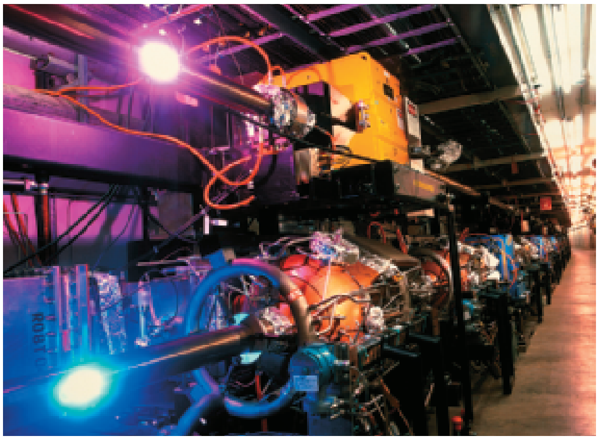

Figure 2
Electrons in the Stanford Linear Accelerator in California (SLAC) reach 99.999999967 percent of the speed of light. At such great speeds, the difference between classical and relativistic theories becomes significant.

rest energy of a body is equal to its mass, *m,* multiplied by the speed of light squared, c^2. Thus, the mass of a body is a measure of its rest energy. This equation is significant because rest energy is an aspect of special relativity that was not predicted by classical physics.

Experimental verification

The magnitude of the conversion factor between mass and rest energy ($c^2 = 9 \times 10^{16}$ m^2/s^2) is so great that even a very small mass has a huge amount of rest energy. Nuclear reactions utilize this relationship by converting mass (rest energy) into other forms of energy. In nuclear fission, which is the energy source of nuclear power plants, the nucleus of an atom is split into two or more nuclei. Taken together, the mass of these nuclei is slightly less than the mass of the original nucleus, and a very large amount of energy is released. In typical nuclear reactions, about one-thousandth of the initial mass is converted from rest energy into other forms of energy. This change in mass, although very small, can be detected experimentally.

Another type of nuclear reaction that converts mass into energy is fusion, which is the source of energy for our sun and other stars. About 4.5 million tons of the sun's mass is converted into other forms of energy every second, by fusing hydrogen into helium. Fortunately, the sun has enough mass to continue to fuse hydrogen into helium for approximately 5 billion more years.

Most of the energy changes encountered in your typical experiences are much smaller than the energy changes that occur in nuclear reactions. Such changes are far too small to be detected experimentally. Thus, for typical cases, the classical equation still holds, and mass and energy can be thought of as separate.

Before Einstein's theory of relativity, conservation of energy and conservation of mass were regarded as two separate laws. The equivalence between mass and energy reveals that in fact these two laws are one. In the words of Einstein, "Prerelativity physics contains two conservation laws of fundamental importance. . . . Through relativity theory, they melt together into *one* principle."

SCILINKS.
www.scilinks.org
Topic: Nuclear Reactions
Code: HF61053

Figure 3
Our sun uses a nuclear reaction called *fusion* to convert mass to energy. About 90 percent of the stars, including our sun, fuse hydrogen, and some older stars fuse helium.