The standard model is still incomplete

While particle physicists have been exploring the realm of the very small, cosmologists have been exploring cosmic history back to the first microsecond of the big bang. Observation of the events that occur when two particles collide in an accelerator is essential to reconstructing the early moments in cosmic history. Perhaps the key to understanding the early universe is to first understand the world of elementary particles. Cosmologists and particle physicists find that they have many common goals, and they are working together to attempt to study the physical world at its most fundamental level.

Our understanding of physics at short distances is far from complete. Particle physics still faces many questions. For example, why does the photon have no mass, while the W and Z bosons do? Because of this mass difference, the electromagnetic and weak forces are quite distinct at low energies, such as those in everyday life, but they behave in similar ways at very high energies.

To account for these changes, the standard model proposes the existence of a particle called the *Higgs boson,* which exists only at the high energies at which the electromagnetic and weak forces begin to merge. The Higgs boson has not yet been found. According to the standard model, its mass should be less than 1 TeV (10^{12} eV). International efforts are under way to build a device capable of reaching energies close to 1 TeV to search for the Higgs boson.

There are still other questions that the standard model has yet to answer. Is it possible to unify the strong and electroweak theories in a logical and consistent manner? Why do quarks and leptons form three similar but distinct families? Are muons the same as electrons (apart from their different masses), or do they have other subtle differences that have not been detected? Why are some particles charged and others neutral? Why do quarks carry a fractional charge? What determines the masses of the fundamental constituents? Can isolated quarks exist? The questions go on and on. Because of the rapid advances and new discoveries in the field of particle physics, by the time you read this book, some of these questions may have been resolved, while new questions may have emerged.

SECTION REVIEW

1. Name the four fundamental interactions and the particles that mediate each interaction.
2. What are the differences between hadrons and leptons? What are the differences between baryons and mesons?
3. Describe the main stages of the evolution of the universe according to the big bang theory.