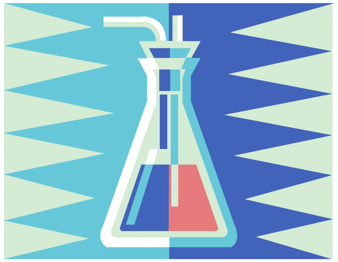
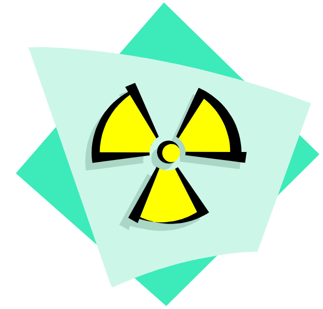
Bioassay

Chapter 6



Objectives:



State the two methods of conducting bioassays.

Describe when bioassays are conducted.

Describe how radioactive material enters and exits the body.

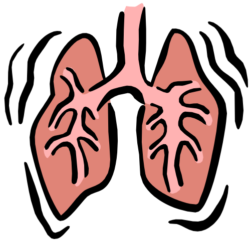
Discuss the advantages and disadvantages of whole body counting versus biological sampling.

Define ALI, DAC, and describe the relationship of ALI to CDE and CEDE.

Bioassay

Radioactive material may enter your body by four different pathways:

- Inhalation
- Ingestion
- Injection or puncture
- Absorption



Of these four pathways, **INHALATION is the most prevalent**.

Internal contamination can be referred to as an ‘uptake’ or ‘intake.’

Elimination of Uptake

Once an uptake occurs, there are ways that radioactive material is removed from/leaves the body (based on solubility/size/etc):

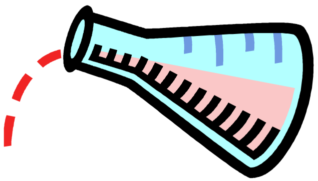
- **Excretion as urine/feces**
- **Expectoration from lungs**
- **Sweating (limited effect)**

Radioactive material may also decay to other isotopes that may remain in the body. However, once they decay to non-radioactive isotopes, they no longer contribute to your dose.

Bioassay

A bioassay is a method of determining the amount of radioactive material in your body. It is used to determine (calculate) the dose from this radioactive material.

There are two techniques for bioassays:



(1) Measure the amount of radioactivity directly - this is called an *in vivo* (in life), a "whole body count" (WBC).

(2) Measure the amount of radioactivity excreted from your body - this is called an *in vitro* (in glass) bioassay. The concentration of radioactivity in urine or fecal samples can be used to determine the amount of activity in your body.

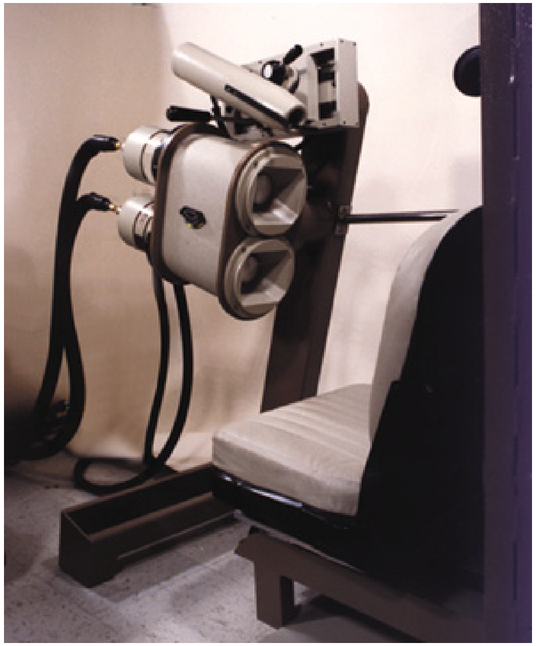
Whole Body Counting

There are two basic WBC systems in use:

- NaI detection systems (e.g., FASTSCAN)
- Germanium solid-state detectors.

Different configurations are used for whole body counting. Some position a detector over an organ to be counted, such as the thyroid (used for both medical and commercial power reactors when there is concern over I-131). A lung counter is used when the concern is for low-energy transuranics. (e.g., Am-241, Pu-239.)

Whole Body Counters



WBC - Applications

Whole body counts (WBC) are useful in measuring gamma emitting isotopes.

A WBC tells how much radioactive material you have in your body when the "count" was conducted, not how much you initially got in your body. It does NOT tell your dose directly.

The amount of radioactive material initially deposited in your body, when you were working in an area and received the intake, can be calculated based on results of your WBC.

WBC - Applications

Frequency of bioassays:

- New hires – when you first arrive at a site,
- Annually – if you are at a site for a long time
- Randomly – to ensure there are no unaccounted exposures,
- Suspected intake – events such as an area “going airborne,” or a wound in a contaminated area
- Termination – when you “permanently” leave the site.

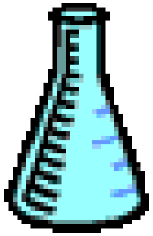
WBC - Limitations

A whole body count (WBC) cannot be used for alpha or beta emitting isotopes.

Additionally, a WBC cannot distinguish activity that is on your body from activity that is in your body.

For this reason if you have a positive count result, the technician may have you do a whole body frisk to ensure you don’t have contamination on you - otherwise the WBC will indicate you have more activity and, therefore, a higher dose will be assigned.

In Vitro Bioassay



- **In-vitro bioassays are useful for alpha and beta radiation which cannot be measured by a WBC, (e.g. carbon-14, tritium).**
- **To determine the intake, it is necessary to determine when the person received the intake.**
- **Beside the aesthetic and health concerns in handling samples, they require expensive laboratory analysis and time to get the results.**

Dose Limits - ALI

- Using the 10CFR20 TEDE and TODE dose limits, the amount of internal activity that would result in these dose levels was derived. This activity level is called the "Annual Limit on Intake" or ALI.*

- ALI - Amount of radioactive material that if ingested/inhaled will give you a committed dose (dose over 50 years) of either 5 rem (stochastic) or 50 rem (deterministic) is called the Annual Limit on Intake (ALI).

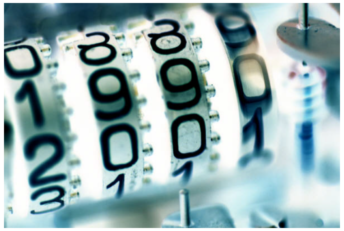
- Units of activity (μCi).

*The derived quantities of isotopes are contained in Appendix B of 10 CFR 20.

Dose Limits - DAC

- **Knowing the amount of curies necessary to reach 1 ALI allows using airborne concentration of the nuclides with the time of inhalation to determine the total intake. The concentration of radioactive material in air that, if breathed for a year, would result in an intake of 1 ALI was also derived (App C of 10 CFR 835).**
- **The assumption is that a person is performing 'light work activity' and they worked 2000 hours in a year (40 hours/week @ 50 weeks/year).**
- **This concentration that gives 1 ALI is called a Derived Air Concentration, or "DAC."**
- **1 DAC (μCi/ml) = 1 ALI / air breathed in work year**

Dose Limits

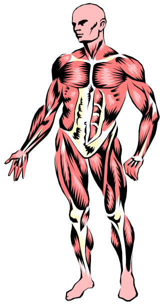


- **ALI - Amount of radioactive material that if ingested/inhaled will give you 5 rem (stochastic) or 50 rem (deterministic) is called the Annual Limit on Intake (ALI). Units of activity (μCi).**

- **DAC - Derived Air Concentration, air concentration if inhaled continuously will result in 1 ALI over a year.**

- **DAC = ALI / air breathed in working year (50 weeks @ 40 hr/wk = 2000 hours)**

Dose Limits



1 ALI = 2000 hours @ 1 DAC = 2000 DAC-hrs. An intake of 1 ALI will give you a dose limit of 5 rem or 50 rem, depending on whether it is stochastic or deterministic, respectively.

If the ALI limit is stochastically based, that is, the 5 rem limit, then:

5 rem/ 2000 DAC-hrs = 2.5 mrem/DAC-hr (stochastic); that is,

1 DAC-hr (1 hour in an area with a concentration of 1 DAC) would result in an internal dose of 2.5 mrem.

1 DAC – hr = 2.5 mrem (stochastic)

Dose Limits

If the ALI limit is deterministically based, that is the 50 rem limit, then 50 rem /2000 DAC-hrs = 25 mrem/DAC-hr, or one hour of exposure in an area with a concentration of 1 DAC would result in a dose of 25 mrem.

1 DAC-hr = 25 mrem (deterministic)

Internal Dose Calculations

The ALI and DAC concept provide us with two methods of calculating the dose from internally deposited radionuclides:

1. bioassays
2. air sampling:

1) If we can determine what the initial intake of activity in the body was, we can determine the dose by the fraction of the ALI deposited. Knowing the relationship between ALI and dose (1 ALI = 5 rem stochastic; or 1 ALI = 50 rem deterministic) we can determine the dose.

Internal Dose Calculations

2) If we know what the airborne concentration of a radionuclide is, we can compare this to the DAC for the radionuclide. Knowing the DAC-fraction, we can then determine the dose by the DAC-to-dose relationship (1 DAC-hr = 2.5 mrem stochastic; or 1 DAC-hr = 25 mrem deterministic).

Review

- Radioactivity enters our body by: inhalation, ingestion, wounds, or absorption. Inhalation is the most likely pathway.
- Bioassay are: *in vivo* – a "whole body count," used for photon emitting nuclides; *in vitro* – e.g., urine or fecal analysis used for beta and alpha emitting nuclides,
- Internal monitoring determines activity in the body and can be used to quantify the intake. The intake is compared to the pre-determined ALI for the nuclide(s) and then used to calculate assigned dose.
- 1 ALI = 5 rem (stochastic) or 50 rem (deterministic)
- 2000 hours @ 1 DAC = 2000 DAC-hours = 1 ALI
- 1 DAC-hour = 2.5 mrem (stochastic) or 25 mrem (deterministic)