

# Fundamental Particles : their names and location



Ask Mish

Left column:found on Earth    Columns 2 and 3: not found naturally on Earth

Quarks

Bosons  
(right  
column)

Leptons

up	charm	top	photons
down	strange	bottom	gluons
electron	muon	tau	W and Z bosons
electron neutrino	muon neutrino	tau neutrino	Higgs boson

# Fundamental Particles- 2 types : F&B



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● FERMIONS	● BOSONS
<ul style="list-style-type: none"><li>● 2 Fermions cannot be in the same</li><li>● time and place =Exclusion Principle</li></ul>	<ul style="list-style-type: none"><li>● 2 Bosons can be in the same time and</li><li>● place = not Exclusion Principle.</li></ul>
<ul style="list-style-type: none"><li>● create MASS : atoms, walls, people</li></ul>	<ul style="list-style-type: none"><li>● FORCE (Energy) carriers only</li></ul>
<ul style="list-style-type: none"><li>● spin <math>1/2</math></li></ul>	<ul style="list-style-type: none"><li>● Spin 1</li></ul>
<ul style="list-style-type: none"><li>● 2types: Quarks, Leptons</li></ul>	<ul style="list-style-type: none"><li>● photons, gluons, W, Z, H.</li></ul>

# Fermions: Quarks & Leptons



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<ul style="list-style-type: none"><li>• QUARKS bind together 2 (Mesons),</li><li>• 3(Baryons) 2,3= Hadrons (Thick)</li></ul>	<ul style="list-style-type: none"><li>• LEPTONS do not bind,</li><li>• 1 only</li><li>• = Thin</li></ul>
<ul style="list-style-type: none"><li>• 6 types: up/down, charm/strange,</li><li>• top/bottom</li></ul>	<ul style="list-style-type: none"><li>• 6 types: electron, muon, tau</li><li>• and neutrino for each</li></ul>
<ul style="list-style-type: none"><li>• charged: <math>+2/3</math> up, charm, top</li></ul>	<ul style="list-style-type: none"><li>• charged: <math>-1</math> electron, muon, tau</li></ul>
<ul style="list-style-type: none"><li>• charged: <math>-1/3</math> down, strange, bottom</li></ul>	<ul style="list-style-type: none"><li>• not charged: neutrino, all 3 types</li></ul>



# Origin of fundamental particles names



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- **Fermions** : **E.Fermi** (1901-1954) of Italy and **P.M.A.Dirac** (1902-1984) of England describe the statistical rule which fermions obey



- **Bosons** : **S. Bose** (1894-1974) of India and **A.Einstein** (1879-1955) of Germany describe the statistical rule which bosons obey

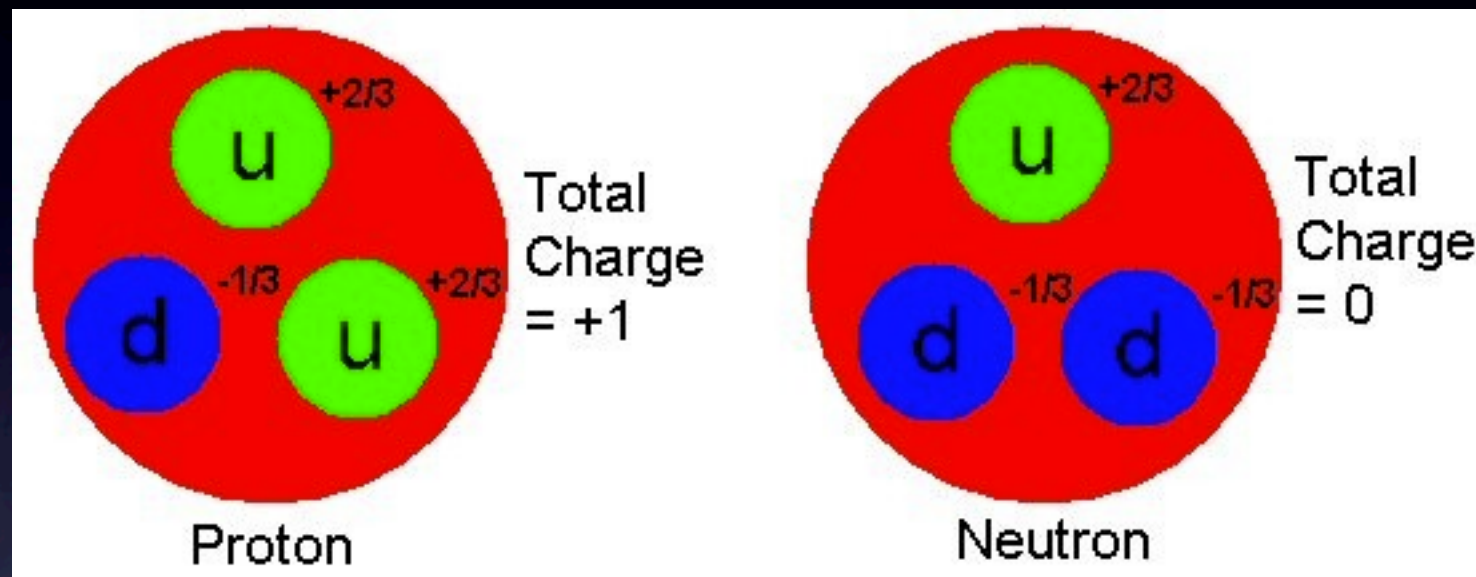


- **Quark** : a drunk seagull from “**Finnegan’s Wake**” by **J.Joyce** ordering **3 quarts** of beer
- **Leptons** : from **leptos** (Gr.) meaning thin

# Quarks & Leptons = mass creators



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6	← Atomic number
C	← Symbol
12.011	← Atomic mass

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- 2 Q up+ 1 Q down= **PROTON** mass 1, electric charge +1
- 1 Q up + 2 Q down= **NEUTRON** mass 1, electric charge 0
- Q c/s t/b=not on Earth
- Total protons = atomic number Z
- Total protons + neutrons = nucleons A
- **ELECTRON**, mass 0, electric charge -1
- muon, tau greater mass, not found on Earth



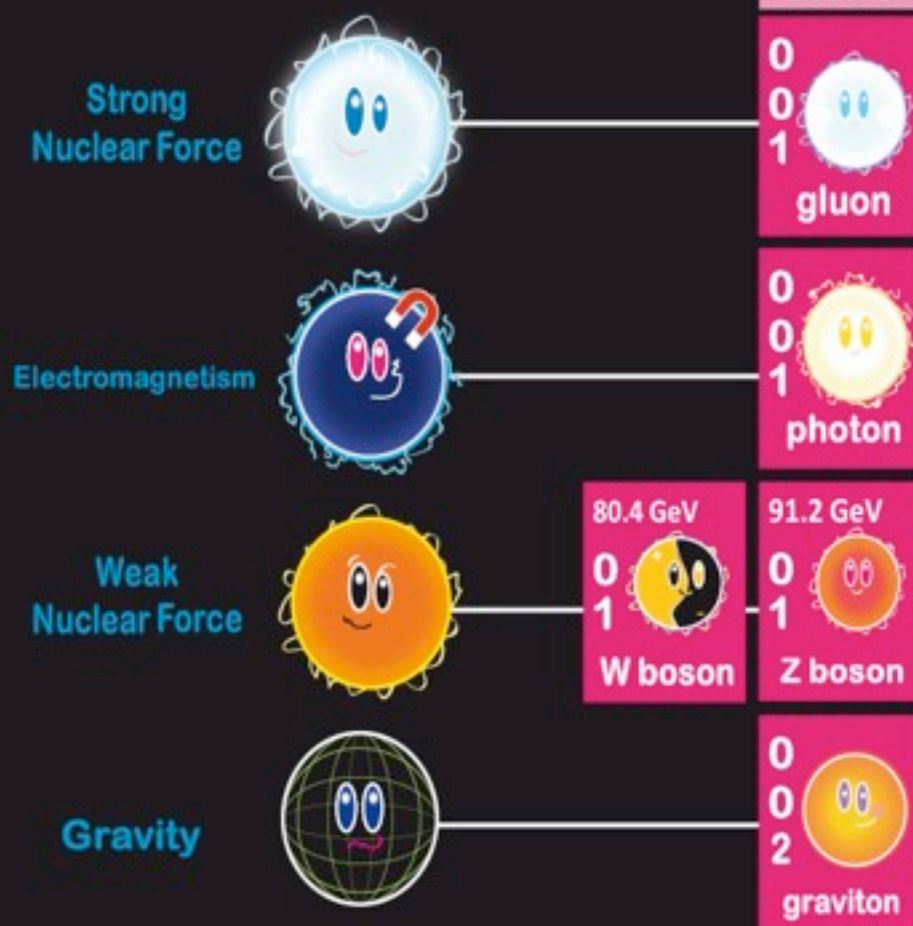
# Bosons= Force carriers



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## STANDARD MODEL of ELEMENTARY PARTICLES

### FORCES



### FERMIONS

#### Quarks

2.4 MeV 2/3 1/2 up	1.27 GeV 2/3 1/2 charm	171.2 GeV 2/3 1/2 top
4.8 MeV -1/3 1/2 down	104 MeV -1/3 1/2 strange	4.2 GeV -1/3 1/2 bottom

#### Leptons

<2.2 eV 0 1/2 electron neutrino	<0.17 MeV 0 1/2 muon neutrino	<15.5 MeV 0 1/2 tau neutrino
0.511 MeV -1 1/2 electron	105.7 MeV -1 1/2 muon	1.777 GeV -1 1/2 tau

- **Gluons** carry **Strong Nuclear Force**, no mass/charge
- **Photons** carry **Electromagnetic Force**, no mass/charge
- **W and Z boson** intermediates **Weak Nuclear Force** huge mass, W: +1/-1, Z has no charge.
- **Higgs boson** intermediates the **force** that make the **differentiation of fundamental particles** in F&L, huge mass, spin 0