BASIC INTERECTIONS OF X-RAYS WITH MATTER

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X ray photons can interact with matter by five ways:

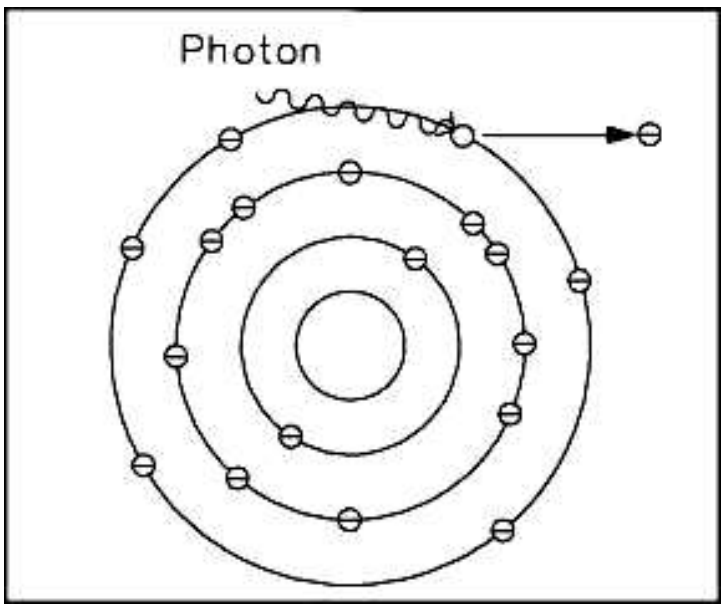
1. Coherent scattering.
2. Photoelectric absorption.
3. Compton scattering.
4. Pair production.
5. Photodisintegration.

However only photoelectric absorption and Compton scattering are of much importance in photon energy range used in diagnostic radiology (30-150 kev), therefore only these two are being discussed here.

PHOTOELECTRIC ABSORPTION

This interaction occurs when relatively lower energy X-ray photons are involved (because this effect is inversely proportional to the third power of the photon energy).

When an incident photon with an energy level only slightly greater than the binding energy of orbital electron encounters the latter, the photon transfers almost all of its energy to the orbital electron which then ejects out of the atom as a photo electron. In this process the incident photon is completely absorbed by the atom.



This absorption is affected both by the *energy of incident photon* and by the *binding energy of the orbital electrons of the material being exposed*. This means that greater the atomic number, the greater is the chance that a photoelectric event will occur.

(This effect is roughly proportional to the third power of the atomic number of the material being exposed).

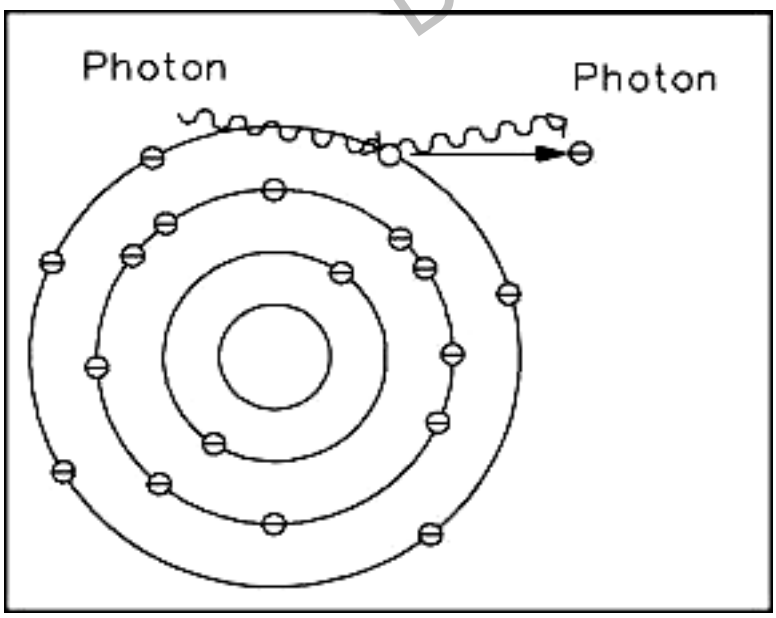
The different body tissues have different effective atomic numbers such as bone is having greater than the soft tissue. Therefore, more photoelectric absorption of X-ray photons will occur in bone than in soft tissue. Because of this differential absorption of X-rays in the body, bone, air, fat and soft tissues are differentiated. Hence photoelectric effect is responsible for virtual X-ray image formation.

The photoelectric effect also increases the radiation dose of the patient as all the energy produced or involved in the effect is absorbed by the patient.

The probability of photoelectric effect decreases as incident photons energy increases and so patient dose can be decreased by using high kvp techniques.

COMPTON EFFECT (Compton scattering)

If the energy of the incident X-ray photon is much higher than the binding energy of the electrons with which they interact, the process of Compton scattering may take place. In this effect, the incident high energy photon encounters a free electron of the outer shell of the atom, ejects it out and loses only a part of its energy and thereby deflecting from its original course. The photons deflected in this manner travel in a new direction and are termed as **scatter radiation.** This scatter radiation may go towards either the radiologist and expose him unnecessarily or may reach the X-ray films (*if deflected at a narrow angle*) to cause radiographic fog.



Compton interactions usually takes place in outer electron shells and *does not depend on the atomic number of material being exposed but depends on density of absorbs and energy of incident X-ray beam.*

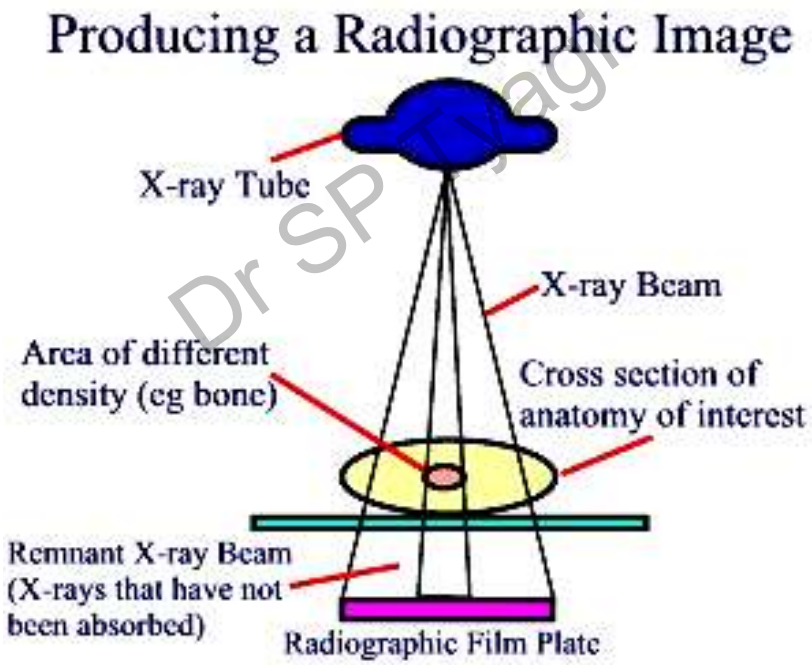
In diagnostic radiology, the objective is to have the maximum amount of differential absorption by the various tissues. For this reason it is desirable to have an X-ray beam that will produce primarily photoelectric interactions. Because photoelectric interactions predominate up to a maximum of 50 kev and

Compton effect dominates above 200 kev, it is undesirable to operate a machine at energies higher than about 125kev.

X-ray energy	**Predominant process**
Upto 50kev	Photoelectric absorption
60-90kev	Photoelectric and Compton effects(almost equally)
200kev-2mev	Compton

On radiographic exposure of soft tissue at

	50kvp	**100kvp**
Photoelectric effect	78.9%	21%
Compton effect	31%	63%



ATTENUATION OF X-RAYS

This refers to the total reduction in the number of X-rays remaining in an X-rays beam after traversing through the structure being exposed.

The extent of attenuation by different body tissues varies (see photoelectric absorption) and thus a contrast is obtained which makes the image on the film corresponding to the body tissues.

Following factors affect the attenuation:

1. Energy of radiation (intensity of incident beam): Higher the energy, lesser the attenuation.
2. Atomic number of the absorber: Generally at lower kvp range attenuation increases as the effective atomic number of absorber increases.
3. Thickness of the absorber: A constant number of photons are absorbed per centimeter of thickness so it is directly proportional to the thickness.
4. Density of the absorber (density refers to the quantity of matter per unit volume): Density, in general is directly related to atomic no. of the tissue, hence attenuation is directly proportional to the density also.

MATERIAL	**EFFECTIVE ATOMIC NUMBER**	**DENSITY**
Muscle	7.4	1.0
Fat	6.3	0.91
Bone	13.8	1.85
Lung	4.0	0.32
Barium	56	3.5
Iodine	53	4.93
Air	-	0.001293
Lead	82	11.35
Concrete	17	2.35