

# **Radiology**

**World of Revision**  
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## FUNDAMENTALS OF RADIOLOGY

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Founding father of radiology : Wilhelm Röntgen (Discovered X-rays : 8<sup>th</sup> Nov 1895).

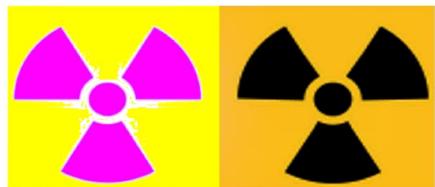


Wilhelm Röntgen



First X-ray image

Symbols :



Trefoil : Radiation hazard



X-ray radiation hazard



Sealed radiation source

Electromagnetic (Em) Spectrum :

- Spectrum of **energy components**.
- Frequency and energy :

Radio waves < microwaves < infrared < light < UV rays < X-rays < gamma rays  
(minimum)  (maximum).

Properties of Em spectrum :

- mass : Absent.
- Velocity :  $3 \times 10^8$  m/s (Speed of light).
- Wave type : Crest and trough.

### X-Rays

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Properties :

Wavelength :  $0.01 - 10 \text{ nm.}$

Frequency :  $3 \times 10^{16} - 3 \times 10^{19} \text{ Hz.}$

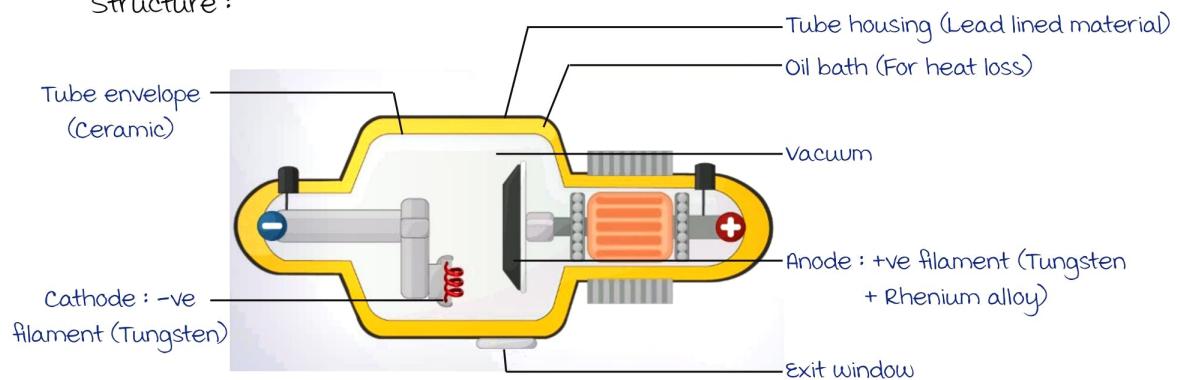
Energy :  $100 \text{ eV} - 100 \text{ KeV.}$

Inverse square law :  

- **Intensity  $\propto 1/r^2$**   
( $r$  : Distance from source).
- Significance : **Radiotherapy.**

----- Active space ----- X-Ray Tube :

Structure :



Functioning :

electric current → Cathode filament



Thermionic emission

(D/t ↑ heat of filament)



Accumulation of electrons around cathode



Acceleration of electrons towards anode



Accelerated electron hit anode

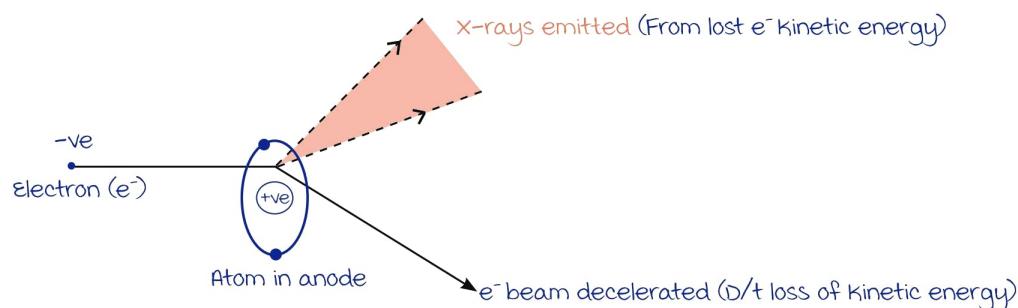


Production of x-rays.

mechanisms of X-Ray Production :

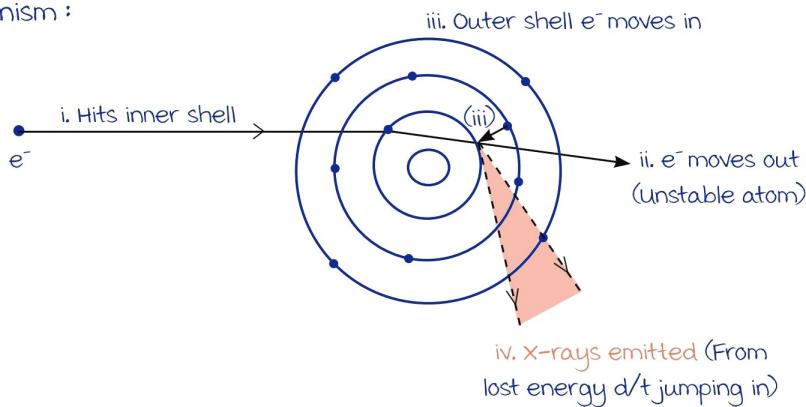
I. Continuous spectrum :

- m/c : 70 - 80 %.
- AKA **Bremsstrahlung** /white radiation/braking radiation.
- mechanism :



## 2. Characteristic spectrum :

- Less common : 20 - 30%.
- Significance : Used in **mammography**.
- mechanism :



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Interactions of X-Rays (In Patient's Body) :

- Compton effect : m/c overall.
- Photoelectric effect : 2<sup>nd</sup> m/c.
- Coherent scattering
- Photo-disintegration
- Pair production

Not seen in diagnostic radiology  
(High energy X-ray beams not used).

	Compton effect/ mid-energy phenomenon	Photoelectric effect/ low energy phenomenon
Cause	Interaction b/w X-ray photon and outer shell e <sup>-</sup>	Interaction b/w X-ray photon and inner shell e <sup>-</sup>
X-ray beam deviation (Scatter radiation)	+	-
Image distortion	+	(Image quality improved)
Desired levels	↓	↑

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**Effects of Radiation**

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Law of Radiobiology/Law of Bergonie & Tribondeau  :

- **Radiosensitivity**  $\propto$  Amount of undifferentiated cells/ cells in active mitosis in tissue.
- maximum radiosensitivity : Bone marrow.

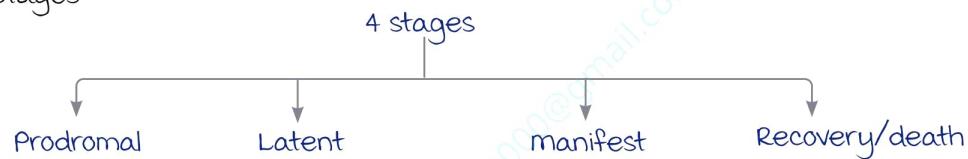
Acute Radiation Syndrome  :

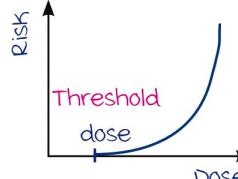
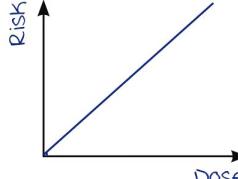
Appearance order

- i. Acute hematological syndromes : 1 - 2 Gy
- ii. Acute GIT syndrome : 6 - 10 Gy
- iii. Acute CNS syndrome : 20 - 30 Gy

} Threshold dose.

Stages :

Deterministic & Stochastic Effects :

	Deterministic effect	Stochastic effect
Onset	Acute - subacute	Chronic
Threshold dose	⊕	⊖
Severity	$\propto$ dose (↑ Dose $\rightarrow$ erythema, necrosis, ulceration of skin)	Not dose related
Risk-dose relationship	Non-linear :   Risk Threshold dose Dose	Linear :   Risk Dose
Examples	<ul style="list-style-type: none"> <li>• Acute radiation syndromes</li> <li>• Cataract</li> <li>• Skin effects</li> <li>• Sterility</li> </ul>	<ul style="list-style-type: none"> <li>• Carcinogenesis</li> <li>• mutations</li> <li>• Chromosomal aberrations</li> </ul>

## Radiation Exposure

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### Radiation exposure values :

	Types	Scans	Exposure values (msv)
Danger	CT/PET/radionuclide studies (Highest exposure)	PET scan	25
		CT abdomen	10
		CT thorax	8
		Bone scan	-
		CT head/brain	3.5
Warning	Diagnostic procedures (multiple exposure)	Barium enema	7
		Intravenous urogram	-
		Barium meal follow through	-
		Barium meal	-
		Barium swallow	-
Safe	Spot radiographs (Exposure once/twice)	micturating cystourethrogram (mcu)	1.2
		Lumbar spine	1.0
		Abdomen x-ray	-
		Hip x-ray	-
		Skull x-ray	-
		Chest x-ray	0.02
		Limb/joint x-ray	0.01 (least)

### ICRP/ICRU Radiation Exposure Guidelines :

- ICRP : International Commission on Radiological Protection.
- ICRU : International Commission on Radiation Units.

		Public exposure	Occupational exposure
Effective dose		1 msv/year	<ul style="list-style-type: none"> <li>20 msv/yr averaged over 5 years</li> <li>OR</li> <li>50 msv in any one year provided that total dose over 5 years is &lt;100 msv</li> </ul>
Annual equivalent dose	Lens of eye	15 msv	150 msv
	Skin	50 msv	500 msv
Pregnant females		< 1 msv	

### AERB Guidelines (India Specific) :

- AERB : Atomic Energy Regulatory Board.
- Similar to international guidelines except :

Effective dose in occupational exposure : 30mSV in any 1 year  
(< 100 mSV in 5 years).

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**Radiation Units, Exposure Factors and TLD Badge**

00:38:05

**Radiation Units :**

	Conventional unit	S.I. unit
Radiation exposure	Roentgen	Coulomb/kg (charge/weight)
Radiation absorbed	Radiation absorbed dose (RAD)	Gray (Gy)
Absorbed dose equivalent	Radiation equivalent in man (REM)	Sievert (SV)
Radioactivity	Curie	Becquerel

**X-Ray Exposure Factors :**

	Tube potential	Tube current
AKA	Kilovoltage peak (kvp)	milli-ampere second (mAs)
Determines	<ul style="list-style-type: none"> <li><math>\propto</math> Penetration</li> <li><math>\propto \frac{1}{\text{Image contrast}}</math></li> </ul>	$\propto$ Image contrast

**Thermoluminescent Dosimeter (TLD) Badge :**

Use : monitors radiation exposure (Range : 0.01 mGy - 10 Gy).

Composition : Phosphor crystals (Lithium fluoride, lithium borate, beryllium oxide).

Assessment : Every 3 months at AERB/BARC (Bhabha atomic research centre)/ Renentech labs.

mechanism :

Radiation exposure  $\rightarrow$  Absorbed by crystals  $\rightarrow$  Electron elevated to high

energy state

Trapped in high energy state  
(electron energy)

Heating of badge (in laboratory)

Releases trapped energy as visible light.

