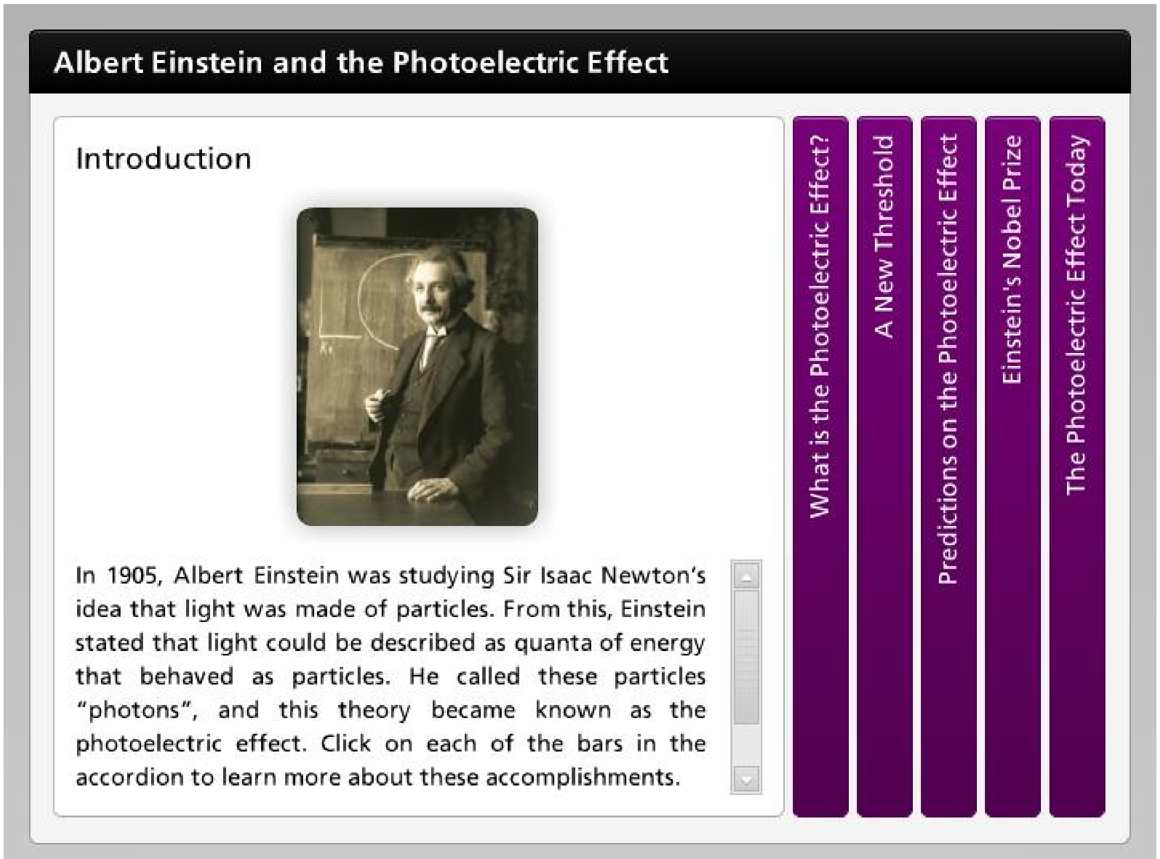
Module 3: Modern Atomic Theory, Electron Structure, and Periodicity
Topic 1 Content: Albert Einstein and the Photoelectric Effect

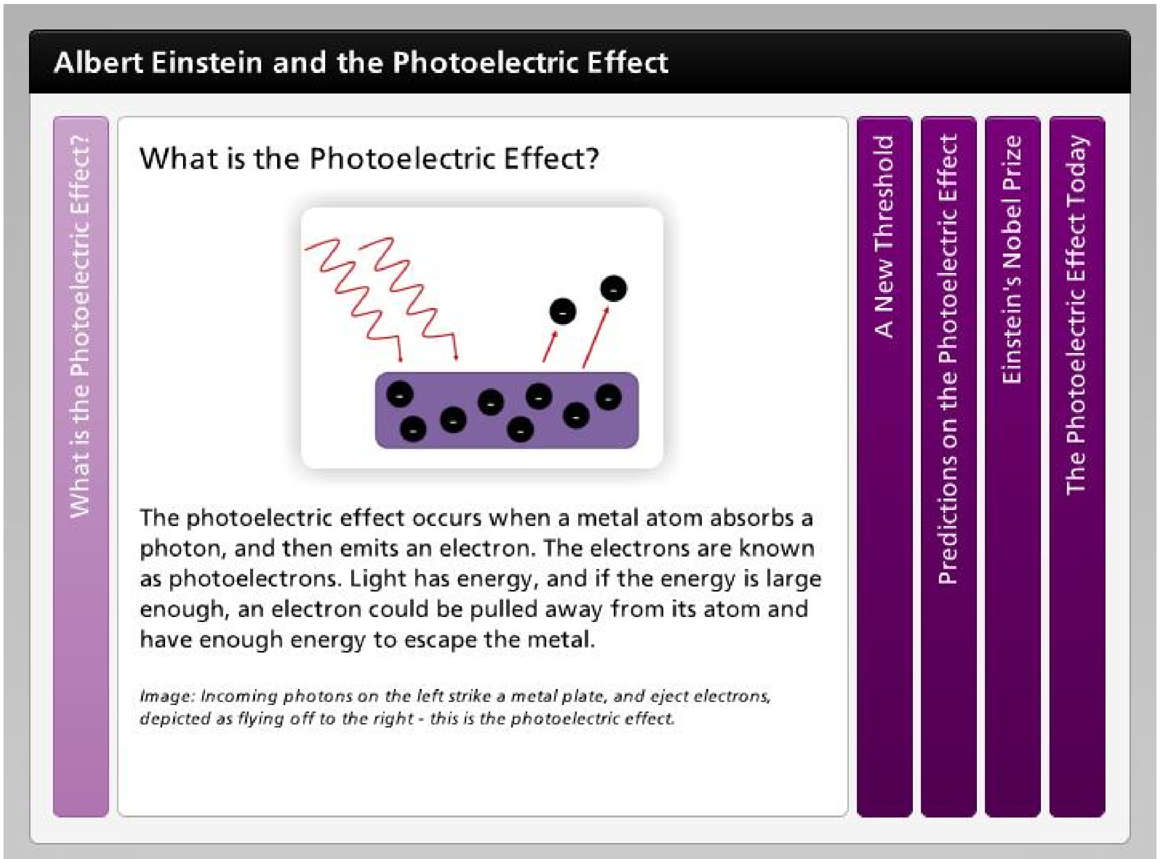
Introduction



In 1905, Albert Einstein was studying Sir Isaac Newton's idea that light was made of particles. From this, Einstein stated that light could be described as quanta of energy that behaved as particles. He called these particles "photons", and this theory became known as the photoelectric effect. Click on each of the bars in the accordion to learn more about these accomplishments.

Image: Albert Einstein during a lecture in Vienna in 1921

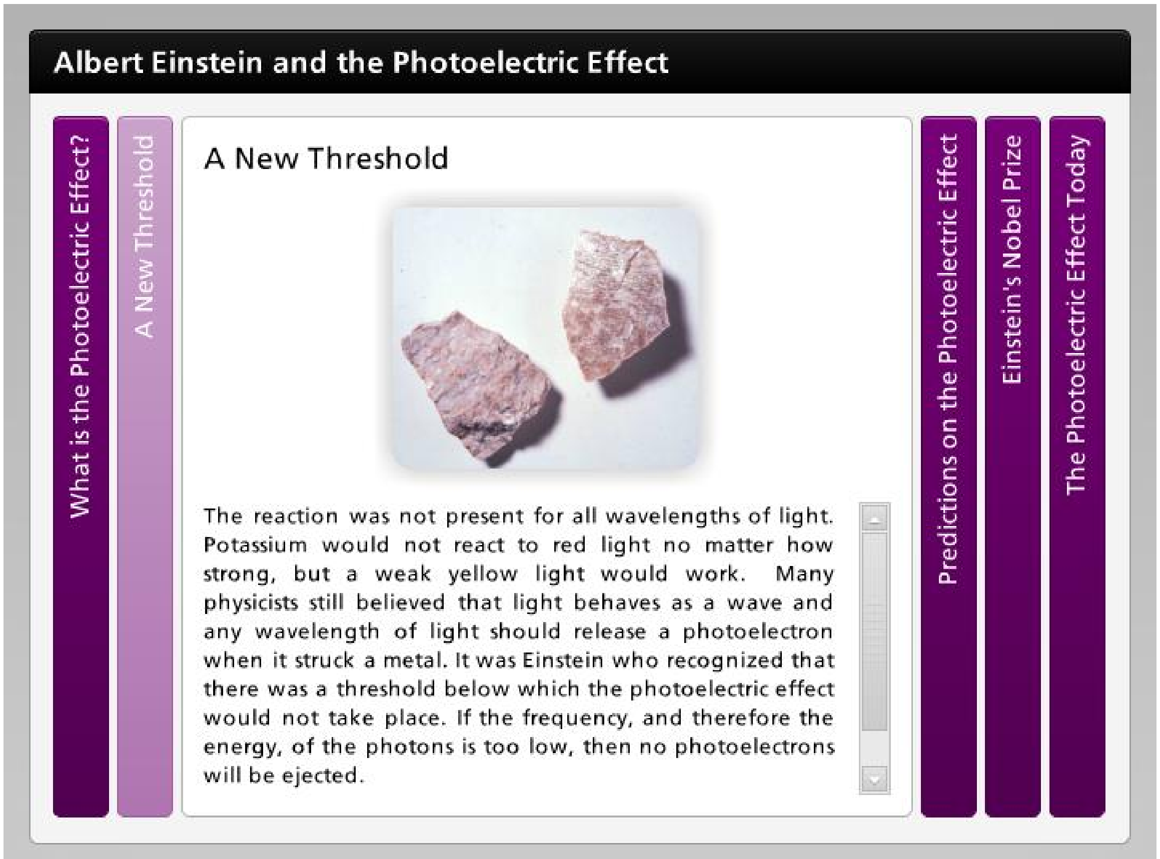
What is the Photoelectric Effect?



The photoelectric effect occurs when a metal atom absorbs a photon, and then emits an electron. The electrons are known as photoelectrons. Light has energy, and if the energy is large enough, an electron could be pulled away from its atom and have enough energy to escape the metal.

Image: Incoming photons on the left strike a metal plate, and eject electrons, depicted as flying off to the right - this is the photoelectric effect.

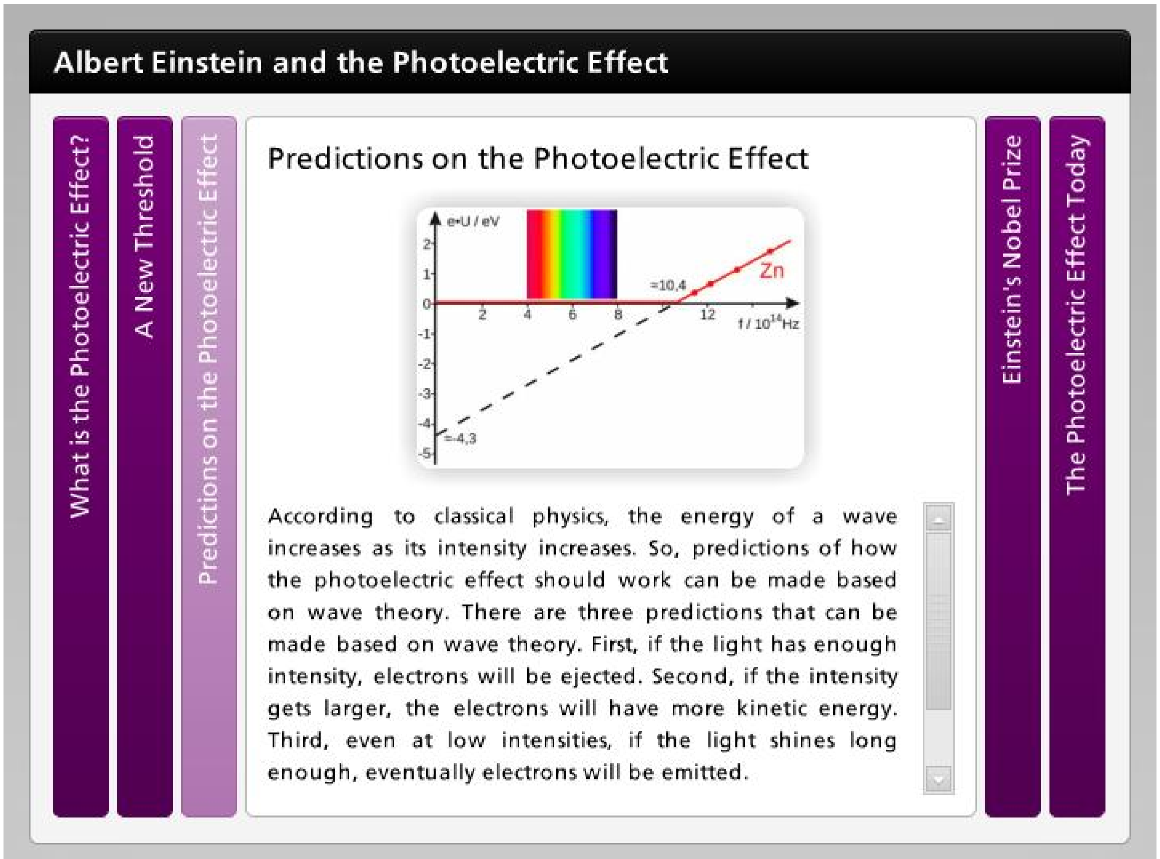
A New Threshold



The reaction was not present for all wavelengths of light. Potassium would not react to red light no matter how strong, but a weak yellow light would work. Many physicists still believed that light behaves as a wave and any wavelength of light should release a photoelectron when it struck a metal. It was Einstein who recognized that there was a threshold below which the photoelectric effect would not take place. If the frequency, and therefore the energy, of the photons is too low, then no photoelectrons will be ejected.

Image: Potassium feldspar

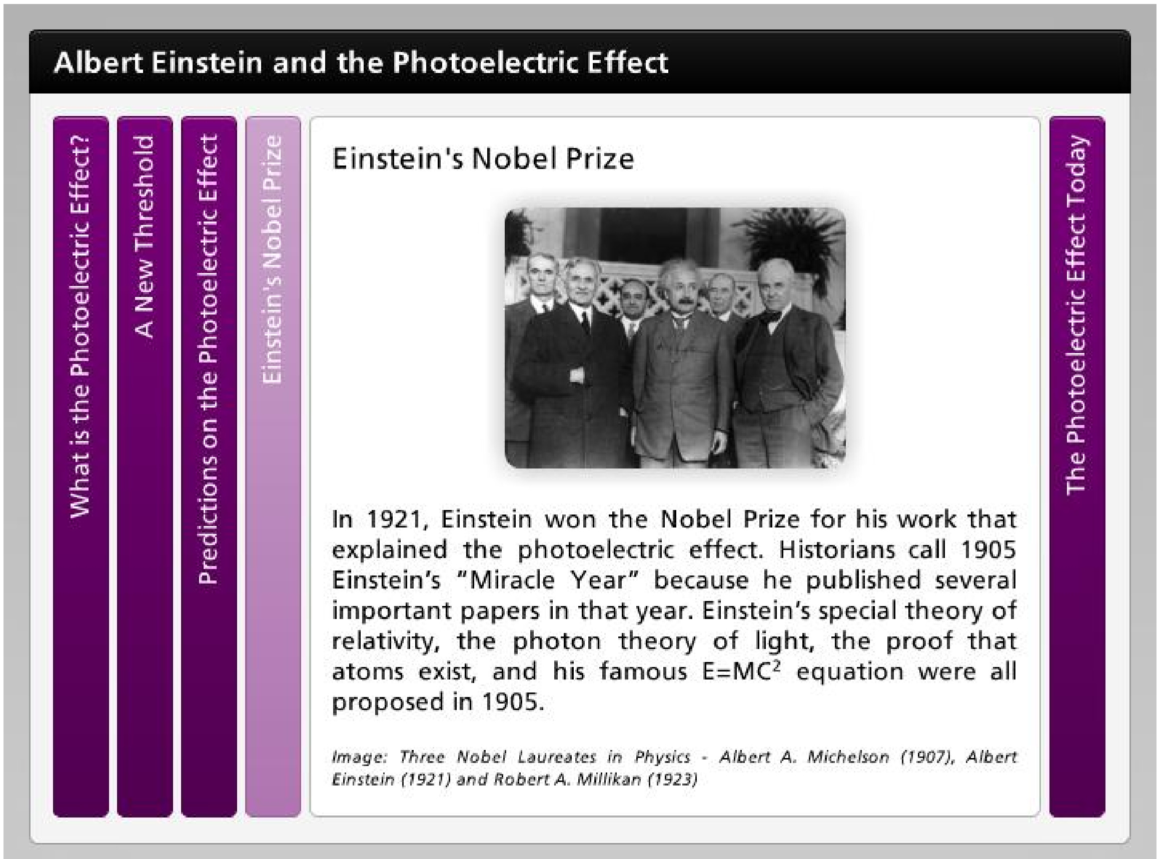
Predictions on the Photoelectric Effect



According to classical physics, the energy of a wave increases as its intensity increases. So, predictions of how the photoelectric effect should work can be made based on wave theory. There are three predictions that can be made based on wave theory. First, if the light has enough intensity, electrons will be ejected. Second, if the intensity gets larger, the electrons will have more kinetic energy. Third, even at low intensities, if the light shines long enough, eventually electrons will be emitted.

Image: A diagram of the maximum kinetic energy as a function of the frequency of light on zinc. Image courtesy of Kdkeller.

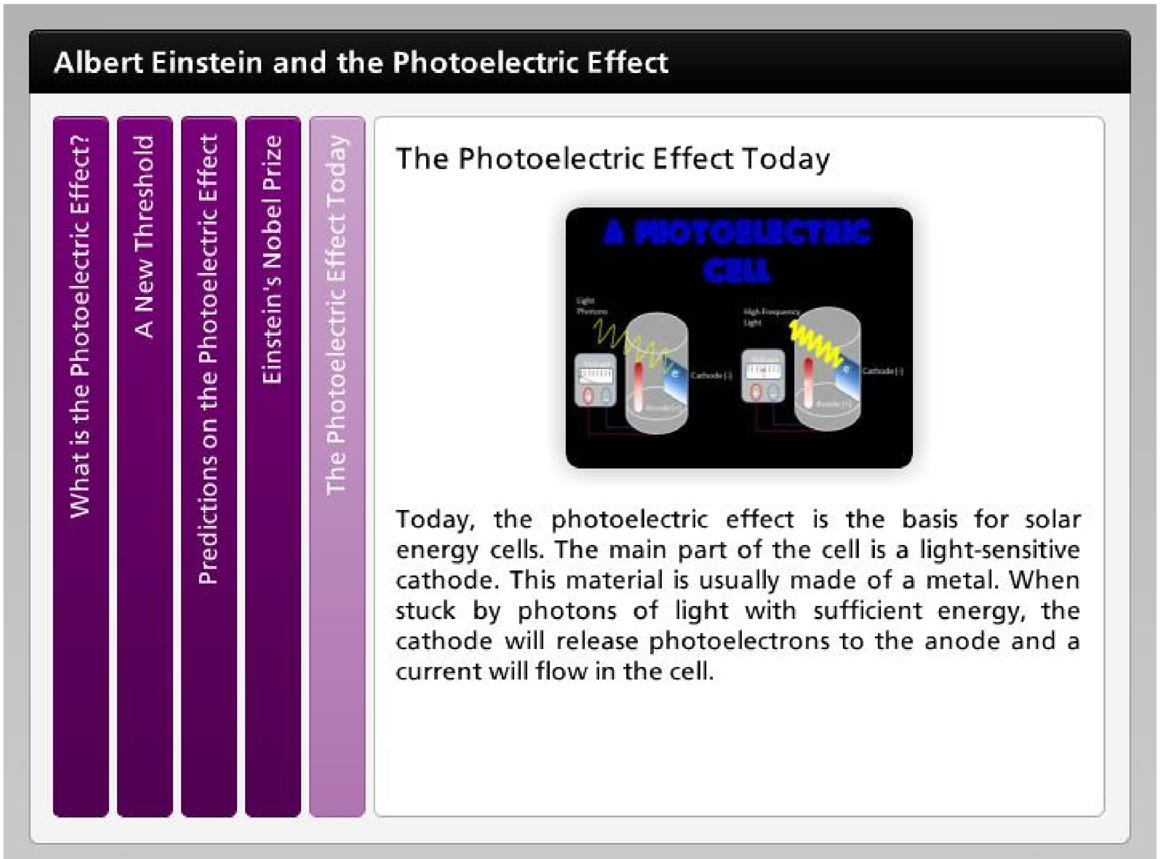
Einstein's Nobel Prize



In 1921, Einstein won the Nobel Prize for his work that explained the photoelectric effect. Historians call 1905 Einstein's "Miracle Year" because he published several important papers in that year. Einstein's special theory of relativity, the photon theory of light, the proof that atoms exist, and his famous $E=MC^2$ equation were all proposed in 1905.

Image: Three Nobel Laureates in Physics - Albert A. Michelson (1907), Albert Einstein (1921) and Robert A. Millikan (1923)

The Photoelectric Effect Today



Today, the photoelectric effect is the basis for solar energy cells. The main part of the cell is a light-sensitive cathode. This material is usually made of a metal. When stuck by photons of light with sufficient energy, the cathode will release photoelectrons to the anode and a current will flow in the cell.