

Analytical X-Ray Safety Training

5. Biological and Health Effects



Training Outline

- history
- sources and uses of X-Rays
- legislation
- **biological and health effects**
- X-Ray safety in the lab
 - exposure
 - SOPs
 - security
 - emergencies
 - summary
- references
- quiz
-

Biological and Health Effects

Radiation is one of the best-investigated hazardous agents.



Factors Determining Biological Effects

- total dose
- dose rate
- energy of radiation
- amount of body exposed
- cell and individual sensitivity

Factors Determining Biological Effects

TOTAL DOSE

- effects from acute doses ($> 1 \text{ Sv} = 100 \text{ rem}$) easily observed
- $<$ effects on chronic dose at 0.1 Sv effects not reliably quantifiable due to no observable effects

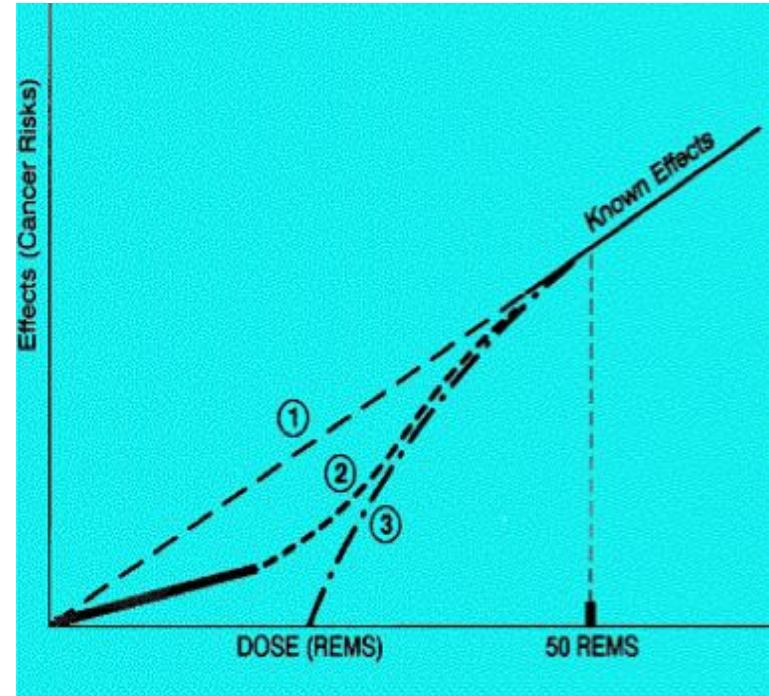
Biological and Health Effects - Dose (D)

- effects from radiation depend on amount of radiation received (absorbed) by the body
- called Dose or Absorbed Dose (D)
 - *quantity of energy deposited in a unit of mass of material*
- ***units of Measure: Gray (Gy) or rad***

$$1 \text{ Gy} = 100 \text{ rad}$$

Radiation Dose Response Curve

- 1) Most conservative model: An increase in dose results in a proportional increase in risk.
- 2) At low doses there is only a slight increase in risk that becomes proportional to dose at higher doses.
- 3) There is a threshold for dose response at which lower doses do not result in increased risk.
- 4) Hormesis model (not shown): Low doses of radiation have a positive effect and decrease overall risk.



Equivalent Dose (H)

- biological effect caused by radiation being deposited in human body
- dependant on type of radiation and energy
- quality factor (QF) used to relate the absorbed dose of various kinds of radiation to the biological damage caused to the exposed tissue since different kinds of radiation cause different degrees of damage.
- the higher the quality factor, the greater biological risk or greater effect than the radiation with a lower quality factor (for the same absorbed dose)

Factors Determining Biological Effects

Low Radiation Dose (Chronic)

Chronic exposure when a relatively small amount of radiation is absorbed by tissue over a long period of time

- result in an increased risk in latent adverse health effects
- < 100 mSv of exposure - No detectable health effects in exposed individual

Historical Doses @ Ryerson Averaged < Reporting Threshold of TLD (<0.1 mSv)

Factors Determining Biological Effects

Large Radiation Dose (Acute)

Biological Effects from large doses potentially occur due to accidental exposures

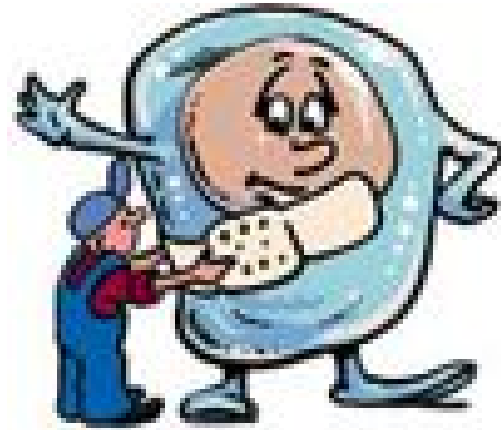
Acute exposure when a large amount of radiation is absorbed by tissue over a single period of time

- 2 – 10 Sv (whole body exposure) cause radiation sickness
- > 10 Sv (whole body exposure) cause death

Factors Determining Biological Effects

Dose Rate

- dependent on amount of radiation over period of time (exposure)
- acute vs. chronic
- if amount of radiation same, acute dose more damaging, since tissues does not have time for repairs



Factors Determining Biological Effects

Energy of Radiation

- X-Rays have wide range of energies (10 to 100 KeV)
- higher the energy deeper the penetration into tissue
- lower energy X-Ray absorbed first layers of skin (shallow dose)

Factors Determining Biological Effects

Amount of Body Exposed

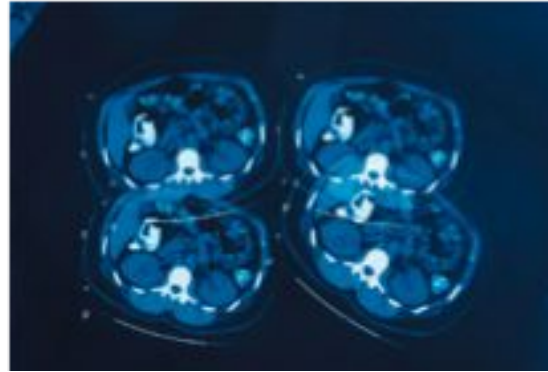
- harder and more damaging for body to recover from dose to large area of body than a small, localized area such as hand
- might include sensitive organs



Factors Determining Biological Effects

Sensitivity

- individual sensitivity to absorbed radiation
- type of cells: some more radiosensitive such as those undergoing cell division



Genetic Effects

Biological effect inherited by children resulting from a modification of genetic material in a parent

- no genetic effects observed in humans only in animal studies
- no statistically significant genetic effects observed in children in Japanese atomic bomb survivors (any effects on offspring from nuclear bombing survivors in Japan in WWII from women already pregnant)

Somatic Effects

Biological effect observed in our lifetime to exposed individual (not carried to offspring)

- skin erythema, severe “sunburn”, and cataracts can occur at doses of 2 Gy (2 Sv)*
- *NOTE: Typical Ryerson doses <0.1 mSv*

**ICRP 85*



Erythema from radiation therapy overexposure

Risk of Cancer

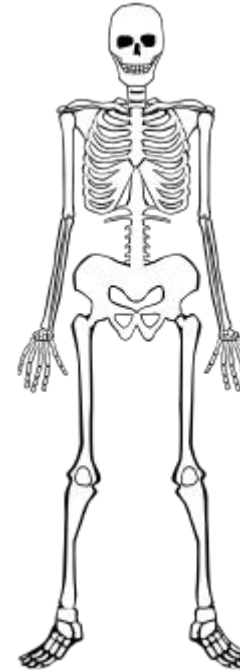
- radiation exposure including exposure to X-Rays does not cause any unique forms of cancer that are not normally observed in humans
- risk estimates derived mostly from survivors of WWII atomic bombings

Evaluation of risk

- the risk of cancer from radiation exposure is conservatively assumed to be linear with dose
- if 1 million people were exposed to 10 mSv then hypothetical estimates of 100 additional leukemia and 700 additional other cancers greater from an acute dose of 10 mSv (BEIR V report)
- *typical Ryerson doses < 0.1mSv*

Health Effects of X-Rays

- due to localized nature of X-Ray beams, acute doses to whole body NOT USUAL
- most health effects occur due to chronic exposure
- most exposure to analytical X-Rays results in exposure to skin and extremities



Continue to: X-Ray Safety in the Lab