Community Management of High-dose Radiological Events

Satellite Conference and Live Webcast
Friday, December 10, 2010
12:00 – 1:30 p.m. Central Time

Produced by the Alabama Department of Public Health
Video Communications and Distance Learning Division

Faculty

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School of Public Health and
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Overview

- **Radiation**
- **Consequences**
- **Vulnerabilities**
- **Management**
- **Community Response**

Radioactivity

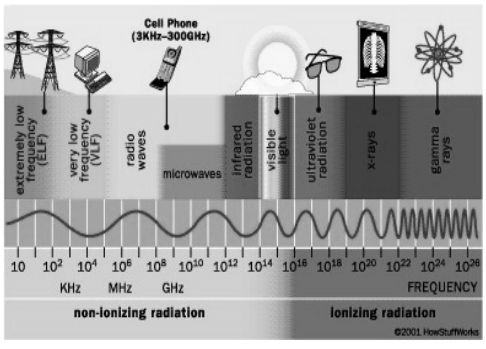
- **The property possessed by some elements (as uranium) or isotopes (as carbon 14) of spontaneously emitting energetic particles (as electrons or alpha particles) by the disintegration of their atomic nuclei; also : the rays emitted**

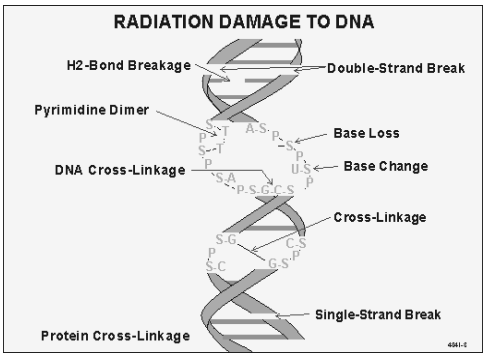
Radioactivity

U_{238} → Thorium$_{230}$ → Radium$_{226}$ → Radon$_{218}$ → Bismuth$_{214}$ → Lead$_{206}$

http://www.nrc.gov/reading-rm/basic-ref/teachers/unit1.html

Radiation



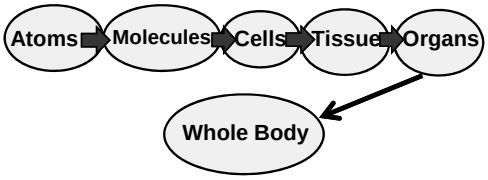


http://www.radiation-scott.org/radsource/3-0.htm

Radiation Injury

- **Local injury resulting from the biological effect of ionizing radiation**
- **Wide-spread injury from ionizing radiation accompanied by systemic disturbances gives rise to radiation sickness**
  - **The Great Soviet Encyclopedia**

Radiation Injury



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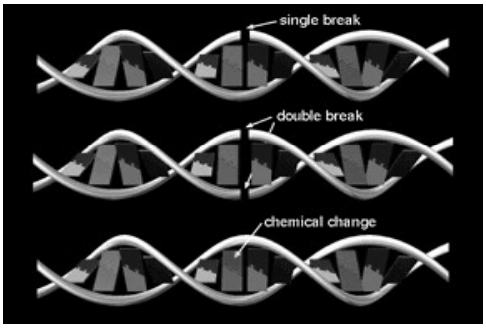
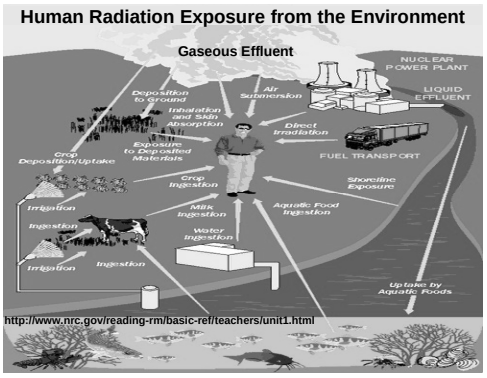
Radiation Injury

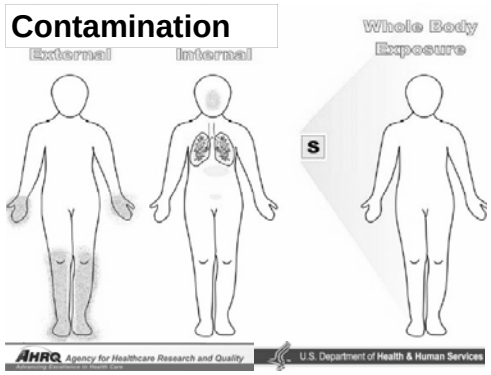
Radiation Injury





Contamination

- Contamination results when a radioisotope (as gas, liquid, or solid) is released into the environment and then ingested, inhaled, or deposited on the body surface

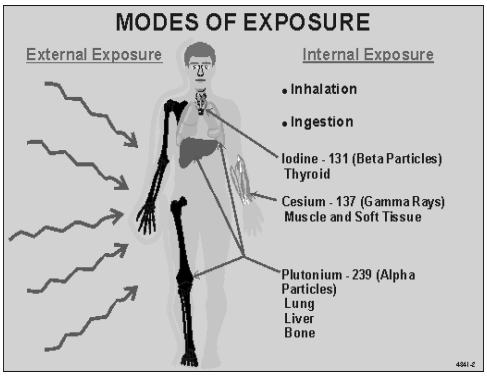


Radiation Exposure

- Radiation exposure occurs when all or part of the body absorbs penetrating ionizing radiation from an external radiation source
- Exposure from an external source stops when
  - A person leaves the area of the source

Radiation Exposure

- The source is shielded completely
- The process causing exposure ceases



Exposure and Contamination Management

- Field
  - Assess
  - Decontaminate

Exposure and Contamination Management

- Medical facility
  - Evaluate
  - Treat life threatening injury
  - Assess internal contamination
  - Treat internal contamination

Internal Contamination

- Diluting agents
  - Water diuresis for tritium
- Blocking agents
  - KI for Iodine131
- Chelating agents
  - Zn-DTPA and Ca-DTPA
- Gastric lavage

Internal Contamination

- Pulmonary lavage
- Emetics
- Purgative/laxative/enemas

Dose Levels of Concern for Emergency Workers

- Of uninjured, healthy, adult emergency workers
  - "Acute deaths" are likely to occur 30–180 days after exposure
  - Acute symptoms are nausea and vomiting beginning within 4 hours

Dose Levels of Concern for Emergency Workers

- The lifetime risk of fatal cancer refers to the excess above and beyond the 24% population likelihood that anyone will die of cancer without the additional radiation exposure

Dose Levels of Concern for Emergency Workers

Short-term Whole-Body Dose	Acute Symptoms (%)	Acute Death, No Medical Care (%)	Acute Death, Medical Care (%)	Excess Risk, Fatal Cancer (%)
0.1 Sv (10 rem)	0	0	0	1
0.5 Sv	0	0	0	4
1 Sv (100 rem)	5–30	<5	0	8
1.5 Sv	40	<5	<5	12
2 Sv	60	5	<5	16
3 Sv	75	30–50	15–30	24
6 Sv	100	95–100	50	>40
10 Sv (1000 rem)	100	100	>90	

March 2010 Radiology, 254, 660-677.

Potential High-dose Events

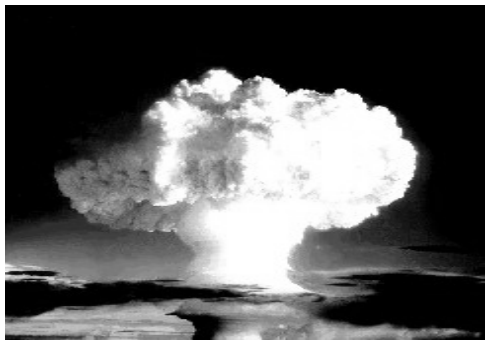
- Nuclear detonation
- Event at a nuclear facility
  - Malfunction
  - Sabotage
  - Accident or crash

Potential High-dose Events

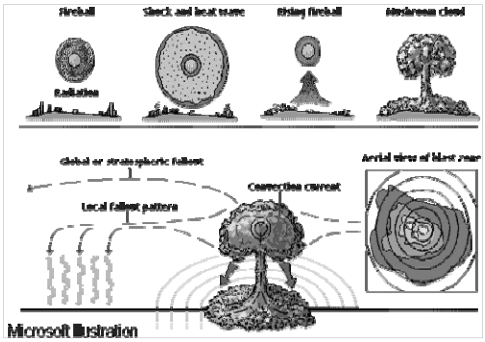
- Terrorist use of an RDD / RED
  - Dirty bomb
  - Exposure device
- Transportation accident

Nuclear Weapons Programs Worldwide

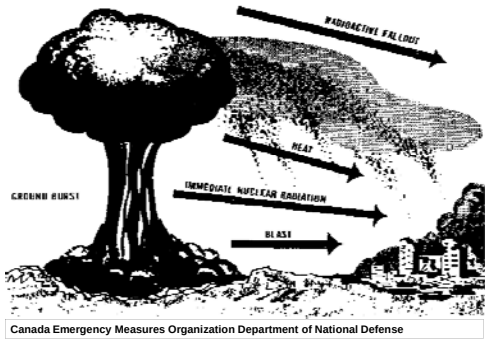
Nuclear Detonation



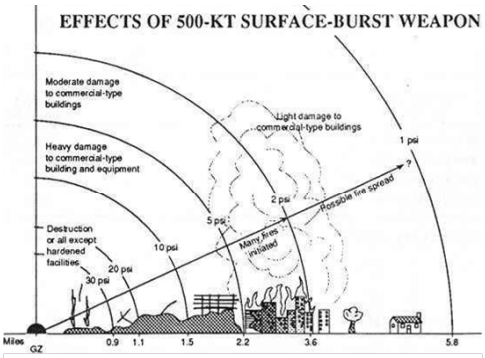
Nuclear Detonation



Ground Burst

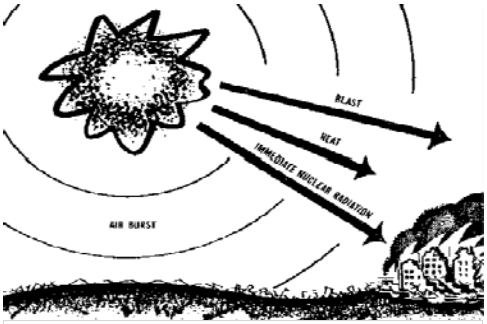


Canada Emergency Measures Organization Department of National Defense



Nuclear Attack Environment Handbook, FEMA - August, 1990

Air Burst



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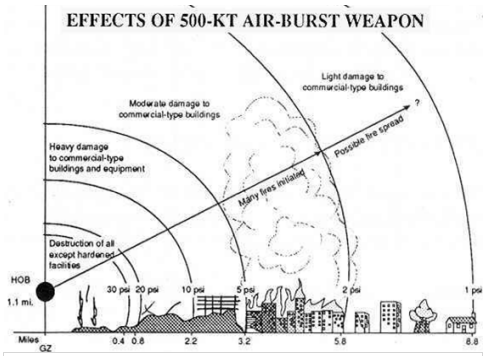
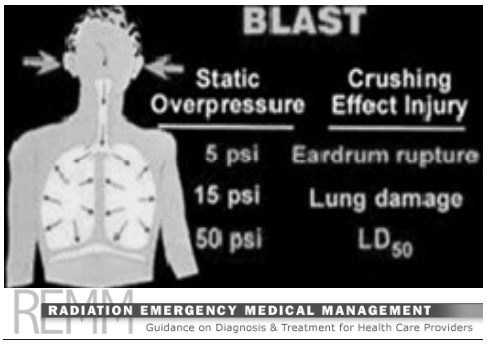


Nuclear Attack Environment Handbook, FEMA - August, 1990

Blast Forces/Waves: Shock Waves



Pressure Wave

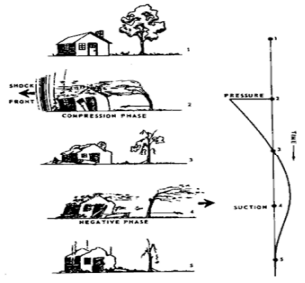
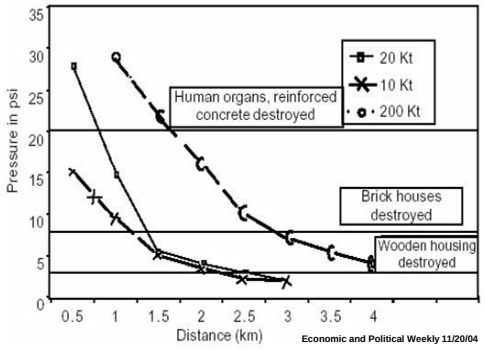


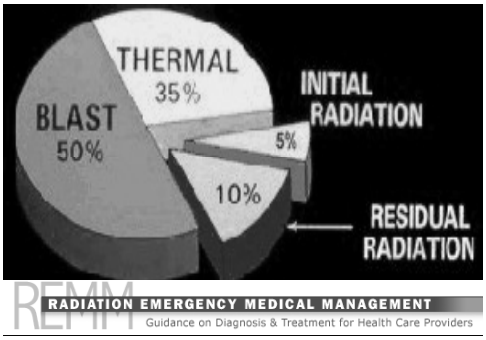
Figure 3-III. Variations of Blast Effects Associated with Positive and Negative Phase Pressures with Time

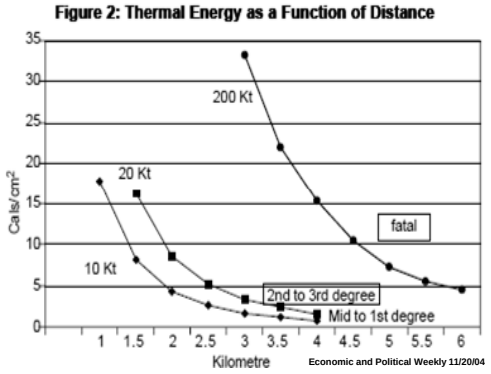
Figure 1: Blast Pressure as a Function of Distance



Economic and Political Weekly 11/20/04

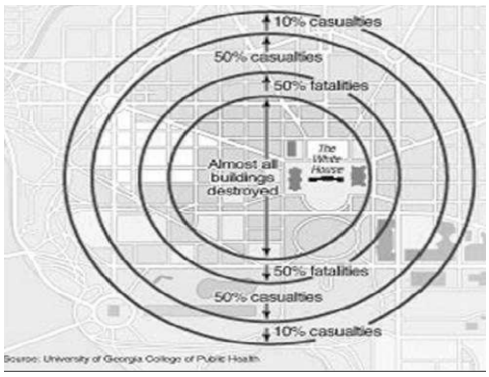
Fireball





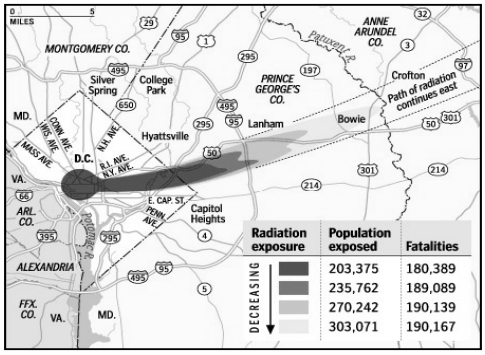
Bomb Blast Scenario

- **The blast from a 10-kiloton nuclear bomb detonated near the White House could kill roughly 100,000 people and destroy a wide area of downtown**



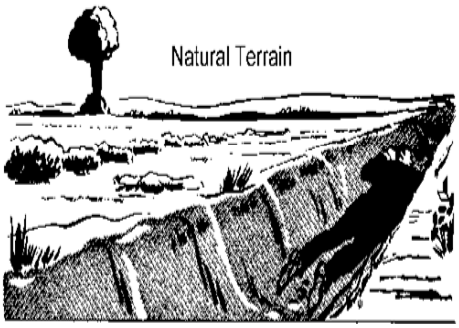
A Hypothetical Blast

- **This map adapted from a White House Homeland Security Council report - depicts an attack on Washington and shows a hypothetical radiation plume from a 10-kiloton weapon**



Source: Homeland Security Council | THE WASHINGTON POST

Shelter



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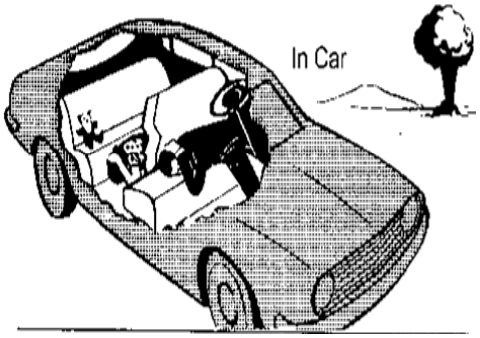

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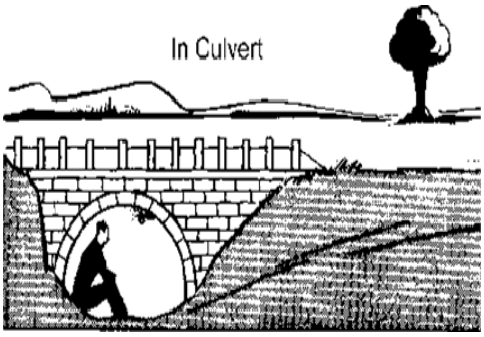
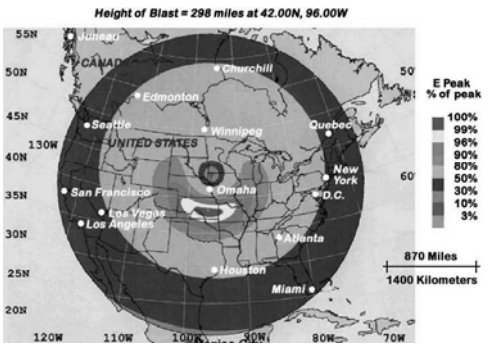
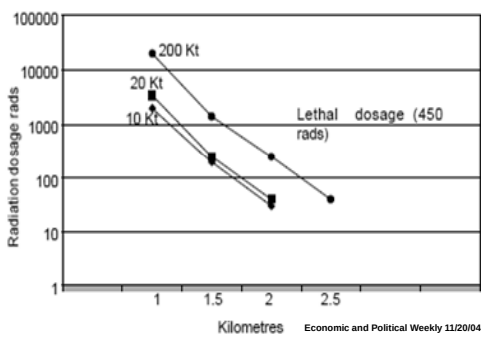
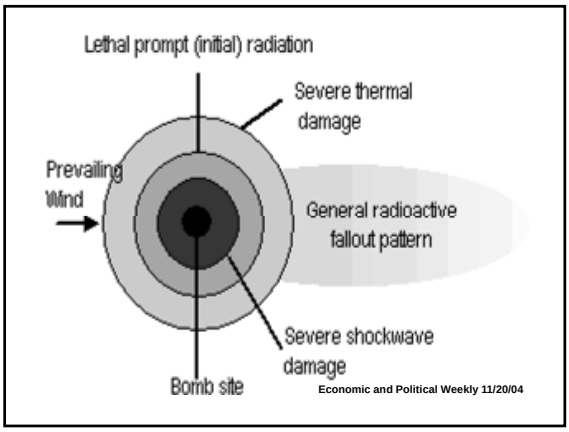


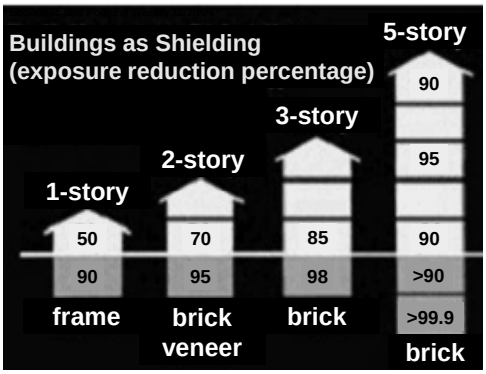
Shelter

Electronic Pulse



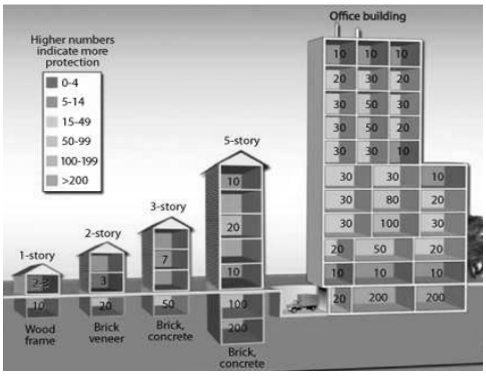






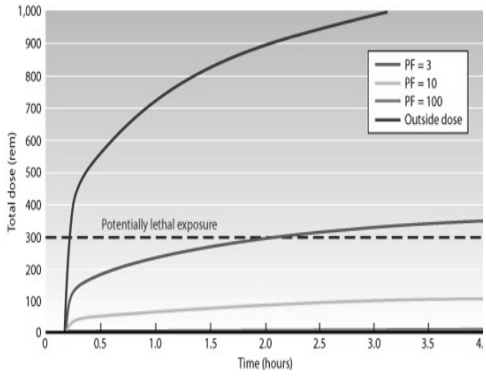
Sample Protection Factors (PFs) for a Variety of Building Types and Locations

- **From Buddemeier BR, Dillon MB. Key Response Planning Factors for the Aftermath of Nuclear Terrorism. Livermore, CA: Lawrence Livermore National Laboratory LLNL-TR-410067, August 2009**

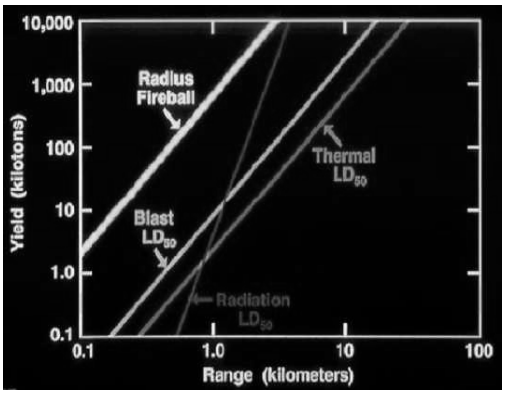


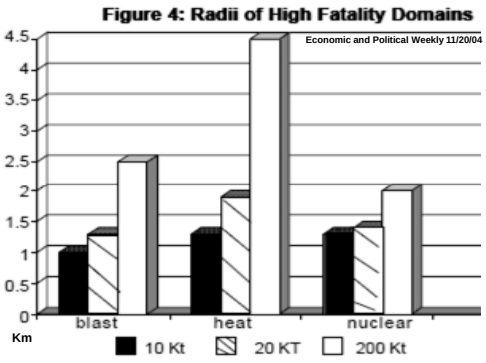
Dose Exposure to Evacuees at Various Departure Times Following a Nuclear Detonation

- **From Buddemeier BR, Dillon MB. Key Response Planning Factors for the Aftermath of Nuclear Terrorism. Livermore, CA: Lawrence Livermore National Laboratory LLNL-TR-410067, August 2009**



Geography of Mortality





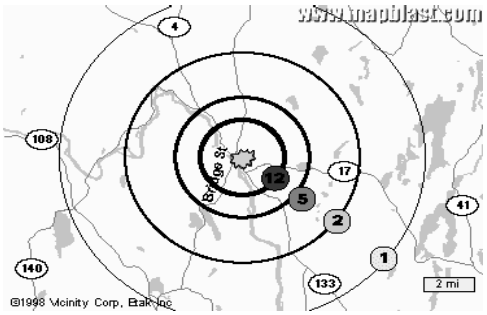
High Fatality Domains

- **There is a combination of blast, thermal and prompt nuclear radiation that creates an inner zone around the nuclear explosion, out to distances of**
  - **1.5 km for a 10-20 Kt weapon**
  - **3.5 km for a 200Kt weapon**

High Fatality Domains

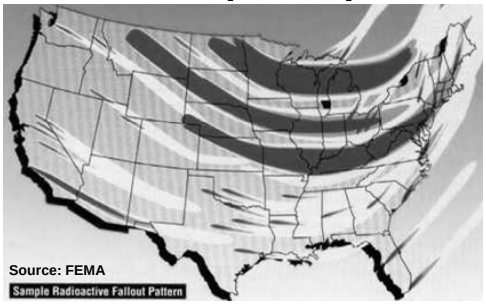
- **Analysis shows that for people unfortunate enough to be within this inner circle and exposed to the full impact of the explosion, there is no defense**

High Fatality Domains

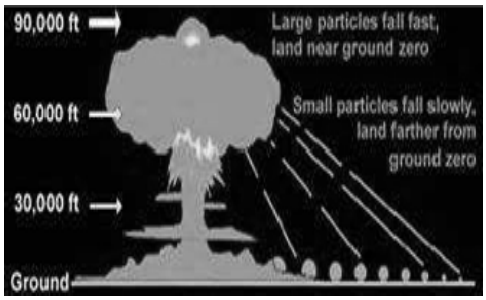


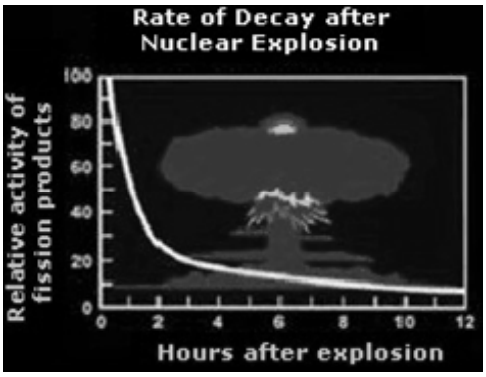
R. RAJARAMAN, Z. MIAN, A. H. NAYYAR Economic and Political Weekly 11/20/04

Delayed Ionizing Radiation Dose (Fallout)



Delayed Ionizing Radiation Dose (Fallout)

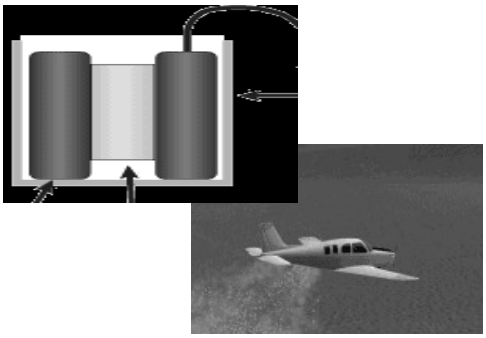




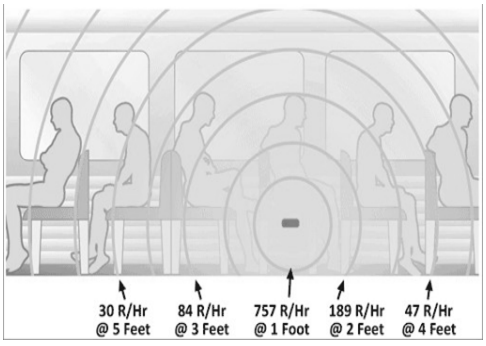
RDD / RED

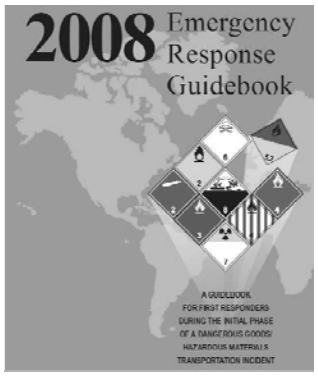
- **Device that causes the purposeful dissemination of radioactive material without a nuclear detonation**

RDD / RED



RDD / RED





Indicators of a Possible Radiological Incident

- Radiation symbols
  - Containers may display a radiation symbol
- Unusual metal debris
  - Unexplained bomb/munitions-like material

Indicators of a Possible Radiological Incident

- Heat-emitting material
  - Material that is hot or seems to emit heat without any sign of an external heat source
- Glowing material
  - Strongly radioactive material may emit or cause radioluminescence

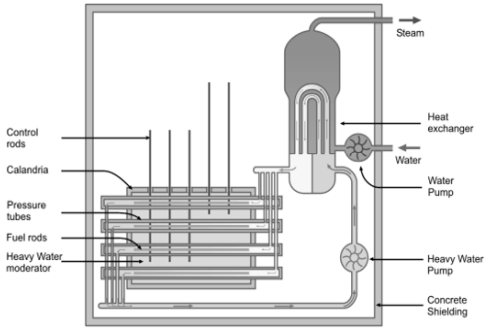
Indicators of a Possible Radiological Incident

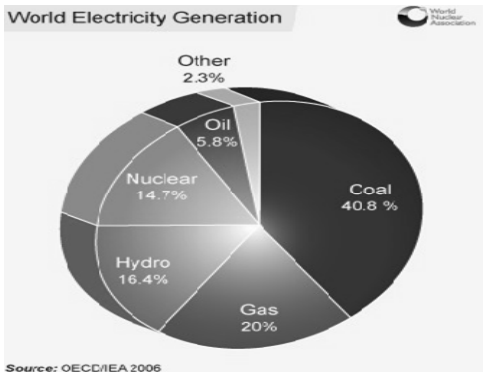
- Sick people/animals
  - In very improbable scenarios there may be unusual numbers of sick or dying people or animals
  - Casualties may occur hours to days or weeks after an incident has occurred

"The need for nuclear energy is going to be driven not only by environmental concerns and the inevitable decline of fossil fuels, but by the rising contribution of electricity for transport and the growth of electricity-consumptive technologies, such as desalination."

– Professor Barry Brook, Sir Hubert Wilkins Chair of Climate Change, University of Adelaide

Event at a Nuclear Facility



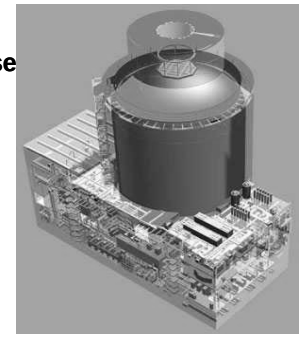


A Nuclear Renaissance

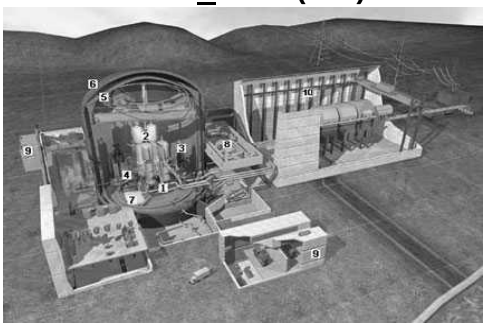
- **Conventional reactor technologies "burn" only approximately 3% of the fissile material**
- **Currently only four countries undertake reprocessing on a commercial scale**
  - **UK, France, Russia and Japan**

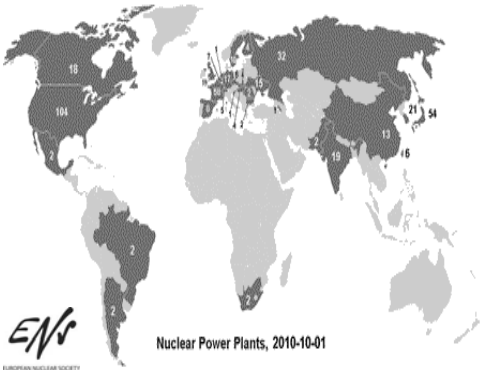
A Nuclear Renaissance

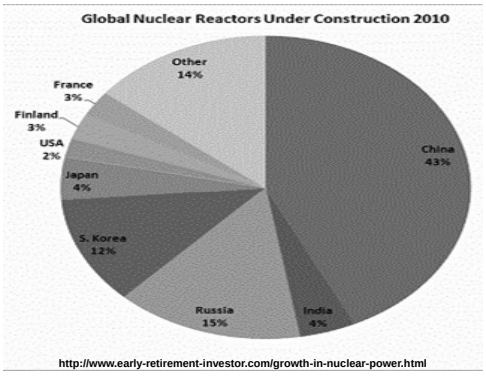
- **The Westinghouse AP1000 is a ~1150 MWe pressurised light water reactor**



AREVA European Pressurised Water Reactor (EPR)



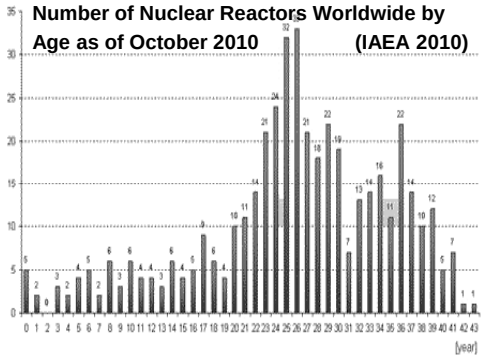




Nuclear Reactor Accidents

- **Evaluate for contamination and exposure**
- **Diagnose/manage contamination**
- **Diagnose/manage Acute Radiation Syndrome**

Number of Nuclear Reactors Worldwide by Age as of October 2010 (IAEA 2010)

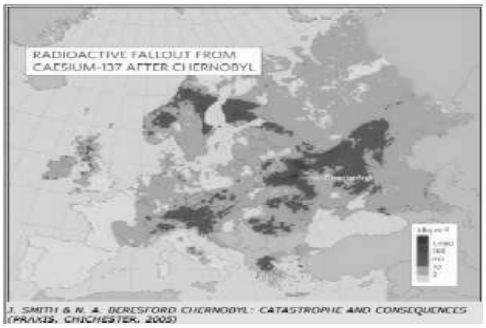


Chernobyl Accident

- **Fewer than 50 deaths directly attributed to radiation almost all being highly exposed rescue workers**
- **UN report predicts that up to 4,000 people could eventually die of the long-term effects**

Chernobyl Accident

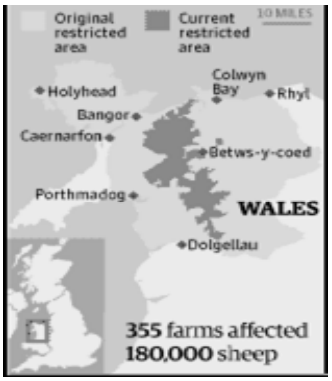
Chernobyl Accident



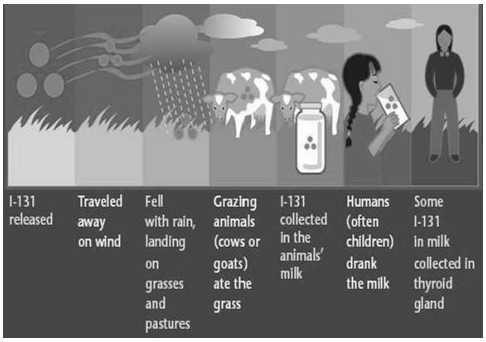
Chernobyl Accident

The Chernobyl Legacy

- **Nearly 370 farms in Britain are still restricted in the way they use land and rear sheep because of radioactive fallout from the Chernobyl accident 23 years ago**
- **This represents a reduction of over 95% since 1986, when approximately 9,700 farms and 4,225,000 sheep were under restriction across the United Kingdom**

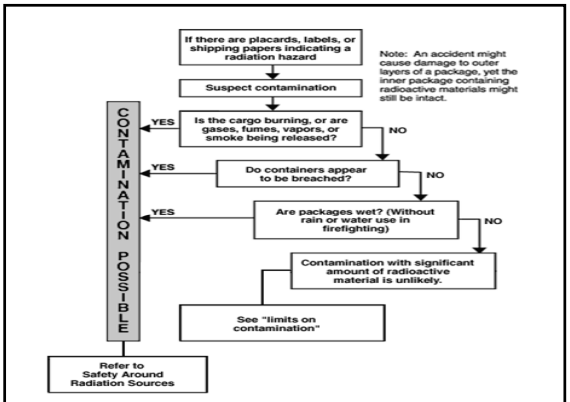


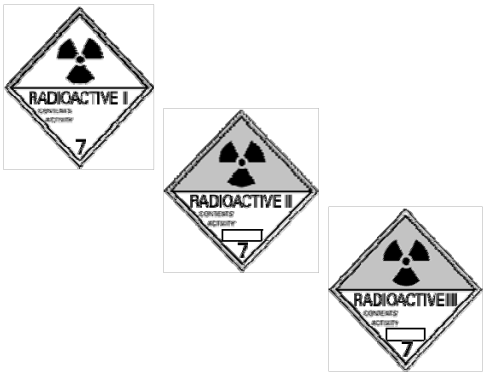
Iodine 131



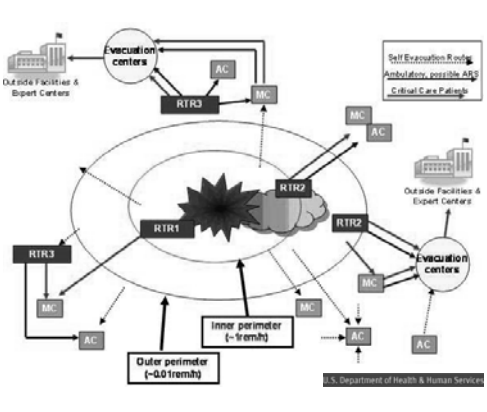
Waste Management

Transportation Accident

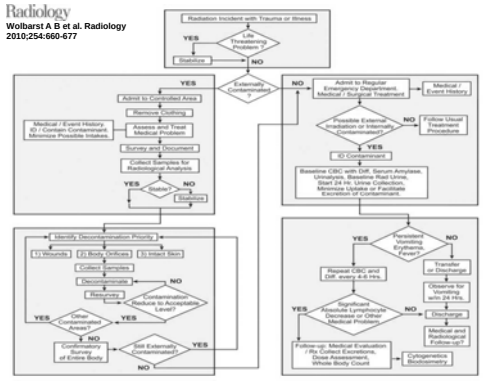




Triage System: Organizing the Medical Response



Medical Treatment Flow Diagram for Those Exposed to Ionizing Radiation



The Three Classic ARS Syndromes

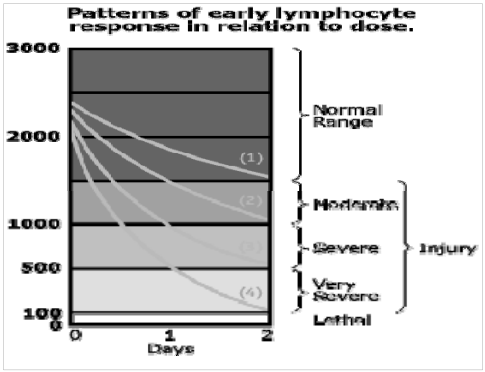
- **Bone Marrow (Hematopoietic) Syndrome**
  - **0.7 - 10 Gy**
- **Gastrointestinal (GI) Syndrome**
  - **6-10 Gy**

The Three Classic ARS Syndromes

- **Cardiovascular (CV) / Central Nervous System (CNS) Syndrome**
  - **20-50 Gy**

The Four Stages of ARS

- **Prodromal stage (N-V-D stage)**
  - **Nausea**
  - **Vomiting**
  - **Diarrhea**
- **Latent stage**
- **Manifest illness stage**
- **Recovery or death**



Hematopoetic Manifest Illness

- **Anorexia, fever, and malaise**
  - **Drop in all blood cell counts occurs for several weeks**
  - **Primary cause of death is infection and hemorrhage**
- **Survival decreases with increasing dose**
- **Most deaths occur within a few months after exposure**

Hematopoetic Manifest Illness

Sistema Límbico ; Un blog de las neurociencias

Recovery

- In most cases bone marrow cells will begin to repopulate the marrow
- There should be full recovery for a large percentage of individuals from a few weeks up to two years after exposure
- Death may occur in some individuals at 1.2 Gy (120 rads)

Recovery

- The LD50/60 is about 2.5 to 5 Gy (250 to 500 rads)

Gastrointestinal Prodrome and Latent

- Anorexia
- Severe Nausea
- Vomiting
- Cramps
- Diarrhea

- Stem cells in bone marrow and cells lining the GI tract are dying

Gastrointestinal Manifest Illness

- Malaise, anorexia, severe diarrhea, fever, dehydration, and electrolyte imbalance
- Death is due to infection, dehydration, and electrolyte imbalance
- Most deaths occur within 2 weeks of exposure

CV/CNS Prodrome and Latent

- Extreme nervousness and confusion
- Severe nausea, vomiting, and watery diarrhea
- Loss of consciousness and burning sensations of the skin
- Patient may return to partial functionality

CV/CNS Manifest Illness

- Return of watery diarrhea, convulsions, and coma
- Onset occurs 5 to 6 hours after exposure
- Most deaths occur within 3 days of exposure

Chernobyl Medal

Consultation

Consultation

- Radiation Emergency Assistance Center/Training Site (REAC/TS) at
  - (865) 576-3131 (M-F, 8 a.m. to 4:30 p.m. EST)
  - (865) 576-1005 (after hours)
  - Web site: http://www.orau.gov/reacts/

Consultation

Consultation

- Medical Radiobiology Advisory Team (MRAT)
  - (301) 295-0316
  - (301) 295-0316

U.S. Army Radiological Advisory Medical Team (RAMT)

- Real-time evaluation of the radiation hazard
- Advising the on-scene Commander
  - Contamination control
  - Radiation exposure risks
  - Protective action guidelines
- Radiological medical support

U.S. Army Radiological Advisory Medical Team (RAMT)

- Assisting local hospitals
  - Contamination control
  - Patient decontamination
  - Medical management of radiation injuries

Medical Radiobiology Advisory Team (MRAT)

- Provides health physics, medical and radiobiological advice worldwide in response to nuclear and radiological incidents
- Armed Forces Radiobiology Research Institute

Uniformed Services University of the Health Sciences
Armed Forces Radiobiology Research Institute

Medical Radiobiology Advisory Team (MRAT)

- Radiation medicine physicians and senior health physicists

Online Resources

- The Biodosimetry Assessment Tool (BAT)
  - A computer program developed by the Armed Forces Radiobiology Research Institute (AFRRI) to provide early diagnostic information to health care providers

DOSE
CONTAMINATION
ERYTHEMA
SIGNS & SYMPTOMS
BIODOSIMETRY ASSESSMENT TOOL

Online Resources

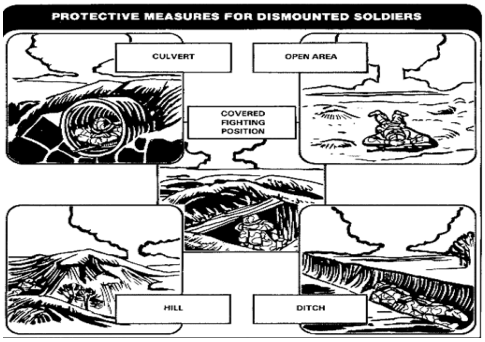
- First-responder Radiological Assessment Triage (FRAT)
  - A software program that contains a number of tools useful to First Responders for the management and assessment of casualties of radiation exposure

Radiation and Trauma

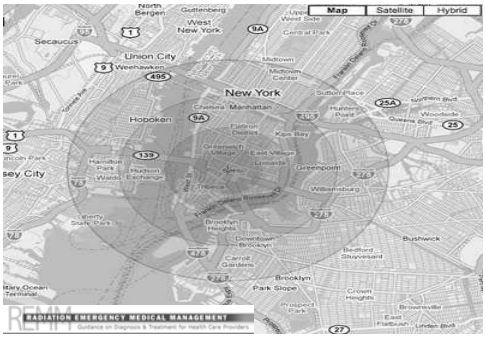
Physical injury without irradiation	Expected changes in triage categories after whole-body irradiation		
	<2 Gy Vomit >4 hrs	2~6 Gy Vomit 1-4 hrs	>6 Gy Vomit <1 hr early erythema
Uninjured	Ambulatory monitoring	Ambulatory monitoring, Administer cytokines and delay hospitalization	
Minimal	Minimal	Delayed	
Delayed	Delayed	Variable	
Immediate	Immediate		Expectant
Expectant			

Community Action: Warning

Blast Protection



Near the Blast



Near the Blast

- **Turn away and close and cover your eyes to prevent damage to your sight**
- **Drop to the ground face down and place your hands under your body**
- **Remain flat until the heat and two shock waves have passed**

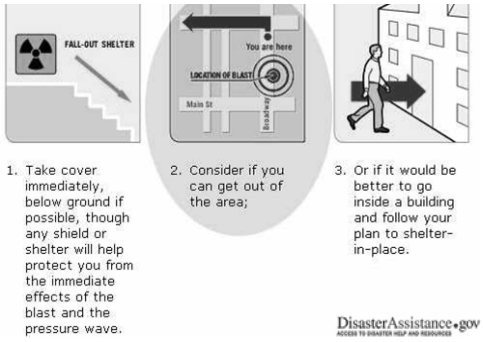
Outside

- **Cover your mouth and nose with a scarf, handkerchief, or other cloth**
- **Remove any dust from your clothes by brushing, shaking, and wiping**
  - **Cover your mouth and nose while you do this**

Outside

- **Move to a shelter, basement, or underground area**
  - **Preferably located away from the direction that the wind is blowing**
- **Remove clothing since it may be contaminated**
  - **If possible, take a shower, wash your hair, and change clothes before you enter the shelter**

Nuclear Blast



Already in a Shelter or Basement

Already in a Shelter or Basement

- **Listen to the local radio or television for information and advice**
  - **Authorities may direct you to stay in your shelter or evacuate to a safer place away from the area**
- **If you must go out, cover your mouth and nose with a damp towel**

Already in a Shelter or Basement

- **Use stored food and drinking water**
- **Do not eat local fresh food or drink water from open water supplies**
- **Clean and cover any open wounds on your body**

If Advised to Evacuate

- **Listen to the radio or television for information about evacuation routes, temporary shelters, and procedures**
- **Before you leave**
  - **Close and lock windows and doors and**
  - **Turn off air conditioning, vents, fans, and furnace**
  - **Close fireplace dampers**

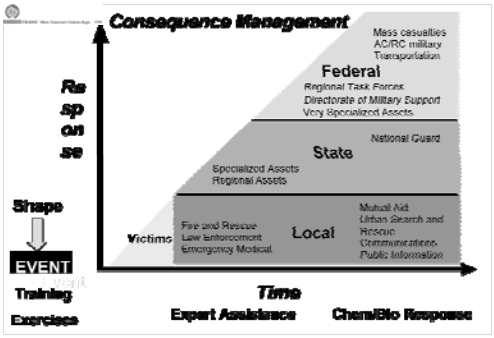
If Advised to Evacuate

- **Take disaster supplies with you**
  - **Flashlight and extra batteries, battery-operated radio, first aid kit and manual, emergency food and water, nonelectric can opener, essential medicines, cash and credit cards, and sturdy shoes**

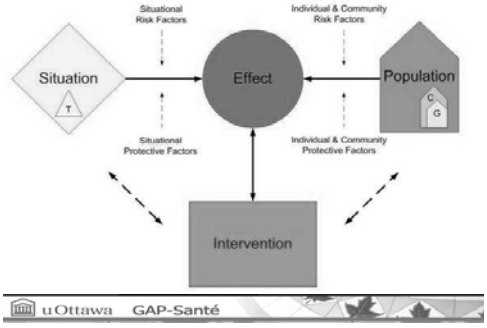
If Advised to Evacuate

- **Remember your neighbors may require special assistance, especially infants, elderly people, and people with disabilities**

Tiered Response



Psychosocial Risk Assessment



Psychosocial Effects of a Radiation Event

- **Pregnancy and unborn child**
- **Special populations**
- **Future health risk**
- **Underlying fear of radiation**
- **Anger over loss of property**
- **Social stigma**
- **PTSD**

Back to the Future

"If we don't deal with these issues now, our children will face them in the future."

Summary

- Radiation
- Consequences
- Vulnerabilities
- Management
- Community
- Response

Summary

"Plans are nothing, planning is everything."

– Gen. Dwight D. Eisenhower

– Gen. George S. Patton

Gen. Dwight D. Eisenhower

Questions?