University of Al-Mustaqbal
College of Science
Department of Medical Physics

Medical Imaging

Second Stage

Lecture 3: X-ray, production of X-ray, and types of X-rays

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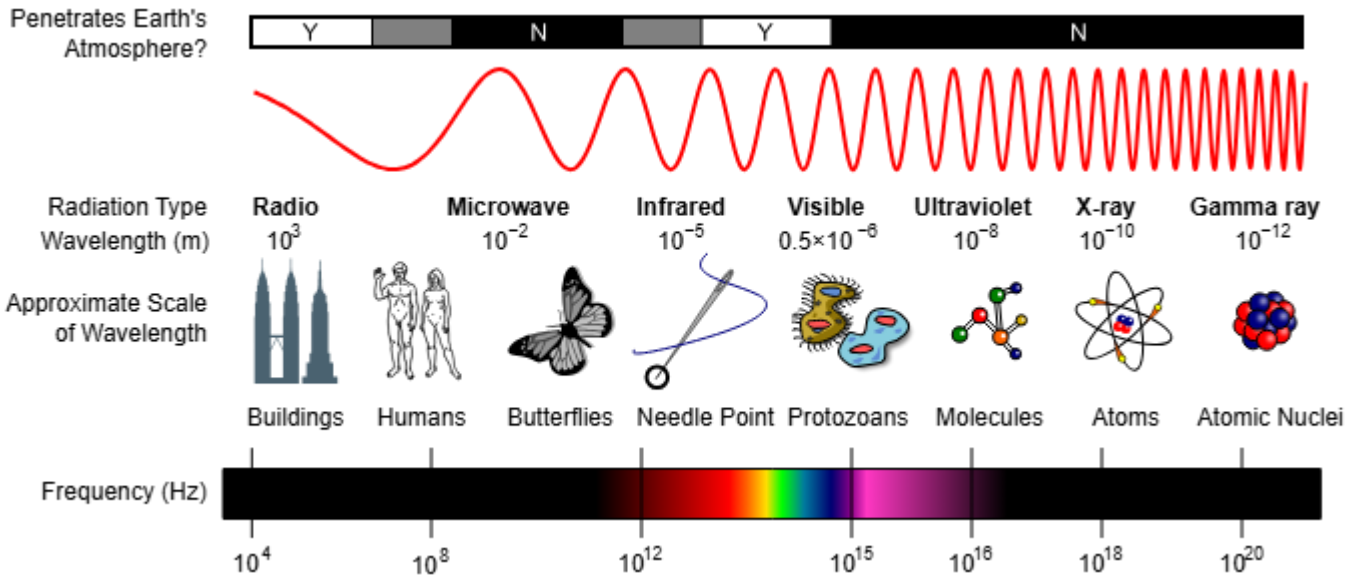
Contents

Introduction to X-ray

X-rays are a form of electromagnetic radiation with high energy and the ability to penetrate solid objects to varying degrees depending on their density. They are widely used in medicine to diagnose fractures, chest diseases, dental problems, and many other conditions.

X-rays lie in the electromagnetic spectrum between ultraviolet rays and gamma rays, characterized by short wavelengths and high frequency.

الاشعة السينية هي نوع من الاشعة الكهرومغناطيسية تمتلك طاقة عالية وقدرة على اختراق الاجسام الصلبة بدرجات مختلفة حسب كثافتها. تُستخدم بشكل واسع في المجال الطبي لتشخيص الكسور، أمراض الصدر، مشاكل الأسنان، والعديد من الحالات الأخرى.
تقع الأشعة السينية في الطيف الكهرومغناطيسي بين الأشعة فوق البنفسجية وأشعة غاما، وتمتاز بقصر طول موجتها وارتفاع ترددها.



Wavelength of X-rays (λ)

X-rays have a very short wavelength, ranging approximately from:

0.01 to 10 nanometers (nm)

or in scientific notation:

10^{-11} to 10^{-8} meters

The shorter the wavelength, the higher the energy and penetrating power.

Frequency of X-rays (f)

The frequency of X-rays ranges approximately from:

3×10^{16} to 3×10^{19} Hertz (Hz)

This is extremely high compared to visible light.

Relationship between wavelength and frequency

$$f \times \lambda = c$$

Where:

- **c** = speed of light (3×10^8 m/s)
- **λ** = wavelength
- **f** = frequency

As frequency increases, wavelength decreases, and vice versa.

Discovery of X-ray and its medical importance

X-rays were discovered in 1895 by the German scientist Wilhelm Röntgen during his experiments with electrical discharge tubes. He noticed an invisible radiation that could penetrate materials and produce images of bones on a photographic plate.

This discovery revolutionized medicine by allowing doctors to see inside the human body without surgery, enabling faster and more accurate diagnosis.

اكتشف العالم الألماني فيلهلم رونتغن الاشعة السينية عام 1895 اثناء تجاربه على انابيب التفريع الكهربائي التفريغ الكهربائي. لاحظ أن إشعاعًا غير مرئي يستطيع اختراق المواد وإظهار صورة للعظام على لوحة حساسة للضوء.
أحدث هذا الاكتشاف ثورة في الطب، حيث أصبح بالإمكان رؤية داخل جسم الإنسان دون تدخل جراحي، مما ساعد في التشخيص السريع والدقيق.

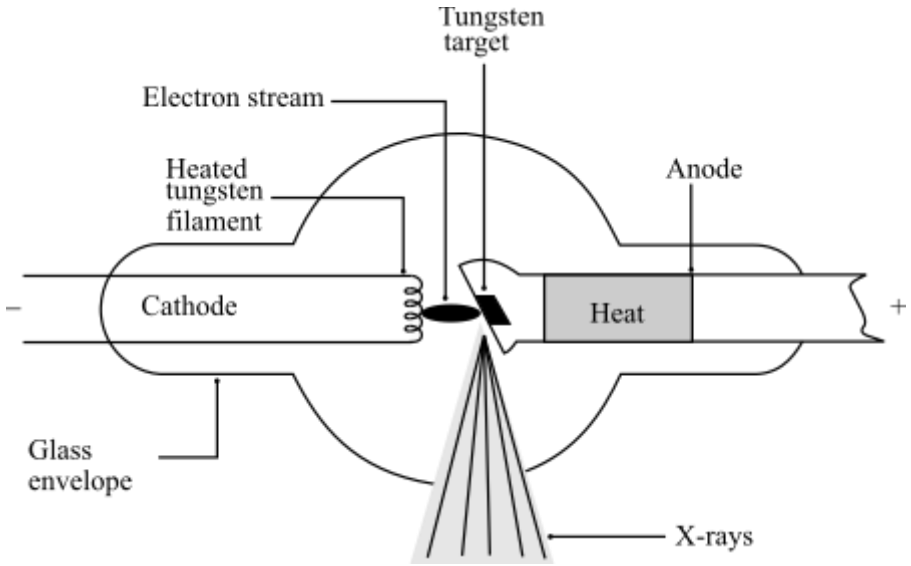
Production of X-ray

X-rays are produced inside a special device called the X-ray tube through the following steps:

1. Heating the filament in the cathode to release electrons.
2. Accelerating the electrons using a high voltage toward the anode.
3. Collision of electrons with the metal target (usually tungsten).

4. Conversion of kinetic energy into X-rays and heat.

About 99% of the energy becomes heat, and only about 1% is converted into X-rays.



Components of the X-ray tube

Cathode

- Contains a tungsten filament
- Responsible for emitting electrons

Anode

- Metal target where electrons strike
- Usually made of tungsten due to its high heat resistance

Vacuum glass envelope

- Prevents electron collision with air molecules

Exit window

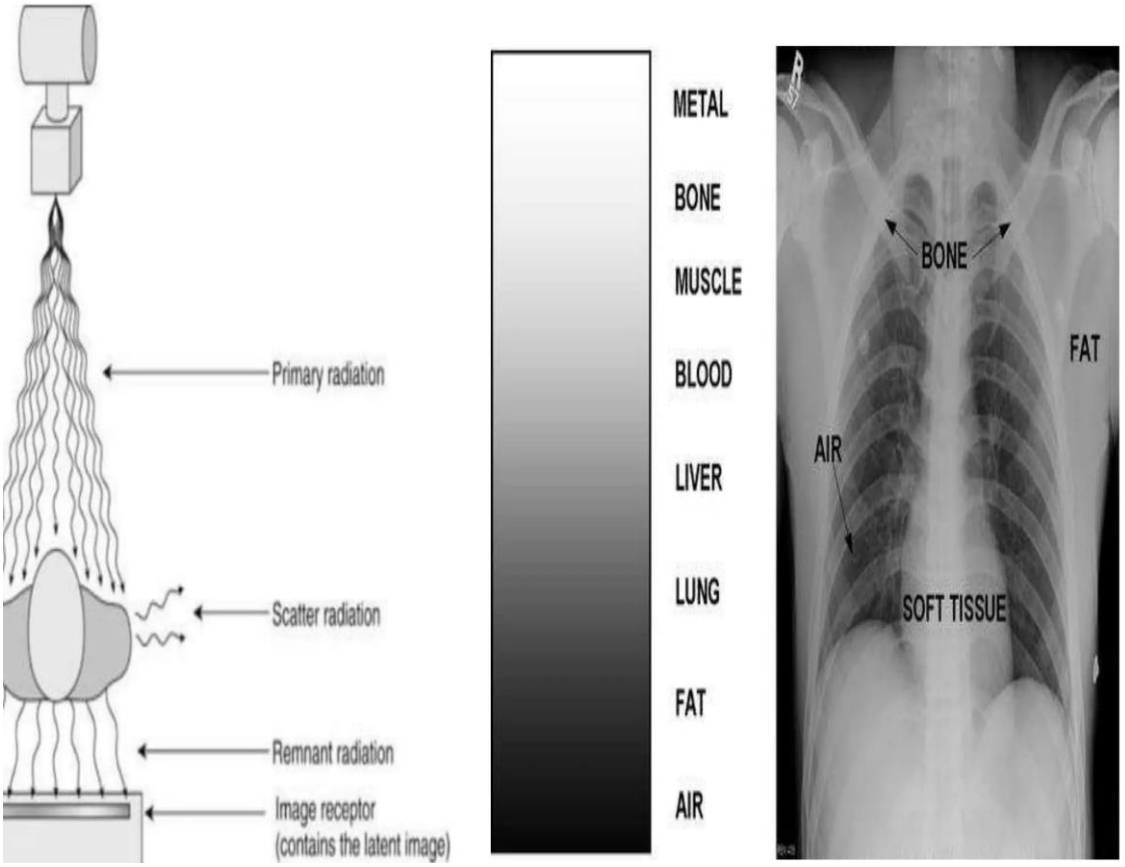
- Allows X-rays to leave the tube toward the patient

Formation of the radiographic image

When X-rays pass through the human body:

- Bones absorb more X-rays and appear white
- Soft tissues absorb less and appear in gray shades
- Air absorbs almost none and appears black

These differences in absorption create the radiographic image on film or digital detectors.



Types of X-ray

1. Diagnostic X-ray

Used to image:

- Bones
- Chest
- Teeth
- Joints

2. Therapeutic X-ray

Used in high doses to treat certain types of cancer.

3. Soft X-ray

- Low energy
- Used for superficial imaging and some industrial applications

4. Hard X-ray

- High energy
- Greater penetrating power
- Used in medicine and industry

Medical applications of X-ray

- Diagnosis of fractures
- Detection of lung infections
- Dental imaging
- Tumor detection
- Monitoring medical devices inside the body

Advantages and limitations

Advantages

- Fast and easy procedure
- Non-invasive
- Relatively low cost
- Widely available in hospitals

Limitations

- Exposure to radiation
- Limited soft tissue detail
- Repeated exposure may be harmful