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Examination paper for TFY4315 Biophysics of ionizing radiation

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Exercise 1. Survival curves. DNA damage (Credit 1)

a) Cell survival curves can be described by the linear-quadratic model or the multitarget model. Explain the advantages and limitations with the two models.

b) DNA can be damaged by ionizing radiation. Explain how DNA is damaged through direct and indirect action. Give examples of types of ionizing radiation that give rise to direct and indirect action. Sketch the cell survival curves obtained by direct and indirect action, and explain the reason for the difference.

c) DNA damage can lead to formation of chromosomal aberration. Anaphase bridge is one such aberration. Explain the formation of anaphase bridge, and how this aberration causes cell death.

Exercise 2. Fractionated radiotherapy (Credit 1)

a) Radiotherapy is given in fractions in order to kill as many cancer cells as possible and at the same time reduce the damage to normal surrounding tissue. Explain how fractionated radiotherapy increases killing of cancer cells and how it spare normal tissue compared to giving the same total dose in one fraction.

b) Sketch the survival curves for early and late responding tissue and explain the difference in α/β-value. Explain which factors are most important for early and late responding tissue: size of the fraction dose and/or overall treatment time.

c) Explain accelerated repopulation. How would you change the fractionation regimen when accelerated repopulation occurs?

Exercise 3. Different treatment modalities (Credit 1)

a) Explain what is brachytherapy. What are the benefits of this treatment modality?

b) Radiotherapy is often combined with chemotherapy. Give 3 reasons for combining the two treatments.

c) Proton therapy is a new radiotherapy modality. Explain the benefit using proton therapy compared with conventional radiotherapy using photons. Explain the principle behind the two techniques for particle treatment delivery: Passive scattering and active scanning.

Exercise 4. Calculations (credit 1)

a) A tumour consisting of 10^8 cells is irradiated and the cell survival curve follows a pure exponential survival curve, i.e. there is no shoulder and the dose Do=3Gy. How large dose is needed when only 1 cell survives?

b) The standard fractionation regimen is 2 Gy per day 5 days per week for 6 weeks. When treating slowly growing tumours, hypofractionation is sometimes preferred, i.e. reduced number of fractions and increased dose per fraction.
You want to increase the dose per fraction to 4 Gy. How many fractions should be given to obtain the same BED (biologically effective dose) as for the standard fractionation regimen? Assume that $\alpha/\beta=3$Gy

c) A rapidly growing tumour is treated with the standard fractionation regimen 2 Gy per day 5 days per week for 6 weeks. The cell number is increasing exponentially from the onset of the treatment and the potential doubling time for the tumour is 4 days. Calculate the additional dose that has to be given to compensate for the tumour growth occurring during the 40 days of treatment in order to obtain the same BED as if not proliferation occurred. Assume that α=0,3/Gy.

Exercise 5. Multiple choice (Credit 1)
You have 3 possible answers. Mark the correct answer. Include the two pages with multi choice questions together with your other answers. Mark the two pages with your candidate number.

a) A charged particle is passing by an atom in the tissue. The probability for energy transfer increase with:
- Increasing the speed of the charged particle
- Increasing the charge of the particle
- Increasing the mass of the particle

b) Radiosensitivity changes through the cell cycle. Rapidly growing cells is most radiosensitive in:
- G1
- S-phase
- Mitosis

c) Sublethal damage occurs not for:
- x-rays
- Neutrons
- γ-rays

d) A reduction in the dose rate and corresponding increased exposure time lead to:
– Slope of survival curve increases
– Slope of survival curve decreases
– The shoulder of the survival curve increases

e) Which of the following statement is not correct?
Hypoxic cells become oxygenated due to:
- Angiogenesis
- Hyperthermia
- Synchronizing the cell population

f) Which of the following is correct about hypoxic cells?
- They are dead cells
- They have a very low proliferating rate
- They have a very high proliferating rate

g) Linear Energy Transfer (LET) indicates energy transferred per unit length of the track. With increasing energy for a given type of charged particle, LET will:
- Increase
- Decrease
- Be unchanged

h) The relationship between LET and the relative biological effectiveness (RBE) when plotting RBE as a function of LET is:
- REB increases linearly with LET
- RBE decreases linearly with LET
- RBE reach a maximum for a certain value of LET

i) When calculating effective dose you need to know the radiation weighting factor W_R. What is W_R. for α-particles?
- 1
- 5
- 20

j) Which diagnostic modality induces the highest radiation exposure to the patient?
- Conventional x-rays
- CT
- PET

k) What are the two general classifications for ionizing radiation?
- Neutrons and α-particles
- X-rays and γ-rays
- Electromagnetic and particulate radiations

l) Which of these tissues or cells respond late to ionizing radiation?
- Skin
- Lung
- Blood cells

m) Which following particles have the shortest range?
- electrons
- neutrons
- α-particles

n) In a rapidly growing cell line, which of the phases in the cell cycle have longest duration?
- G1
- S-phase
- G2

o) Specific targeted radiotherapy is based on:
- A pure radioactive isotope with high affinity towards the tumour tissue
- Focus the x-ray toward the tumour
- Thermosensitive liposome carrying a drug

p) The Oxygen enhancement ratio for α-particles is?
- 1
- 2.5
- 10

q) What is the most common mechanism for death of normal cells?
- Mitotic death
- Apoptosis
- Necrotic death

r) Normal cells are radiosensitive if:
- They have a high proliferating rate
- They have a low proliferating rate
- They are well differentiated

s) Hyperthermia can be combined with radiotherapy. What is the target for hyperthermia?
- DNA
- Protein
- Both DNA and protein