

## Radiation Biology: Stochastic Effects of Radiation Exposure

Bushong, Chapter 34

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### Late Effects

- Because the damage produced by radiation is manifest over long periods of time, the resultant damage is termed "Late Effects"
- May remain dormant for many years
- May never manifest in the exposed individual
- These are referred to as stochastic effects
  - The probability of a long-term effect taking place

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### Late Effects

- Two categories of late effects:
  - Somatic effects
    - Occurring in the exposed individual (or fetus)
  - Genetic effects
    - Observed in succeeding generations

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### Late Effects

- Stochastic
  - Non-threshold effects
  - Random
  - Any increase in dose increases the **probability** of an effect (NOT severity)

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### Late Effects

- Deterministic
- Have a threshold for effects
  - Below a certain dose, damage is not observed
  - Above a certain dose, **severity** of damage is increased

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### Late Deterministic

- Late deterministic somatic effects
  - Cataract formation**
  - Fibrosis
  - Organ atrophy
  - Loss of parenchymal cells
  - Reduced fertility**
  - Sterility**

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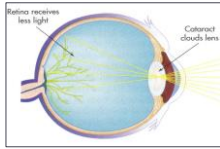
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### Late Deterministic

#### Cataractogenesis:

- ❑ A high probability of formation with a single dose of 2 Gy
- ❑ Results in partial loss of vision
- ❑ 15 year average latent period (varies from five to 30 years)
- ❑ Nonlinear, threshold model



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### Late Stochastic

- ❑ Single most important somatic effect induced by radiation is carcinogenesis
  - ❑ First reported case of radiation induced carcinoma was in 1902
  - ❑ Within 15 years, there were 100 cases of skin cancer reported

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### Risk Estimates

- ❑ While early effects of high dose radiation exposure are easily identifiable and measurable, late effects are more difficult to assess

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### Human Data

- Sources of data for human exposures
  - Occupational exposure
  - Atomic Bomb survivors
  - Medical exposure
  - Fallout accidents in the Pacific Testing Grounds
- \*\*\*\* Experimental radiation is NOT conducted on humans

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### Human Data

- Malignancies in which radiation has been implicated as a causative factor
  - Leukemia
  - Skin carcinoma
  - Osteosarcoma
  - Lung cancer
  - Thyroid cancer
  - Breast cancer

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### In Utero Exposure

- Effects are time and dose related:
  - Prenatal death
  - Neonatal death
  - Congenital abnormalities
  - Malignancy induction
  - Impairment of growth
  - Mental retardation
  - Genetic effects

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### Genetic Effects

- ❑ Impact of radiation on future generations
  - ❑ All genetic information is stored in the DNA
  - ❑ It has been shown that radiation exposure may damage or change the sequencing of the DNA (mutations)

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### Genetic Effects

- ❑ There are “normal” spontaneous mutations unrelated to radiation exposure
  - ❑ The number of spontaneous mutations in each generation is termed mutation frequency
- ❑ The mutation frequency may be altered by mutagens
  - ❑ Viruses
  - ❑ Chemicals
  - ❑ Radiation

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### Genetic Effects

- ❑ These mutations are “inheritable”
- ❑ Some mutations may be detrimental to life
- ❑ Some may lead to deformities or disease processes

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### Doubling Dose

- ❑ The dose of radiation which ultimately doubles the mutation frequency
- ❑ Radiation has a linear effect on mutation frequency

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### Doubling Dose

- ❑ The doubling dose for humans has been estimated at 1 Sv by the BEIR VII Committee (2005)
- ❑ In 2001 the United National Scientific Committee on the Effects of Atomic Radiation estimated the doubling dose in humans to be 1 Gy of sparsely ionizing low-dose radiation

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### Life Span Shortening

- ❑ Chronically exposed individuals of low dose radiation die younger, than those not exposed
- ❑ Examination at death revealed:
  - ❑ A decrease in the numbers of parenchymal cells and blood vessels
  - ❑ An increase in connective tissue in organs (generally an indication of aging)
  - ❑ It appears that radiation may accelerate the aging process

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## Cancer Induction

- Radiation causes cancer**
- Controversy over dose (as low as 0.25 Gy)
- Doses much lower can induce malignancies in utero
- Infants and children more radiosensitive
- Latent periods vary with different types of cancer
  - Five to 30 years
  - For leukemia, seven to 12 years, but risk returns to normal after 20 years

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## In Summary

- Late effects can be a result of high doses and low doses
- Three major types of late somatic effects
  - Cataractogenesis: deterministic
  - Embryologic (birth defects) and carcinogenesis: stochastic
- Radiation protection guidelines are based on the stochastic effects of radiation and on the linear, nonthreshold response

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