

Ultraviolet light is often used as a disinfectant to kill bacteria in city water supplies or to sterilize equipment in hospitals. Scientists use ultraviolet light to determine the chemical makeup of atoms and molecules and also the nature of stars and other celestial bodies. Ultraviolet light is also used to harden some kinds of dental fillings.

X rays

As the wavelengths of electromagnetic waves decrease, the associated photons increase in energy. X rays have very short wavelengths, about the size of atoms, and are usually thought of in terms of their energy instead of their wavelength.

While the German scientist Wilhelm Conrad Roentgen was experimenting with vacuum tubes, he accidentally discovered X rays. A week later, he took an X-ray photograph of his wife's hand, which clearly revealed her wedding ring and her bones. This first X ray is shown in **Figure 24**. Roentgen called the phenomenon *X ray* to indicate that it was an unknown type of radiation, and the name remains in use today.

You are probably familiar with the use of X rays in medicine and dentistry. Airport security also uses X rays to see inside luggage. Emission of X rays from otherwise dark areas of space suggests the existence of black holes.

Gamma rays

The shortest wavelength electromagnetic waves are called *gamma rays*. As with X rays, gamma rays are usually described by their energy. The highest-energy gamma rays observed by scientists come from the hottest regions of the universe.

Radioactive atoms and nuclear explosions produce gamma rays. Gamma rays can kill living cells and are used in medicine to destroy cancer cells. The universe is a huge generator of gamma rays. Because gamma rays do not fully pierce Earth's atmosphere, astronomers frequently mount gamma-ray detectors on satellites.



Figure 24
Wilhelm Roentgen took this X-ray image of Bertha Roentgen's hand one week after his discovery of this new type of electromagnetic radiation.

SECTION REVIEW

1. What concepts did Maxwell use to help create his theory of electricity and magnetism? What phenomenon did Maxwell's equations predict?
2. What do electric and magnetic forces have in common?
3. The parts of the electromagnetic spectrum are commonly described in one of three ways. What are these ways?
4. **Critical Thinking** Where is the energy of an electromagnetic wave stored? Describe how this energy can be used.