



FRANZCR Examination Phase 1
Radiation Oncology

Paper 1

9 September 2016

9:30am

Time Allowed: 2.5 Hours

INSTRUCTIONS

- There are a total of FIVE questions numbered 1 – 5.
- Each question has four sub-parts which relate to the four Oncology Science subjects. The paper indicates which subject is being assessed in each sub-part. The following abbreviations will be used –

ANA = Anatomy
RCB = Radiation and Cancer Biology
PATH = Pathology
PHY = Radiation Oncology Physics

- All questions are worth 20 marks. **The marks allocated to each sub-part of the questions are indicated in brackets.**
- Write your answers in the book provided, or on the answer sheets provided as directed in the questions.
- Start each question on a new page.
- Only use a black or blue pen.
- All questions are to be attempted.
- You may use diagrams, tables or lists in your answers.
- At the end of the examination please write your candidate number on each page used in the answer booklet.
- Hand **all** papers to the invigilator. No papers are allowed to be taken from the exam room. **THIS INCLUDES THE EXAMINATION QUESTION PAPERS.**

Question 1

ANA

The abducens nerve (cranial nerve VI) has the longest subarachnoid course of any of the cranial nerves and is fixed at certain points along its course. As such it is at risk of being stretched and damaged due to pathology causing downward pressure on the brainstem.

- a. List the components of the brainstem. **(0.5 marks)**
- b. Outline the anatomical relations of the pons. **(1.5 marks)**
- c. Describe the course of the abducens nerve from its origin in the brainstem to its muscle insertion. **(4 marks)**

RCB

The tolerance dose of normal tissues will be a determining factor in the total radiation dose that a tumour will receive when a patient is undergoing radiation therapy.

- a. Define the term tolerance dose. **(0.5 marks)**

As cancer treatments improve and patients survive longer after a cancer diagnosis, there is an increased likelihood that patients may be referred to a Radiation Oncologist for retreatment with radiation in a previously irradiated area.

- b. Explain the concept of “forgotten dose”. **(1 mark)**
- c. Outline which factors need to be assessed when considering retreatment to a previously irradiated area? **(4.5 marks)**

PATH

- a. Describe the pathological changes that occur as a result of radiation-induced injury to neural tissue. **(2 marks)**

Question 1 cont

PHY

Patients receiving radiation therapy for cancers of the head and neck require good immobilisation to minimise intra and inter fraction motion. This is combined with image guidance to improve accuracy of treatment delivery.

- a. Outline the main features of cone beam CT (CBCT) that make it useful for daily image guidance. In your answer note the effect of kV CBCT and MV CBCT on the image produced. **(3 marks)**
- b. What are the disadvantages of using CBCT? **(1 mark)**

The radiation dose a patient receives from CBCT's will contribute to the total dose of radiation a patient receives during a course of radiation treatment, particularly if this form of image guidance is performed daily. In some centres, this additional dose is accounted for in the radiation treatment plan.

- c.
- i. What is the estimated effective radiation dose a patient receives from a **diagnostic** head CT. **(0.5 marks)**
- ii. List the factors that may impact on the effective radiation dose a patient receives when undergoing a CBCT? **(1.5 marks)**

Question 2

ANA

- a. Describe the lymphatic drainage of the lips. Include the most likely first echelon nodes and possible secondary echelon nodes for each sub-site. **(3 marks)**
- b.
- i. List the cartilages of the larynx. **(1 mark)**
- ii. Name the nerves that supply the larynx and state their major function including the implication of nerve damage to each. **(2 marks)**

RCB

Necrosis seen within tumour deposits on imaging is often indicative of areas of relative hypoxia.

- a. How can the presence of tumour hypoxia affect the tumour control probability from a course of fractionated radiation therapy? **(1 mark)**
- b. Write brief notes on SIX example strategies to overcome tumour hypoxia in such situations. **(3 marks)**
- c. Tumour hypoxia is commonly classified into acute and chronic hypoxia. Explain the proposed difference in mechanism between acute and chronic hypoxia. **(2 marks)**

PATH

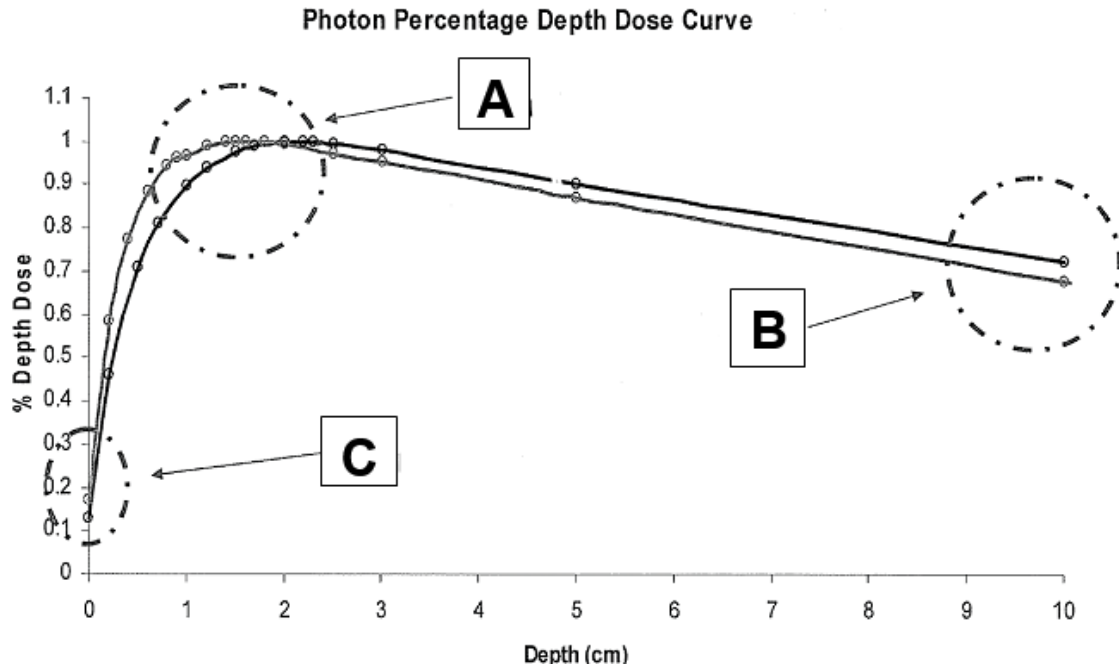
Immunohistochemistry (IHC) has become a fundamental component of cancer pathology and diagnosis.

- a. List the key steps in the process of indirect immunohistochemical staining. **(1 mark)**
- b. Give TWO examples of commonly used IHC markers when assessing histopathological tissue for diagnosis, treatment or prognosis purposes. **(1 mark)**

Question 2 cont

PHY

The graph below shows the percent depth dose (PDD) curves for two photon beams with the same SSD and field size but different energies.



- a. Define the term “percentage depth dose”. **(1 mark)**

- b. Explain the physical basis for the differences in the PDD curves for the two beams at points “A”, “B” and “C” on the graph. **(3 marks)**

- c. Suggest the probable photon energies for the two beams. **(0.5 marks)**

- d. Explain how the PDD will change if:
 - i Field size is increased
 - ii Source skin distance (SSD) is increased**(1.5 marks)**

Question 3

ANA

A 37-year old lady, in her 2nd trimester, has been diagnosed with locally advanced anal squamous cell cancer. She has been referred for an opinion regarding sphincter-preserving radiation treatment.

- a. Describe the relations of the anal canal in a female? **(2 marks)**
- b. Describe the lymphatic drainage of the anal canal. **(2 marks)**
- c. Describe the innervation of the anal canal. **(2 marks)**

RCB

- a. List the factors influencing risk of radiation toxicity to a foetus. **(1 mark)**
- b. Briefly describe the effects of ionising radiation on a foetus throughout gestation. Include in your answer dose limits, risk estimates and the corresponding gestation period at risk. **(4 marks)**
- c. State the recommended annual dose limits for a: **(1 mark)**
 - i Pregnant female
 - ii Foetus

PATH

- a. Describe at least TWO uses of a staging system? **(1 mark)**
- b. List THREE commonly used staging systems and a corresponding tumour site for each. **(1 mark)**

Question 3 cont

PHY

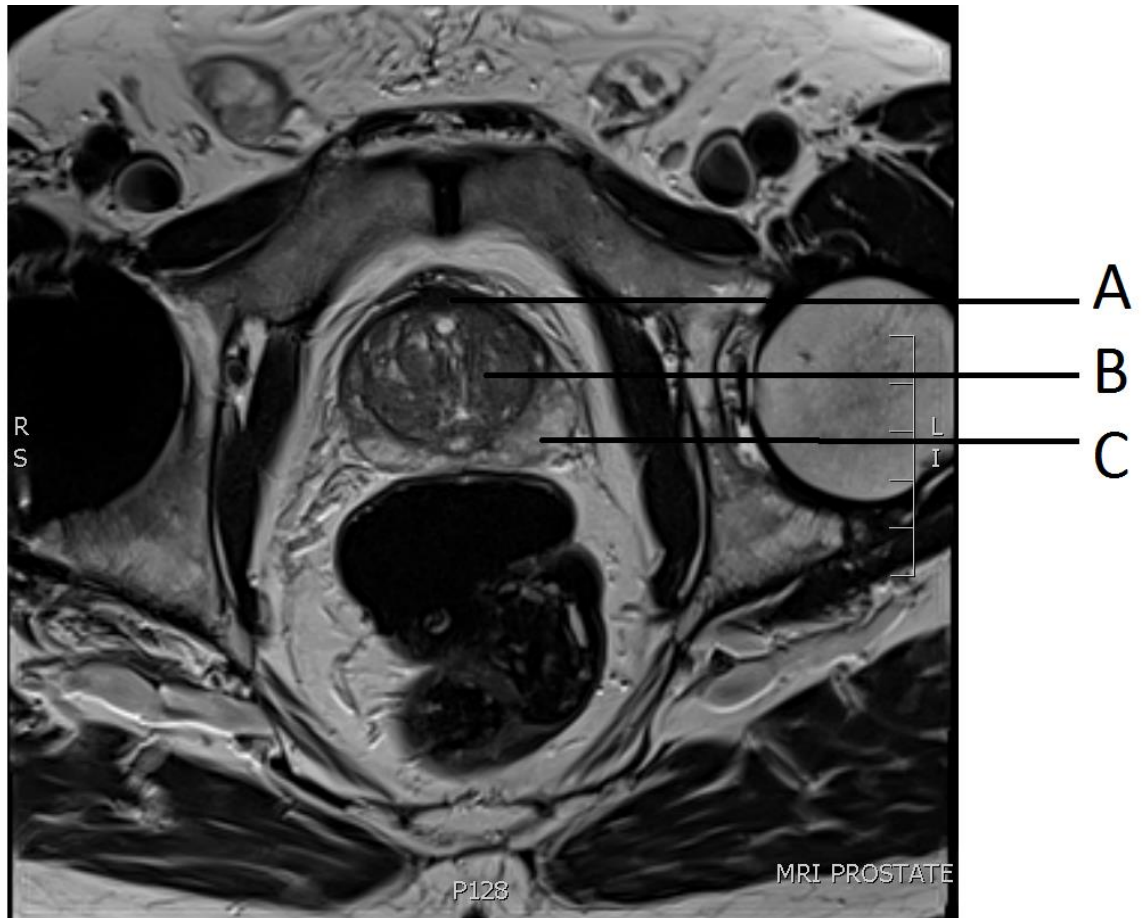
- a. Explain the difference between forward-planning and inverse-planning in radiation therapy. **(2 marks)**
- b. Briefly describe the steps required to be able to safely deliver a course of Intensity-modulated radiation therapy (IMRT) treatment. **(3 marks)**
- c. List THREE methods of delivering IMRT treatment. **(1 mark)**

Question 4

ANA

- a. Below is a T2 weighted axial MRI image through the mid-lower prostate gland. Name the structures or zones within the prostate labelled A-C on the MRI. **(2 marks)**

(Answers are to be written in your answer booklet, not on the question paper)



- b. Name the nodal groups which drain the prostate gland. **(2 marks)**
- c. After spinal cord injury the nervous control of micturition can be disrupted. Explain how the following systems control micturition and at which spine levels: **(2 marks)**
- Sympathetic outflow
 - Parasympathetic

Question 4 cont

RCB

- a. List THREE methods to assay gamma-H2AX. **(1 mark)**
- b. Briefly describe the steps involved in the Comet assay. **(2 marks)**
- c. Briefly describe the process of homologous recombination (HR) and non homologous end joining (NHEJ) repair of DNA double strand breaks and the difference in the end products of each repair process. **(3 marks)**

PATH

- a. List the morphological features of: **(2 marks)**
- i Apoptosis
 - ii Necrosis

PHY

- a. On the same graph, draw percentage depth dose curves for a 6MV photon 10X10cm field, 100cm SSD to illustrate the difference between absorbed dose and kerma in a water phantom. **(2 marks)**
- b. Explain TWO ways that dynamic or virtual wedges may be generated by linear accelerators. **(2 marks)**
- c. Outline one disadvantage of MLC collimation for an ELECTRON beam, and explain how this can be overcome. **(1 mark)**
- d. Explain why an electron applicator is needed for treatment with an electron beam. **(1 mark)**

Question 5

ANA

- a. Describe the macroscopic structure of the cervix uteri. **(2 marks)**
- b. Describe the immediate anatomical relations of the cervix. **(1 mark)**
- c. Describe the histologic features of the cervix mucosa in a mature premenopausal adult woman. **(2 marks)**
- d. List the nodal stations that drain the cervix uteri. **(1 mark)**

RCB

- a. Consider the statement: "Infection by high-risk types of HPV (Human Papilloma Viruses) alone is sufficient for progression to cancer". **(1 mark)**

Indicate whether this statement is TRUE or FALSE, and briefly justify your answer.
- b. List FIVE different mechanisms of virally mediated oncogenesis. **(2.5 marks)**
- c. For EACH of the five different mechanisms listed above, give ONE example of a pathway that is affected by HPV. **(2.5 marks)**

PATH

- a. What are tumour suppressor genes? **(1 mark)**
- b. Describe how a mutation in the Retinoblastoma gene can contribute to oncogenesis. **(1 mark)**

PHY

- a. Describe the purpose of a record and verify system (RVS). **(1 mark)**
- b. Give FIVE examples of errors in treatment delivery that can be picked up by the daily use of RVS. For each, suggest one possible origin of the error. **(5 marks)**



FRANZCR Examination Phase 1
Radiation Oncology

Paper 2

9 September 2016

2.00pm

Time Allowed: 2.5 Hours

INSTRUCTIONS

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Question 6

ANA

- a. Draw a labelled diagram demonstrating the structure of the bronchial tree from the trachea to the segmental bronchi bilaterally. **(4 marks)**
- b. List the medial, lateral and anterior relations of the azygous vein as it courses through the mediastinum. **(2 marks)**

RCB

A course of radiation therapy is commonly delivered over a number of fractions.

- a.
- i List the radiobiological factors that provide a rationale for the tumour response to conventional fractionation. **(1 mark)**
 - ii Stereotactic body radiation therapy (SBRT) typically delivers treatment in a small number of fractions at a large dose per fraction (ie. extreme hypofractionation). Discuss the radiobiological effects of this treatment approach on tumours with reference to the factors identified in (i). **(5 marks)**

PATH

- a. List the potential acute and late pathological manifestations of radiation-related heart disease. **(2 marks)**

Question 6 cont

PHY

- a.** Describe the following photon interactions with matter: **(4.5 marks)**
- i** Coherent scattering
 - ii** Photoelectric effect
 - iii** Compton effect
- Include a reference to the dependence on beam energy and atomic number (Z) for each process.
- b.** Briefly define and explain how the following may apply to therapeutic radiation photon beams: **(1.5 marks)**
- i** Exponential attenuation
 - ii** Non-exponential attenuation

Question 7

ANA

- a. Draw a labelled diagram illustrating the external gross anatomy of the stomach. **(2 marks)**
- b. Describe the lymphatic nodal drainage of the stomach. **(4 marks)**

RCB

- a. Define the term “*abscopal effect*” and provide TWO clinical examples. **(2 marks)**
- b. Describe TWO proposed explanations to account for *abscopal effects*. **(1 mark)**
- c. Define the term “*bystander effect*” and provide a clinical example. **(1 mark)**
- d. Briefly describe the growth of a tumour over time and how this is impacted by the tumour microenvironment. **(2 marks)**

PATH

- a. Provide a brief description of:
- i Tumour angiogenesis and comment on the phenomenon known as ‘angiogenic-switch’. **(1.5 marks)**
 - ii List TWO mediators involved in angiogenesis. **(0.5 marks)**

Question 7 cont

PHY

- a. Define the following terms:
- i Beam quality and how it is specified for kV and MV photons. **(1 mark)**
 - ii Effective energy **(0.5 marks)**
 - iii Half value layer **(0.5 marks)**
- b. On one set of labelled axis, draw a schematic graph showing the changes in spectral distribution of a 200 kVp x-ray beam with the following filters: **(1.5 marks)**
- Aluminium
 - Tin + Aluminium
 - Copper + Tin + Aluminium

Flattening filters are used to ensure beam intensity is uniform in cross section. Modern Linear accelerators offer a delivery technique known as “FFF” (Flattening Filter Free).

- c. On one labelled graph, draw the following two beam profiles: **(2.5 marks)**
- i a conventional 6MV photon beam *and*
 - ii a FFF 6 MV photon beam
- both for a 10x10 cm field at 10 cm depth in water and comment on the differences between the two profiles.

Question 8

ANA

- a. Describe the microscopic structure of the skin of the scalp. **(4 marks)**
- b. Describe the function, and microscopic features of eccrine (merocrine) and apocrine sweat glands. **(2 marks)**

RCB

- a. Describe the step by step cell culture technique and process of generating a clonogenic cell survival curve. **(3 marks)**
- b. Draw a fully labelled typical cell survival curve for densely ionising (e.g. neutrons or α particles) and sparsely ionising radiation (i.e. photons) including the α/β ratio for the sparsely ionising radiation curve. **(3 marks)**

PATH

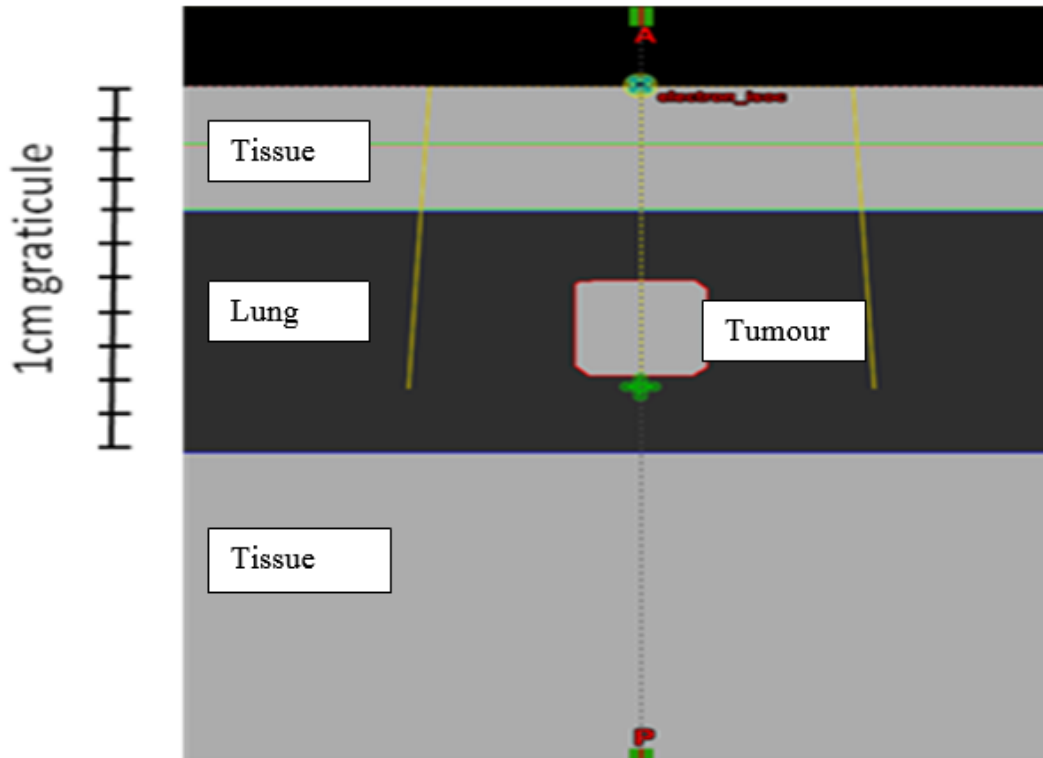
Question 8

- a. List the FOUR major histological types of cancer based on cell of origin. **(2 marks)**

Question 8 cont

PHY

Below is a hypothetical setup of tissue, lung and a tumour freestanding in lung. A **12MeV electron** beam is directed onto the setup with the central axis passing through the centre of the tumour.



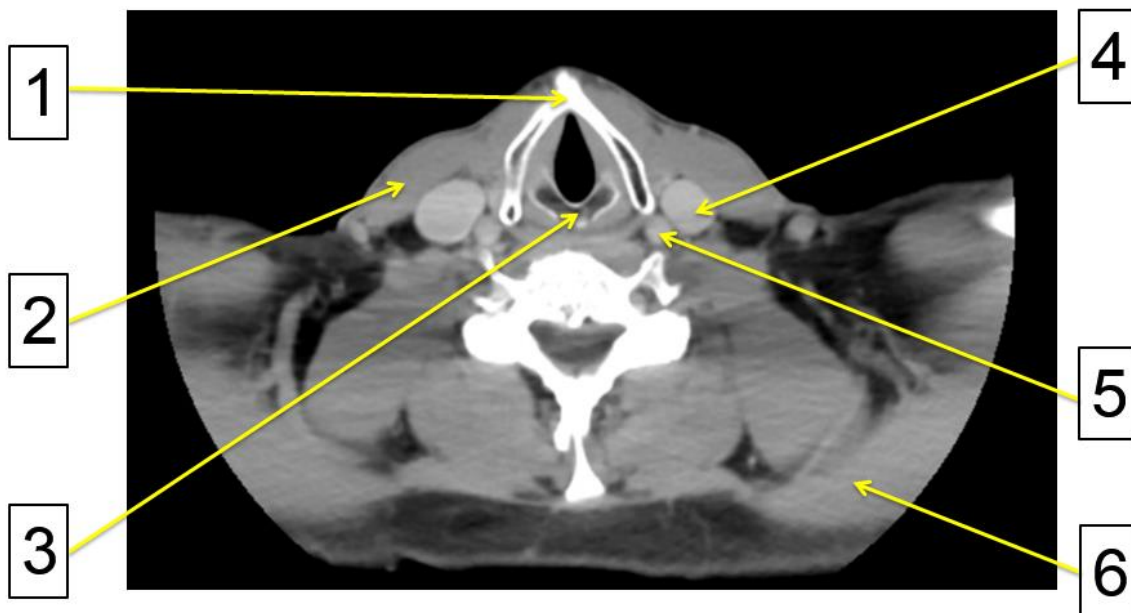
- a. Draw and label the percentage depth dose curve of the central axis. **(3 marks)**
(Answers are to be written in your answer booklet, not on the question paper).
- b. Describe the main features and explain the shape of the depth dose as: **(3 marks)**
- The beam initially enters tissue
 - Then passes from tissue to lung
 - Then passes from lung to the tumour
 - Then passes back to lung
 - Then passes through the tissue beyond

Question 9

ANA

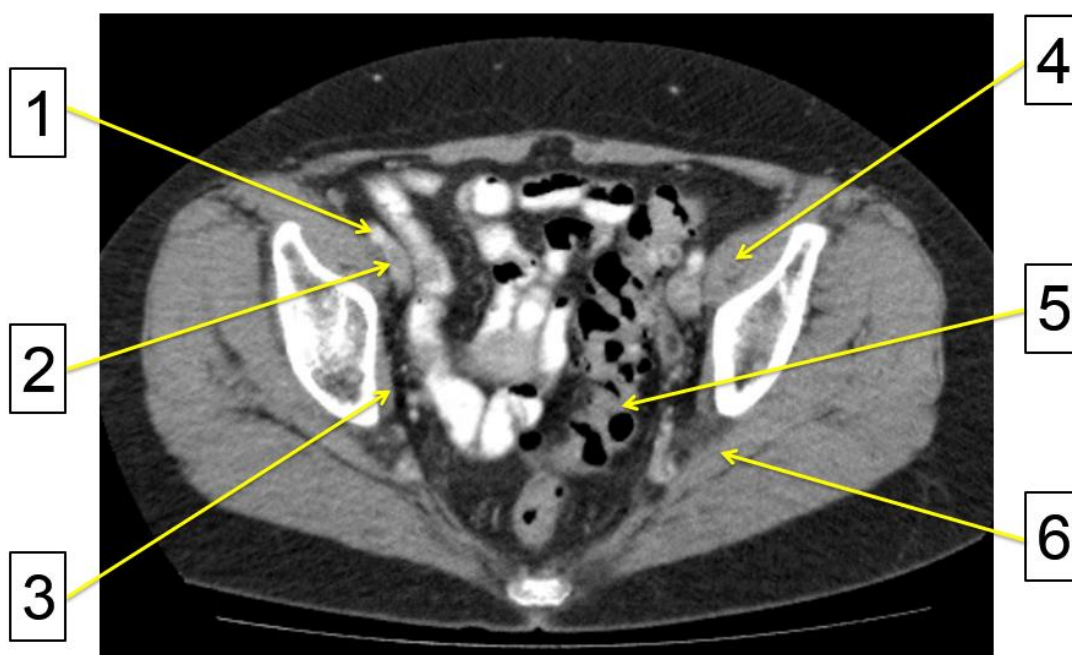
- a. Name the structures labelled 1 to 6 on the axial CT slice of the neck. (2 marks)
Indicate laterality where applicable.

(Answers are to be written in your answer booklet, not on the question paper).



- b. Name the structures labelled 1 to 6 on the axial CT slice of the female pelvis. (2 marks)
Indicate laterality where applicable.

(Answers are to be written in your answer booklet, not on the question paper).

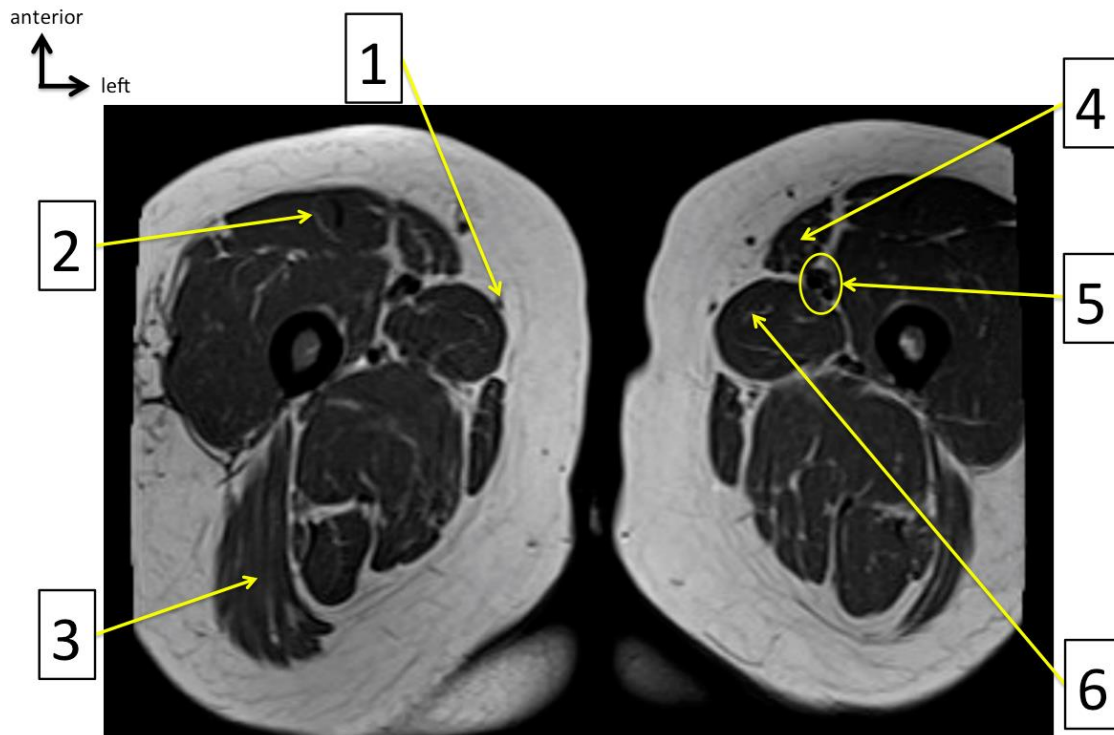


Question 9 cont

ANA cont

- c. Name the structures labelled 1 to 6 on the axial (T1 weighted) MRI slice of the upper thighs. Indicate laterality where applicable. NB: 5 has two structures. **(2 marks)**

(Answers are to be written in your answer booklet, not on the question paper).



RCB

- a. Describe the characteristics of stochastic effects versus deterministic (non-stochastic) effects of ionising radiation, giving an example of each effect. **(3 marks)**

The International Commission on Radiological Protection (ICRP) has published recommendations on dose limits to protect people against the detrimental effects of radiation.

- b. Describe the main assumptions used to set these dose limits for radiation protection and discuss the limitations to these assumptions. **(2 marks)**
- c. What are the ICRP recommended dose limits for: **(1 mark)**
- occupational exposure
 - public radiation exposure

Question 9 cont

PATH

- a. Define the following terms:
- i Chromosomal translocation (0.5 marks)
 - ii Gene amplification (0.5 marks)
 - iii Epigenetic changes (0.5 marks)
 - iv Polymorphisms (0.5 marks)

PHY

Question 9

- a. Define radioactive equilibrium and describe TWO types of radioactive equilibrium, providing a practical example of each. (3 marks)
- b. Using a table, compare Iodine-131, Strontium-89 and Samarium-153, with regards to the following: (3 marks)
- i type(s) of radiation emitted
 - ii physical half-life
 - iii physical form in which they are used and technique of delivery to patient
 - iv an example of clinical use

Question 10

ANA

- a. Name the three main neurovascular structures, and their afferent or efferent branches, that traverse the parotid gland. **(1.5 marks)**
- b. State the key surface anatomy landmarks that can be used to delineate the parotid gland. **(1.5 marks)**
- c. Describe the intracranial course of the facial nerve, noting any key roots or branches. **(3 marks)**

RCB

- a. Briefly explain the difference between a cyclin and a cyclin dependent kinase and how they interact. **(2 marks)**
- b. Draw a graph showing the concentration of the four main cyclins involved in the regulation of the cell cycle through the duration of a cell cycle. **(2 marks)**
- c. Give a detailed explanation of what occurs during the G1-S phase checkpoint and why this is important at a cellular level. **(2 marks)**

PATH

- a. There are various methods available to a clinician to try and obtain cells for a "tissue" diagnosis. **(2 marks)**

Give the potential advantages for each of the following techniques:

- Fine need aspiration (FNA)
- Core biopsy
- Cytology from fluid drainage

Question 10 cont

PHY

Radiation therapy can be used to treat malignant lesions in the parotid gland.

- a. Discuss several physical differences and dosimetric implications of electing to treat a PTV (which has been derived from a CTV encompassing the parotid gland with a uniform 0.5cm expansion trimmed to skin), with respect to the following techniques: **(6 marks)**
- i Direct electron field
 - ii Wedged pair of photon beams
 - iii Volumetric Arc Therapy (VMAT)