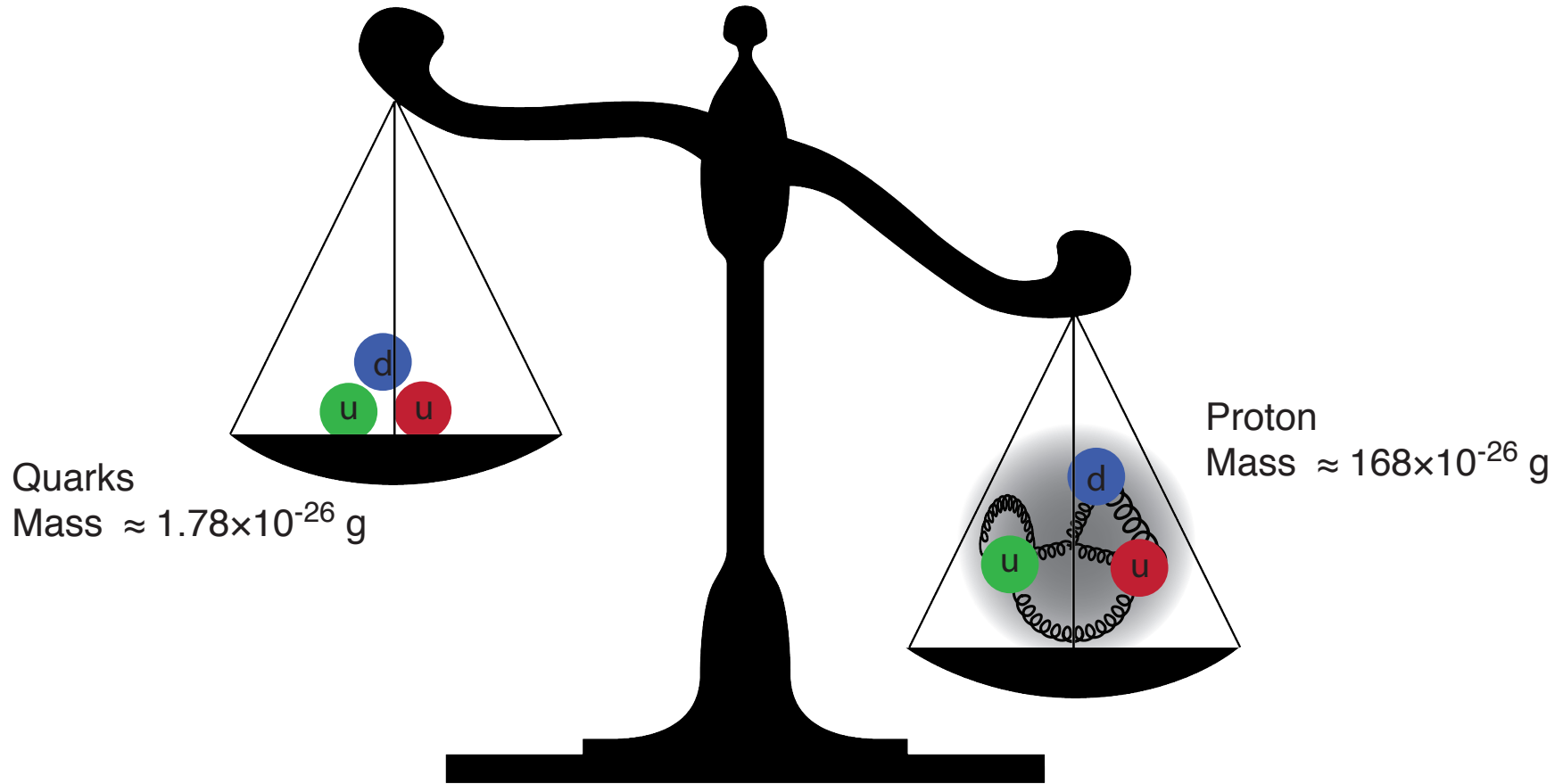


# The Weight of Matter



Atoms are the building blocks of the visible matter of the universe. They are made up of electrons, protons, and neutrons. The protons and neutrons cluster together in the center of the atom, surrounded by a shell of orbiting electrons. If the atom were the size of a baseball stadium, this center – the nucleus - is the size of a baseball on the mound. Nevertheless, 99.9% of the mass of an atom is contained in its nucleus. This mass is nearly the sum of the masses of its protons and neutrons, neglecting the small amount of mass lost to the nucleus' binding energy (from  $E= m c^2$ ).

Proton and neutrons, in turn, are built of quarks and gluons. The Higgs field gives the quarks mass while the gluons remain massless. Surprisingly, the mass of the quarks in a proton (or neutron) adds up to around  $1.78 \times 10^{-26}$  g, while the proton itself weighs 100 times more, approximately  $168 \times 10^{-26}$  g. The remaining 99% of the mass of the proton is created by a complex set of dynamical interactions in which gluons play a central part.