1st Generation Fermions

Up Quark

Quarks

CLASSIFICATION: Fermion > Quark

SPIN: ½ [Wikipedia](#)

CHARGE: +⅔

MASS: 1.5-3.3 MeV

SYMBOL: u

●○○○○○○○○○○○○
LIGHT HEAVY

[BUY](#)

The **UP QUARK** is the smallest of the six quarks and is subject to the strong force. A [proton](#) contains two up quarks (and one down quark) so the up quark is very important for everyday life. As it comprises all the physical matter we see around us, it is, of course, stable. It was one of the first quarks to be discovered (in 1964).

Down Quark

Quarks

CLASSIFICATION: Fermion > Quark

SPIN: ½ [Wikipedia](#)

CHARGE: -⅓

MASS: 3.5-6.0 MeV

SYMBOL: d

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LIGHT HEAVY

[BUY](#)

Like its friend the up quark, the **DOWN QUARK** is found in everyday matter and is stable, but is ever so slightly heavier. Also discovered in 1964 (by Murray Gell-Mann), quarks were first called “aces.” Both the down quark and up quark are also found in many [baryons](#) and [mesons](#). Two down quarks and an up make up a [neutron](#).

Electron Neutrino

Leptons

CLASSIFICATION: Fermion > Lepton

SPIN: ½ [Wikipedia](#)

CHARGE: 0

MASS: >3 eV

SYMBOL: ν_e

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LIGHT HEAVY

[BUY](#)

The **ELECTRON-NEUTRINO** is a wily particle of practically zero mass. Like all neutrinos, it is notoriously difficult to detect. Electron-neutrinos travel at close to the speed of light and rarely interact with anything. Discovered in 1956, they are the result of radioactive decay. Most found on Earth originate from the sun.

Electron

Leptons

CLASSIFICATION: Fermion > Lepton

SPIN: ½ [Wikipedia](#)

CHARGE: -1

MASS: 0.510 MeV

SYMBOL: e^-, β^-

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LIGHT HEAVY

[BUY](#)

The **ELECTRON** is a particle typically found orbiting the nucleus of an atom. Subject to the electromagnetic, gravitational and [weak](#) forces, electrons are stable. Historically, it was the first particle to be discovered in 1897 by J.J. Thomson. Electrons are one of the most familiar particles to us as we encounter them in so many realms of everyday life: chemical reactions, magnetism, electricity, etc.

2nd Generation Fermions

Charm Quark

Quarks

CLASSIFICATION: Fermion > Quark

SPIN: ½

[Wikipedia](#)

CHARGE: $+^{2}/_{3}$

MASS: 1.16-1.34 GeV

SYMBOL: c

LIGHT HEAVY

[BUY](#)

The **CHARM QUARK**, first observed in 1974, was discovered by both Brookhaven National Lab and SLAC (Stanford Linear Accelerator Center). It was originally inferred from the [J/ψ](#) particle and is slightly lighter than the [tau](#). [Baryons](#) and [mesons](#) made of charm quarks are called "charmed" particles.

Strange Quark

Quarks

CLASSIFICATION: Fermion > Quark

SPIN: ½

[Wikipedia](#)

CHARGE: $-^{1}/_{3}$

MASS: 70-130 MeV

SYMBOL: s

LIGHT HEAVY

[BUY](#)

Despite its name, there's nothing particularly strange about the **STRANGE QUARK**, a second generation quark discovered by Murray Gell-Mann in 1964 when he developed the quark model. Particles containing a strange quark are said to have a "strangeness" value of -1. It it comparable in mass to the [muon](#) and has a short lifetime.

Muon Neutrino

Leptons

CLASSIFICATION: Fermion > Lepton

SPIN: ½

[Wikipedia](#)

CHARGE: 0

MASS: <0.17 MeV

SYMBOL: ν_{μ}

LIGHT HEAVY

[BUY](#)

Associated with the muon, the **MUON-NEUTRINO** is slightly heavier than the electron-neutrino. There is experimental evidence that neutrinos oscillate from one type to another which means electron-, muon- and tau- neutrinos are all "flavors" of one particle. Muon-neutrinos were discovered in 1962. They react via the weak force.

Muon

Leptons

CLASSIFICATION: Fermion > Lepton

SPIN: ½

[Wikipedia](#)

CHARGE: -1

MASS: 105 MeV

SYMBOL: μ^-

LIGHT HEAVY

[BUY](#)

Sometimes referred to as a "heavy" electron, the **MUON** lives fast and dies young—a muon's lifetime is 2.2 microseconds before it usually decays into an electron and other particles. Discovered in 1937, muons come from cosmic radiation and are about 206 times heavier than the electron. At sea level, the flux of muons is approximately one per square centimeter per minute.

3rd Generation Fermions

Top Quark

Quarks

CLASSIFICATION: Fermion > Quark

SPIN: ½ [Wikipedia](#)

CHARGE: +⅔

MASS: 169-173 GeV

SYMBOL: t

LIGHT HEAVY

[BUY](#)

The massive and extremely short-lived **TOP QUARK** is too unstable to be found in any [baryons](#) or [mesons](#). The last of the six quarks to be discovered, it wasn't until 1995 at Fermilab that physicists finally observed this (predicted) particle. It is the most massive observed particle in the Zoo and usually decays into a bottom quark via the [weak interaction](#).

Bottom Quark

Quarks

CLASSIFICATION: Fermion > Quark

SPIN: ½ [Wikipedia](#)

CHARGE: -⅓

MASS: 4.13-4.37 GeV

SYMBOL: b

LIGHT HEAVY

[BUY](#)

The **BOTTOM QUARK** is about four times the mass of the [proton](#) and is easily identified in experiments. Originally named "beauty," the bottom quark was discovered in 1977 by Leon Lederman's group at Fermilab. It is often the decay product of the short-lived top quark and would be a decay product of the [Higgs boson](#).

Tau Neutrino

Leptons

CLASSIFICATION: Fermion > Lepton

SPIN: ½ [Wikipedia](#)

CHARGE: 0

MASS: <18 MeV

SYMBOL: ν_τ

LIGHT HEAVY

[BUY](#)

The **TAU-NEUTRINO** is the most recent particle to be discovered in the Zoo. The heaviest of the neutrinos (35 times more massive than the electron), the tau-neutrino was discovered in 2000 at Fermilab. It is stable but new research indicates it oscillates to other neutrino types (see muon-neutrino).

Tau

Leptons

CLASSIFICATION: Fermion > Lepton

SPIN: ½ [Wikipedia](#)

CHARGE: -1

MASS: 1.776 GeV

SYMBOL: τ^-

LIGHT HEAVY

[BUY](#)

The heaviest lepton, the **TAU**, is about 3,490 times the mass of the electron. Discovered in 1975 at SLAC (Stanford Linear Accelerator Center), the tau is the only lepton that can decay into [hadrons](#) (because of it hefty mass). It really lives fast and dies young, with a lifetime of 3 x 10-13 second — and is often produced through electron-positron annihilation.

Bosons

Photon

Bosons

CLASSIFICATION: Boson

SPIN: 1 [Wikipedia]

CHARGE: 0

MASS: 0

SYMBOL: γ

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LIGHT HEAVY

BUY

The massless wavicle we know and love, the **PHOTON**, better known as light, always travels at the speed of light and communicates the electromagnetic force in many forms from microwaves to gamma rays. About 1012 photons of sunlight fall on a pinhead each second. Displaying both wave and particle characteristics, photons were first postulated by Einstein in 1905.

Gluon

Bosons

CLASSIFICATION: Boson

SPIN: 1 Wikipedia

CHARGE: 0

MASS: 0

SYMBOL: g

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LIGHT HEAVY

BUY

The **GLUON** is the force-carrying particle of the strong nuclear force, which holds quarks together and binds the nucleus of atom. Discovered in 1979, it is stable, massless, and comes in 8 color states. At extremely high temperatures, quarks and gluons fluidly mix into a quark- gluon plasma. It is theorized that gluons can interact with each other and form glueballs.

Z Boson

Bosons

CLASSIFICATION: Boson

SPIN: 1 Wikipedia

CHARGE: 0

MASS: 91 GeV

SYMBOL: Z

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LIGHT HEAVY

BUY

Like the W boson, the **Z BOSON** is another extremely massive boson, so named because physicists at the time thought it was going to be the last particle to be discovered (or "Z" for zero charge). Like the W, the Z is a carrier of the weak force and lives for less than a billionth of a billionth of a second. Discovered at CERN in 1983.

W Boson

Bosons

CLASSIFICATION: Boson

SPIN: 1 Wikipedia

CHARGE: -1

MASS: 80.398 GeV

SYMBOL: W^-

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LIGHT HEAVY

BUY

He may be a weak force boson, but he's got formidable heft! Discovered in 1983 at CERN, the **W BOSON** is best known for nuclear decay. Very massive and extremely short-lived (10^{-25} or 0.0000000000000000000000001 second), a W boson is heavier than an atom of iron. Unlike other bosons, it has either positive or negative charge. The W stands for weak force.

Theoretical

Higgs Boson

Theoretical

CLASSIFICATION: Boson

SPIN: 0

Wikipedia

CHARGE: 0 (±1 SUSY)

MASS: 96-129 GeV

SYMBOL: H

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LIGHT HEAVY

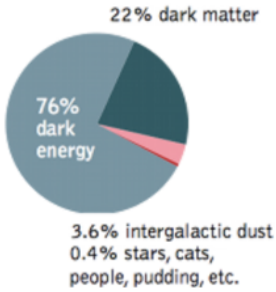
BUY

The **HIGGS BOSON** is the particle everyone wants to meet, but for now he's playing hard to get. Physicists believe the Higgs is responsible for giving mass to all other particles. He was finally detected at the Large Hadron Collider in Geneva, and only sticks around for a millionth of a billionth of a billionth of a second before decaying into other particles.

Dark Matter

CLASSIFICATION: Theoretical

Wikipedia



BUY

DARK MATTER is the name given to material in the universe that does not emit or reflect light, but is necessary to explain the observed gravitational effects in stars and galaxies. Along with dark energy, this mysterious stuff comprises 96% of the universe. Some physicists believe supersymmetric partner particles (SUSY) to be a candidate for dark matter.

Baryons

Proton

Nucleons

CLASSIFICATION: Hadron > Baryon

SPIN: ½

Wikipedia

CHARGE: +1

MASS: 938.272 MeV

SYMBOL: p

QUARKS: uud

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LIGHT HEAVY

BUY

The **PROTON** is not a fundamental subatomic particle, as it contains smaller constituents (3 quarks). It forms the nucleus of an atom and determines a chemical element's atomic number. It is not known if protons decay—their half-life is theorized to be at least 10^{35} years, many times the age of the universe. Protons are the particle of choice for experiments at high-energy colliders.

Neutron

Nucleons

CLASSIFICATION: Hadron > Baryon

SPIN: ½

Wikipedia

CHARGE: 0

MASS: 939.565 MeV

SYMBOL: n

QUARKS: udd

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LIGHT HEAVY

BUY

The **NEUTRON** is bound by the strong nuclear force to the proton in the nucleus of an atom. Like the proton, it contains 3 quarks. If isolated outside the atom, a neutron will decay in about 15 minutes into a proton, electron and electron-antineutrino (known as beta decay). The number of neutrons determines the isotope of a chemical element. It was discovered in 1932 by James Chadwick.

Hypotheticals

Tachyon

CLASSIFICATION: Non-Physical

Wikipedia

There was a lady named Bright,

Who traveled faster than light.

She once went away,

in a relative way,

and returned the previous night.

BUY

A fun hypothetical particle to think about, the **TACHYON** is superluminal, meaning it travels faster than light, thus violating Einstein's theory of relativity. It would take an infinite amount of energy to slow a tachyon down to light speed, its rest mass is an imaginary number and it accelerates as it loses energy. No wonder that when a tachyon shows up in your equation, it signifies an instability.

Graviton

Theoretical

CLASSIFICATION: Theoretical > Boson

SPIN: 2

Wikipedia

CHARGE: 0

MASS: 0

SYMBOL: G

LIGHT HEAVY

BUY

As the force carrier of gravity and smallest bundle of a gravitational field, the **GRAVITON** would hypothetically permeate the universe but so far has never been detected. Theoretically everywhere, gravitons can communicate force over large distances because they're massless (as does their cousin boson the photon). The Particle Zoo graviton has big legs for jumping branes.