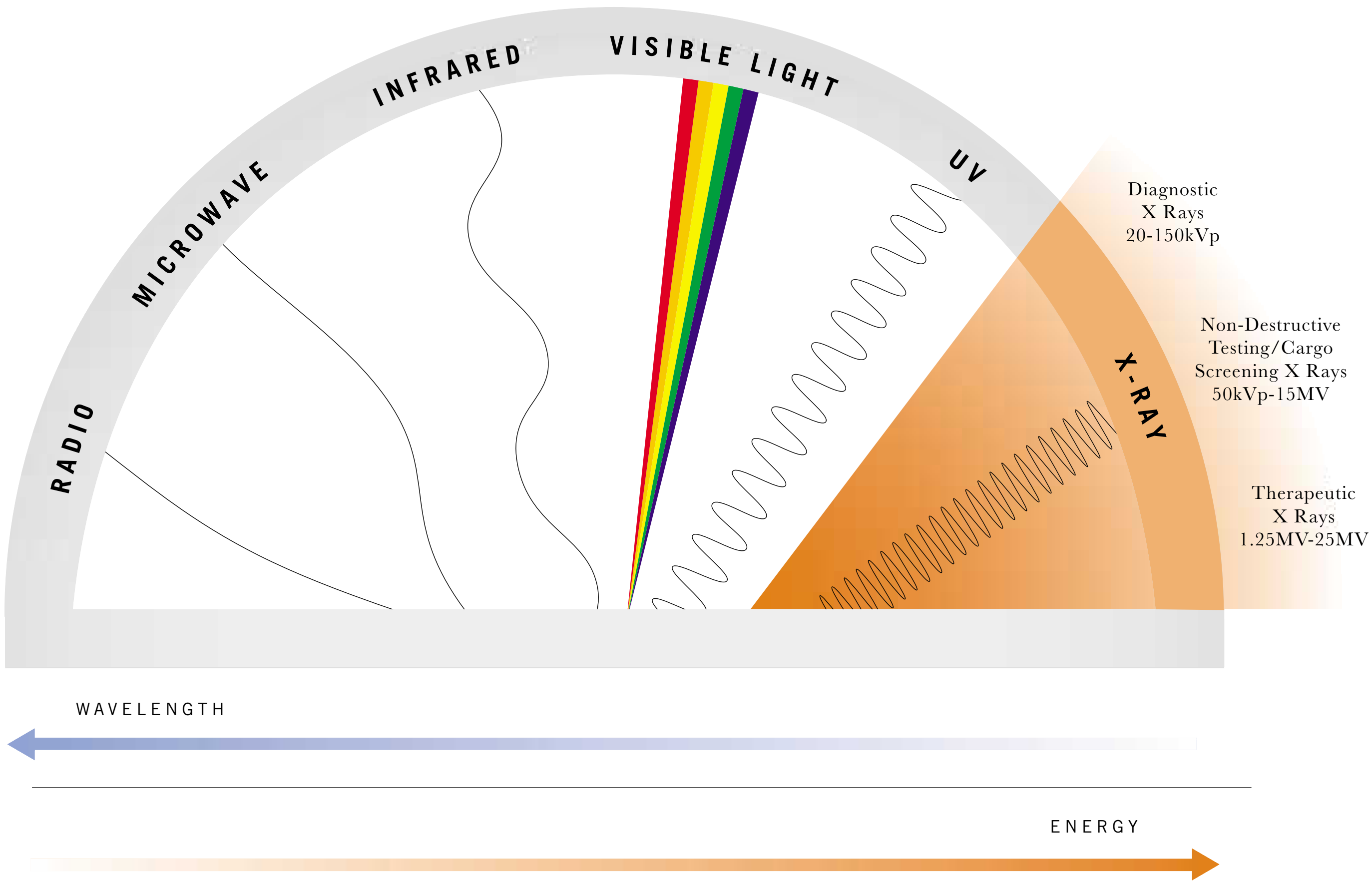
The Electromagnetic Spectrum



We "see" images through light – the radiation emitted by electrons when they lose energy. This radiation is carried in massless particles called photons, and travels in waves that move through a vacuum at a constant speed of 186,282 miles per second. Scientists speak about the dual nature of light because it behaves both as a stream of photon particles and as the rippling motion of pure energy waves through space. Although most of us think of light in terms of what we see with our eyes, scientists consider light in a broader sense, as electromagnetic radiation.

Electromagnetic radiation is categorized either according to the energy of its photons, or by the frequency or length of its waves. This spectrum of electromagnetic radiation extends from radio waves, with energies of less than a billionth of an electron volt per photon and wavelengths measuring more than 10,000 kilometers (6,220 miles), to gamma rays, with energies topping a billion electron volts per photon and wavelengths of less than 10 trillionths of a meter. Visible light, the electromagnetic radiation that can be seen with our eyes, constitutes less than a millionth of one percent of the electromagnetic spectrum.

Depending upon the energy and wavelength of the incoming electromagnetic radiation, matter can either be transparent, or it can absorb or reflect light back. The surface of the human body absorbs and reradiates photons at energies ranging between 1.61 and 3.18 electron volts. This is the visible light region of the electromagnetic spectrum and explains why we can see people but cannot see beneath their skin. To look beneath the skin at the body's internal structure you need photons at energies high enough to penetrate tissue and bone. Photons at energies between 20 thousand and 150 electron volts are ideal for diagnostic imaging purposes. These photons are X rays.

Diagnostic imaging depends not only upon the ability of photons to penetrate deep below the skin but also upon their ability to "see," or resolve, small details. This is a function of wavelength. For example, visible light waves, ranging in wavelengths from 700 nanometers (red) to 400 nanometers (violet), are simply too large to ever resolve images of structures the size of a typical protein molecule. No matter how high the magnification, visible light waves would pass over such molecules unaffected. It would be like trying to determine the size and shape of a tennis ball by observing its impact on the movement of ocean waves.

X rays have wavelengths several thousand times shorter, some even less than an angstrom, which is the unit of scale for measuring atoms. This makes X-ray photons ideal for imaging the structures of atoms common in the human body: hydrogen, carbon, oxygen, and calcium. X rays are also ideal for imaging nitrogen, which is a key component, along with hydrogen, carbon, and oxygen, of most chemical explosives. ■

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