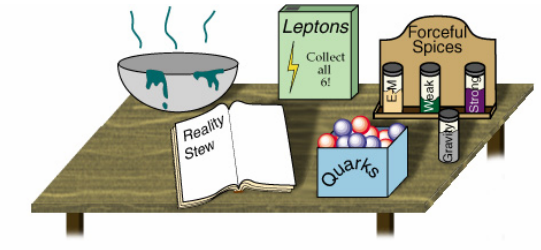
Name _____
The Standard Model of Particle Physics



Matter: it's what you have learned that makes up the world

Protons, Neutrons and Electrons

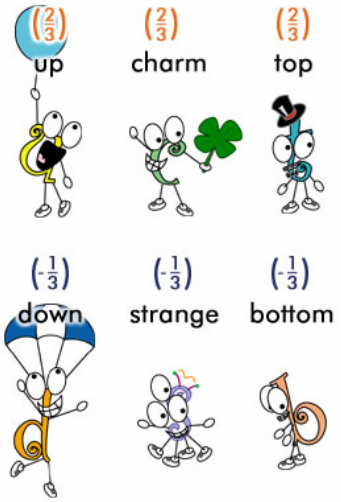
Just like there is good and evil, matter must have something like itself but different.

This is called an **Antimatter!**

Proton has the Antiproton

Neutron has the Antineutron

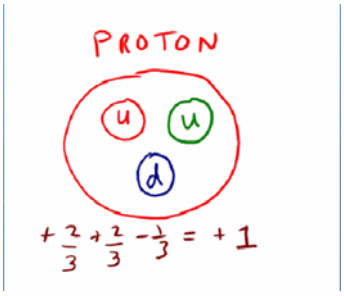
Electron has the Positron

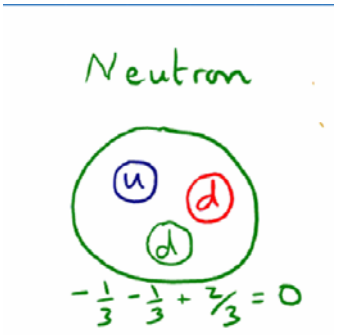


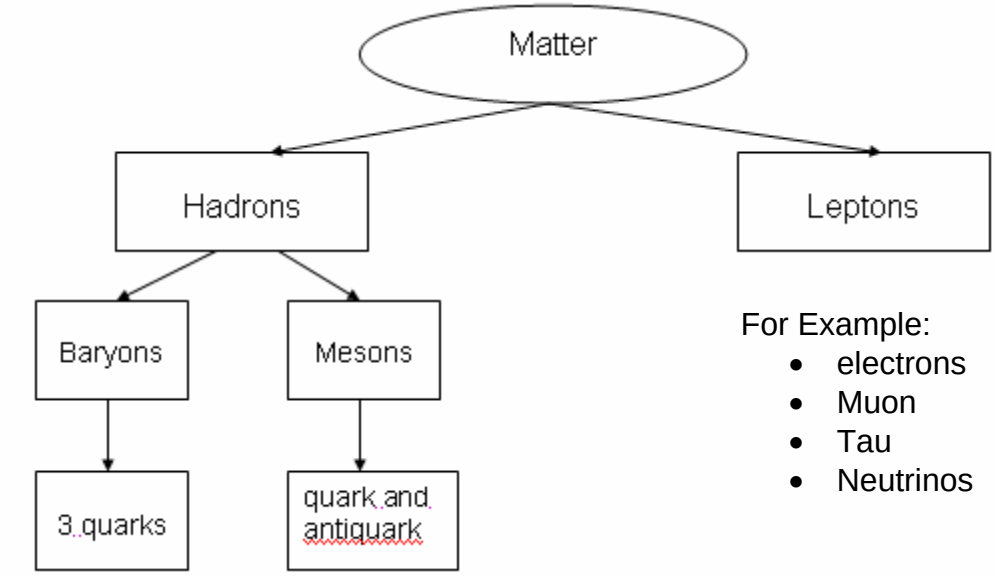
Are these the smallest pieces of matter..No! Quarks hve been found!

The charge on a baryon or meson is the sum of the quark charges.

For Example:







For Example:
- Protons
- Neutrons

For Example:
- Kaon
- Pion

For Example:
- electrons
- Muon
- Tau
- Neutrinos

Fundamental Forces in Nature: What you need to know:

- ✓ The *Standard Model of Particle Physics* is the most current theory on atomic structure
- ✓ The *Standard Model* is a theory, not a law, that is used to explain the existence of all particles that have been observed and the forces that hold atoms together or lead to their decay
- ✓ Scientists refer to particles as force carriers because forces are brought about as a result of an exchange of particles
- ✓ *Four fundamental forces in nature*: strong (nuclear), weak, electromagnetic and gravitational
- ✓ The *weak force is another short-range nuclear force that is responsible for some forms of nuclear decay*
- ✓ *Electric and magnetic forces* combine to make the electromagnetic force
- ✓ Weak force + electromagnetic force = single electroweak force
- ✓ *Grand Unification Theories (GUT's)* attempt to add the strong force to the combined electroweak force
- ✓ *Theories of Everything (TOE's)* attempt to add the gravitational force and combine all four forces togther – currently not yet developed
- ✓ Scientists are always trying new ways to understand atomic structure!
- ✓ SEE YOUR REFERENCE TABLES!

The Four Fundamental Forces in Nature

Force	Relative Strength	Range of Force	Force Carrier	Mass	Charge
Strong(nuclear)	1	Approx 10^{-15} m	gluon	0	0
Electromagnetic	10^{-2}	Proportional to $1 / r^2$	photon	0	0
Weak	10^{-13}	$< 10^{-18}$ m	W boson W boson Z boson	80.6 GeV 80.6 GeV 91.2 GeV	+e -e 0
Gravitational	10^{-38}	Proportional to $1 / r^2$	graviton	0	0

Classification of Subatomic Particles

Particles can be classified according to the types of interactions they have with other particles
If the force carrier particles are excluded, all particles can be classified into two groups according to the types of interactions with other particles

Hadron – interacts through the all four forces (strong, weak, electromagnetic and weak)

- *Examples: Protons and Neutrons*

- **Hadron group can be subdivided into baryons and mesons**

  - **Baryon –** is an elementary particle that can be transformed into a proton or neutron and some number of mesons and lighter particles. Baryon is also known as a heavy particle
  - **Meson** – is a particle of intermediate mass
  -

- **Antiparticles –** is a particle having mass, lifetime and spin identical to the associated particle, but with charge of opposite spin (if charged) and magnetic moment reversed in sign
  - An antiparticle is associated with each particle
  - Antiparticles have a bar over the symbol for the particle
  - **Example:** p is $\bar{}$ as an antiparticle and is a stable baryon, negative in charge and same mass
  - ***Positron*** – is the antiparticle of an electron
  - ***Antineutron*** – neutron's antiparticle has same mass, no charge but opposite magnetic moment and spin
  - ***Antineutrino*** – identical to neutrino except for direction of spin
  - ***Antimatter*** – is material consisting of atoms that are composed of antiprotons, antineutrons, and positrons

Lepton – interacts through electromagnetic, weak and gravitational forces only an have a mass less than a proton

- *Examples: Electrons, positrons and neutrinos*
- **Positron –** is a particle whose mass is equal to the mass of an electron and has a positive charge
- **Neutrino –** is a neutral particle that has little, if any, mass, but does possess both energy and momentum

The Quark

- ***Baryons and mesons are composed of more fundamental particles called quarks***
- ***Quark –*** is one of the basic particles, having charges of + or – 1/3e or + or – 2/3 e
- Many of the elementary particles are made up of quarks
- This means that the charge on the electron is no longer considered to be the smallest nonzero charge that a particle possess
- *The quarks are named up, down, charm, strange, top and bottom*
- *Every baryon* is a combination of three quarks
- *Every meson* is a combination of a quark and an antiquark
- ***Antiquark*** – is the antiparticle of a quark, having electric charge, baryon number and strangeness opposite in sign to that of the corresponding quark
- SEE YOUR REFERENCE TABLES!
- *Proton quark content* is *uud* (up, up, down) – see RT: they add to +1
- *Neutron quark content* is *ddu* (down, down, up) – see RT: they add to 0
- ***When quarks combine to form baryons, their charges add algebraically to a total of 0, +1 or –1***

Classification of Matter – See RT