg		81 Tl		82 Pb		83 Bi		84 Po		85 At		86 Rn	
87 Fr		88 Ra		89-102 * * *		103 Lr		104 Rf		105 Db		106 Sg		107 Bh		108 Hs		109 Mt		110 Uun		111 Uuu		112 Uub		113 Uuq											

* Lanthanide series

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 144.91	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05
89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu 244.06	95 Am 243.06	96 Cm 247.07	97 Bk 247.07	98 Cf 251.08	99 Es 252.08	100 Fm 257.10	101 Md 258.10	102 No 259.10

* Actinide series

Questions

- How would you explain the difference between an atom and an element?
- What distinguishes one element from another?
How do the atoms of different elements differ?
- What types of evidence might be used to conclude that you had isolated a new element?
- What types of elements would be difficult to identify?



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Dalton's Atomic Theory

- Elements are composed of small indivisible, indestructible particles called atoms
- All atoms of an element are identical and have the same mass and properties
- Atoms of a given element are different from atoms of other elements
- Compounds are formed by combinations of atoms of two or more elements
- Chemical reactions are due to the rearrangements of atoms, atoms (matter) are neither created nor destroyed during a reaction.



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Dalton's Atomic Theory

- Does Daltons Theory still hold?
- What tenets are no longer valid?
- What tenets are still true?



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Atoms have sub-structure

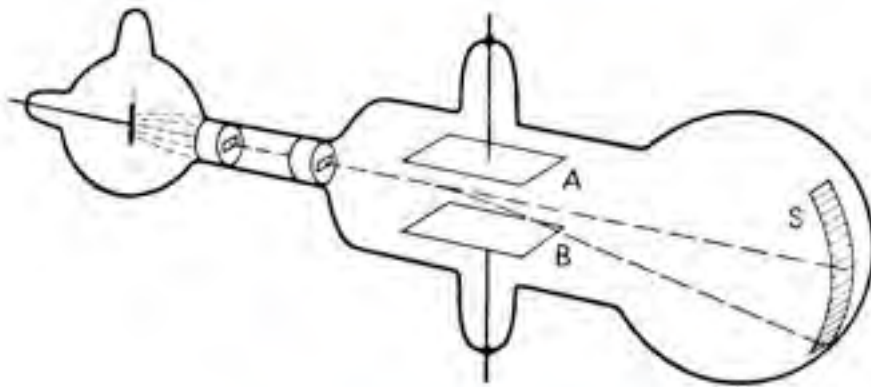
- Which subatomic particle was discovered first? (and why do you think this is so?)
 - A. Proton
 - B. Electron
 - C. Neutron
 - D. Quark



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Thomson's Experiment



[Watch JJ Thomson](#)

Thomson's experiments showed that...

- "Particles" emerged from one disc (the cathode) and moved to the other (the anode)
- These particles could be deflected by electrical fields in a direction that would indicate they were negatively charged.
- The particles could also be deflected by magnetic fields.
- The particles carried the electrical charge – that is if the ray was bent, for example by a magnetic field, the charge went with it.
- The metal that the cathode was made of did not affect the behavior of the ray – so whatever the composition of the ray – it appeared to be independent of the element that it came from

Note: In all of these experiments, + and – are meant to

Question

- What is the evidence from Thomsons expt that **all** atoms contain electrons?
 - The particles were attracted to the + electrode
 - The particles were deflected by magnetic fields
 - The particles were deflected by electrical fields
 - The particles were identical regardless of the identity of the cathode (where they were emitted from)

Thomson's Plum Pudding Atom

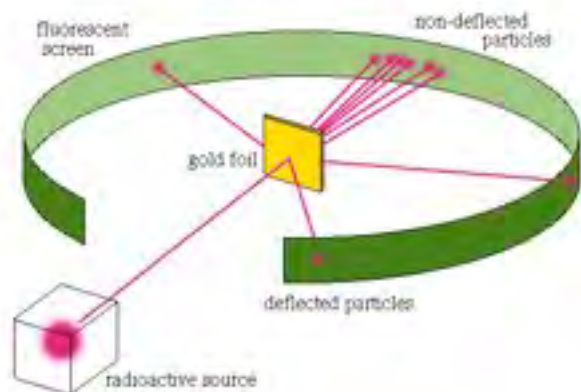
- Atoms contain electrons "embedded" in the atom like raisins in a plum pudding.



This is a plum pudding (not a picture of the model)



Rutherford's Experiment



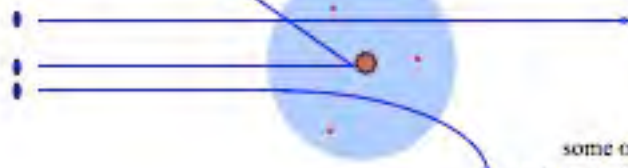
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a few of the
 α particles
do not go through

Nuclear Atom

most α particles
go straight through

some α particles
go through, but are deflected



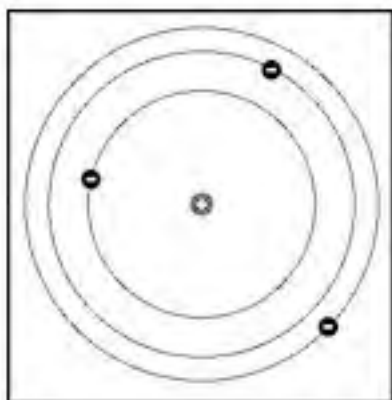
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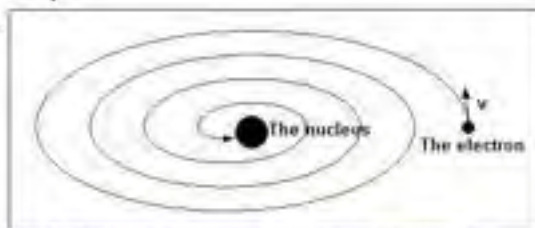
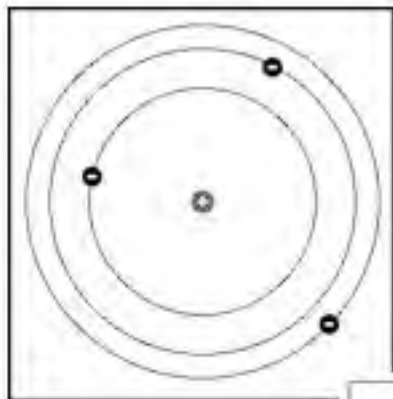


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Rutherford's Planetary Model



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In the planetary model of atom, the electron should emit energy and spirally fall on the nucleus.

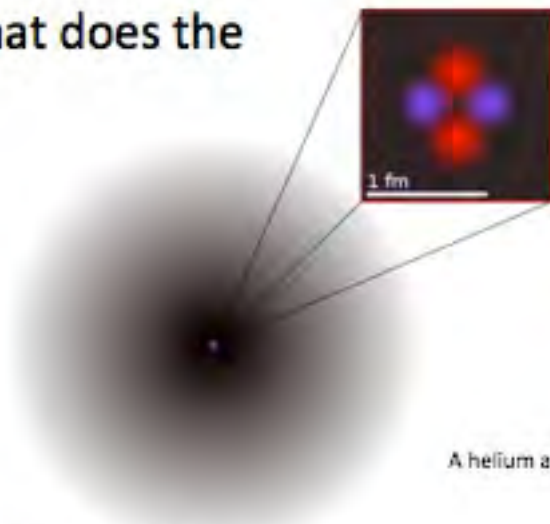
Neutrons (discovered 1932)

- Harder to detect!
- Why?
- Are neutral in charge
- Slightly heavier than protons



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So what does the



A helium atom

1 Ångström (=100,000 fm)

Group Activity



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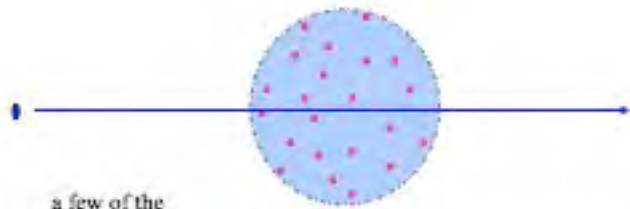
Discovery of the Nucleus (Rutherford)

- [Watch Rutherford](#)
- [Play with the Rutherford applet](#)
- What was the experimental evidence that atoms have a nucleus?
- What was the problem with Rutherford's Planetary Model?



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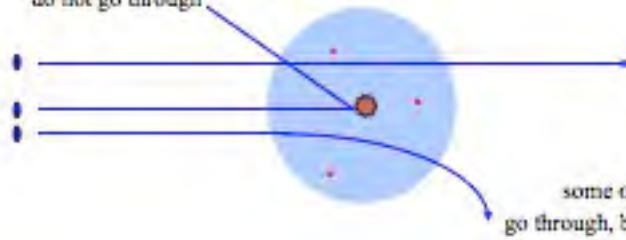
Plum Pudding Atom



if atom was like
a plum pudding,
all the α particles
should go
straight through

a few of the
 α particles
do not go through

Nuclear Atom



most α particles
go straight through

some α particles
go through, but are deflected