MEDICAL CHEMISTRY
GENERAL CHEMISTRY

University Of Fallujah

College Of Medicine

Lecture : Radioactivity

Stage : 1st Stage

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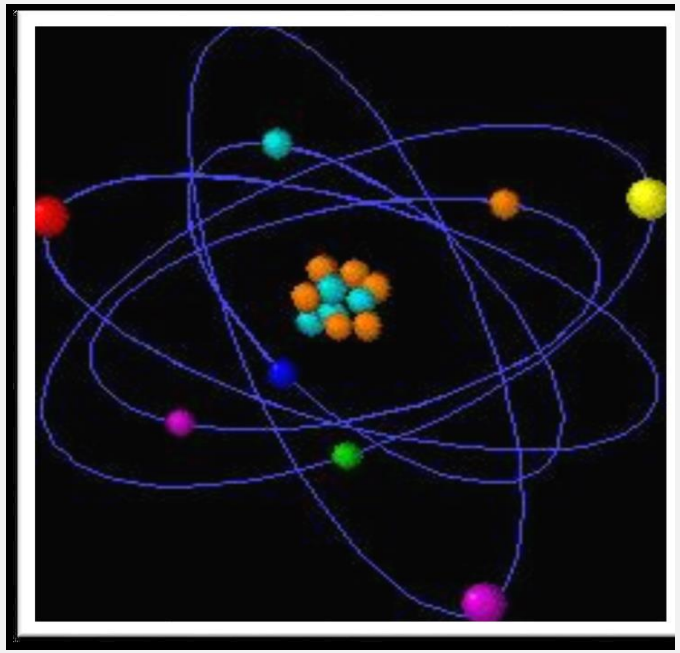
Learning Objective :

- To know what is the Radioactivity .
- To know what the medical importance for Radioactivity Elements .
- To know what the types of Radiation .
- To know the medical uses of Radioactivity Elements .

RADIOACTIVITY

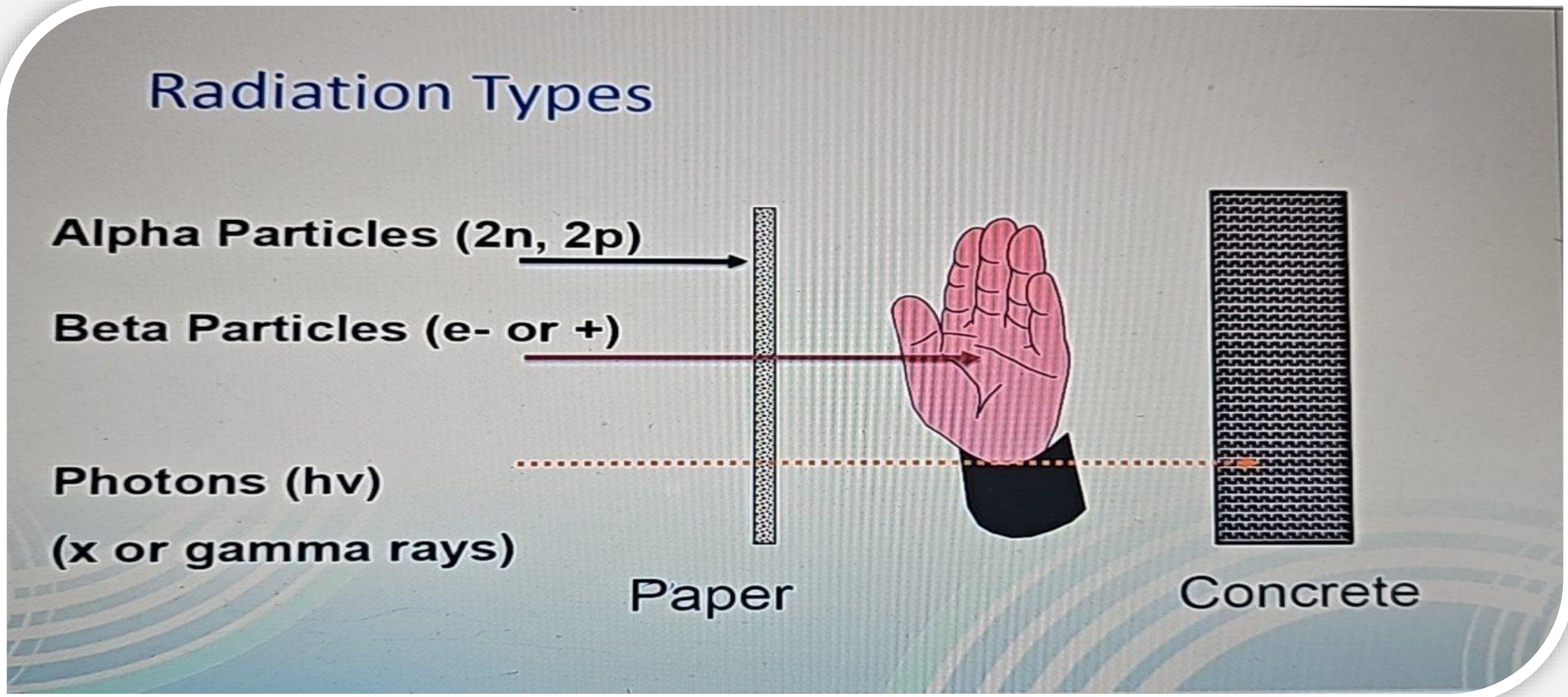
- What is radioactivity?
- Nuclear decay or radioactivity, is the process by which a nucleus of an unstable atom loses energy by emitting ionizing radiation.
- A material that spontaneously emits this kind of radiation which includes the emission of alpha particles , beta particles , gamma rays and conversion electrons

RADIOACTIVITY

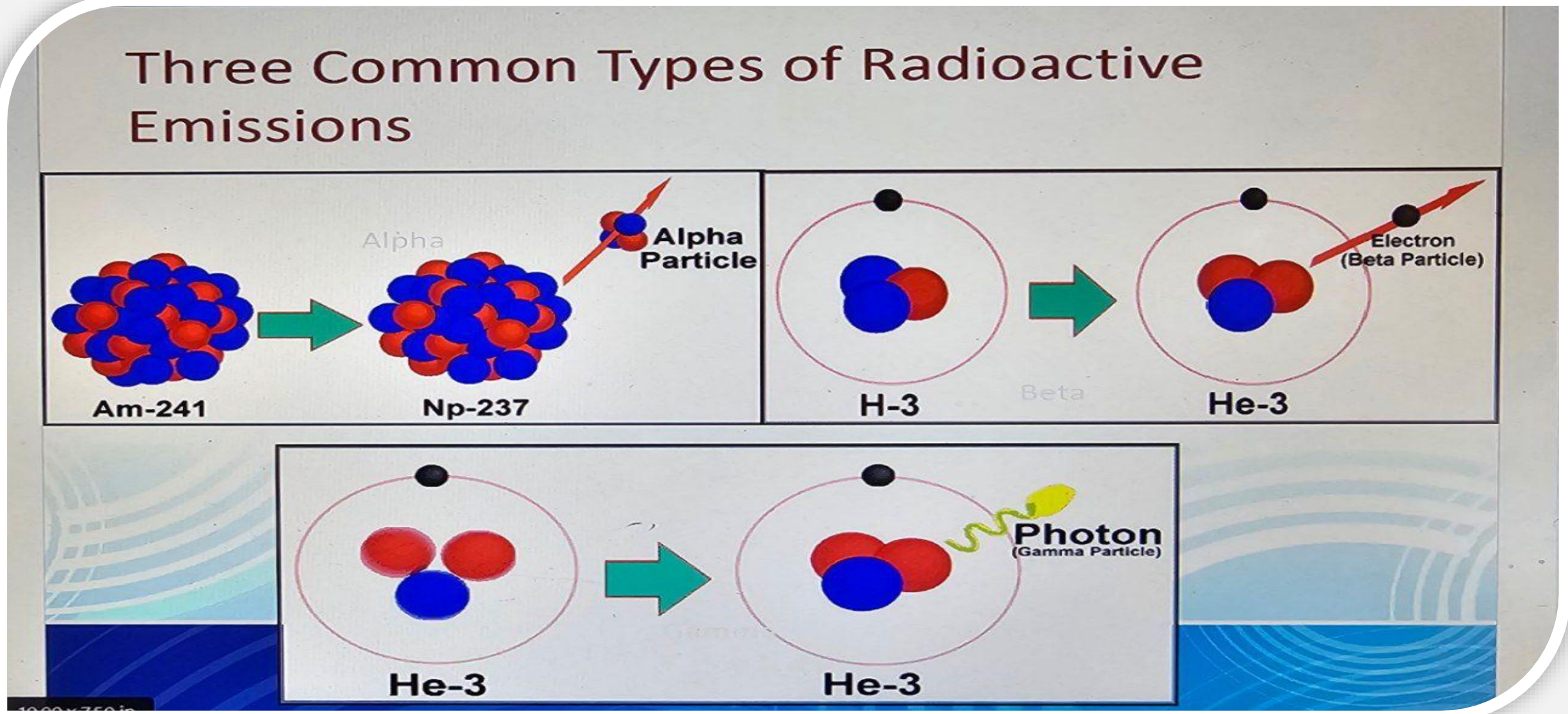


- Why are elements radioactive ?
- Unstable nucleus.
- Has excess energy.
- Wants to go to "ground state."
- Becomes stable by emitting ionizing radiation.

RADIOACTIVITY



RADIOACTIVITY



RADIOACTIVITY

- **Alpha Particles :**
  - Two neutrons and two protons
  - Charge of +2
  - Emitted from nucleus of radioactive atoms
  - Transfer energy in very short distances (10 cm in air)
  - Shielded by paper or layer of skin
  - Primary hazard from internal exposure
  - Alpha emitters can accumulate in tissue (bone, kidney, liver, lung, spleen) causing local damage

RADIOACTIVITY

- **Beta Particles:**

- Small electrically charged particles similar to electrons
- Charge of -1
- Ejected from nuclei of radioactive atoms
- Emitted with various kinetic energies
- Shielded by wood, body penetration 0.2 to 1.3 cm depending on energy
- Can cause skin burns or be an internal hazard of ingested

RADIOACTIVITY

- **Gamma-rays :**
  - Electromagnetic photons or radiation (identical to x-rays except for source)
  - Emitted from nucleus of radioactive atoms – spontaneous emission
  - Emitted with kinetic energy related to radioactive source
  - Highly penetrating – extensive shielding required
  - Serious external radiation hazard

RADIOACTIVITY

- **X-rays :**
  - Overlap with gamma-rays
  - Electromagnetic photons or radiation
  - Produced from orbiting electrons or free electrons – usually machine produced
  - Produced when electrons strike a target material inside and x-ray tube
  - Emitted with various energies & wavelengths
  - Highly penetrating – extensive shielding required
  - External radiation hazard
  - Discovered in 1895 by Roentgen

RADIOACTIVITY

- **Reducing Exposure :**

1. **Time**

(Reduce the spent near the source of radiation).

2. **Distance**

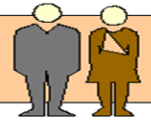
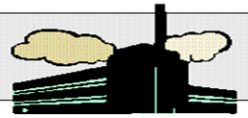
(Increase the distance from the source of radiation).

3. **Shielding**

(Place shielding material between you and the source of radiation).

RADIOACTIVITY

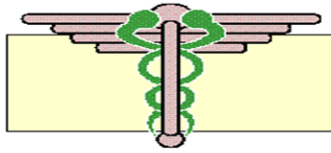
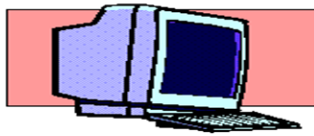
Radiation from Natural Sources

	Source	mrem/year
	Cosmic rays	28
	The earth	26
	Radon	200
	The human body	25
	Building materials	4

Transparency 4-1

RADIOACTIVITY

Radiation from Manmade Sources

	Source	mrem/year
	Medical	90
	Fallout	5
	Consumer products	1
	Nuclear power	0.3

RADIOACTIVITY

Units of Radioactivity

- The Becquerel (Bq): Disintegration per second, dps
- The curie (Ci)

  1 Ci = 37,000,000,000 Bq

  so 1 mCi = 37 MBq; and 1 μCi = 37 kBq
- rem: Rem is the term used to describe equivalent or effective radiation dose.
- In the International System of Units, the Sievert (Sv) describes equivalent or effective radiation dose. One Sievert is equal to 100 rem.

RADIOACTIVITY

- **Radiation Units :**

- Exposure – X (coul/kg)

  (Related to energy)

- Absorbed Dose – Gray (Gy)

  (amount of energy absorbed)

- Equivalent Dose – Sievert (Sv)

  (makes different sources of radiation equivalent)

RADIOACTIVITY

- **Radioactive Isotopes in Medicine**
- The radioactive isotopes were first used in medicine for diagnostic procedures during the early 1930s.
- This eventually laid the foundation for nuclear medicine.
- This article will cover all the information regarding the procedures and uses of radioactive isotopes in medicine.

RADIOACTIVITY

- **What is Nuclear Medicine ?**

- Nuclear medicine is the branch of science under medicine, that uses radiation to give information regarding the functioning of a specific organ in the human body or to treat a disease. This collected information gives accurate and immediate diagnosis of the patient's illness.

- Radioactive isotopes in medicine are used to form images of the thyroid, bones, heart, liver and many other organs. Radioactive isotopes used in medicine have also helped in treating diseased organs and tumors.

RADIOACTIVITY

- **What is Nuclear Medicine ?**
- Nuclear medicine uses radiation to provide diagnostic information about the functioning of a person's specific organs, or to treat them.
- Diagnostic procedures are now routine.

RADIOACTIVITY

- **Diagnostic techniques in nuclear medicine**
- Medical diagnosis refers to the process of attempting to determine and/or identify a possible disease or disorder and the opinion reached by this process.
- Diagnostic techniques in nuclear medicine use radioactive tracers which emit gamma rays from within the body. These tracers are generally short-lived isotopes linked to chemical compounds which permit specific physiological processes to be scrutinized. They can be given by injection, inhalation or orally.

RADIOACTIVITY

- **Diagnostic techniques in nuclear medicine**
- Positron Emission Tomography (PET)- a more precise and sophisticated technique using isotopes produced in a cyclotron. These are detected by a PET camera and give very precise indication of their origin .

RADIOACTIVITY

- **Radionuclide therapy (RNT)**

- Rapidly dividing cells are particularly sensitive to damage by radiation. For this reason, some cancerous growths can be controlled or eliminated by irradiating the area containing the growth.
- Internal radionuclide therapy is by administering or planting a small radiation source, usually a gamma or beta emitter, in the target area. Short-range radiotherapy is known as brachytherapy, and this is becoming the main means of treatment.

RADIOACTIVITY

- **Radionuclide therapy (RNT)**

- External irradiation (sometimes called teletherapy) can be carried out using a gamma beam from a radioactive cobalt-60 source.

RADIOACTIVITY

- **Biochemical Analysis :**

- It is very easy to detect the presence or absence of some radioactive materials even when they exist in very low concentrations. Radioisotopes can therefore be used to label molecules of biological samples in vitro (out of the body).
- Pathologists have devised hundreds of tests to determine the constituents of blood, serum, urine, hormones, antigens and many drugs by means of associated radioisotopes. These procedures are known as **radioimmuno-assays** and, although the biochemistry is complex, kits manufactured for laboratory use are very easy to use and give accurate results.

RADIOACTIVITY

- **Diagnostic Radiopharmaceuticals:**

- Diagnostic radiopharmaceuticals can be used to examine blood flow to the brain, functioning of the liver, lungs, heart or kidneys, to assess bone growth, and to confirm other diagnostic procedures. Another important use is to predict the effects of surgery and assess changes since treatment.
- A radioisotope used for diagnosis must emit gamma rays of sufficient energy to escape from the body and it must have a half-life short enough for it to decay away soon after imaging is completed.

RADIOACTIVITY

- **Therapeutic Radiopharmaceuticals :**
  - For some medical conditions, it is useful to destroy or weaken malfunctioning cells using radiation. The radioisotope that generates the radiation can be localized in the required organ in the same way it is used for diagnosis - through a radioactive element following its usual biological path, or through the element being attached to a suitable biological compound. In most cases, it is beta radiation which causes the destruction of the damaged cells. This is radionuclide therapy (RNT) or radiotherapy.

RADIOACTIVITY

- **SOME Isotopes used in Medicine :**

- Many radioisotopes are made in nuclear reactors, some in cyclotrons. Generally neutron-rich ones and those resulting from nuclear fission need to be made in reactors, neutron-depleted ones are made in cyclotrons. There are about 40 activation product radioisotopes and five fission product ones made in reactors.
- Reactor Radioisotopes (half-life indicated)

RADIOACTIVITY

- **SOME Isotopes used in Medicine :**

- Bismuth-213 (46 min): Used for targeted alpha therapy (TAT), especially cancers, as it has a high energy (8.4 MeV).
- Chromium-51 (28 d): Used to label red blood cells and quantify gastro-intestinal protein loss.
- Cobalt-60 (5.27 yr): Formerly used for external beam radiotherapy, now used more for sterilizing
- Erbium-169 (9.4 d): Use for relieving arthritis pain in synovial joints.
- Holmium-166 (26 h): Being developed for diagnosis and treatment of liver tumours.

RADIOACTIVITY

- **SOME Isotopes used in Medicine :**

- **Iodine-125 (60 d):** Used in cancer brachytherapy (prostate and brain).
- **Iodine-131 (8 d)*:** Widely used in treating thyroid cancer and in imaging the thyroid; also in diagnosis of abnormal liver function, renal (kidney).
- **Iodine-123 (13 h):** Increasingly used for diagnosis of thyroid function, it is a gamma emitter without the beta radiation of I-131.

RADIOACTIVITY

- **SOME Isotopes used in Medicine :**
- Rhenium-186 (3.8 d): Used for pain relief in bone cancer. Beta emitter with weak gamma for imaging.
- Technetium-99m (6 h): Used in to image the skeleton and heart muscle in particular, but also for brain, thyroid, lungs (perfusion and ventilation

RADIOACTIVITY

- **SOME Isotopes used in Medicine :**
- Xenon-133 (5 d)*: Used for pulmonary (lung) ventilation studies.
- Carbon-11, Nitrogen-13, Oxygen-15, Fluorine-18:These are positron emitters used in PET for studying brain physiology and pathology, in particular for localising epileptic focus.
- Iron-59 (46 d): Used in studies of iron metabolism in the spleen.

RADIOACTIVITY

- **SOME Isotopes used in Medicine :**

- **Copper-64 (13 h):** Used to study genetic diseases affecting copper metabolism, such as Wilson's and Menke's diseases, and for PET imaging of tumours, and therapy.

- **Fluorine-18:Indium-111 (2.8 d):** Used for specialist diagnostic studies, eg brain studies, infection and colon transit studies.
- **Potassium-42 (12 h):** Used for the determination of exchangeable potassium in coronary blood flow.

RADIOACTIVITY

External/Internal Exposure Limits for Occupationally Exposed Individuals

Annual Dose Limits

	Adult (>18 yrs)	Minor (< 18 yrs)
Whole body*	**5000 mrem/yr**	**500 mrem/yr**
Lens of eye	**15000 mrem/yr**	**1500 mrem/yr**
Extremities	**50000 mrem/yr**	**5000 mrem/yr**
Skin	**50000 mrem/yr**	**5000 mrem/yr**
Organ	**50000 mrem/yr**	**5000 mrem/yr**

RADIOACTIVITY

Human Annual Exposure

Activity	Typical Dose
Smoking	280 millirem/year
Radioactive materials use in a UM lab	**<10 millirem/year**
Dental x-ray	10 millirem per x-ray
Chest x-ray	8 millirem per x-ray
Drinking water	5 millirem/year
Cross country round trip by air	5 millirem per trip
Coal Burning power plant	0.165 millirem/year

RADIOACTIVITY

ACUTE DOSE(RAD) EFFECT

0-25	No observable effect.
25-50	Minor temporary blood changes.
50-100	Possible nausea and vomiting and reduced WBC.
150-300	Increased severity of above and diarrhea, malaise, loss of appetite.
300-500	Increased severity of above and hemorrhaging, depilation. Death may occur
> 500	Symptoms appear immediately, then death has to occur.


THANK YOU
FOR YOUR
ATTENTION