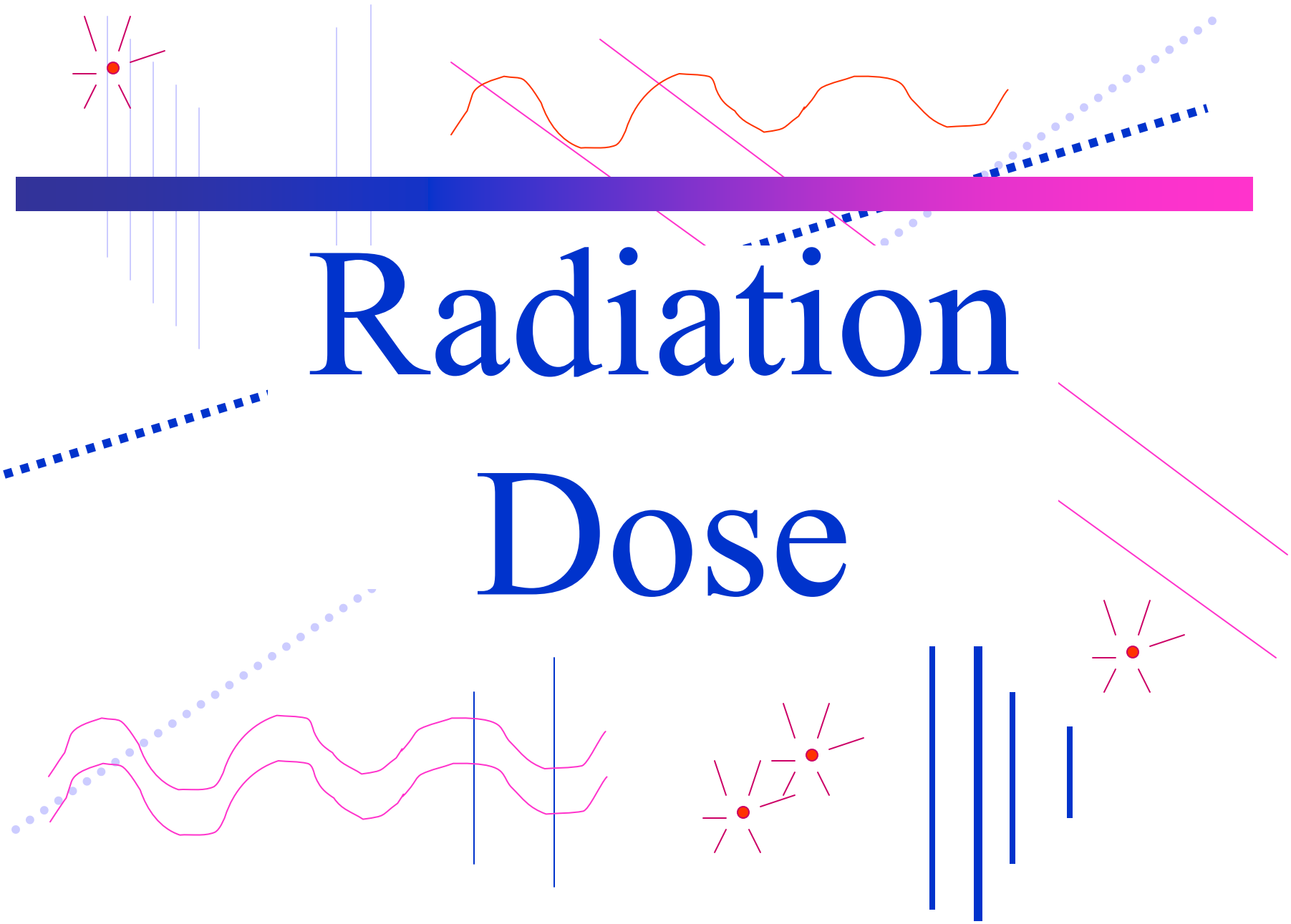
Radiation Dose



Radiation Dose

One of the most confusing things about understanding radiation effects is visualizing "how much" radiation is involved. It is very difficult to keep the units which measure radiation straight. A number describing the amount of radiation means nothing without evaluating the units, but this is not easy.

For example...

...try to match the letter with the amount of radiation involved in each example

- Amount of potassium 40 in the body
- Dose to Atomic bomb survivors
- You can safety hold this amount of alpha radiation
- One coast to coast flight
- A diagnostic X-ray

A. Billions of becquerels

B. About 250 picocuries

C. 2-10,000 millirem

D. 0-5 Gy

E. 2 millirads

(Answers: B, D, A, E, C... confusing isn't it?)

Commonly Used Radiation Units

Each of these units has a different technical meaning. All are used by experts to talk about radiation. With so many terms, you can see why it is important to know what the unit means when you are evaluating radiation information.

Absorbed dose (Gray or rad)
Average dose
Organ dose
Dose commitment
Collective dose
Effective dose (Sievert or rem)
Committed effective dose
Equivalent dose
Collective equivalent dose
Committed equivalent dose
Uniform equivalent dose
Dose equivalent
Collective dose equivalent
Ambient dose equivalent
Directional dose equivalent
Individual dose equivalent
Individual dose equivalent, penetrating
Individual dose equivalent, superficial
Dose and dose-rate effectiveness factor
Man-gray
Man-sievert
Tissue weighting factor
Relative biological effectiveness (RBE)
Quality factor (Q)
Fatality probability coefficient
Nominal fatality probability coefficient
Radiation weighting factor (w_R)
Linear energy transfer (LET)
Radioactivity (Becquerel or curie)

Understanding Radiation Units

Activity

The number of times each second a radioactive material decays and releases radiation.

Dose (Absorbed)

The amount of radiation energy absorbed into a given mass of tissue.

Dose (Equivalent)

Measures the energy per unit mass times adjustments for the type of radiation involved (quality factor) and the biological response in the tissue (a weighting factor).

Equivalent dose converts dose into a measure of risk.

Understanding Radiation Units

Activity

- Disintegration/sec=1 **Becquerel** (Bq)
- 37 billion Bq = 1 curie

Dose (Absorbed)

- 1 joule/kg=1 **Gray**(Gy)
- 1Gray=100 rad =100,000 mrad

Dose (Equivalent)

- Gray x quality factors= **Sievert** (Sv)
- 1 Sievert =100 rem =100,000 mrem

Standard Units

S.I. Units

How much is a picocurie (pCi)?

- Many times the media reports excess radiation in picocuries. It takes 1,000,000,000,000 pCi to make 1 Curie. A becquerel is 1 disintegration/second. It takes 27 pCi to make one Bq, so a pCi represents less radioactivity that a Bq and results in very, very little dose.

How much is a Becquerel(Bq)?

- The natural ^{40}K activity in the body of an adult human of normal weight is 4000-6000 Bq.
- There is an average of about 50 Bq per cubic meter of air inside a home from radon.
- Even though a ^{60}Co source of strong gamma radiation containing billions of Bq can kill you if you are standing 5 meters from it, it is harmless at a distance of 100 meters.
- A Bq has 27 times more disintegrations than a pCi, but is still a very small amount of radiation.

ABSORBED DOSE

How much radiation is an X-ray?

- **An average chest X-ray may give a dose of 10 millirads. This is the same as 0.01 rads or 0.0001 Gray.**

- **A millirad is comparatively small. Average normal background level of radiation is 370 mrad/year.**

- **One Gray is a relatively large amount of radiation. If 3-4 Gray are delivered over a short time to the whole body, they can be deadly.**

EQUIVALENT DOSE

What is equivalent dose?

Different types of radiation behave in different ways. In order to compare the amount of risk or biological change that occurs, quality factors are introduced.

For example:

- The damage produced by 1 Gy of **x-radiation** is equal to that produced by 1 Gy of gamma radiation. Thus, gamma radiation has a quality factor of 1 or 1 Gy gramma rays x 1 =1 Sv.

- The damage produced by 20 Gy of **x-radiation** is equal to that from 1 Gy of **alpha radiation**. Alpha radiation has a quality factor of 20 or 1 Gy of alpha radiation x 20 = 20 Sv.

- Quality factors for other types of radiation are between 1 & 20.

EQUIVALENT DOSE

Radiation Weighting Factors

Type and Energy Range		Weighting Factor
X and γ rays, electrons, positrons and muons		1
Neutrons	<10 keV	5
Neutrons	10 keV to 100 keV	10
Neutrons	>10 keV to 2 MeV	20
Neutrons	> 2 MeV to 20 MeV	10
Neutrons	>20 MeV	5
Protons, other than recoil protons and energy >2 MeV		2
Alpha particles, fission fragments, nonrelativistic heavy nuclei		20

EQUIVALENT DOSE

Tissue Weighting Factors

0.01	0.05	0.12	0.20
Bone surface	**Bladder**	**Bone Marrow**	**Gonads**
Skin	**Breast**	**Colon**	
	Liver	**Lung**	
	Esophagus	**Stomach**	
	Thyroid		
	Remainder		

EQUIVAENT DOSE

How much is a Sievert (Sv)?

Radiation induced cancers have been seen in the atomic bomb survivors exposed to as low as 0.2 Sieverts.

A Sievert is a relatively large amount of radiation.

The annual background radiation exposure for a typical American is 0.0037 Sv, 3.7 mSv or 370 millirem.

1 Sv = 1000 mSv = 100,000 mrem

EQUIVAENT DOSE

How much is a millirem (mrem)?

- **The annual background radiation exposure for a typical American 370 mrems.**
- **The average dose from watching color TV is 2 mrem each year.**
- **The granite from Grand Central Station exposes its employees to 120 mrem of radiation each year**
- **People in Denver receive 50 mrem more each year than those in LA because of the altitude.**
- **The nuclear industry contributes to less than 1 mrem/year to an individual's background radiation.**
- **A millimrem is a small unit of measure**.

A millirem measures the amount of radiation energy absorbed into the tissue.

1000 millirems =1 rem =0.01 Gy

1 Gy=1 Joule /kg times a quality factor to adjust for the type of radiation (alpha, beta, or gamma)

But how much energy is that?

1 calorie=amount of energy to heat up 1 milliliter of water 1 degree C.

Therefore 4.16 Gy would produce the same amount of energy it would take to heat up 1 milliliter of water 1 degree C.

Dose-rate

The effectiveness of the dose is dependent on the dose-rate