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# ELECTROMAGNETIC RADIATION AND MEDICAL IMAGING

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## Electromagnetic Radiation and Medical Imaging

Modern medicine has entered an era of technological innovation and advancement. At the forefront of this advancement is medical imaging, which has integrated itself into modern medical practice. *Medical imaging* is a medical practice that generates an image of the internal human body through electromagnetic radiation. The discovery and study of electromagnetic radiation have allowed for the rapid advancement of medical imaging.

## Electromagnetic Radiation

Electromagnetic radiation is energy transmitted by waves with electric and magnetic fields (Flowers et al., 2019). These electromagnetic waves have an electric-field component and a magnetic-field component because the activity of one field induces the other. This relationship enables the propagation of electromagnetic energy through space. Such energy exists in various forms, including some used in medical imaging. Electromagnetic radiation can be observed everywhere, not just in the light and radiation from the sun; it is also seen in many of today's medical imaging techniques.

## Types of Electromagnetic Radiation

Electromagnetic radiation consists of energies that are categorized into two groups of radiation. The energies that electromagnetic radiation comprises include radio waves, microwaves, infrared light, visible light, ultraviolet light, X-rays, and gamma rays. These ranges of energies can be grouped into two groups of radiation: ionizing radiation or non-ionizing radiation. The ionizing radiation group consists of X-rays, gamma rays, and some forms of ultraviolet light (Flowers et al., 2019). Due to the properties of X-rays and gamma rays, they are used for many of today's medical imaging techniques. Such types of radiation have sufficient energy to strip atoms and molecules from the tissue and alter chemical reactions in the body (Zamanian et al., 2005). The non-ionizing radiation group comprises radio waves, microwaves, infrared, visible, and ultraviolet light (Flowers et al., 2019). The main difference between the two groups is that ionizing radiation has more energy and is thus utilized in medical imaging.

## Discovery of Electromagnetic Radiation

Electromagnetic radiation was first explored in the 1800s by Sir William Herschel, who discovered that a thermometer that sat outside of the red light produced by the glass prism had the highest temperature, discovering infrared light (Mattson et al., 2013). This discovery was expanded a year later by Johann Wilhelm Ritter. Ritter wondered if there would be a light beyond the purple light of the spectrum, which led to the discovery of ultraviolet light (Mattson et al., 2013). In 1867, James Clerk Maxwell, using his theories and equations, predicted that there would be light with higher wavelengths than infrared light (Mattson et al., 2013). This prediction was proven in 1887 when Heinrich Hertz produced radio waves in his laboratory (Mattson et al., 2013). Later, in 1895, X-ray was discovered by Wilhelm Conrad Röntgen when experimenting with vacuum tubes (Mattson et al., 2013). Finally, Paul Villard discovered gamma rays in 1900 when researching the radiation from radium (Mattson et al., 2013). In 1914, Ernest Rutherford discovered that gamma rays had much shorter wavelengths but were similar to X-rays (Mattson et al., 2013).

**Significance of Electromagnetic Radiation**

The discovery and study of electromagnetic radiation uncovered the properties of ionizing and non-ionizing radiation. The most common medical imaging techniques depend on the properties of such radiation to generate contrast. An accurate image of the human body's interior could be produced through such contrast. The significance of electromagnetic radiation cannot be exaggerated. Electromagnetic radiation provides us with much of the medical technology we use today. For example, medical imaging helps locate and differentiate cancer. Not only does electromagnetic radiation provide us with medical imaging, but it also provides many other useful technologies that improve our comfort in life. Technology, such as those for communication, health and science, entertainment, food, and many others, makes living life easier and more enjoyable (Flowers et al., 2019). Examples of such technology include microwave ovens, radios, wireless data and communication, dental curing, and cell phones.

**Development of Medical Imaging**

After Röntgen discovered the X-ray, many applications of the technique rapidly started being established. X-ray continued to be the only accurate way to image the interior of a body until the use of radiopharmaceuticals such as radioactive iodine and a small collimated sodium iodide detector (Elliott, 2005). This new method allowed for the accurate imaging of the thyroid. It was not until 1951 that Ben Cassen created the rectilinear scanner, and the increased development of radiopharmaceuticals allowed for imaging other organs (Elliott, 2005).

Then, in 1962, sonar, a method for detecting and pinpointing the distance and direction of objects beneath the water's surface, was used by Ian Donald as the first imaging technique without ionizing radiation (Elliott, 2005). Although the sonar was typically used to detect ships in World War II, sonars sent high-frequency sound waves into the body, bounced back, and used to create electrical pulses to create images of the interior body (Rubin, 2017). The single-photon emission computed tomography, also known as SPECT, was created in 1963 by David Kuhl and Roy Edwards, and positron emission tomography, also known as PET, was created in 1972 by Michel Ter-Pogossian (Elliott, 2005).

The first CT scanner was created in 1967, becoming one of history's most critical medical creations (Bercovich et al., 2018). The first-ever use of computed tomography or CT on a live patient was recorded in 1971 (Bercovich et al., 2018). Magnetic resonance imaging was developed around 1972 by Paul Lauterbur and Peter Mansfield through many contributions (Elliott, 2005). Medical imaging has become what it is today through many different variations of imaging techniques and continues to advance.

**Types of imaging**

Today, the most recognizable types of medical imaging include X-ray projection imaging, computed tomography, nuclear imaging, magnetic resonance imaging, and ultrasound imaging (Haidekker, 2013). These are just some of the many types of medical imaging. *X-ray projection* imaging is the oldest type of imaging, created right after the discovery of the X-ray (Haidekker, 2013). The type of imaging is a projection technique that can reveal very fine features using contrasts (Haidekker, 2013). Contrasts are made due to the absorption of X-rays where high densities, such as bone, absorb more radiation while low densities, such as tissue, absorb less radiation. This difference in absorption is the cause of the contrast that can clearly be seen in X-ray imaging. *Computed tomography*, or CT, can image in 2D or 3D (Haidekker, 2013). CT is far better than X-ray projection imaging in showing contrast; however, it is evident that X-ray projection imaging is superior compared to CT scans in imaging finer details (Haidekker, 2013). *Nuclear imaging* uses radioactive substances, called radiopharmaceuticals, that accumulate at certain points of the body, and the distribution of such substances can be determined (Haidekker, 2013). The most notable kinds of nuclear imaging include single-photon emission computed tomography or SPECT and positron emission tomography, or PET (Haidekker, 2013). Like CT, *magnetic resonance imaging* or MRI is also capable of imaging in 2D or 3D. However, unlike those listed above, MRIs do not utilize the properties of ionizing radiation (Haidekker, 2013). *Ultrasound imaging* also does not utilize such properties and instead relies on the properties of sound waves in tissue to create images (Haidekker, 2013).

## The Future of Medical Imaging

The future of medical imaging is bright, especially with the recent rise of artificial intelligence. *Machine learning*, a system that can improve and learn to recognize patterns of features, has been used in medical imaging to analyze and recognize patterns of diseases in screenings and images (Lewis et al., 2019). Machine learning can detect and diagnose diseases with exposure to lower radiation levels (Lewis et al., 2019). Other AI tools, such as machine learning, can be similarly incorporated into medical imaging and forever revolutionize it. Researchers have already started developing and incorporating new AI tools to develop medical imaging further (Lewis et al., 2019). Deep learning has outperformed modern image registration methods (Lewis et al., 2019). The further development of AI in medical imaging will result in more accurate diagnostics and make it much safer.

## Conclusion

Medical imaging is continuing to evolve as the study of electromagnetic radiation increases. Medical imaging has evolved through countless studies since the discovery of electromagnetic radiation. These studies include experiments, observations, equations, and models that explain the function of electromagnetic radiation and its counterpart, medical imaging. Nonetheless, even with a thorough investigation, medical imaging still has flaws. Flaws include the danger of radiation and problems in identifying and diagnosing certain diseases. However, with innovations such as artificial intelligence, such flaws will be unnoticeable soon. AI tools such as machine learning and deep learning will eliminate the safety and misdiagnosis risks of medical imaging. Electromagnetic radiation has become the power of one of modern's most important and advanced technology, medical imaging.

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