

NUCLEAR AND PARTICLE PHYSICS

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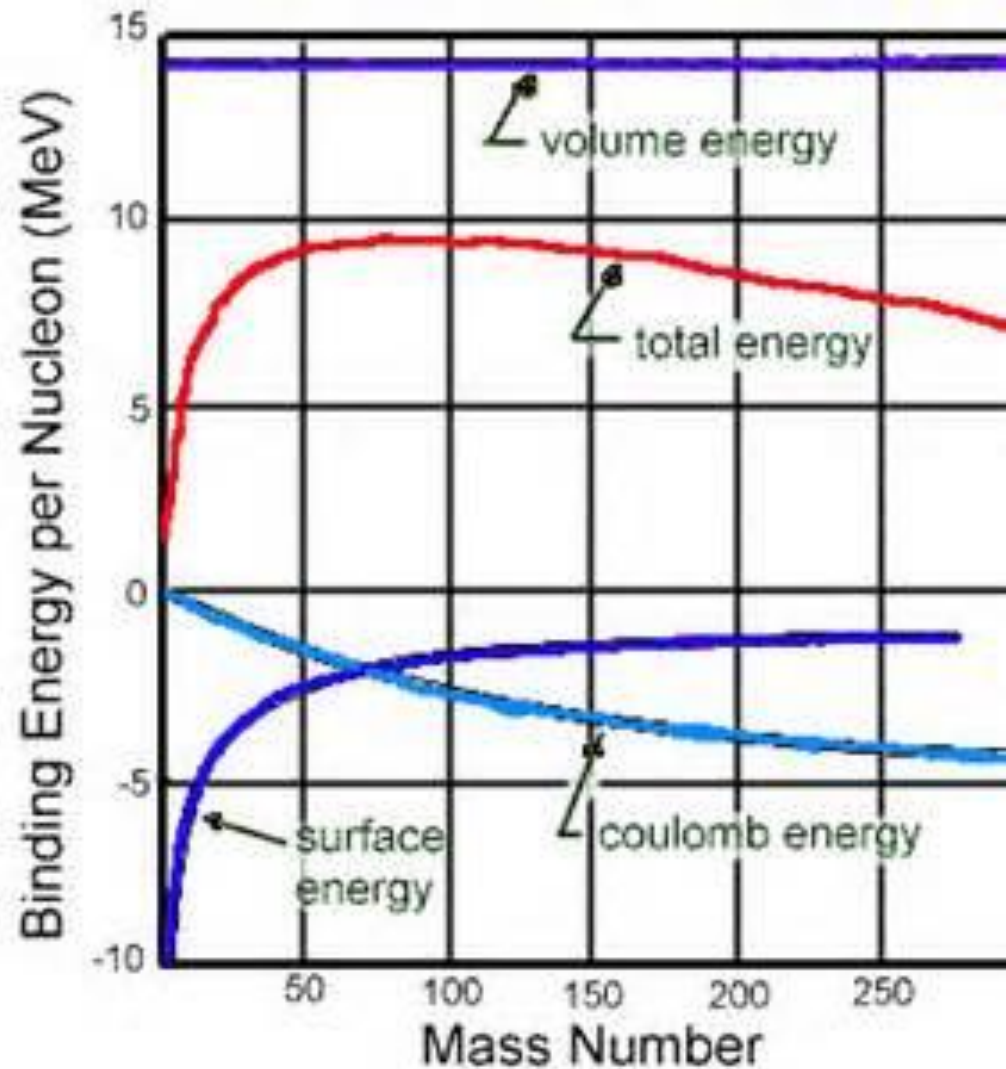
Liquid Drop Model

$$\frac{E_b}{A} = a_V - a_S A^{-1/3} - a_C Z(Z-1)A^{-4/3}$$

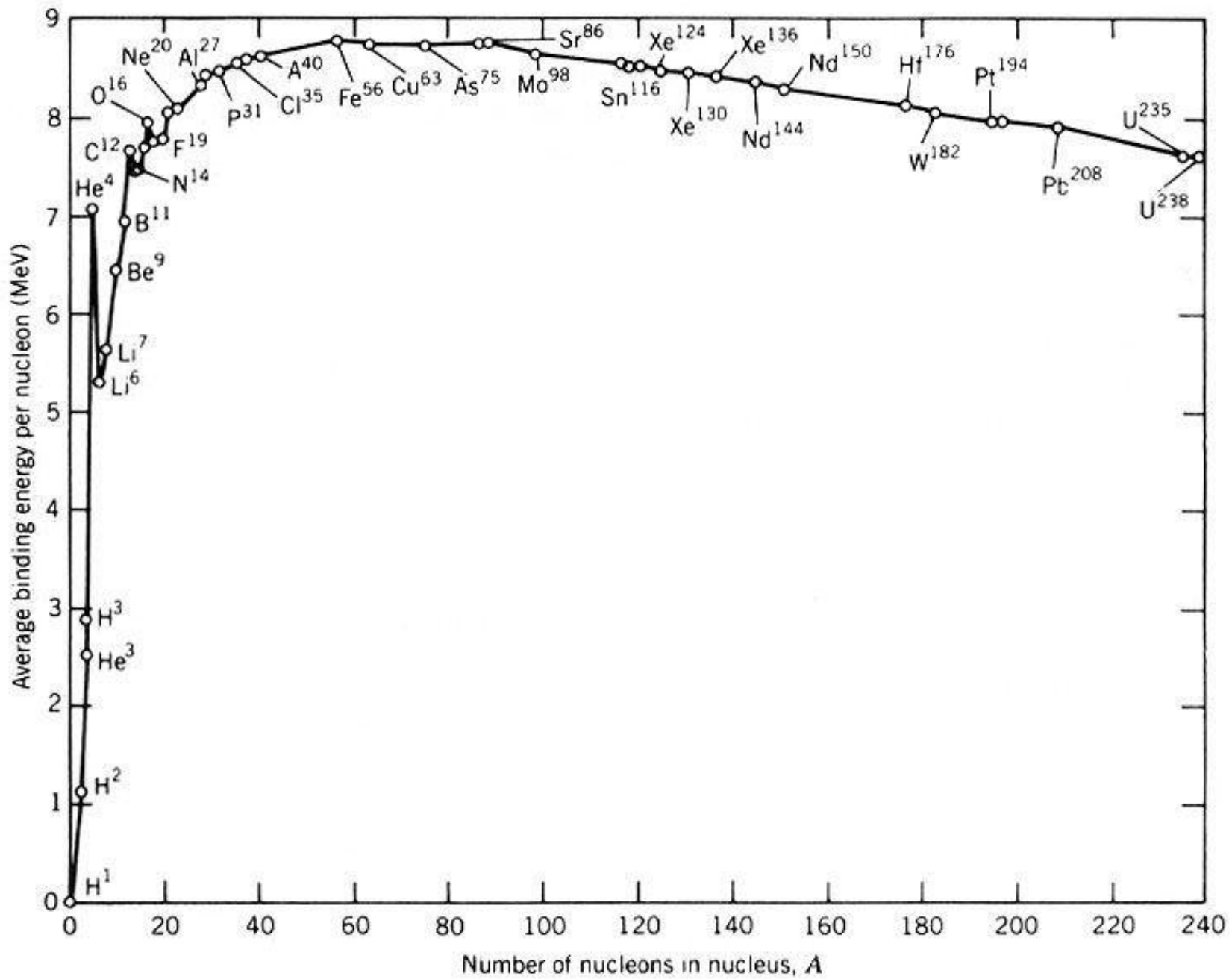
$$a_V = 14.1 \text{ MeV}$$

$$a_S = 13 \text{ MeV}$$

$$a_C = 0.6 \text{ MeV}$$

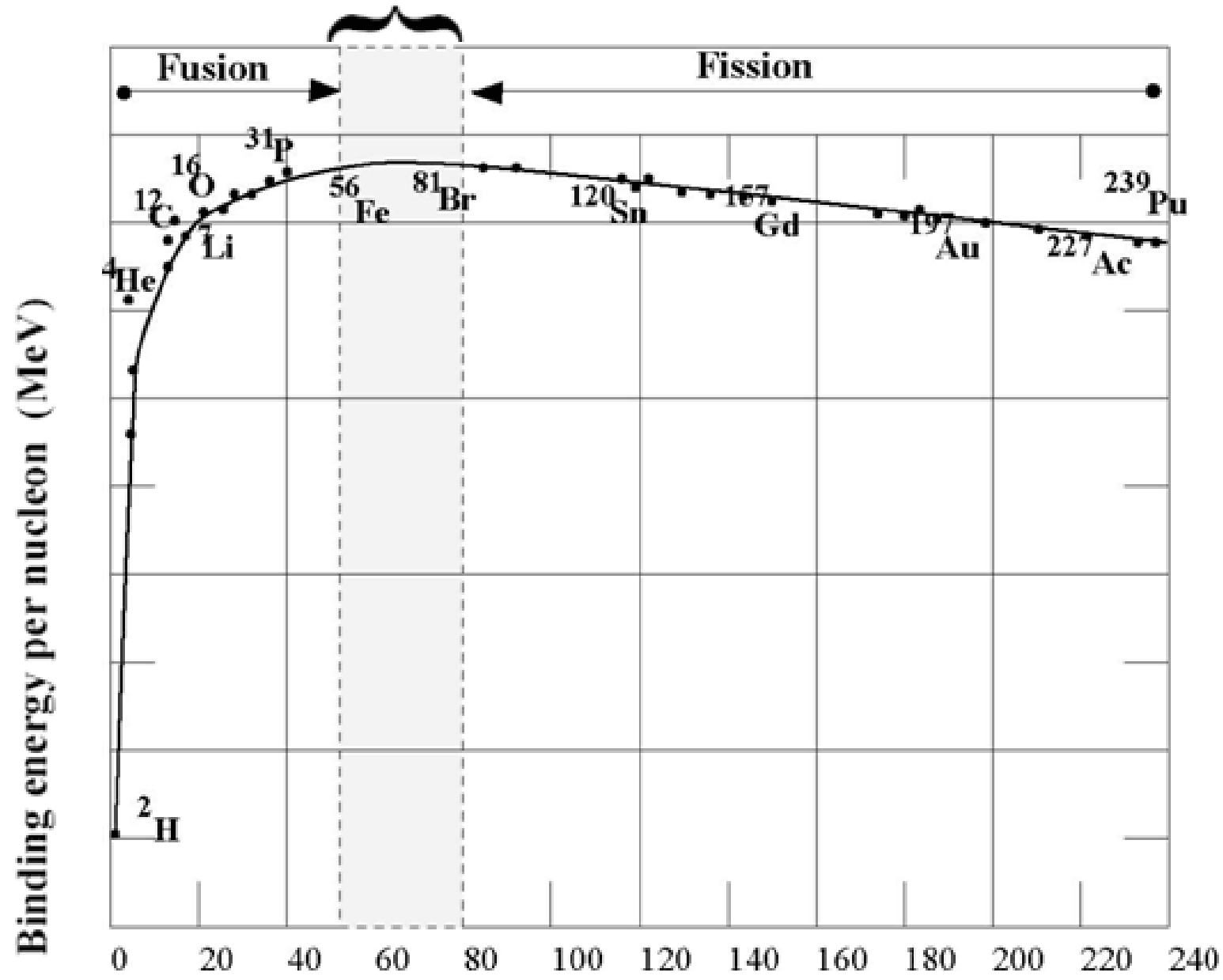


Binding Energy

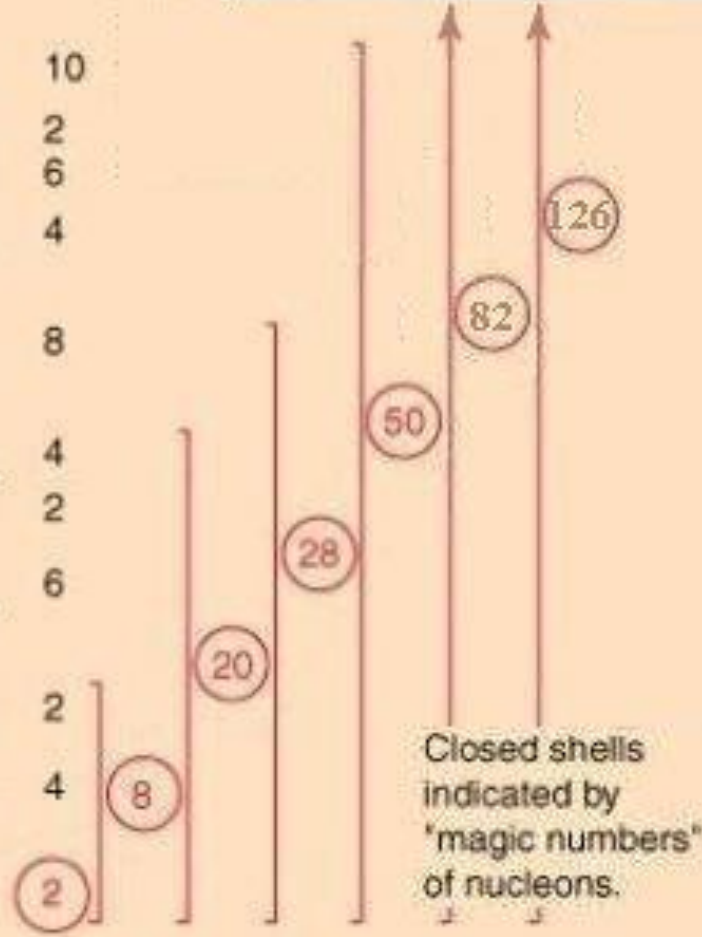
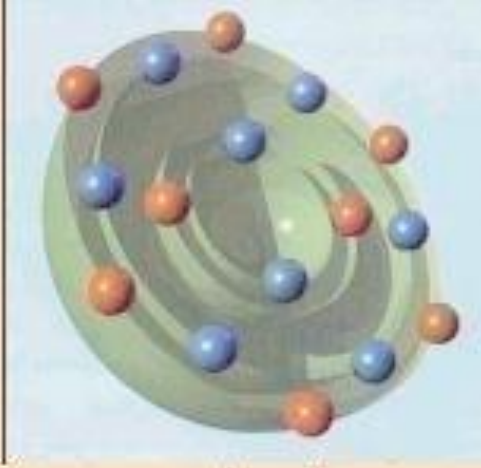
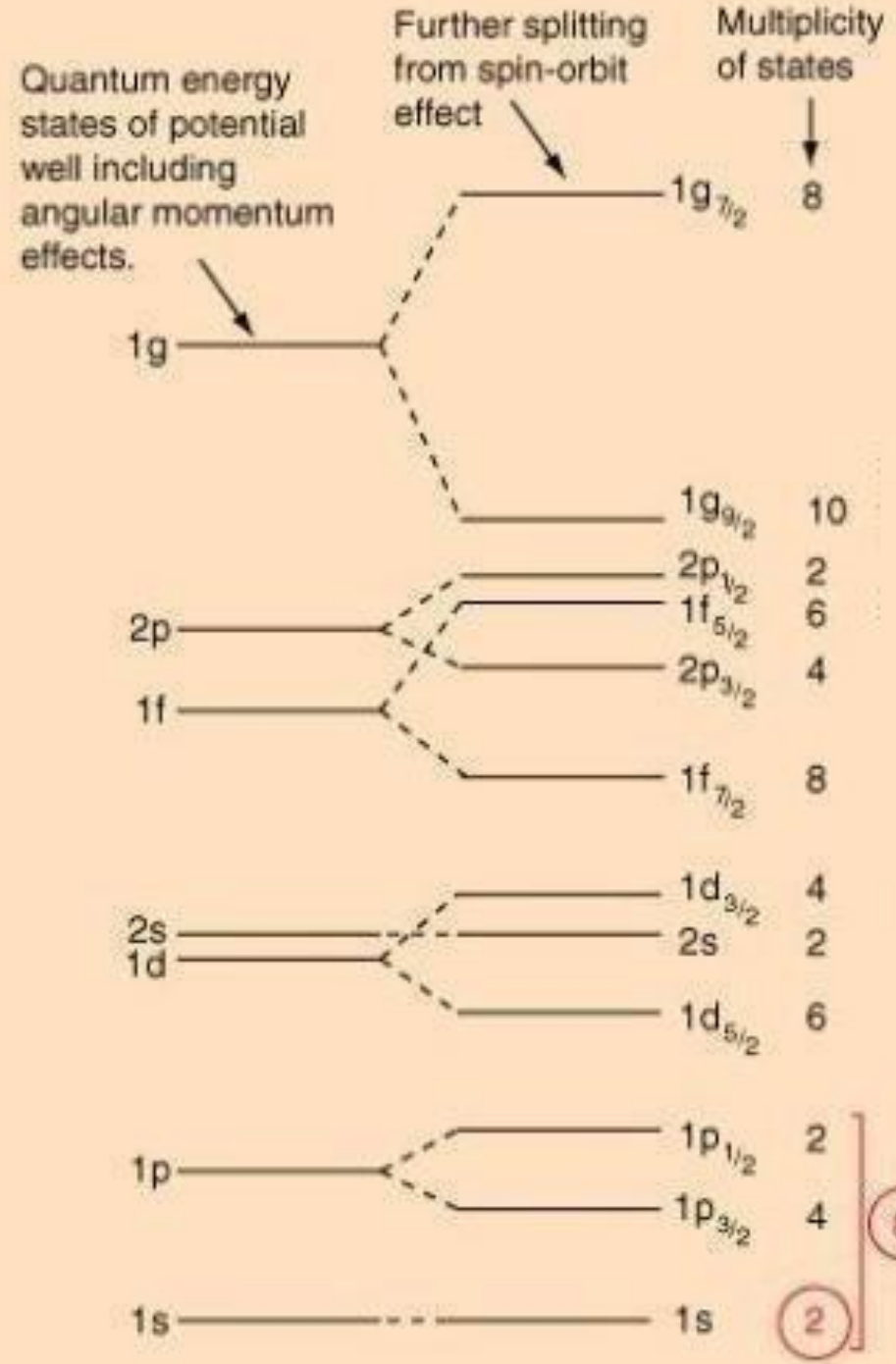


Binding Energy

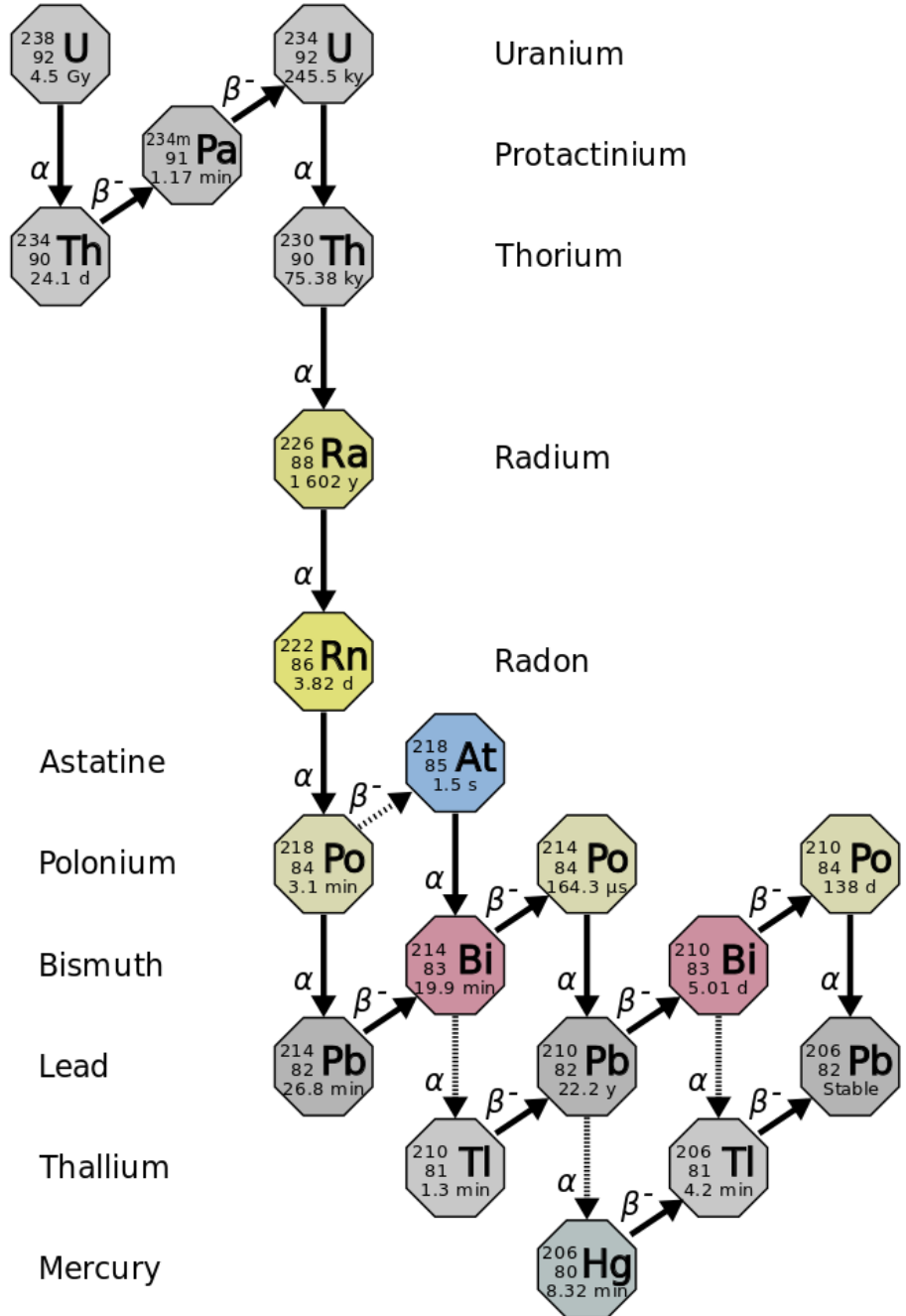
Region of greatest stability



Shell Model

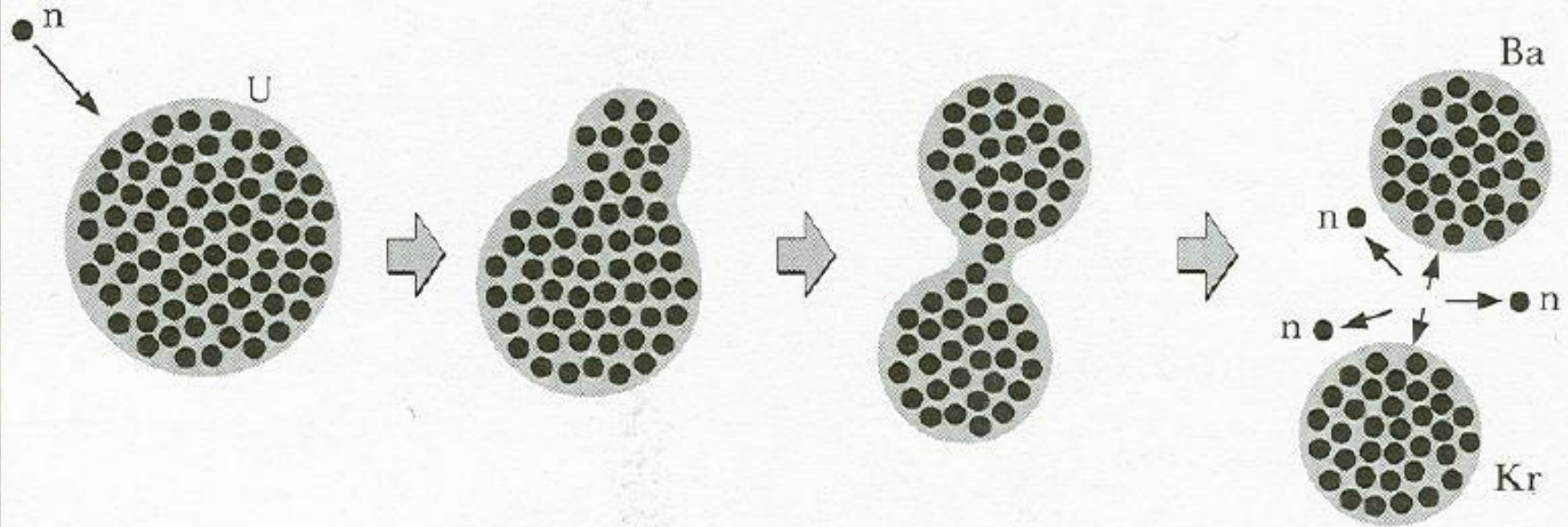


Alpha - Beta decays



Nuclear Fission

Disintegration of uranium by a slow neutron



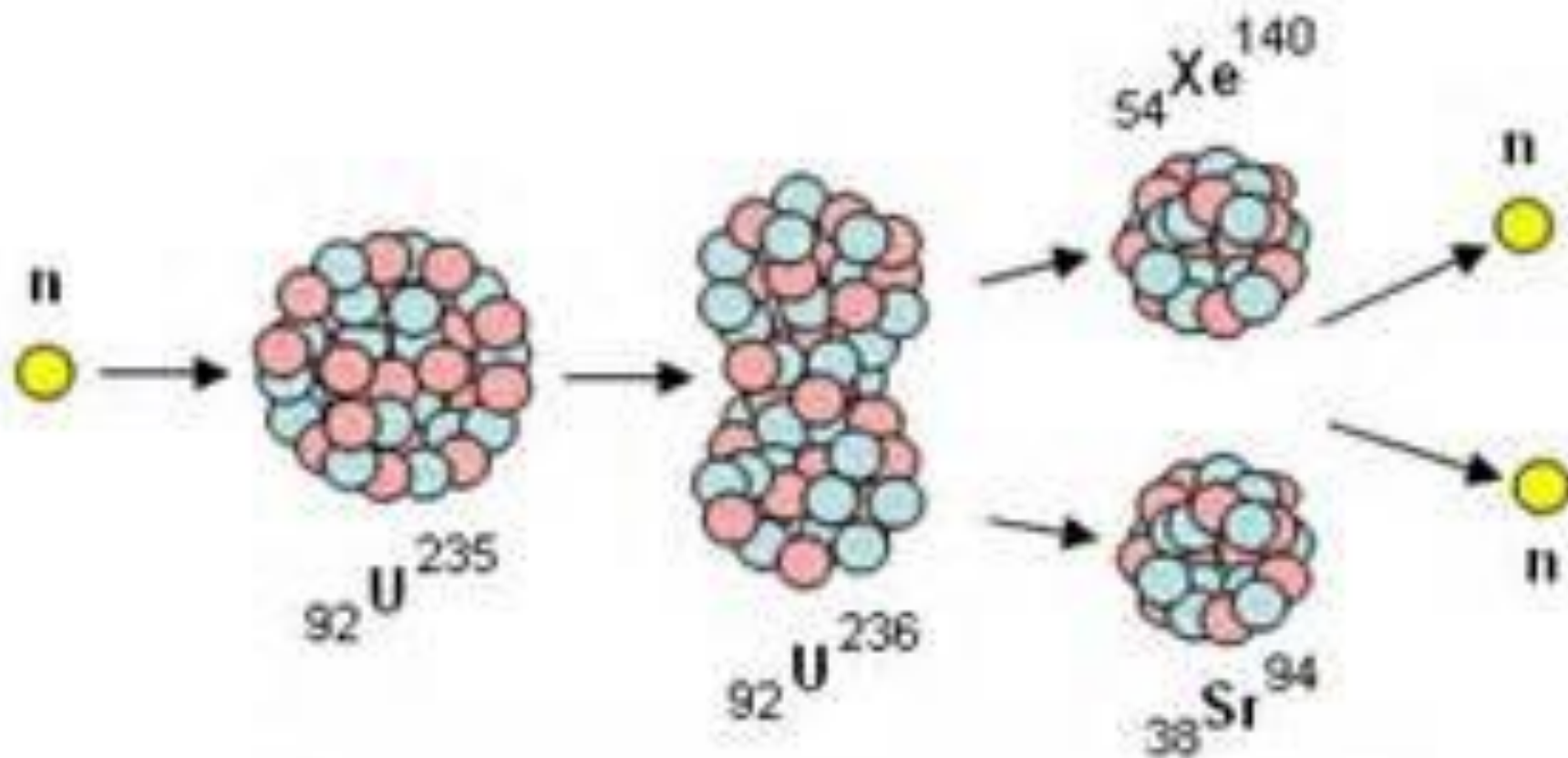
slow neutron hits uranium 235 nucleus and is absorbed

nucleus now unstable; starts to wobble like perturbed drop of water

point of no return; nucleus has developed a waist

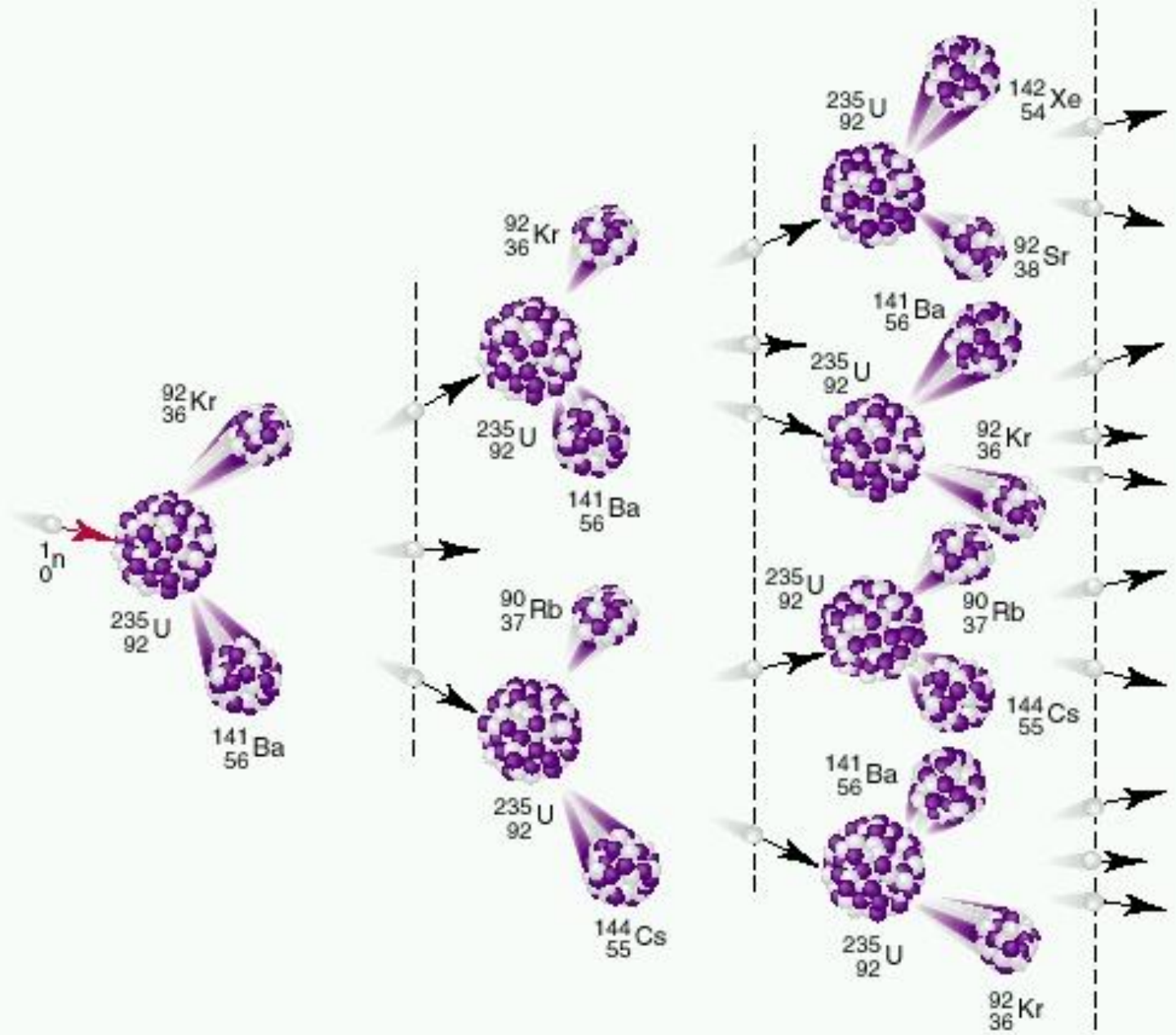
nucleus splits in smaller, stable nuclei of barium and krypton, releasing energy, and two or three more neutrons

Fission of Uranium-235



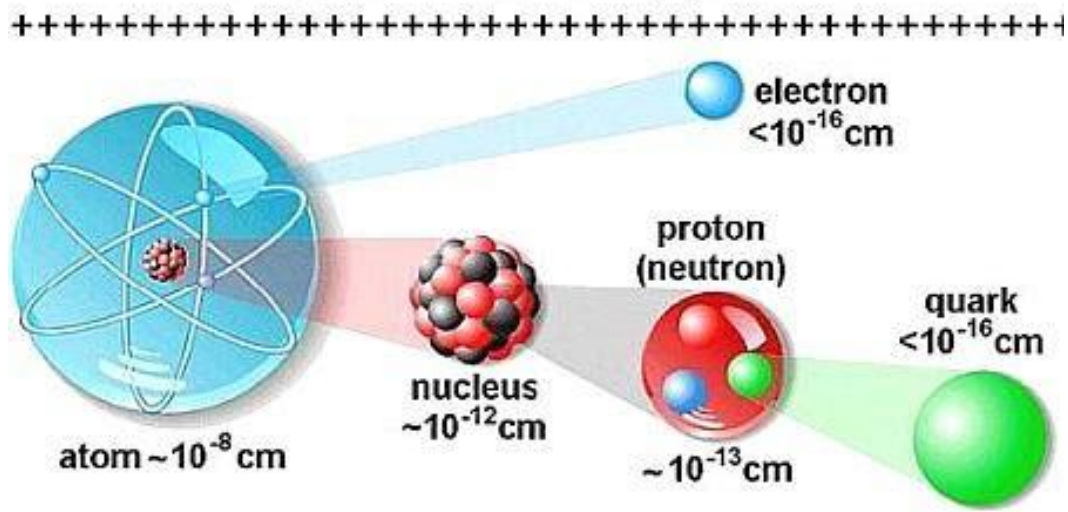
Neutron bombardment of uranium-235
resulting in one possible fission

Chain Reaction



Scale of matter

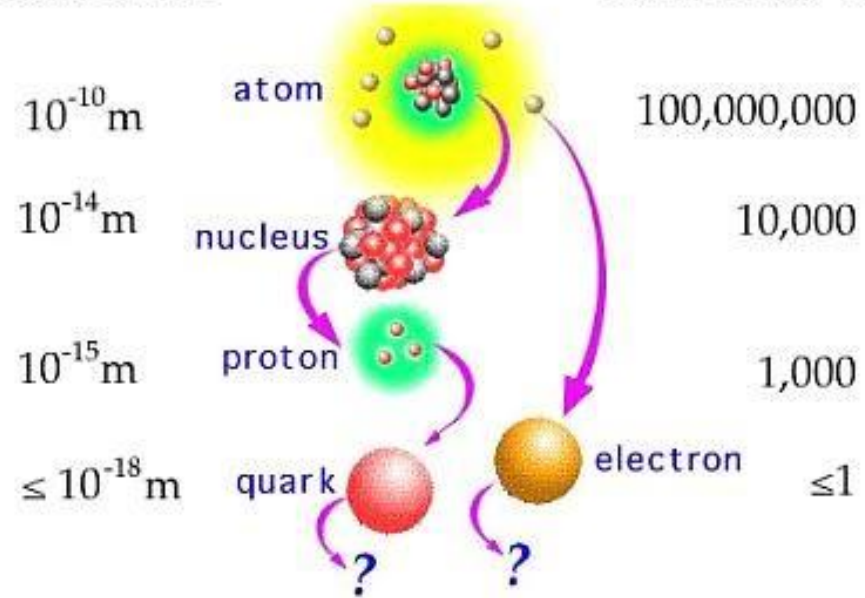
Particle Physics: Probing the fundamental interactions of elementary particles



+++++

Scale in m:

Scale in 10^{-18} m:









+++++

Fermion

(Particle of matter)

Particles

Leptons

Tau		Electric Charge -1	Tau Neutrino		Electric Charge 0
Muon		-1	Muon Neutrino		0
Electron		-1	Electron Neutrino		0

Scale of e

Quarks

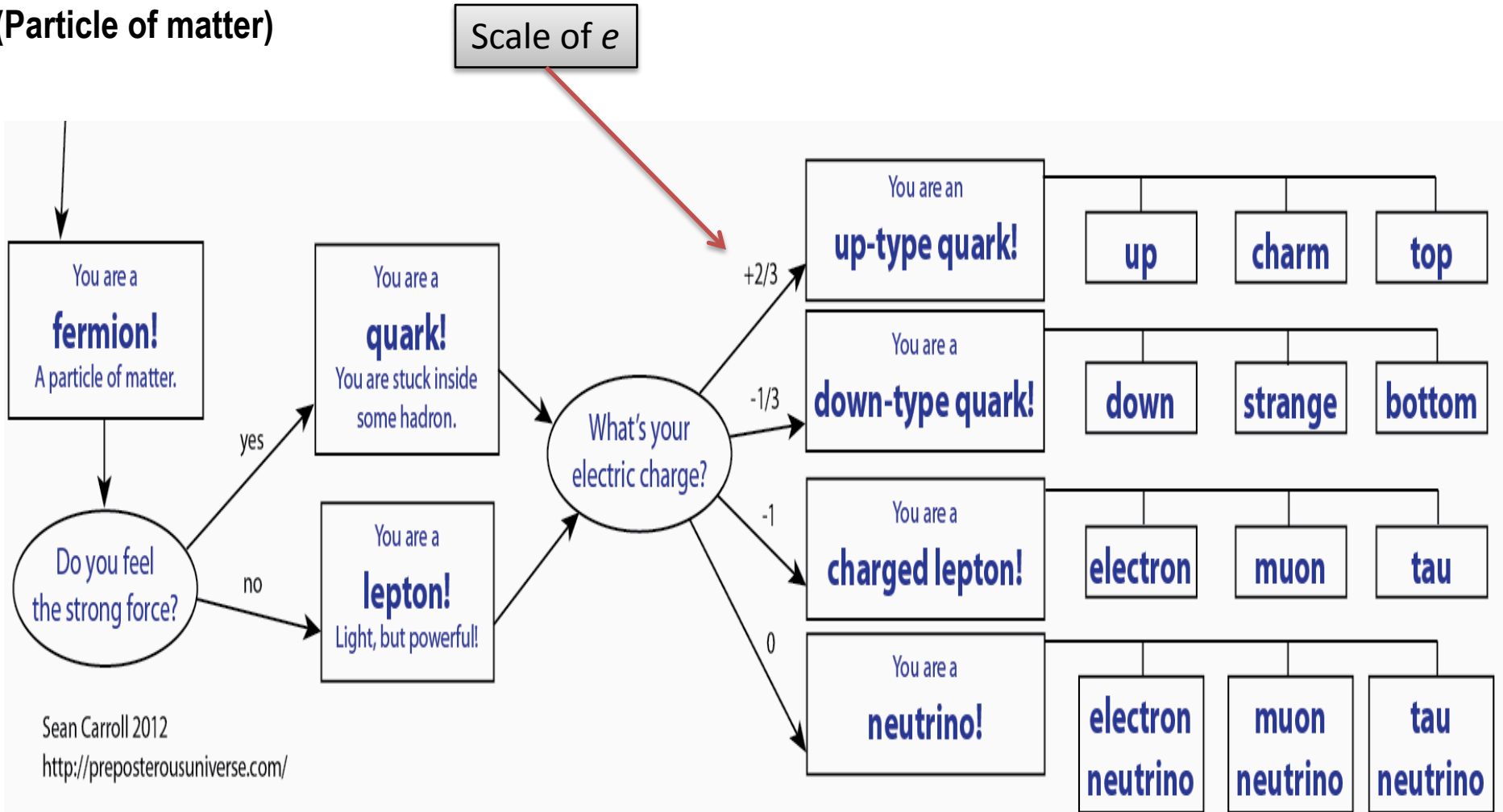
3	<u>B</u> ottom		Electric Charge -1/3	<u>T</u> op		Electric Charge 2/3
2	<u>S</u> trange		-1/3	<u>C</u> harm		2/3
1	<u>D</u> own		-1/3	<u>U</u> p		2/3

each quark: ●R, ●B, ●G 3 colors

The particle drawings are simple artistic representations

Fermion

(Particle of matter)



Scale of e

You are a **fermion!**
A particle of matter.

You are a **quark!**
You are stuck inside some hadron.

You are a **lepton!**
Light, but powerful!

What's your electric charge?

You are an **up-type quark!**

You are a **down-type quark!**

You are a **charged lepton!**

You are a **neutrino!**

up

charm

top

down

strange

bottom

electron

muon

tau

electron neutrino

muon neutrino

tau neutrino

Sean Carroll 2012
<http://preposterousuniverse.com/>

(Name) → Electric Charge
 lifetime → Number of Color Charges
 (Symbol) → Mass

Model of Elementary Particles

Three Generations of Matter (Fermions)

Q
u
a
r
k
s

I	II	III
Up $+2/3$ stable u 3 1.5 - 4 Mev	Charm $+2/3$ variable c 3 1.15 - 1.35 Gev	Top/ Truth variable t 3 ~ 174 Gev

Down $-1/3$ variable d 3 4 - 8 Mev	Strange $-1/3$ variable s 3 80 - 130 Mev	Bottom/ Beauty variable b 3 4.6 - 4.9 Gev
---	---	---

L
e
p
t
o
n
s

Electron Neutrino 0 stable ν_e < 3 ev	Muon Neutrino 0 stable ν_μ < 0.19 Mev	Tau Neutrino 0 stable ν_τ < 18 Mev
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Electron -1 stable e 0.511 Mev	Muon -1 2×10^{-6} s μ 105.6 Mev	Tau -1 3×10^{-13} s τ 1.777 Gev
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Force Carriers (Gauge Bosons)

Range

Photon 0 stable γ 0

Electro-magnetism
 Infinite

Gluon 0 stable g 8 0

Strong Interactions
 10^{-13} cm

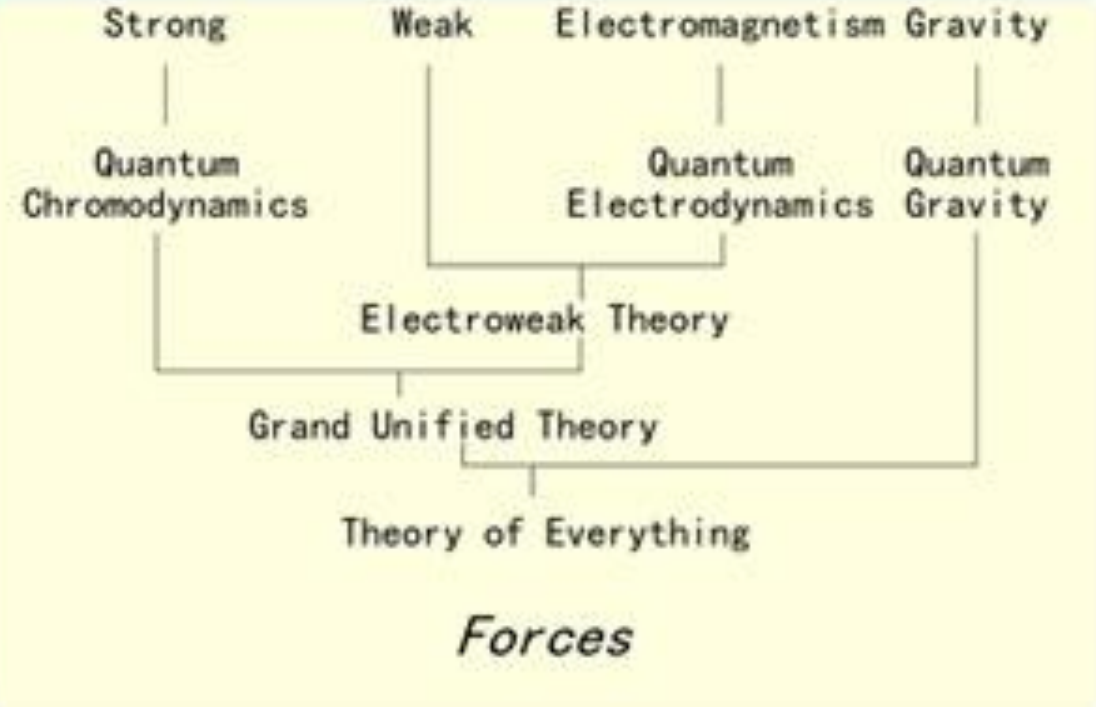
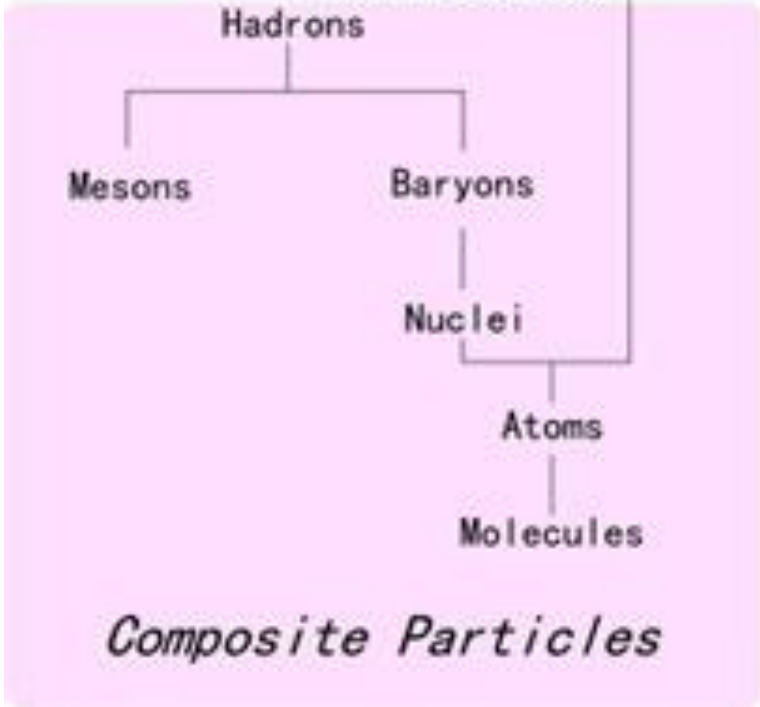
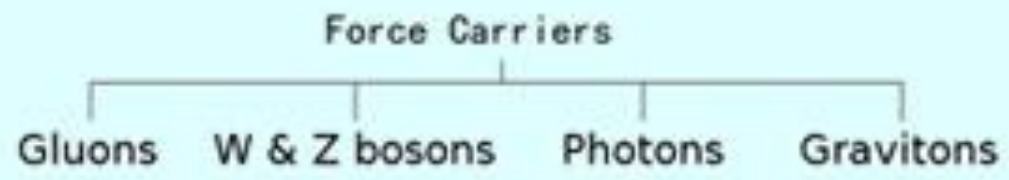
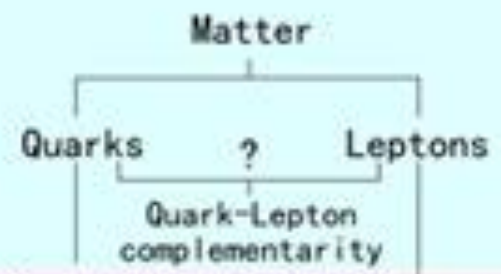
Z zero 0 10^{-25} s Z 91.19 Gev

Weak Interactions
 10^{-16} cm

W plus minus ± 1 10^{-25} s W 80.4 Gev
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Matter and Force Field

Elementary Particles



Composite Particles

Forces