Biological Effects of Radiation

United States Environmental Protection Agency

15th Annual OSC Readiness Training Program

www.oscreadiness.org
What are the effects from radiation?
Radioactive Material can be Harmful!

- It need not be feared;
- But it MUST command your respect;
- Even as small as 1 Nanocurie ($1 \times 10^{-9}$ Curie) if deposited in the right place can cause cancer.
Biological Effects

- We know more about biological effects with ionizing radiation than other environmental factors.

- Four large groups of people provided data:
  - Early Radiologist
  - Atomic bomb survivors
  - Large accidents (Chernobyl)
  - Radiation therapy patients
Chernobyl Reactor Accident
Chernobyl Radiation and Trauma Injuries

Acute Deaths: 31

Injuries and Hospitalizations: 300
An acute exposure may only be to a part of the body.

Analytical x-ray machines may deliver doses of several million mrem in a few seconds!

Accidents have resulted in the loss of fingers.

Strong beta emitters (P-32) can provide large doses to the hands.
Injury from X-ray Source

6 - 21 Weeks after exposure. Small ulcerated present.

18 – 21 months after exposure. Tissue necrosis.

After skin grafting
1945 criticality Accident @ Los ALomos
General Public Perceptions

◆ Common Views
  ▪ Mysterious
  ▪ Cannot detect by our five senses
  ▪ Sinister
  ▪ Unknown Danger
  ▪ Deadly
  ▪ Causes Cancer
Media Perceptions

Media avoids complex risk assessments with only two words:

- Deadly Radiation
- Lethal radioactivity
- Ticking Time bomb
- Toxic substances
- Hazardous wastes
General Scientific Perceptions

◆ Scientists’ Views
- Part of natural world
- Easily measurable
- Risks are well known
- Major benefit in medicine
- Cures Cancer
Risks Associated With Occupational Exposure

Is There a Safe Level of Exposure to Ionizing Radiation?
Dose vs. Effect

- $\text{LD}_{50} = 450$ RADs to Whole Body (Gamma Radiation)

$\text{LD}_{50} = 400$ RADs to Whole Body (30 Day Exposure)

(4 Gray = 400 RADs)
Ionizing Radiation

- Cell
  - Cell damage
    - Altered metabolism and function
    - Repair
    - Transformation

- Cell death
  - Scarring
Acute Radiation Syndrome
Other Levels

- 100 RADs to Whole Body
  - Skin Redness
  - Hair Loss
  - Skin Cancer
  - Onset of radiation syndrome
Other Symptoms

- Nausea / Vomiting
- Malaise & Fatigue
- Increased Body Temperature
- Hemopoietic Syndrome – Blood
  (100 RAD - Gamma)
- Gastrointestinal Syndrome (400 RADs Gamma)
- Central Nervous System Syndrome
  (1000 RADs - Gamma)
Some Everyday Risks

- Same Chance of Death (1 in 1,000,000)
- 300 Mile Automobile Ride
- Eat 40 Tablespoons of Peanut Butter
- Living 2 Days in Boston
- Drinking 0.5 Liter of Wine
- Living with a Smoker for 2 Months
- 2.5 mRem to Whole Body
Dose vs. Effect

- Hiroshima
- Nagasaki
- Czech Mine Workers
- Industrial Accidents
- Military Accidents
- Medical Accidents
- Chernobyl
High Dose Effects

◆ But What About Low Dose Effects?

Does ZERO Dose EQUAL ZERO Risk?
Acute Effects of Exposure

◆ Skin Redness  (Sunburn-like)
Radiation Therapy Accident
Very Lucky Lady!
Health Effects

◆ Somatic
  Tissue Damage
  Skin Redness
  Hair Loss
  Sterility
  Cancer
Biological effects depend on whether it is an ACUTE DOSE or a CHRONIC DOSE.

**ACUTE**
Large dose in a short time

**CHRONIC**
Small does over a long time
Health Effects

- Genetic Mutations
- DNA Damage
- Birth Defects
Risks Associated With Occupational Exposure

- Delayed Effects
  - Cancer
  - Bone Cancer
  - Lung Cancer
  - Leukemia
  - Cataracts
Annual Exposure Limits

- Whole Body: 5,000 mRem
- Skin: 30,000 mRem
- Eyes: 15,000 mRem
- Hands, Feet, Arms: 75,000 mRem
- Ankles (Extremities)
Women of Reproductive Age

- Lower Exposure Limits:
  
  500 mRem per Year  
  No More Than 40 mRem / Month!  
  First Trimester is most Sensitive Time
Modes of Exposure

- **External**
  - Irradiation
  - External Surface Contamination
Understanding Exposure

Exposure may be known and recognized or clandestine as:

> large radiation exposures, such as a nuclear bomb or catastrophic damage to a nuclear power station

> small radiation source emitting continuous gamma radiation producing chronic intermittent exposures (such as radiological sources from medical treatment)
Understanding Exposure Cont’d

- skin contamination with radioactive material ("external contamination")
- internal radiation from absorbed, inhaled, or ingested radioactive material ("internal contamination")
External Contamination
Internal Contamination

INTERNAL CONTAMINATION
Modes of Exposure

◆ Internal

Avoid:

> Inhaling It
> Absorbing It thru Your Skin
> Eating It
> Getting Punctured by a Contaminated “Sharp”
“Enough Said ...”