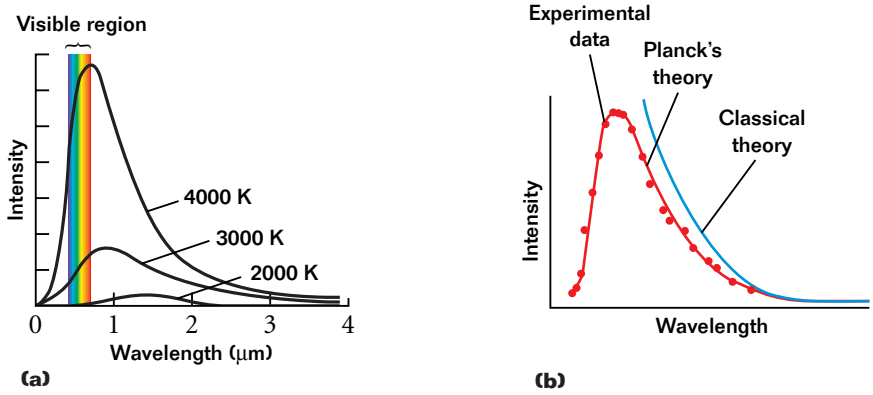

Figure 3
(a) This graph shows the intensity of blackbody radiation at three different temperatures. **(b)** Classical theory's prediction for blackbody radiation (the blue curve) did not correspond to the experimental data (the red data points) at all wavelengths, whereas Planck's theory (the red curve) did.

Experimental data for the radiation given off by an object at three different temperatures are shown in **Figure 3(a).** Note that as the temperature increases, the total energy given off by the body (the area under the curve) also increases. In addition, as the temperature increases, the peak of the distribution shifts to shorter wavelengths.

Scientists could not account for these experimental results with classical physics. **Figure 3(b)** compares an experimental plot of the blackbody radiation spectrum (the red data points) with the theoretical picture of what this curve should look like based on classical theories (the blue curve). Classical theory predicts that as the wavelength approaches zero, the amount of energy being radiated should become infinite. This prediction is contrary to the experimental data, which show that as the wavelength approaches zero, the amount of energy being radiated also approaches zero. This contradiction is often called the **ultraviolet catastrophe** because the disagreement occurs at the ultraviolet end of the spectrum.

ultraviolet catastrophe

the failed prediction of classical physics that the energy radiated by a blackbody at extremely short wavelengths is extremely large and that the total energy radiated is infinite

Experimental data for blackbody radiation support the quantization of energy

In 1900, Max Planck (1858–1947) developed a formula for blackbody radiation that was in complete agreement with experimental data at all wavelengths. Planck's original theoretical approach is rather abstract in that it involves arguments based on entropy and thermodynamics. The arguments presented in this book are easier to visualize, and they convey the spirit and revolutionary impact of Planck's original work.

Planck proposed that blackbody radiation was produced by submicroscopic electric oscillators, which he called *resonators.* He assumed that the walls of a glowing cavity were composed of billions of these resonators, all vibrating at different frequencies. Although most scientists naturally assumed that the energy of these resonators was continuous, Planck made the radical assumption that these resonators could only absorb and then give off certain discrete amounts of energy.

When he first discovered this idea, Planck was using a mathematical technique in which quantities that are known to be continuous are temporarily