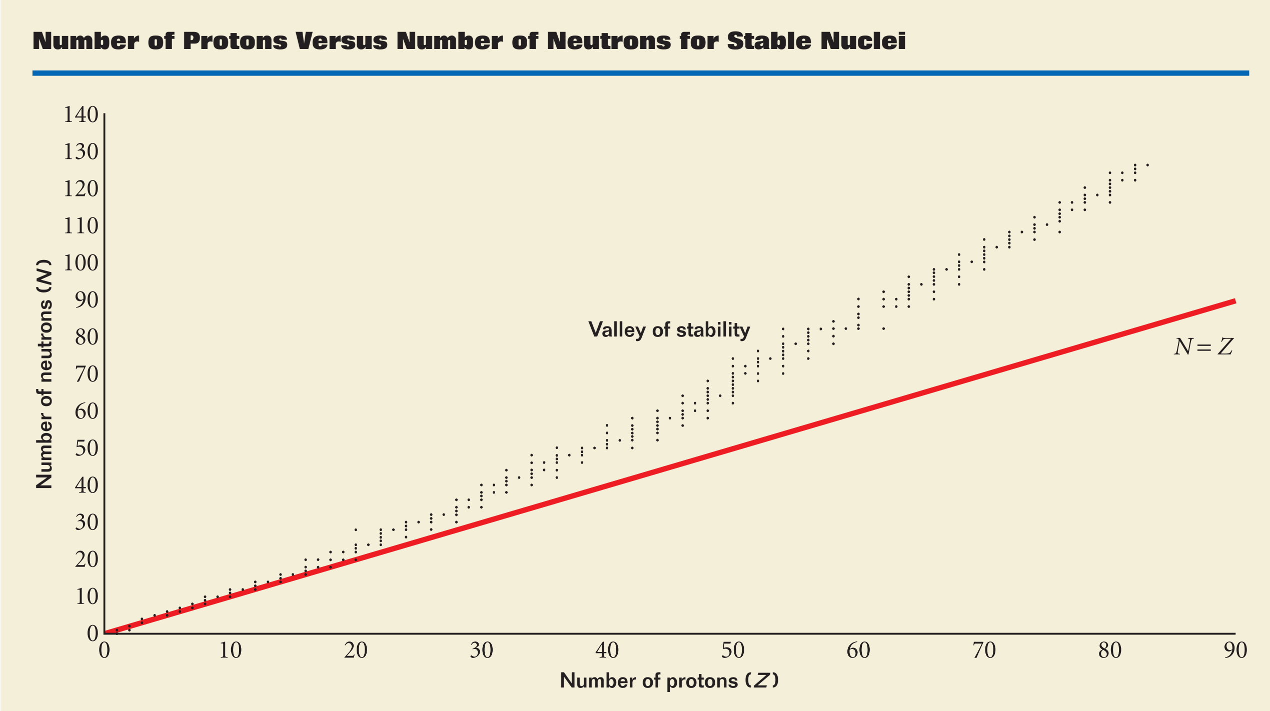

Figure 3
Each data point in this graph represents a stable nucleus. Note that as the number of protons increases, the ratio of neutrons to protons also increases. In other words, heavy nuclei have more neutrons per proton than lighter nuclei.

The strong force has some properties that make it very much unlike other types of force. The strong force is almost completely independent of electric charge. For a given separation, the force of attraction between two protons, two neutrons, or a proton and a neutron has the same magnitude.

Another unusual property of the strong force is its very short range, only about 10^{-15} m. For longer distances, the strong force is virtually zero.

Neutrons help to stabilize a nucleus

A plot of neutron number versus atomic number (the number of protons) for stable nuclei is shown in **Figure 3.** The solid line in the plot shows the location of nuclei that have an equal number of protons and neutrons ($N = Z$). Notice that only light nuclei are on this line, while all heavier nuclei fall above this line. This means that heavy nuclei are stable only when they have more neutrons than protons. This can be understood in terms of the characteristics of the strong force.

For a nucleus to be stable, the repulsion between positively-charged protons must be balanced by the strong nuclear force's attraction between all the particles in the nucleus. The repulsive force exists between all protons in a nucleus because the electrostatic force is long range. But a proton or a neutron attracts only its nearest neighbors because of the nuclear force's short range. So, as the number of protons increases, the number of neutrons has to increase even more to add enough attractive forces to maintain stability.