RADIATION AND INDOOR ENVIRONMENTS NATIONAL LABORATORY

RADIATION SAFETY FACT SHEET

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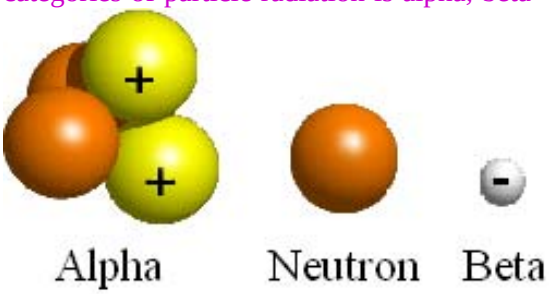
Photon Radiation

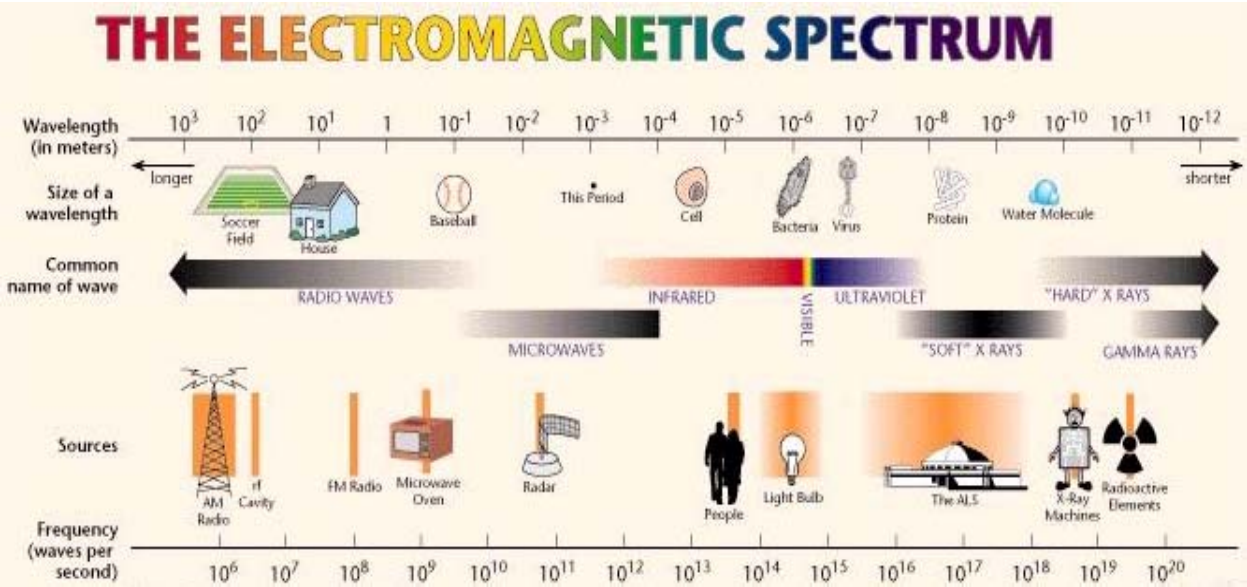
Radiation can be divided into two general categories: photon and particle radiation. Photons have no mass and travel at the speed of light; in fact light is composed of photons and is a form of electromagnetic radiation. Photons travel in waves, much like the waves in the ocean, and the wavelength (distance between waves) determines how much energy a photon has. The longer the wavelength the less energy the photon has and the shorter the wavelength the more energy. When a photon has enough energy to ionize matter (remove electrons), it considered to be ionizing radiation. Gamma rays and x-rays are the two types of ionizing photon radiation. The difference between these types of radiation is where it is produced. Gamma rays are emitted from the nucleus of unstable atoms, and x-rays are created by interaction in the electron cloud surrounding the nucleus of an atom. X-rays typically have less energy than gamma rays although this is not always true. The best material for stopping photon radiation is high density material such as lead and iron.

Particle Radiation

Particle radiation is radiation with mass and is considered ionizing because of how fast it is traveling. Particle radiation is emitted from unstable atoms when they transform to a more stable atom. The three main categories of particle radiation is alpha, beta



and neutron radiation. Alpha particles are composed of two protons and two neutrons (a helium nucleus) and have a charge of +2. A beta particle is an electron and has a charge of -1 while neutron radiation is composed of neutrons with no charge. Due to its large charge and relatively slow velocity (it's still traveling at ~5% the speed of light); an alpha particle will only travel about an inch in air while beta particles and neutrons both have a range of several yards in air.



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Effects of Radiation

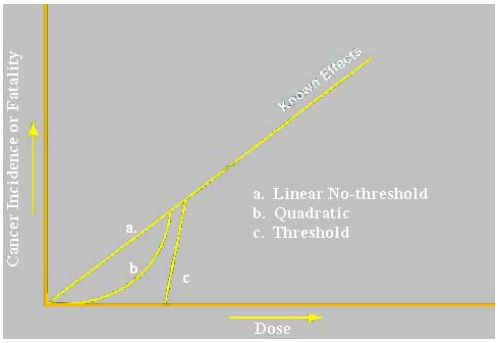
The effects of radiation exposure can be put into two categories, deterministic and stochastic. Deterministic effects are those that will appear at a set dose and the severity of the effect is determined by the dose; the more dose the worse the effect gets. These effects are erythema (reddening of the skin similar to sunburn), epilation (hair loss), cataracts, and radiation sickness. Table 1

Table 1

Effect	**Dose (rem)**
Erythema	200 to the skin
Epilation	300
Cataracts	200 to the lens
Radiation Sickness	250

lists the dose necessary for the onset of the of the described effect.

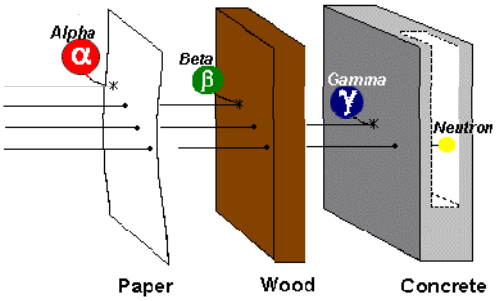
Stochastic effects are also called probabilistic effects. In these types of effects the severity of the effect is not related to the dose (you either get cancer or you don't, the cancer isn't worse due to a higher dose). In addition stochastic effects do not have a threshold dose above which it can be said with certainty that an effect will be seen. It can't be said that someone who has smoked for 40 years will get lung cancer; they are just more likely to develop it than someone who has never smoked. It's also possible to develop lung cancer from smoking just one cigarette. An increase in dose just increases the probability of the effect occurring. The stochastic effect associated with radiation exposure is cancer. The radiation induced cancer comes from the Japanese atomic bomb survivors. The effect of low doses of radiation is unknown, so it is assumed that there is an increase in cancer risk with an increase in dose. This assumption, known as the linear no-threshold model (LNT), is very conservative and is the basis for all radiation protection standards in the U.S. There are a couple of other proposed models called the quadratic and threshold models that are not as conservative. These models state that at low



doses there is no (or a slightly increased) risk for developing cancer.

Radiation Protection

There are three principles considerations in limiting radiation dose. These factors are time, distance, and shielding. If the time an individual is in a radiation field is short the dose can be limited. The further someone is from a radiation source, the lower the dose exposure rate. Radiation fields follow the inverse square law which means if you double the distance the dose rate is one quarter, triple the distance and the dose rate is 1/9. Alpha particles cannot penetrate the dead layer of skin and are considered to only be an internal hazard. Normal protective clothing will stop most beta particles. Since it takes a large amount of material to shield against photons and neutrons, the best way to limit exposure is by using one of the other



two principles. If there is potential for airborne radioactive material, a respirator should be worn until an expert becomes available to assess the hazard.