Despite many extensive efforts, no isolated quark has ever been observed. Physicists now believe that quarks are permanently confined inside ordinary particles by the strong force. This force is often called the *color force* for quarks. Of course, quarks are not really colored. Color is merely a name given to the property of quarks that allows them to attract one another and form composite particles. The attractive force between nucleons is a byproduct of the strong force between quarks.

THE STANDARD MODEL

The current model used in particle physics to understand matter is called the *standard model.* This model was developed over many years by a variety of people. Although the details of the standard model are complex, the model's essential elements can be summarized by using **Figure 15.**

According to the standard model, the strong force is mediated by gluons. This force holds quarks together to form composite particles, such as protons, neutrons, and mesons. Leptons participate only in the electromagnetic, gravitational, and weak interactions. The combination of composite particles, such as protons and neutrons, with leptons, such as electrons, makes the constituents of all matter, which are atoms.

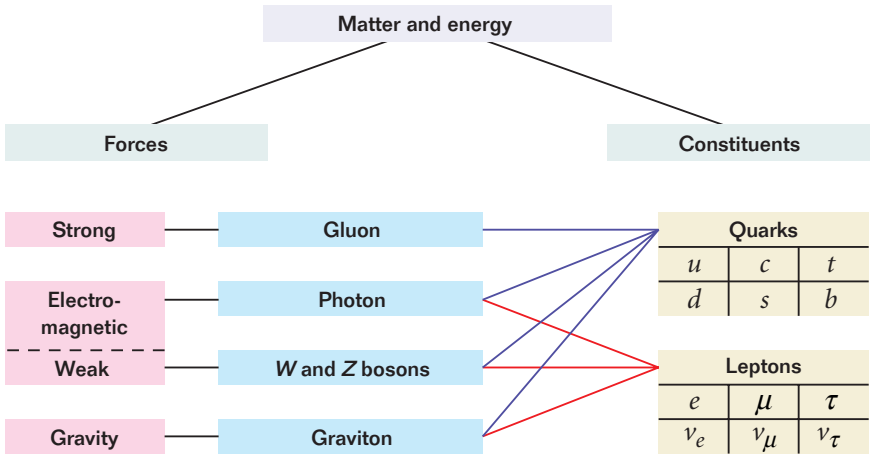

Figure 15
This schematic diagram summarizes the main elements of the standard model, including the fundamental forces, the mediating field particles, and the constituents of matter.

The standard model can help explain the early universe

Particle physics helps us understand the evolution of the universe. If we extrapolate our knowledge of the history of the universe, we find that time itself goes back only about 13 billion to 15 billion years. At that time, the universe was inconceivably dense. In the brief instant after this singular moment, the universe expanded rapidly in an event called the *big bang.* Immediately afterward, there were such extremes in the density of matter and energy that all four fundamental interactions of physics operated in a single, unified way. The temperatures and energy present reduced everything into an undifferentiated "quark soup."

Did you know?

The word *atom* is from the Greek word *atomos,* meaning "indivisible." At one time, atoms were thought to be the indivisible constituents of matter; that is, they were regarded as elementary particles. Today, quarks and leptons are considered to be elementary particles.