22.55 Principles of Radiation Interactions **Name:_____**
Spring 2004
Professor Coderre
Exam 2
April 30, 2004

You have 2 hours to complete this exam.
This exam is closed book.
Please show all work on the attached sheets.

This exam consists of 6 questions worth a total of 100 points.
The point values for each question are indicated in parentheses next to the question number.

1. Short answers (5 points each)

1a) Describe the major types of radiation in space. Describe the sources, the relative energies, and the relative abundances.

1b) Two detectors for galactic cosmic rays are flown on the space shuttle, one exposed directly to space, the other behind 1.5 g/cm^2 aluminum shielding. The equivalent dose (mSv) measured behind the aluminum was *higher* than the unshielded measurement. How can this be?

1c) What is the “radon problem” and how is it related to our annual background effective dose?
How are risk estimates per unit activity of radon derived?
Why is it so difficult to simply determine the effect of radon as a function of dose delivered?

1d) Explain how ***Repopulation*** can spare early responding tissues, but not late responding tissues.

2. (20 points)
A patient with a head and neck tumor close to the spinal cord is scheduled to receive 50 Gy in 25 2-Gy fractions. The tolerance of the spinal cord is 50 Gy delivered in 25 2-Gy fractions. *An error is made in the clinic.* The first 5 fractions that the patient receives are 4 Gy instead of 2 Gy.

You decide to complete this patient's treatment using a smaller number of 2-Gy fractions. How many more 2-Gy fractions are needed?

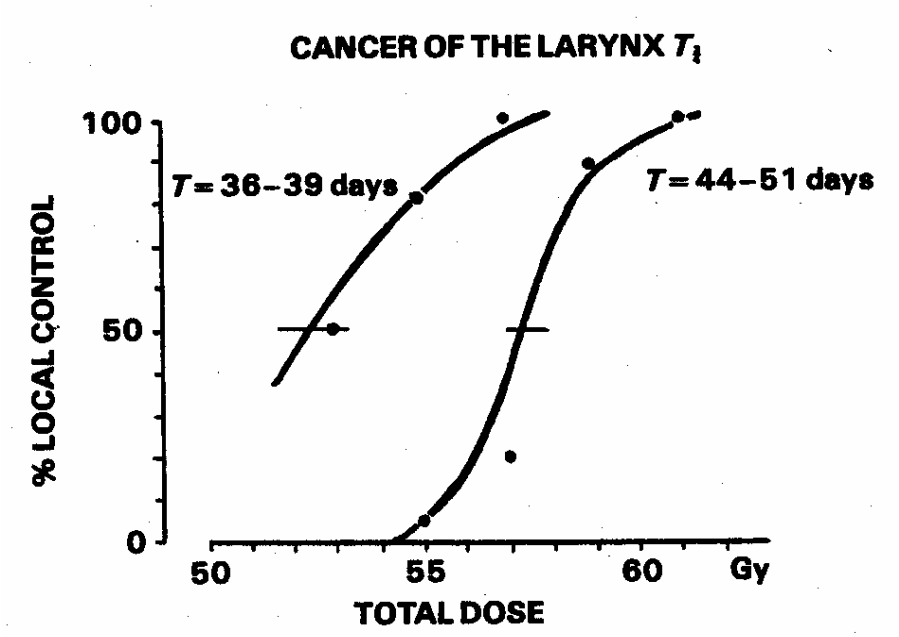
Do not exceed the spinal cord tolerance. Which treatment is more effective against the tumor, the original plan, or the revised plan? Be specific, support your choice with calculations. Ignore tumor repopulation during the treatments.

3. (20 points)
Refer to the figure below.

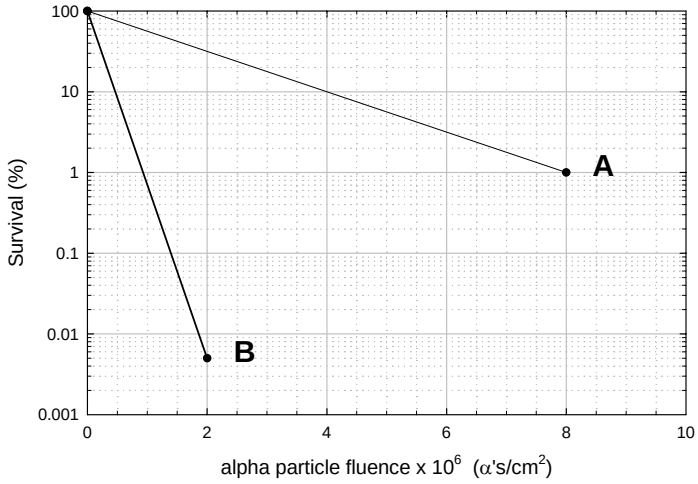
- **56 Gy delivered in 38 days controls 80% of tumors.**
- **56 Gy delivered in 50 days controls 5% of tumors.**

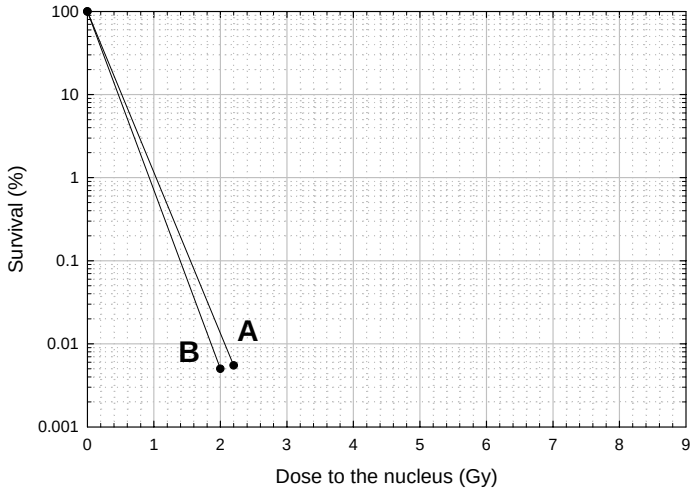
Assume that the radiation therapy is delivered only on the weekdays with the weekends off (i.e., 1 fraction per day, 5 days per week).

Explain these results.
Discuss two possible causes for this major difference in % local control.
In your answer, discuss the effects of the two different treatment schedules on the tumor and on the normal tissues.



4. (10 points)
Cell lines A and B are irradiated with collimated alpha particles on a mylar film. The results are shown in the following two graphs. When the survival fraction is plotted versus alpha particle fluence or versus dose, the cell lines appear very different. Explain these data (in words, no calculations are necessary). How can the two cell lines be different in one graph and the same in the other?





5. (20 points)
The early clinical trials with fast neutrons had an unfortunate clinical outcome due to excessive late normal tissue damage. Why was there so much late normal tissue damage?
As part of your answer include sketches of isoeffect curves and the comparable cell survival curves for both early and late normal tissues exposed to x rays and neutrons. Explain your sketches.

6. (10 points)
Two groups of rats with implanted brain tumors are treated with BNCT using two different boron compounds. Group 1 receives BNCT using Compound A; Group 2 receives BNCT using Compound B. Each group is then split into two arms: one is monitored for long-term survival; the other is sacrificed immediately after the neutron irradiation, the brain tumor removed, disaggregated into a single cell suspension, and a colony-forming assay performed to measure clonogenic tumor cell survival (an *in vivo/in vitro* assay).

In Group 1, the long-term survival was > 90% and the *in vivo/in vitro* clonogenic tumor cell survival was 0.001.
In Group 2, the long-term survival was > 90% and the *in vivo/in vitro* clonogenic tumor cell survival was 0.9.
Explain these results. How can the long-term survival be the same but the tumor clonogenic survival so different?