64.1: Matter

All of (ordinary) matter is found to be made of two types of particles: quarks and leptons. There are six types of quarks (called up, down, charmed, strange, top, and bottom) and six types of leptons (the electron, muon, tau lepton, and their associated neutrinos.) (Table 64.1.1)

Table 64.1.1. The basic particles of matter.

Quarks	Leptons
Up (u)	Electron (e^-)
Down (d)	Electron neutrino (v_e^0)
Charmed (c)	Muon (μ^-)
Strange (s)	Muon neutrion (μ^-)
Top (t)	Tau lepton (τ^-)
Bottom (b)	Tau neutrino (v_τ^0)

Quarks are never observed in isolation: they occur only as a system of three quarks (called a baryon), or as a quark-antiquark pair (called a meson). (An antiquark is a form of antimatter, described below.) Examples of baryons are the proton (which consists of two "up" quarks and one "down" quark) and the neutron (which consists of two "down" quarks and one "up" quark). Baryons and mesons together are collectively known as hadrons, so a hadron refers to a collection of bound quarks.

Quarks are held together in hadrons by a very strong force that becomes stronger the farther apart the quarks are separated. This is why they are not observed in isolation.

Leptons consist of the electron, the muon (which acts like a heavy electron), and the tau lepton (which acts like a very heavy electron). Each of these particles has a charge of $-e$. In reactions in which these particles are produced, there is generally also a neutrino particle. Neutrinos are very light particles with almost no mass, and for the most part they pass right through ordinary matter; in fact, there are billions of them passing through your body right now. Only very rarely do they interact with ordinary matter, but occasionally they do. Physicists have built neutrino "telescopes" to detect them; these telescopes consist of underground pools
filled with cleaning fluid surrounded by light detectors. In the rare event that a neutrino interacts with ordinary matter, it emits a brief flash of light which is detected and recorded.

Both quarks and leptons are, as far as we can observe, point masses. None of them has any internal structure that we're currently aware of.