Radiation biology
and
Radiation protection

Lecture 11

135°   135°

6 feet   6 feet

90°   90°

Imad Brinjikji

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Radiobiology
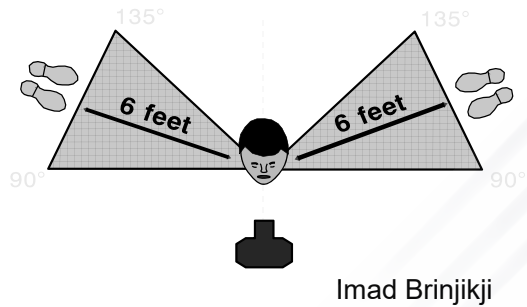
o **The effects of radiation on the living systems and the response of living systems to ionizing radiation.**

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Radiation chemistry

Direct   indirect

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Radiation chemistry

Direct

$$x\text{-radiation} + RH \longrightarrow R^{\bullet} + H^{+} + e$$

o **RH is a biologic molecule, R· is a free radical.**
o **About 1/3 of biologic effects of x-ray exposure result from direct effects.**
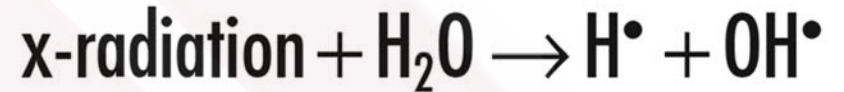
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Radiation chemistry

Direct

Dissociation

$$R^\bullet \rightarrow X + Y^\bullet$$

Cross-linking

$$R^\bullet + S^\bullet \rightarrow RS$$

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Radiation chemistry

indirect

$$\text{x-radiation} + H_2O \rightarrow H^\bullet + OH^\bullet$$

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Radiation chemistry

indirect

$$RH + OH^\bullet \rightarrow R^\bullet + H_2O$$

$$RH + H^\bullet \rightarrow R^\bullet + H_2$$
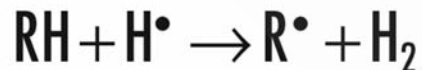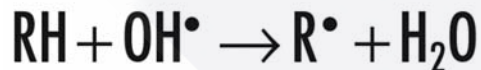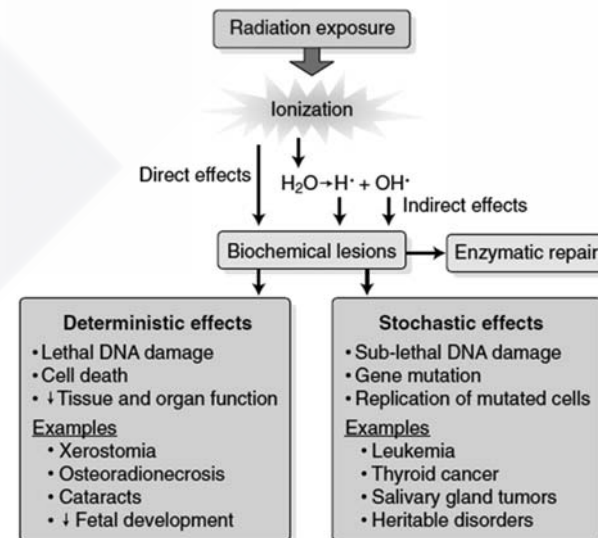
The newly formed molecules (in direct and indirect interactions) differ in the structure and function from the original molecules

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These direct and indirect interactions leads to:

Radiation exposure

Ionization

Direct effects

$H_2O \rightarrow H^\cdot + OH^\cdot$

Indirect effects

Biochemical lesions → Enzymatic repair

Deterministic effects
- Lethal DNA damage
- Cell death
- ↓ Tissue and organ function

Examples
- Xerostomia
- Osteoradionecrosis
- Cataracts
- ↓ Fetal development

Stochastic effects
- Sub-lethal DNA damage
- Gene mutation
- Replication of mutated cells

Examples
- Leukemia
- Thyroid cancer
- Salivary gland tumors
- Heritable disorders

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Deterministic stochastic and effects

	Deterministic Effects	Stochastic Effects
Examples	Mucositis resulting from radiation therapy to oral cavity	Radiation-induced cancer
	Radiation-induced cataract formation	Heritable effects
Caused by	Killing of many cells	Sublethal damage to DNA
Threshold dose?	Yes: Sufficient cell killing required to cause a clinical response	No: Even one photon could cause a change in DNA that leads to a cancer or heritable effect
Probability of having effect and dose	Probability of effect independent of dose; all individuals show effect when dose is above threshold	Frequency of effect proportional to dose; the greater the dose, the greater the chance of having the effect

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Relative radiosensitivity of various cells and tissues

High

Divide regularly
Long mitotic futures
Undergo no or little differentiation between mitoses

> High
> Lymphoid organs
> Bone marrow
> Testes
> Intestines
> Mucous membranes

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Relative radiosensitivity of various cells and tissues

Intermediate

Divide occasionally in response to demand for more cells

> Fine vasculature
> Growing cartilage
> Growing bone
> Salivary glands
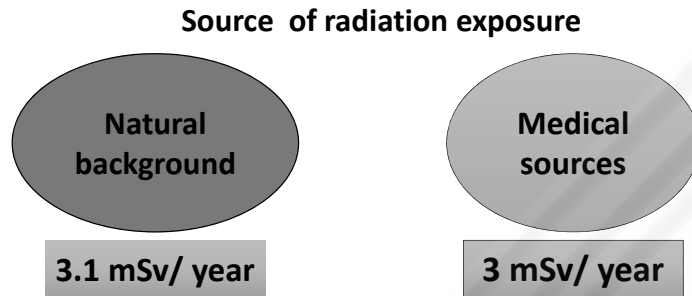> Lungs
> Kidney
> Liver

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Relative radiosensitivity of various cells

Low

Highly differentiated
When mature are incapable of division

> Neurons
> Muscle

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Radiation protection

Source of radiation exposure

| Natural background	Medical sources
3.1 mSv/ year	**3 mSv/ year**

Radiation protection

- **Medical exposure is related to some individuals (e.g. sick, old people).**

- **25% of all medical exposures are related to dentistry, but they contribute to 0.26% only from total exposure.**
  - **Linear nonthreshold (LNT) hypothesis.**
  There is no threshold dose below which there is no additional risk, even at very Low doses <NO SAFE DOSE>.
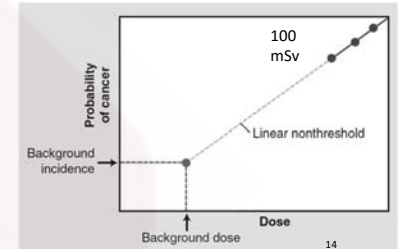
Radiation protection

Radiographic technique		Full-mouth D-speed	Full-mouth F-speed	Full-mouth CCD
Intraoral	Rectangular	-	35 µSv 4 days	17 µSv 2 D
	Round	388 µSv 46 D	171 µSv 20 D	85 µSv 10 D
Extra-oral imaging				
Panoramic		9 - 24 µSv / 1-3 D		
MDCT	Chest	5800 µSv / 682 D (1.9 yrs)		
	Head	180- 1500 µSv / 21-177 D		
Cone-beam CT		19-1073 µSv / 2-126 D		

ADA (2012) recommendations

- Use E/F-speed film or digital sensors

- Use holders to support film or digital sensors intraorally (don't use finger to support the film).

- Make exposures with 60 to 70 kVp (the patient dose is reduced with higher kVp exposures).

ADA (2012) recommendations

• Replace short pointed aiming tubes with open-ended aiming cylinders (between 20-40 cm).

• Use rectangular collimation for periapical and bitewing images (up to fivefold).

• Protective thyroid collars should be used whenever possible.

ADA (2012) recommendations

• **Stand at least 2 m away from patient and away from the x-ray machine.**
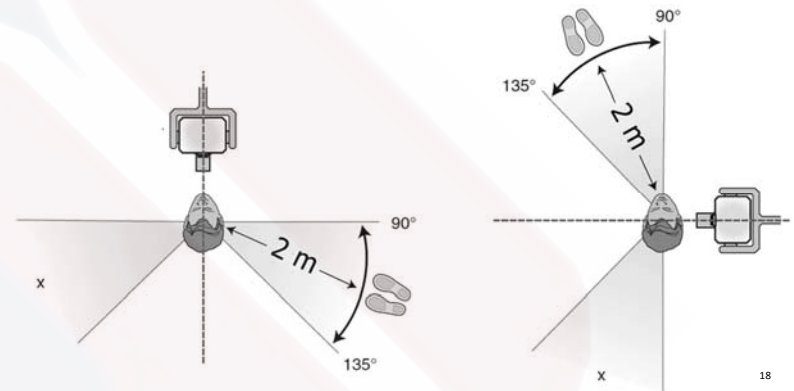
ADA (2012) recommendations

• **With film, use time-temperature film processing rather than "sight" processing, or use an automatic processor (Don't overexpose and under-develop).**

• **The operator (or nurse) should never hold films or sensors in place.**

The end