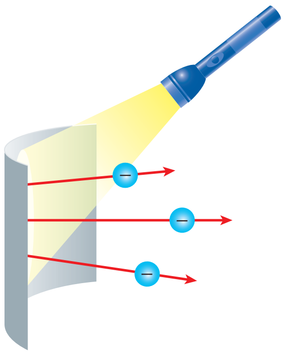
THE PHOTOELECTRIC EFFECT

(a)



(b)

Figure 4
A light beam shining on a metal **(a)** may eject electrons from the metal **(b).** Because this interaction involves both light and electrons, it is called the photoelectric effect.

As you learned in the chapter "Electromagnetic Induction," James Maxwell discovered in 1873 that light was a form of electromagnetic waves. Experiments by Heinrich Hertz provided experimental evidence of Maxwell's theories. However, the results of some later experiments by Hertz could not be explained by the wave model of the nature of light. One of these was the **photoelectric effect.** When light strikes a metal surface, the surface may emit electrons, as **Figure 4** illustrates. Scientists call this effect the photoelectric effect. They refer to the electrons that are emitted as *photoelectrons.*

photoelectric effect

the emission of electrons from a material surface that occurs when light of certain frequencies shines on the surface of the material

Classical physics cannot explain the photoelectric effect

The fact that light waves can eject electrons from a metal surface does not contradict the principles of classical physics. Light waves have energy, and if that energy is great enough, an electron could be stripped from its atom and have enough energy to escape the metal. However, the details of the photoelectric effect cannot be explained by classical theories. In order to see where the conflict arises, we must consider what should happen according to classical theory and then compare these predictions with experimental observations.

As was stated in the chapter on waves, the energy of a wave increases as its intensity increases. Thus, according to classical physics, light waves of any frequency should have sufficient energy to eject electrons from the metal if the intensity of the light is high enough. Moreover, at lower intensities, electrons should be ejected if light shines on the metal for a sufficient time period. (Electrons would take time to absorb the incoming energy before acquiring enough kinetic energy to escape from the metal.) Furthermore, increasing the intensity of the light waves should increase the kinetic energy of the photoelectrons, and the maximum kinetic energy of any electron should be determined by the light's intensity. These classical predictions are summarized in the second column of **Table 1.**

Table 1 The Photoelectric Effect

	Classical predictions	Experimental evidence
Whether electrons are ejected depends on . . .	the intensity of the light.	the frequency of the light.
The kinetic energy of ejected electrons depends on . . .	the intensity of the light.	the frequency of the light.
At low intensities, electron ejection . . .	takes time.	occurs almost instantaneously above a certain frequency.