SNS COLLEGE OF TECHNOLOGY

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Department of Biomedical Engineering

Vision Tit 2 Vision Title 3

Course Name: 19BME301 – Medical Physics

III Year : V Semester

Unit V – BASIC RADIATION QUANTITIES

WHAT IS DOSIMETRY?

Dosimetry is ***the act of measuring or estimating radiation*** doses and assigning those doses to individuals.

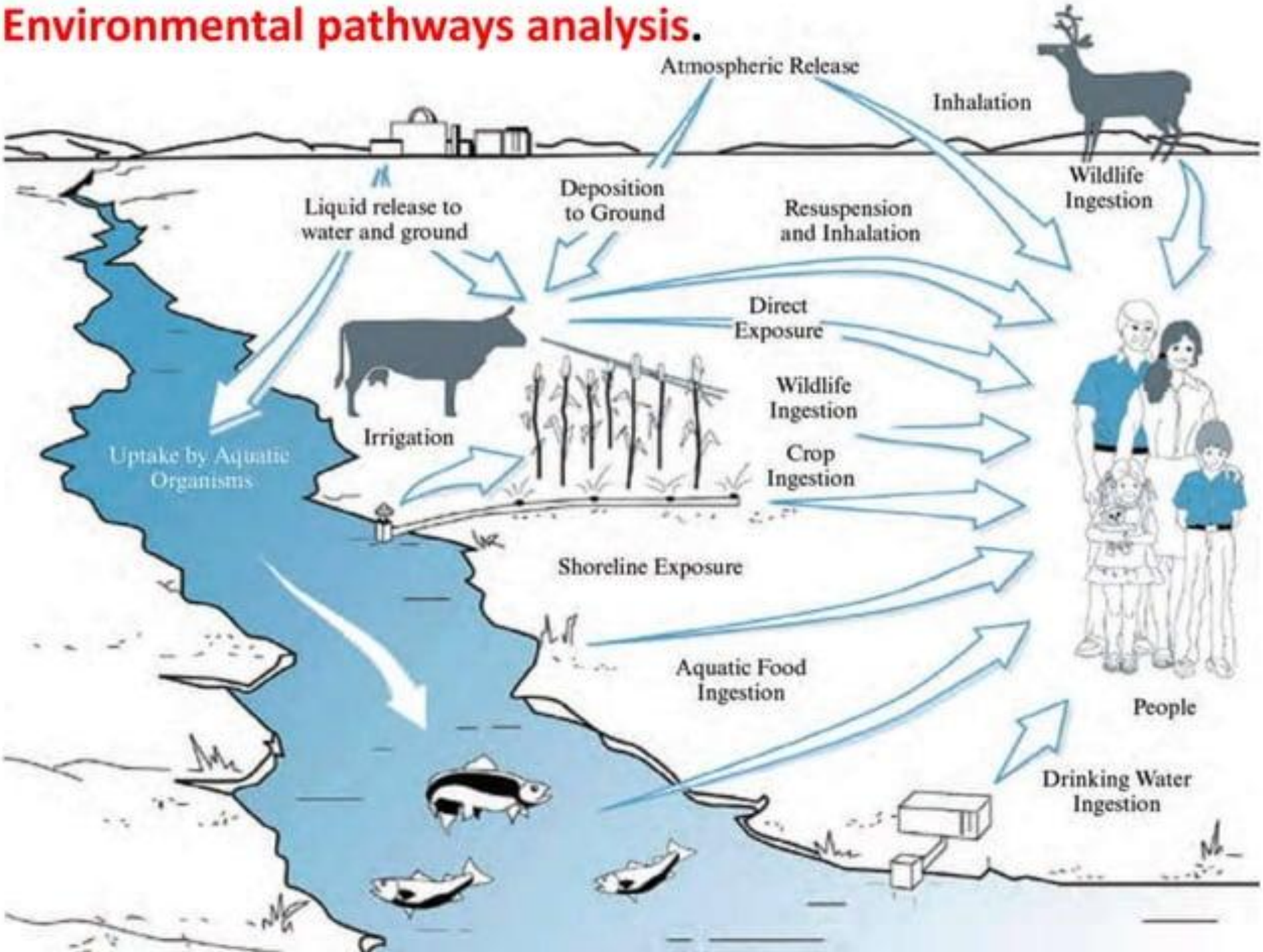
There are two types of radiation exposure:

- **EXTERNAL EXPOSURE,** which occurs when the radiation source or nuclear substance is outside of the body.
- **INTERNAL EXPOSURE,** which occurs when the radiation is emitted by nuclear substances inside the body

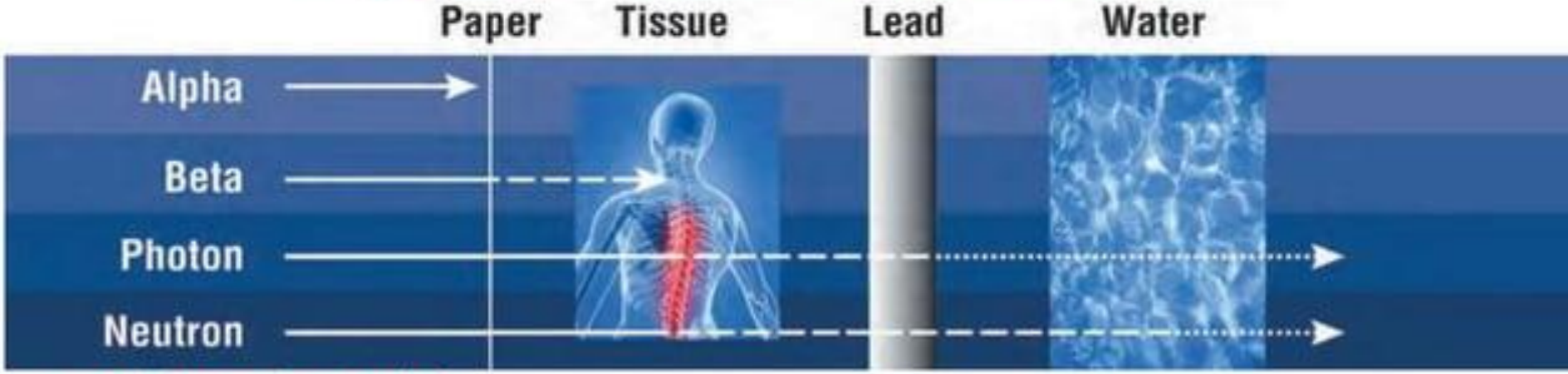
Three methods are commonly used to determine radiation doses to humans:

- **Personal dosimetry**;
- Indirect monitoring using measured dose rates **or airborne concentrations** of nuclear substances; and indirect
- Monitoring using **environmental pathways** analysis.

Environmental pathways analysis.



Types of radiation



- **Alpha radiation (α)** consists of alpha particles that are made up of two protons and two neutrons each and that carry a double positive charge. Due to their relatively large mass and charge.

- **Beta radiation (β)** consists of charged particles that are ejected from an atom's nucleus and that are physically identical to electrons. Beta particles generally have a negative charge.

- **Gamma radiation** consists of photons that originate from within the nucleus, and **X-ray radiation** consists of photons that originate from outside the nucleus.

- All other sources of **neutrons** depend on reactions where a nucleus is bombarded with a certain type of radiation (such as photon radiation or alpha radiation), and where the resulting effect on the nucleus is the emission of a neutron.

Dose Quantities

Absorbed Dose

Radiation energy absorbed per unit mass of a substance (Gy)

Equivalent dose

The concept of equivalent dose allows different types of ionizing radiation to be considered equally with respect to their potential to cause harm

Effective dose

Different tissues and organs may vary in how they respond biologically to a given type of radiation

DOSIMETER

A dosimeter is a small radiation detection device worn by an individual, used to measure doses from ionizing radiation.

- Dosimeters are classified into two general categories, passive and active:
  - A ***passive dosimeter*** produces a radiation-induced signal, which is stored in the device. The dosimeter is then processed and the output is analyzed.
  - An ***active dosimeter*** produces a radiation-induced signal and displays a direct reading of the detected dose or dose rate in real time.

EXTERNAL DOSIMETRY

External dosimetry is the ***measurement of dose*** when the radiation source is outside of (or external to) the body.

Dosimetry for photon and beta radiation

- Beta and photon radiation are hazardous to the skin and the eye, as they can deposit energy in the sensitive cells of these tissues.
- while both photon and beta radiation can contribute to an equivalent dose to the skin and eye, photons are the ***main contributor*** to the external component of the effective dose.
- The penetrating ability or probability of interaction of radiation is related to the radiation's energy.
- Each different nuclear substance emits a specific energy or energy range when it undergoes radioactive decay therefore, ***only some beta particles and photons present an external risk*** to the human body.

Thermoluminescent dosimeters

- When ionizing radiation passes through the ***detector (chip),*** its atoms release some of their electrons.
- The electrons eventually ***become trapped in impurities*** (also called doping centres) within the dosimeter, where they remain in their excited state (a state in which their energy is elevated relative to the ground state).
- The chip is then **heated** in a TLD reader7 (consisting mainly of a heater, a photomultiplier tube8 and a recorder), and the trapped electrons return to the ground state and emit photons of visible light. The amount of light emitted relative to the temperature is called the **glow curve**. This curve is analyzed to determine the dose.

- There are many types of TLDs these include lithium fluoride, calcium sulphate and lithium borate dosimeter.

A whole-body thermoluminescent dosimeter badge


CNSC/CCSN (LAB)
613 - 990 - 6044
04163
MGP
DMC 2000 S
mm
0
1cm
2
3
4
5
6
1/32"
1/16"
1
2

Dosimetry for neutron radiation

- Neutrons ***interact differently in matter*** than photon and beta radiation, neutron detectors have different physical principles than instruments for detecting photon and beta radiation.
- Two types of neutron dosimeters are personal neutron dosimeter and portable neutron survey meters.

Solid-state nuclear track detectors

1. A solid-state nuclear track detector uses a **material called CR–39 plastic**
2. The reaction produces charged particles.
3. The protons produce tracks in the dosimeter that are later made visible through a chemical etching process
4. After etching, the tracks are viewed, and the number of tracks is related to the dose.

INTERNAL DOSIMETRY

Internal dosimetry is the measurement of doses due to nuclear substances that have entered the body by way of ingestion, inhalation or other means.

- **Internal dosimetry involves two steps**:

1. The level of radiation inside a person's body is estimated using one of three methods:

a) ***in-vivo*** **bioassay** (direct measurement of radioactivity in the body)

b) ***in-vitro*** **bioassay** (measurement of radioactivity in a person's urine or feces)

c) measurement of radioactivity in **workplace air**

2. The resulting internal radiation dose is calculated.

In-vivo bioassay

A typical lung counter

In-vitro bioassay

A liquid scintillation analyzer.

Measurement of radon decay products in workplace air

A personal alpha dosimeter.

How internal radiation doses are calculated

The dose to a worker caused by internal radiation exposure is calculated using the following two steps:

- **Determine which organs and tissues** nuclear substances are deposited into
- **Estimate** how much radiation energy is absorbed by the organs and tissues.

- **A biokinetic model** It relates the quantity of nuclear substances taken into the body to the quantity retained in organs and tissues, and to the rate at which the substances are excreted from the body.
- **A dosimetric model** calculates how much radiation energy is absorbed by the organs and tissues as a result of the nuclear substances that are in the body.

Measurement uncertainty in external dosimetry

i. Primarily caused by a lack of knowledge about the **environment** in which a dosimeter will be used; the **response of a dosimeter** can vary based on the instrument's calibration relative to the field it is measuring.

ii. **Lack of precision** in dosimeter response, due partly to differences in material composition of the detector

iii. Inexact dosimeter calibration standards

iv. Bias in the interpretation of output of the processing device

v. The orientation of the dosimeter's user relative to the radiation field being measured

• Measurement uncertainty in internal dosimetry

- Lack of knowledge of the **exact time** of an intake
- **Variation** among individuals' metabolisms
- **Uncertainty or variability** in the characteristics of the material to which a worker may have been exposed (particularly the size of dust particles);
- **Absorption characteristics** of the material in the respiratory tract and in the gut; and the composition of the mixture of nuclear substances to which a worker may have been exposed

Thank You