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Department of Physics

Examination paper for TFY4315 Biophysics of ionizing radiation

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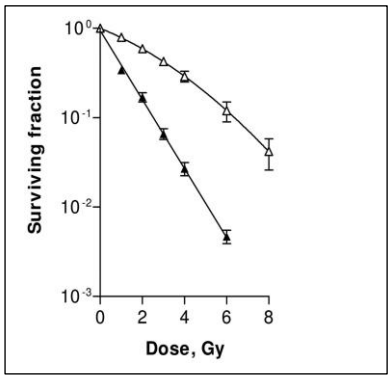
Date Signature

Exercise 1: Survival curves for different types of ionizing radiation

a) The survival curves in the figure below are typical for two types of ionizing radiation.
Describe which type of radiation that causes the two different survival curves.
Explain why they have different shape.



The survival curves can be described by the linear-quadratic model and the parameter α/β.
Explain what the parameters α and β represent.
Explain the dose $D= \alpha/\beta$.
Indicate an estimate of α/β for the two curves, and draw a figure showing how you obtained the estimate.

b) The two survival curves have an OER value of respectively 1.0 and 2.5.
Define OER.
Explain why the OER values are different for the two survival curves.

Exercise 2: Damage of normal tissue

a) A challenge using radiotherapy is to reduce the damage of normal tissue. Normal tissues are classified as fast or slow responding, and skin and kidney are such examples, respectively,
Indicate a property of the tissue that determines the radiosensitivity of the tissue.
Draw a sketch of the survival curves for fast and slow responding tissue.

b) The severity of normal tissue damage is also determined by the organization of the tissue. Tissue is organized in functional-structural units (FSU).
Explain what causes the difference in radiosensitivity for FSU in kidney and skin.

Exercise 3: Different treatment modalities

a) Ionizing radiation can be combined with hyperthermia.
Describe 3 factors that contribute to ionizing radiation combined with hyperthermia are more effective than ionizing radiation alone.
Which property of cancer tissue and normal tissue contributes to cancer tissue being more sensitive to hyperthermia than normal tissue?

b) Ionizing radiation can be targeted using radioactive isotopes having a high affinity for cancer cells or accumulate to a larger extent in tumour tissue than normal tissue.
Give an example on how free isotopes and an example on how conjugated isotopes can be used in cancer therapy.
Explain how your examples can enhance the specific uptake in tumours and reduce the uptake in normal tissue.

Exercise 4: Fractionated radiotherapy

a) A common fractionation regimen is: 2 Gy/fraction, once per day for 5 days, in 6 subsequent weeks.
Describe four reasons to give fractionated radiotherapy, and explain how it is possible to achieve increased radiosensitivity for cancer cells and at the same time reduce damage of normal tissue.

b) Assume a patient having a rapidly growing tumour in the neck.
How would you change the fractionation regimen from the above mentioned regimen and at the same time reduce the damage on normal tissue as much as possible?

Exercise 5: Calculations

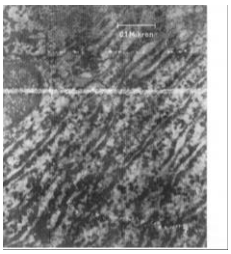
a) Assume that a treatment regimen: 2 Gy per fraction, once per day, 5 days a week for 6 weeks gives a biological equivalent dose BED=72Gy.
The treatment is changed to 4 Gy per fraction, once per day, 3 days per week.
For how long time must the patient be treated to achieve the same BED?

b) The cancer cells in a tumour is growing exponentially and increases from 10^8 cells to 10^9 cells in one week (7 days).
Estimate which extra dose of ionizing radiation the patient must receive to compensate for the increase in cell number.

Exercise 6: Multiple choice

You have 3 possible answers. Mark the correct answer by setting x in front of the correct answer. You have to hand in the two sheets with multiple choice questions together with the other answers. Write your candidate number on the sheets.

a) The figure below shows ionizing density for different types of radiation. The path with highets ionizing density is caused by
   - 500 kev protons
   - 1Mev electrons
   - 5 kev electrons



b) Which of the following chromosomal aberration can be repaired:
   - Anaphase bridge
   - Ring aberration
   - Symmetrical translocation

c) Apoptosis contributes to:
   – Increased radiosensitivity
   – Reduced radiosensitivity
   - No effect on radiosensitivity

d) Assume that the dose rate is reduced and the total exposure time increased. How does that affect the radiosensitivity?
   – Increase in radiosensitivity
   - Reduction in radiosensitivity
   – No effect

e) What is the relationship between LET and the energy of ionizing radiation?
   - Increase with increasing energy
   - Decrease with increasing energy
   - LET is constant when energy is increasing

f) What characterize stochastic effect?
   - Has threshold
   - Probability of the effect increases with increasing dose
   - The severity of the effect increases with increasing dose.

g) The total population is exposed to ionizing radiation due to natural background and medical diagnostic. How much larger is the contribution from medical diagnosis?
   - Medical diagnostic exposure is 4 times higher
   - Medical diagnostic exposure is 2 times higher
   - The two contributions are equal in magnitude

h) Radiotherapy is often combined with chemotherapy using a drug. Below is 3 proposed reasons for why combining radiotherapy and chemotherapy.
One is wrong, which?
- Drugs makes cells more sensitive to radiation
- Radiotherapy and chemotherapy kill different cell populations
- Chemotherapy is more specific towards tumours compared with radiotherapy.

i) Which method is **not** used to spread the proton beam laterally
- Using a rotating wheel with variable thickness
- Placing a scattering material (foil) in front of the proton source
- Scanning the proton beam across the tumour volume.

j) Multitarget model was earlier used to describe survival curves. Which of the following statements is correct for the multitarget model:
- It is a simple model with few parameters
- Gives a god fit for high doses
- Gives a good fit for low doses

k) Which of the following statements is not correct for brachytherapy close to the radioactive source?
- The dose rate is low
- No repair of sublethal damage takes place
- All cells will be killed independent of their radiosensitivity

l) Relative biologic effectiveness (RBE) for neutrons is:
– Biggest for low doses
– Biggest for high doses
– Independent of the dose

m) Radiation weighting factor for neutrons is:
- 1
- 20
- Depending on the energy of the neutrons