

Chapter 2

Radiation Protection and Regulation

Objectives

- **Identify the average annual dose to the population from all sources of radiation**
- **Identify the contributors to population dose**
- **Understand the mission of the NRC and Agreement State Radiation Protection Programs**
- **Discuss the dose limits for various groups and how these limits are applied to different parts of the body**
- **Identify the NRC's regulation for radiation protection**
- **Discuss the philosophy of ALARA**

Sources of Public Radiation Exposure

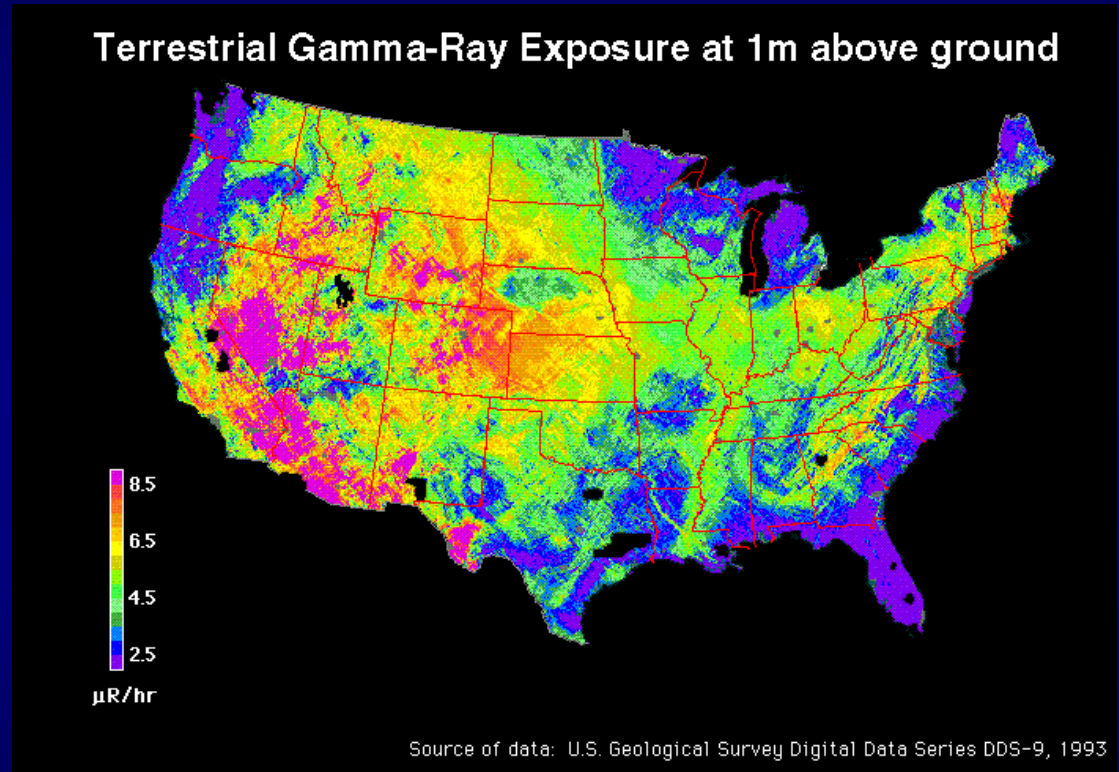
Terrestrial Gamma Radiation

- The dose rates from radioactivity (K, U, Th) in the soil vary throughout the country.



Uranium
ore

- Higher dose rates are in magenta.



Note that $8.5 \mu\text{R/hr}$ is equal to about 75 mrem/yr (continuous exposure).

Radon

- **Radon (Rn-222) is produced by the radioactive decay of uranium-238 found naturally in the soil. Radon is a noble gas that readily diffuses through soil into homes.**
- **Radon and its radioactive decay products are the largest contributors to natural background dose.**



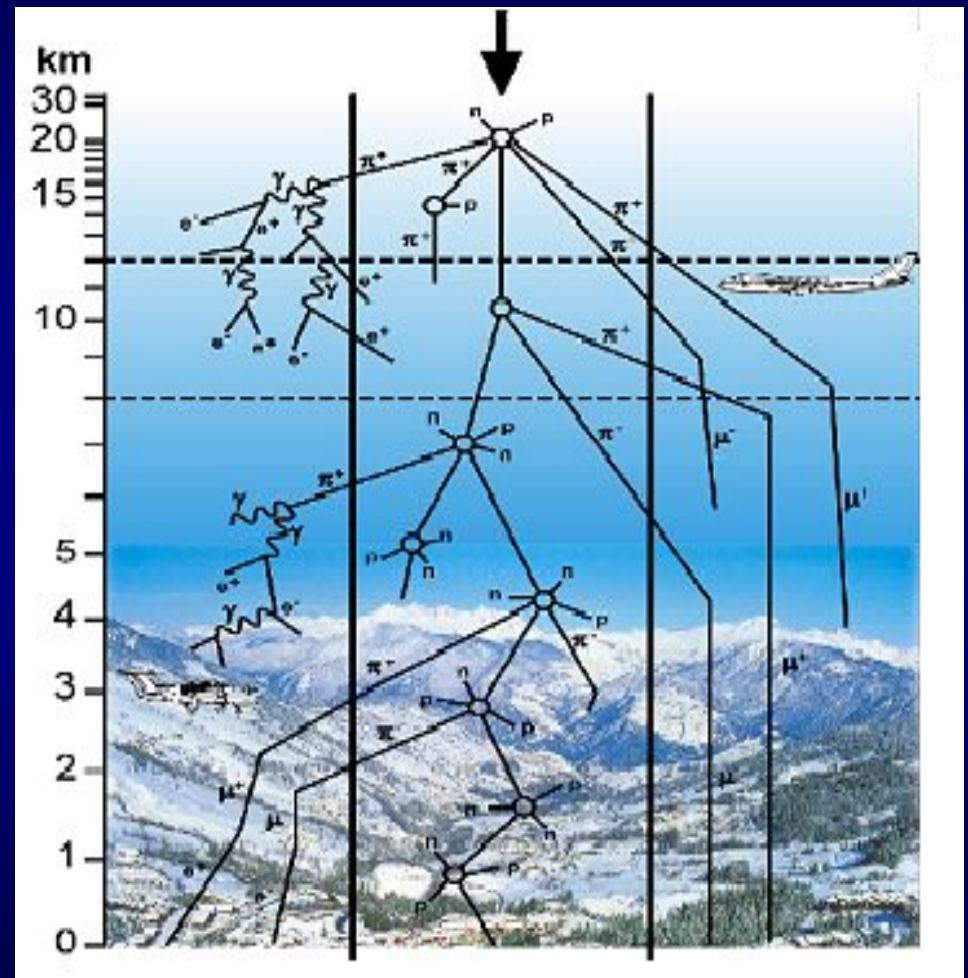
Cosmic Radiation

- Cosmic radiation interacts with molecules of nitrogen in the upper atmosphere of the earth to produce radioactive materials that are part of our environment.
- Carbon-14, a radioactive isotope with a half-life of 5,730 years, is produced in this manner.



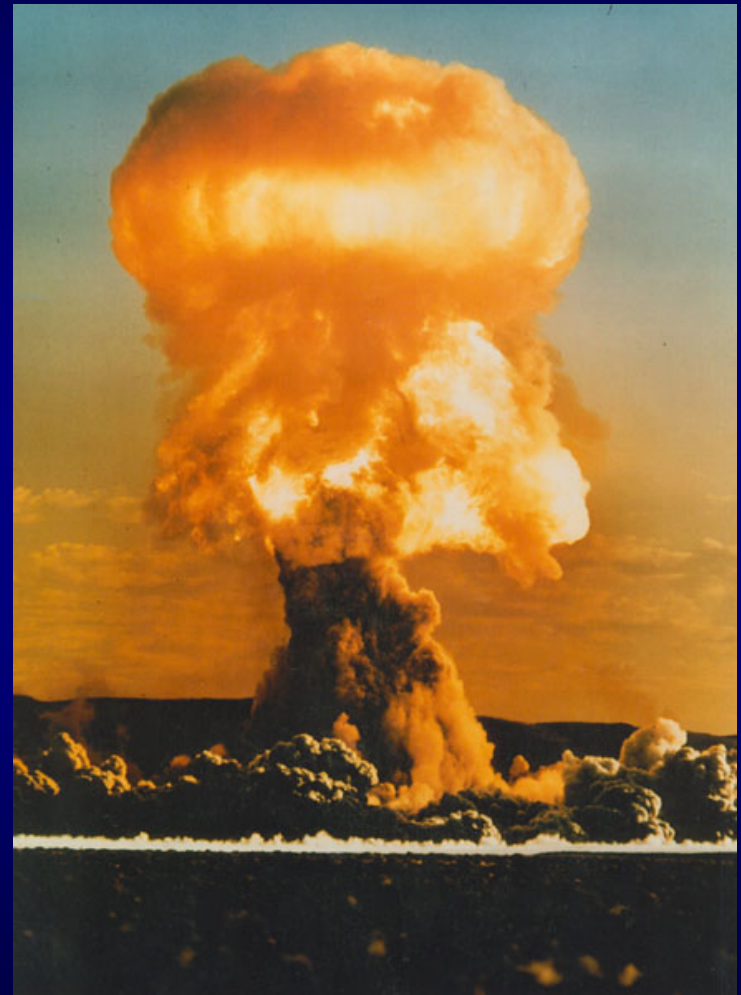
Cosmic Radiation

- **Cosmic radiation is reduced as it interacts with the atmosphere**
- **Dose rate increases by a factor of 2 when going from sea level to 10,000 feet altitude**
- **Cosmic radiation can be a significant concern for astronauts (e.g. solar flares)**

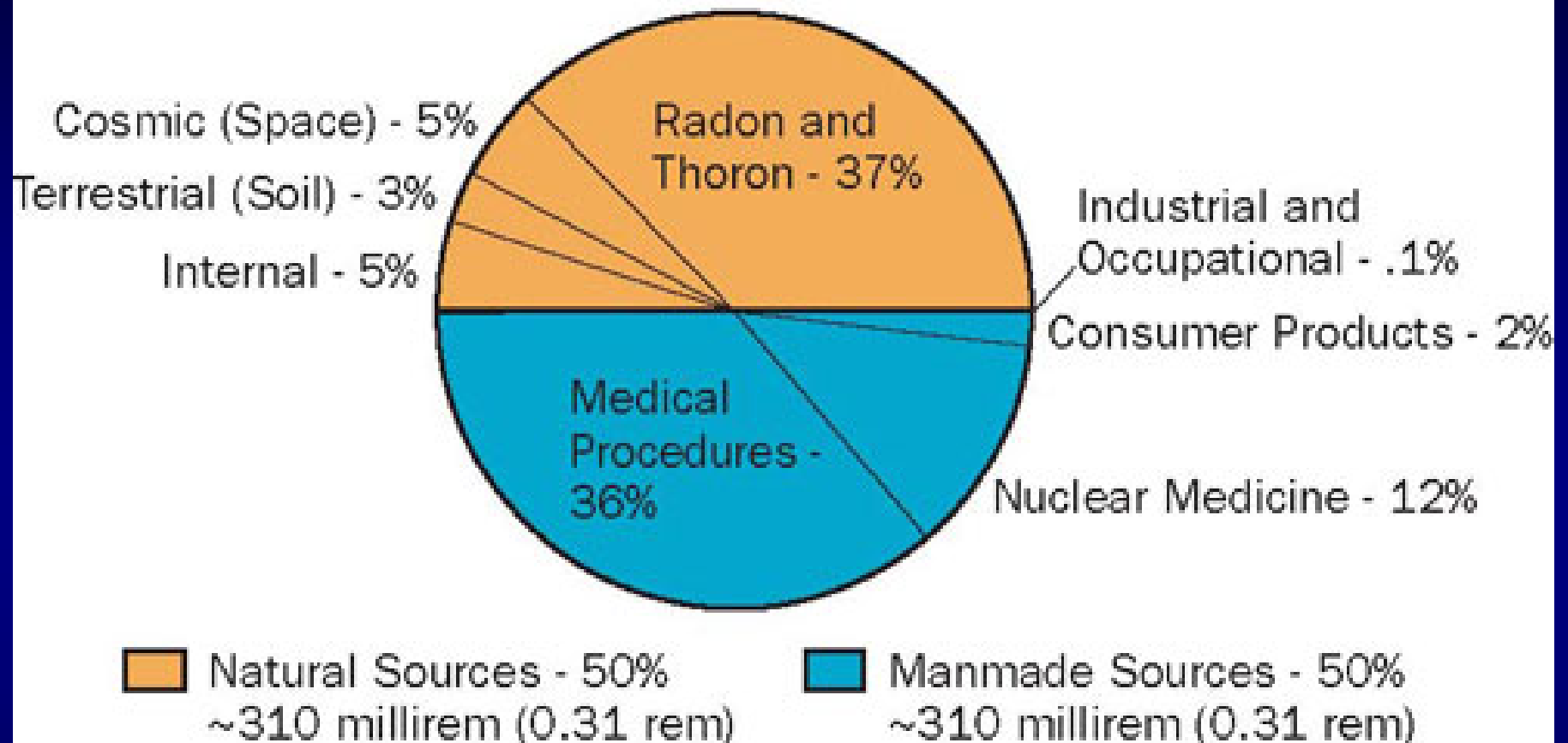


Fallout

- **Nuclear weapons testing during the 1950's and 1960's resulted in fission products being dispersed in the environment.**
- **Most fission products have short half-lives and are no longer present in the environment (e.g., I-131 with an 8-day half-life). However, isotopes with long half-lives such as Cs-137 (half-life of about 30 years) are still present.**



Sources of Radiation Exposure in the United States



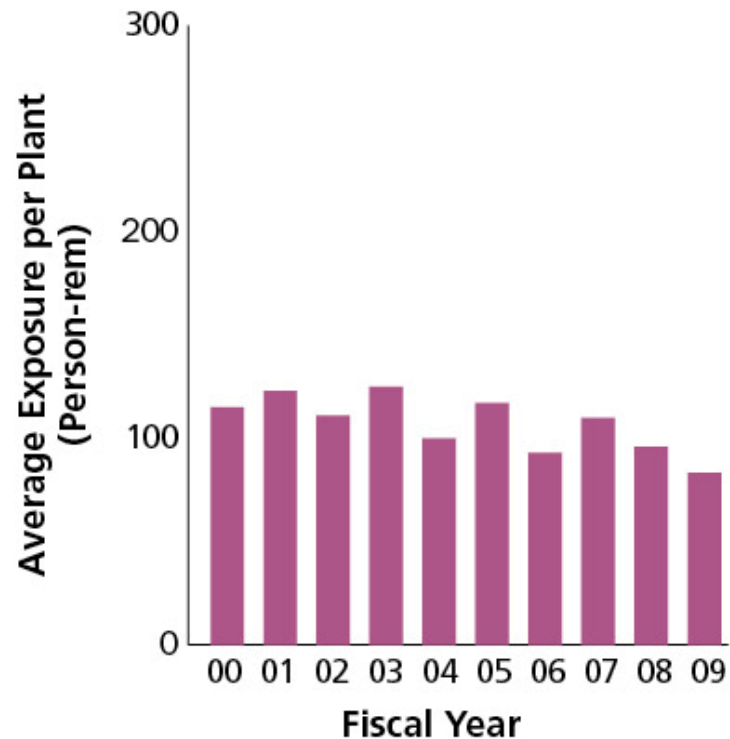
Source: NCRP Report No.160(2009)

Full report is available on the NCRP Web site at www.NCRPpublications.org.

The average annual dose from all sources of radiation is ~ 620 mrem.

Industry Performance Indicators: Annual Industry Averages
FY 2000–2009—for 104 Plants

Collective Radiation Exposure



This indicator monitors the total radiation dose accumulated by plant personnel.

Further Explanation:

In 2009, those workers receiving a measurable dose of radiation received an average of about 0.1 rem.

For comparison purposes, the average U.S. citizen receives 0.3 rem of radiation each year from natural sources (i.e., the everyday environment). See "Exposure" section in the Glossary.

Note: Data represent annual industry averages, with plants in extended shutdown excluded. Data are rounded for display purposes. These data may differ slightly from previously published data as a result of refinements in data quality.

Source: Licensee data as compiled by the U.S. Nuclear Regulatory Commission

Regulations

The Big Picture

NRC
&
Agreement States

Nuclear
(power, RAM, X-ray)

Radiation
(ionizing)

Risk
Genetic? & Somatic
(stochastic & deterministic)

Protection
(Health Physics: prevent deterministic
effects, minimize stochastic risk)



NRC Mission

The mission of the U.S. Nuclear Regulatory Commission is to ensure **adequate** protection of public health and safety, to promote common defense and security, and to protect the environment in the use of nuclear materials in the US.

Evolution of Standards

Time Period	Maximum Permissible Dose (rem/year)
1925-1931	10% of skin erythema dose (SED ~ 600 rad)
1931-1936	50
1936-1948	30
1948-1958	15
1958-1994	External: 5 (actually 1¼ per quarter) 12 (if lifetime < 5(Age-18), 3 per quarter) Internal: 5 (about 520 MPC-hrs per quarter)
1994-Today	5 (total = external + internal)

Applicability of Standards

Groups

Members of the Public

Occupationally Exposed

Minors

Declared Pregnant Women

Embryo/Fetus

Medical Patient

Body Parts

Whole Body

Extremities

Skin

Lens of the Eye

Internal Organs

Incremental Dose and Risk Level

LIMIT/LEVEL	DOSE	RISK
Background	Not regulated	Not controllable
Exempt Quantities	Small	Minimal
ALARA	Achievable, by definition	Lowest Possible
Regulatory Limit	Permissible	No Undue
Emergency Limit	Permissible in Exceptional Cases	Tolerable

Ranking of Perceived Risk (1-30)

Activity/Technology	League of Women Voters	College Students	Business Executives	Experts
Nuclear Power	1	1	8	20
Motor Vehicles	2	5	3	1
Handguns	3	2	1	4
Smoking	4	3	4	2
Motorcycles	5	6	2	6
Alcohol	6	7	5	3
General Aviation	7	15	11	12
Police Work	8	8	7	17
Pesticides	9	4	15	8
Surgery	10	11	9	5

Ranking of Perceived Risk (1-30)

Activity/Technology	League of Women Voters	College Students	Business Executives	Experts
Fire Fighting	11	10	6	18
Large Construction	12	14	13	13
Hunting	13	18	10	23
Spray Cans	14	13	23	26
Mountain Climbing	15	22	12	29
Bicycles	16	24	14	15
Commercial Aviation	17	16	18	16
Electric Power (non-nuclear)	18	19	19	9
Swimming	19	30	17	10
Contraceptives	20	9	22	11

Ranking of Perceived Risk (1-30)

Activity/Technology	League of Women Voters	College Students	Business Executives	Experts
Skiing	21	25	16	30
X-Rays	22	17	24	7
Football (HS & College)	23	26	21	27
Railroads	24	23	20	19
Food Preservatives	25	12	28	14
Food Coloring	26	20	30	21
Power Mowers	27	28	25	28
Prescription Antibiotics	28	21	26	24
Home appliances	29	27	27	22
Vaccinations	30	29	29	25

10 CFR 20

Standards for Protection Against Radiation

10 CFR Part 20.1001

PURPOSE

It is the purpose of the regulations in this part to **CONTROL** the receipt, possession, use, transfer and disposal of licensed material by any licensee in such a manner that the **TOTAL DOSE** to an individual (including doses from **LICENSED AND UNLICENSED** radioactive material and from radiation sources other than background radiation) **DOES NOT EXCEED THE STANDARDS** for protection against radiation prescribed in the regulations in this part. However, nothing in this part shall be construed as limiting actions that may be necessary to **PROTECT HEALTH AND SAFETY**.

The ALARA philosophy

As Low As is
Reasonably Achievable

Regulatory Definitions (10 CFR 20.1003)

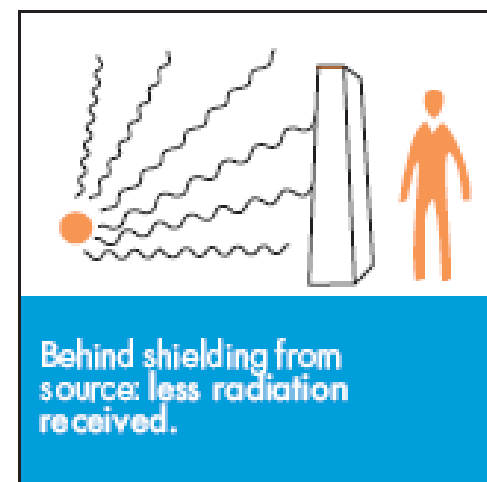
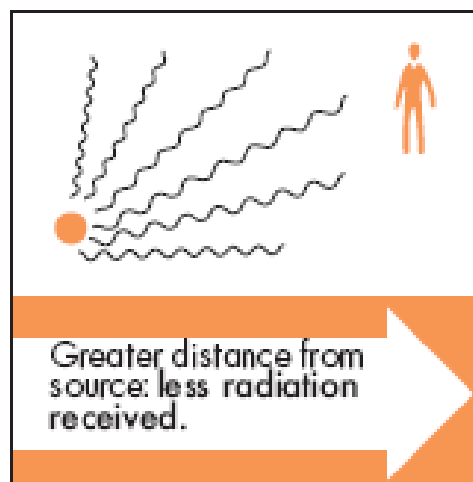
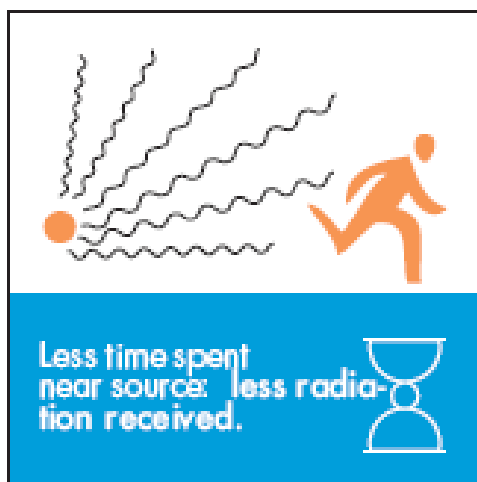
ALARA

Means making **EVERY REASONABLE EFFORT** to maintain exposures to radiation **AS FAR BELOW THE DOSE LIMITS** in this part **AS IS PRACTICAL CONSISTENT WITH** the purpose for which the licensed activity is undertaken, taking into account the state of **TECHNOLOGY**, the **ECONOMICS** of improvements in relation to state of technology, the economics of improvements in relation to **BENEFITS** to the public health and safety, and other **SOCIETAL AND SOCIOECONOMIC CONSIDERATIONS**, and in relation to **UTILIZATION** of nuclear energy and licensed materials **IN THE PUBLIC INTEREST.**

ALARA: Minimizing Dose

“Although exposure to ionizing radiation carries a risk, it is impossible to completely avoid exposure. Radiation has always been present in the environment and in our bodies. We can, however, avoid undue exposure through the following protection principles:”

<http://www.nrc.gov/about-nrc/radiation/protects-you/protection-principles.html>



Regulatory Definitions (10 CFR 20.1003)

RESTRICTED AREA

Means an area, access to which is limited by the licensee for the purpose of **PROTECTING INDIVIDUALS AGAINST UNDUE RISKS** from exposure to radiation and radioactive materials.

Compliance vs. Liability

While a nuclear utility may have some confidence that carefully following the NRC's permissible dose limits for external and internal exposure set forth in 10 CFR 20 will avoid regulatory fines, no such confidence exists that the same low doses will protect a nuclear utility from being assessed huge judgments in personal injury lawsuits. Examples:

- **A jury awarded \$10.5 million to Karen Silkwood, even though her dose was only about $\frac{1}{4}$ of a maximum permissible body burden and even though she had no cancer or other demonstrated ill effect due to her radiation exposure.**
- **Three Mile Island (TMI) owners made settlements to avoid further lawsuits.**

Question

If the biological risk due to radiation exposure is the same for everyone, why would the dose limit for members of the public be set at 2% of that for radiation workers (100 mrem vs. 5000 mrem)?

Question

Why would the dose limit for a 17-year-old who works in a licensed facility (e.g., hospital volunteer) be 10% of the dose limit for an 18-year-old coworker?

QUESTIONS?

**END OF
RADIATION PROTECTION
and
REGULATION**