22.01 Introduction to Ionizing Radiation
Fall 2003
Problem Set # 7

Due Date: Wednesday, November 5, 2003

1. Three individuals are involved in a radiation accident in which they are exposed to photon and neutron radiation. The first person receives a whole-body dose of 1.0 Gy neutrons and 1.0 Gy photons. The second receives a dose of 0.25 Gy neutrons and 1.0 Gy photons. The third receives a dose of 0.5 Gy of neutrons and 5.0 Gy photons. [Assume a weighting factor of 10 for neutrons.]
   a) What are the physical doses to each individual?
   b) What are the equivalent doses to each individual?
   c) What are the effective doses to each individual?

2. Distinguish between "direct" and "indirect" effects of radiation. Give an example of the sequence of events beginning with energy deposition in tissue (you choose the radiation type) and ending in cell death for both the direct and indirect actions of radiation in a cell.

3. Calculate the effective dose for an individual who has received the following exposures:
   (a) 1 mGy alpha to the lung
   (b) 2 mGy thermal neutron, whole body
   (c) 5 mGy gamma, whole body
   (d) 200 mGy beta to the thyroid

4. What properties of a particular radionuclide may make it more biologically hazardous than another of the same activity?

5. A 250 g rat bearing an implanted experimental tumor that weighs 1.5 g is given an injection of a tumor-seeking drug labeled with ^{32}P [$t_{½}$ = 14.3d, average beta energy = 0.70 MeV, no gamma.] Assume that the drug distributes uniformly throughout the body almost instantaneously, and that the tumor accumulates 5 times more than normal body tissues. The drug is bound permanently to tumor but clears from all normal tissues in 24 hours. The average dose to the whole body must be kept below 1 Gy over the first 24 hours. How much dose will the tumor receive in one week? (You can ignore the decay during the first 24 hours.)

6. A worker ingests a solution containing an alpha-emitting radionuclide. The short range of the alphas limits the dose to the esophagus, stomach and colon only, which receive doses of 10 mGy, 50 mGy and 100 mGy, respectively.

(a) Calculate the equivalent dose to these organs. How does it differ from the absorbed dose? Also calculate the effective dose.
(b) What whole body dose from thermal neutrons would result in the same effective dose?
(c) What whole body dose from 1 MeV gammas would result in the same effective dose?

7. Tritium, as tritiated water, distributes rapidly into body water. Assume a whole body distribution. Calculate the uniform concentration of tritium in Bq g^{-1} that would give an equivalent dose of 1 mSv/week.

8. Search the internet (or the library) to answer to following:

a) How does a smoke detector containing an alpha-emitting radionuclide work?
b) What is the average <u>hourly</u> dose to an individual from such a smoke detector if they are sitting on the floor directly below it?
c) Why do we use smoke detectors if they deliver a radiation dose?