



**MEDICAL UNIVERSITY – PLEVEN**  
**FACULTY OF PUBLIC HEALTH**  
**CENTER FOR DISTANCE LEARNING**

# **RADIOTOXICOLOGY**

*Лектор: доц. д-р В. Данчева, дм*



---

□ **The radiotoxicology - biokinetics and the biological effects of the internally deposited radionuclides.**

- ✓ if we know the **quantitative relationship** among **exposure, intake, uptake, deposition, and elimination** of a radioisotope, we can calculate the **radiation dose** from a **given exposure**.



**Models for internal dosimetry consider two categories of parameters: radiological and biological.**

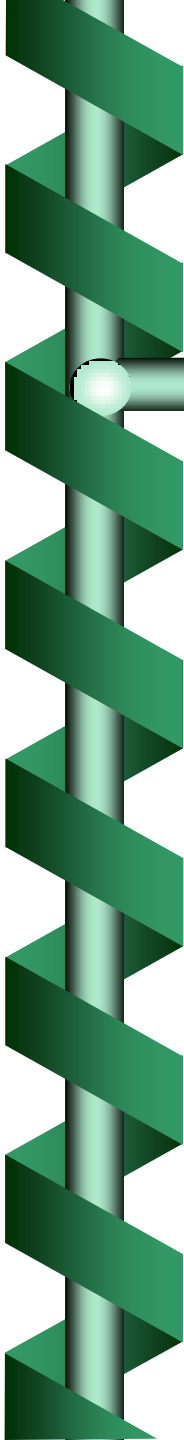
---

**a) Radiological parameters are:**

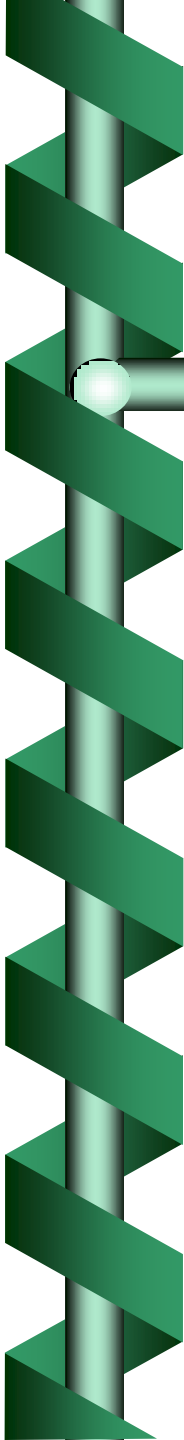
- type of radiation;
- energy of the radiation;
- half-life of the radionuclide;
- radioactive progeny;

**b) Biological parameters are:**

- chemical form;
- ingestion rate;
- inhalation rate;
- particle size;
- respiration rate;
- metabolic pathway;
- retention and excretion;
- organ size;

- 
- 
- Occupational exposure guidelines are **100** mSv in **5** years (average, **20** mSv per year) with a limit of **50** mSv in any single year.
  - General public standard is **1** mSv per year. (Natural background radiation is approximately **3** mSv/year.)

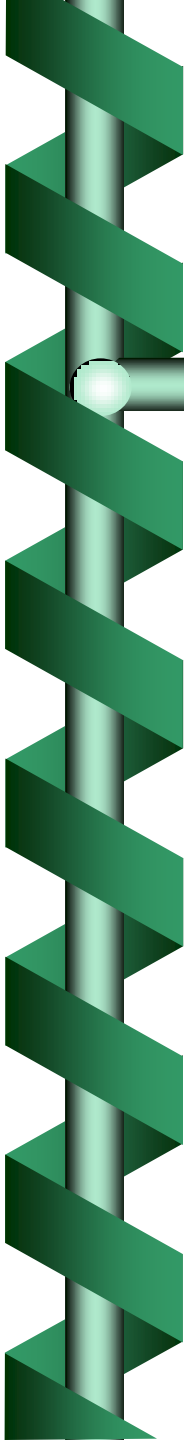
Recommended exposure limits are set by International Council on Radiation Protection (ICRP).

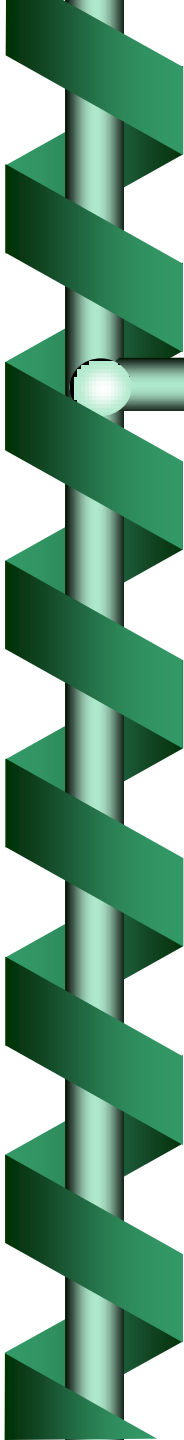


---

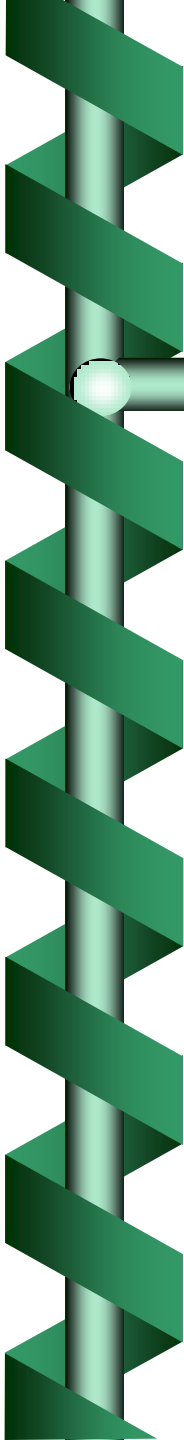
❑ **Soluble radionuclides** fall into one of **three categories**, according to their **metabolic pathways** and distribution within the body:

1. Radionuclides that are uniformly **distributed within the body**, such as **tritium** ( $\text{H}^3$ ), **cesium** ( $\text{Cs}^{137}$ ) etc.
2. Radionuclides that are *concentrated in specific organs*, such as **mercury in the kidney**, **iodine in the thyroid**, etc.
3. Radionuclides that are **deposited in the skeleton**, such as **radium** ( $\text{Ra}^{226}$ ), **strontium** ( $\text{Sr}^{90}$ ), etc.

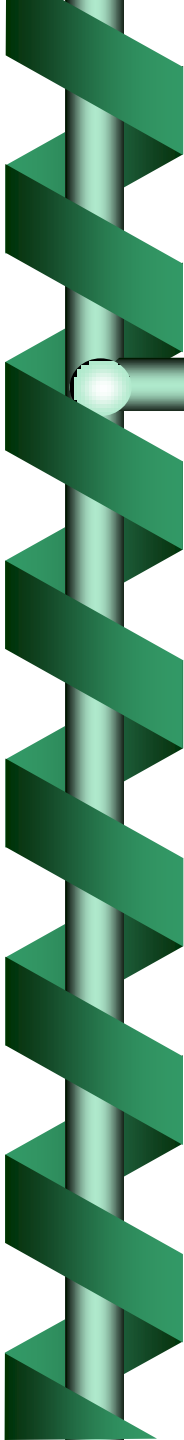
- 
- 
- ❑ During the **early stages** of nuclear accidents mixtures of **noble gases (e.g. krypton, xenon)**, iodine and particulate material may be released in the atmosphere and can be **intaken in the human body**.
  - ❑ Of the **radionuclides** potentially available for release in a **nuclear reactor accident** in the **short-term**, radioiodines, particularly **iodine<sup>131</sup>**, are by a **far the most significant** in view of their huge quantities in the reactor core and their volatility.

- 
- The physical half-life of the **iodine 131** is **8.05** days. It emits  **$\beta$** -particle and  **$\gamma$** -rays.
  - **Iodine**, including the **isotopes 131, 133** is **rapidly** and **completely absorbed** by the **gastrointestinal tract** within 30 to 60 minutes of ingestion
  - Inhaled radionuclides reach equilibrium in the body within about 30 minutes

- **Iodine** is **rapidly concentrated** by the **thyroid**, reaching its maximum euthyroid uptake in 48 hours
- Iodine is almost **instantaneously synthesized** into **thyroid hormones**, primarily **thyroxin**, which is only **slowly released**.

- 
- The thyroid can be protected using stable form of iodine.
  - ❑ **If 100 mg of KI** (stable form of iodine) is administered at the **same time or shortly before** exposure to **radioiodine**, **thyroid blockade is almost 97%** complete, and the thyroid takes up **only 3%** of the administered radioiodine.
    - ✓ **Potassium iodide given 3 hours later reduces** the uptake to **only 50%** of control value, and **after 6 hours KI no longer** has a **significant protective effect**.
    - ✓ If there is **no new exposure** to radioiodine, KI administration should be continued **for 2 or 3** additional days;
    - ✓ If **exposure to I<sup>131</sup> persists**, then administration of **KI should be continued**.

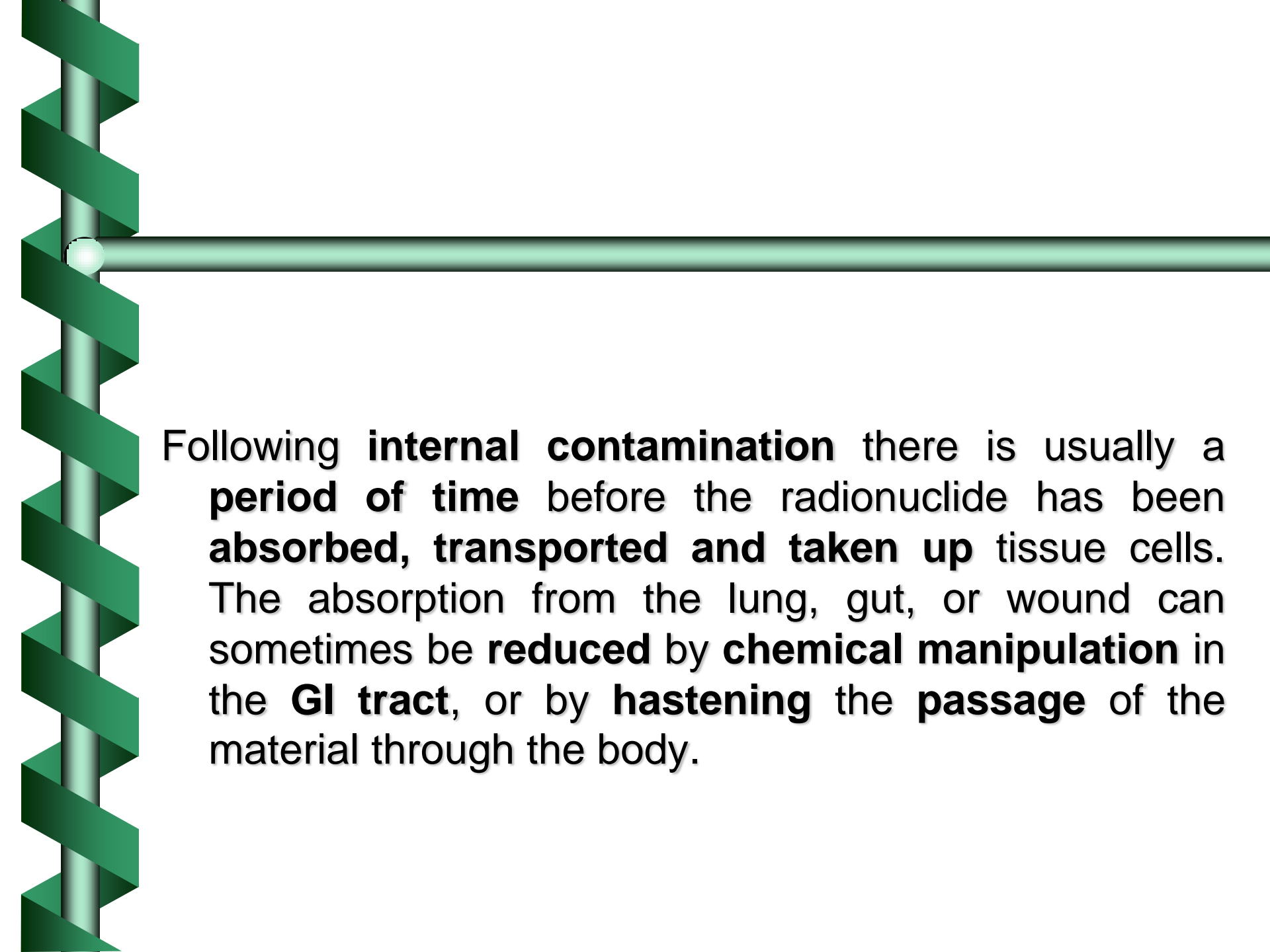


- 
- 
- ❑ The main biological effects of the **radioiodine** are **hypothyroidism** and **thyroid cancer**.
  - ❑ During the **intermediate** and **late** phases after nuclear accident the most dangerous radionuclides are **Cesium-137** and **Strontium-90**.
  - ❑ **Cesium-137** is **beta** and **gamma** emitting isotope. Its physical half-life is **30** years.
    - ✓ the **effective** half-life is **70** days.
    - ✓ the cesium-137 is **uniformly** distributed within the body.
    - ✓ the radiocesium damages the most radiosensitive tissues: **haematopoeitic, reproductive**.

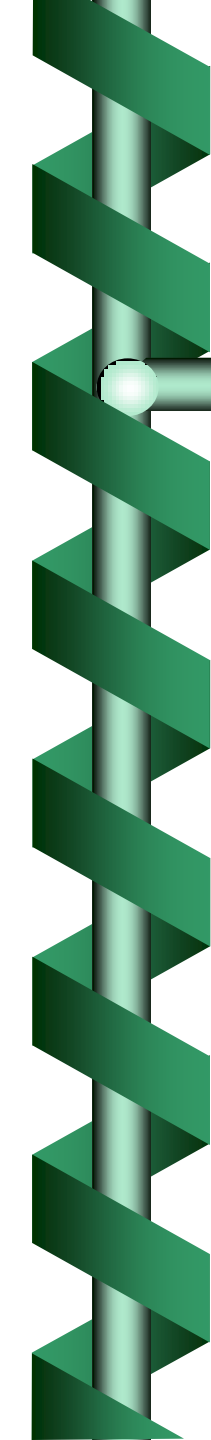
- 
- 
- ❑ **Strontium-90** is only **beta emitting** radionuclide.
    - ✓ its **physical half-life** is **28 years**.
    - ✓ the **effective half-life** is **15 years**.
    - ✓ the radiostrontium is deposited mainly in the **skeleton**
    - ✓ the most important biological effect of strontium is **osteosarcoma**.



# **Treatment of internal contamination with radionuclides**



Following **internal contamination** there is usually a **period of time** before the radionuclide has been **absorbed, transported and taken up** tissue cells. The absorption from the lung, gut, or wound can sometimes be **reduced** by **chemical manipulation** in the **GI tract**, or by **hastening** the **passage** of the material through the body.

- 
- 
- ● **Alkalizing the stomach** may cause the formation of relatively **insoluble hydroxides** or will at least keep the **pH high** enough to **reduce solubility** of some metal salts.
    - **Metals** such as **copper, iron, or plutonium** are generally more available for **later absorption** after spending some time in the **acid milieu** of the stomach.
    - With **chromium, opposite is true. Acid gastric juice** reduces **hexavalent chromium** to the **poorly absorbed trivalent ion**.
    - The administration of **cathartics** such as magnesium sulfate will **shorten the intestinal transit** time, thereby reducing absorption and radiation exposure to the gut wall and nearby tissues.

- 
- ● **Once absorbed**, uptake can be reduced by the use of **blocking agent, isotopic dilution, or chelating agents**.

A **blocking agent** is a chemical that **saturates a tissue** with a nonradioactive element, thereby **reducing the uptake** of the radionuclide.

**Isotopic dilution** refers to the administration of **large quantities** of the **stable isotope** of the radionuclide so that, the **opportunity** for **incorporation** of atoms of the radionuclide is **lessened**.

**Chelating agent** binds metal into **complexes**, prevents tissue uptake and allows **urinary excretion**. If given promptly, **diethylenetriaminepentacetic acid (DTPA)** will greatly reduce the uptake of **absorbed  $^{232}\text{Pu}$**  in the **skeleton**. Chelating agents such as **EDTA, DTPA, BAL, penicillamine, or deferoxamine** are sometimes useful after uptake, but their effectiveness is greatly reduced.



# **Iodine Prophylaxis**

## Recommended single dosage of stable iodine according to age group

Age group	Mass of Iodine(mg)	Mass of KI Potassium Iodide (mg) Tablets: 65 mg, 130 mg, 250 mg	Mass of KIO <sub>3</sub> Potassium Iodate mg	Fraction of 100 mg tablet (5% tincture of Iodine (drops))
Adults and adolescents (over 12 y)	100	130	170	1 (2, ½)
Children (3-12 years)	50	65	85	1/2
Infants (1 m to 3 y)	25	32	42	1/4 20 drops
Neonates (birth to 1 m)	12.5	16	21	1/8 10 drops