The Royal Australian and New Zealand College of Radiologists®

The Faculty of Radiation Oncology

Candidate Number: _____

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FRANZCR Examination

Phase 1 Radiation Oncology

Paper 1

8 September 2017

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

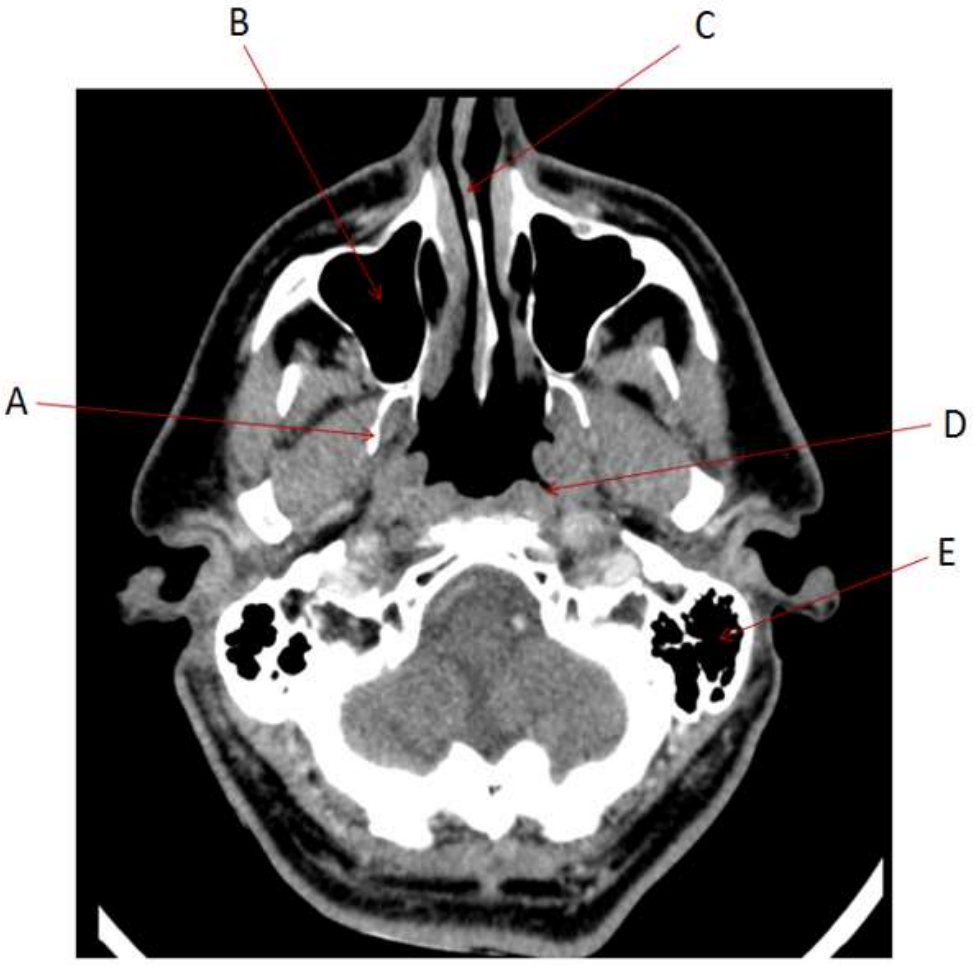
ANA

a. With the aid of a labelled cross sectional diagram through the nipple, indicate the major macroscopic components of the female breast. **(2 marks)**

b. Use a separate labelled diagram to the one from part a, to illustrate the microscopic and histological features of the female breast lobules and ducts. **(2 marks)**

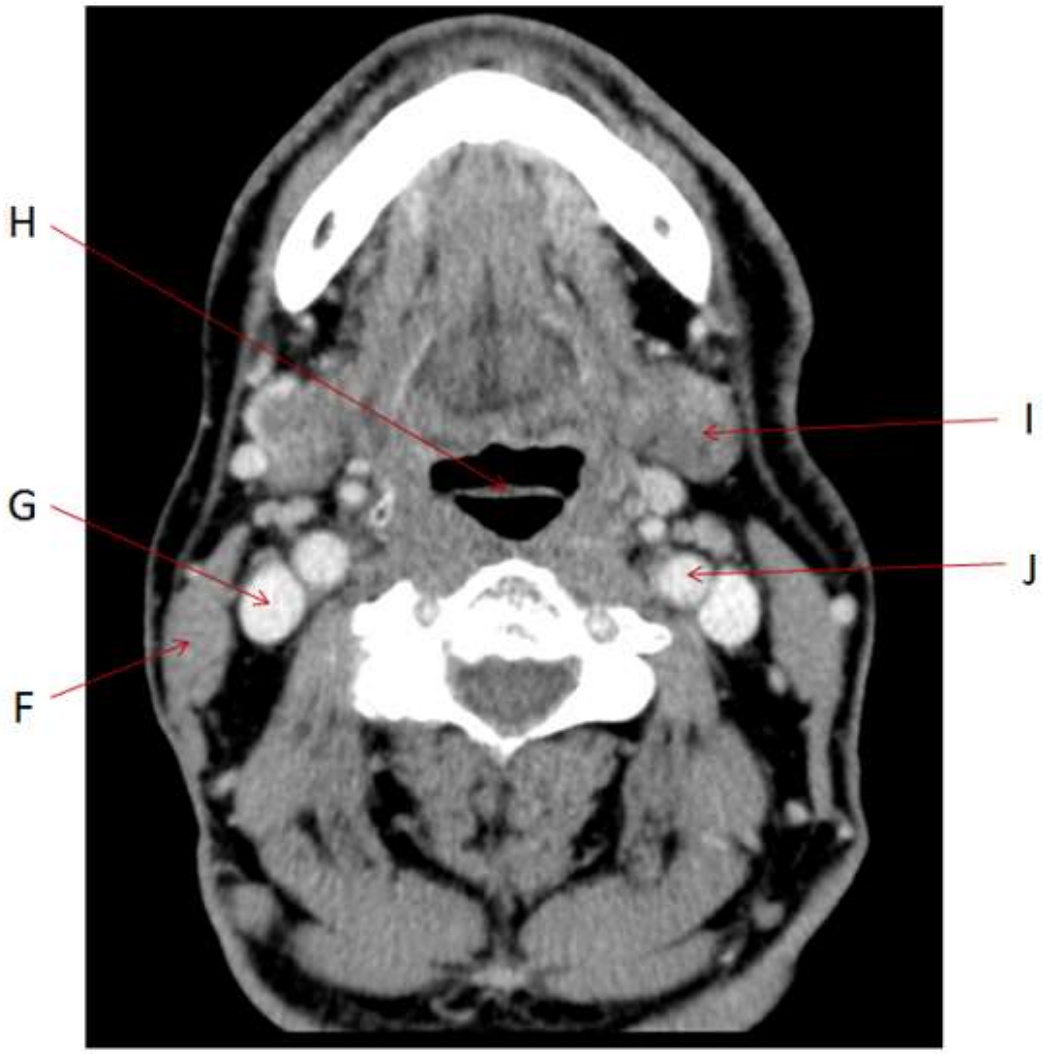
c. Name the structures labelled A-J in the two CT images below. Indicate laterality where applicable. **(2 marks)**

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



Question 1 cont

ANA cont



RCB

a. Briefly outline the clinical evidence supporting the significance of tumour hypoxia for patient outcomes in head and neck radiotherapy. (Exact details of specific clinical trials is not expected). **(3 marks)**

b. What is the role of HIF-1 in tumour hypoxia? **(2 marks)**

c. List THREE (3) ways that the impact of hypoxia can be reduced during a course of radiotherapy that does NOT include the addition of a treatment agent such as a radiosensitiser. **(1 mark)**

Question 1 cont

PATH

When interpreting histology reports certain reported features are regarded as predictive or prognostic factors.

a. List FIVE (5) features that are routinely reported on such reports that are prognostic or predictive. **(1 mark)**

b. Select ONE (1) of the five features that you have listed above and explain why this feature is prognostic or predictive. **(1 mark)**

PHY

a. For each of the following FOUR (4) types of photon interactions with matter draw a **diagram** AND describe the process of interaction. Also state the probability of interaction based on photon energy, atomic number or density of the material (Z) where relevant. **(6 marks)**

i. Coherent scattering

ii. Photoelectric effect

iii. Compton scattering

iv. Pair production

Question 2

ANA

a. Describe the histological features of skin. **(3 marks)**

b. Describe the lymphatic drainage of the skin of the temporal area. **(1 mark)**

c. Describe the lymphatic drainage of the upper limb. **(2 marks)**

RCB

a. Describe the features of an ideal toxicity scoring system that can be used in radiotherapy. **(1.5 marks)**

b. In general, describe briefly the various grades used in a toxicity scoring system. (e.g RTOG/EORTC toxicity scoring system). **(1 mark)**

c. Draw a labelled diagram of the normal tissue complication probability of spinal cord toxicity (for conventional fractionation). **(2 marks)**

d. What are the limitations of QUANTEC dose limits? **(1.5 marks)**

PATH

a. Using a TABLE compare and contrast cytological features of malignant and benign cells. **(2 marks)**

Question 2 cont

PHY

Treatment planning based on computed tomography (CT) data is standard in most modern radiation therapy centres.

a. Describe the physics principles behind image acquisition with CT scanners (generation of x-ray does not need to be included). **(1.5 marks)**

b. Explain how the CT data set obtained from CT simulation is used for radiation therapy planning. **(1.5 marks)**

c. List the important differences between a diagnostic CT and a CT-simulator. **(1 mark)**

d. For patients undergoing image-guided radiotherapy an onboard Kilovoltage cone-beam CT (CBCT) is often used. Explain the differences between a CT-simulator and CBCT. **(2 marks)**

Question 3

ANA

a. With the aid of a diagram, table or flowchart, outline the structure of the brachial plexus from the roots to the FIVE (5) main nerves. **(4 marks)**

b. Describe the adjacent anatomical landmark structures along the course of the brachial plexus from the roots to the cords. **(2 marks)**

RCB

Patients often receive chemotherapy sequentially or concurrently with radiotherapy to enhance tumour cell kill.

a. Briefly describe the concept of 'spatial cooperation' and give TWO (2) clinical examples of its use. Each example should apply this concept with a different clinical objective. **(2 marks)**

b. Explain THREE (3) mechanisms by which systemic therapy can **enhance** the cytotoxic effect of radiotherapy (ie. give a synergistic, rather than an additive effect). **(4 marks)**

PATH

a. Define 'tumour suppressor gene' and briefly state how such genes can be involved in carcinogenesis. **(1 mark)**

b. Give TWO (2) examples of tumour suppressor genes. **(1 mark)**

Question 3 cont

PHY

With respect to megavoltage photon beams:-

a. Define the term 'penumbra'. **(1 mark)**

b. List THREE (3) methods used to adjust beam shape. **(1 mark)**

c. Describe the effect of shielding by 'half beam blocking' on: **(2 marks)**

i. Shape of the isodose curves

ii. The divergent edges of the beam

iii. Penumbra

d. Outline the disadvantages of using Multi Leaf Collimator (MLCs) to shape a megavoltage photon beam as compared to other techniques of beam shaping. **(2 marks)**

Question 4

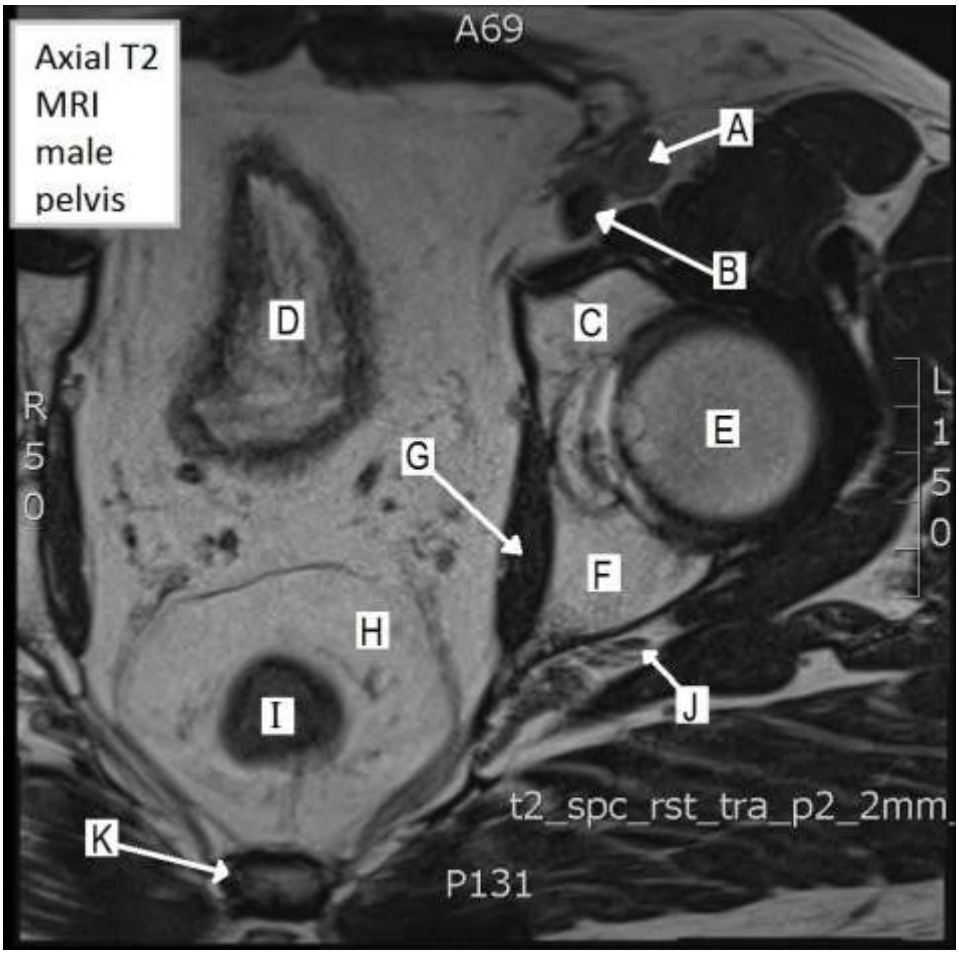
ANA

a. Draw a coronal view of the landmark structures of the male bladder, illustrating precisely the relative locations of the external urethral sphincter, trigone, and opening of the ureters. **(2 marks)**

b. Draw a sagittal view of the external anatomy of a male bladder. **(2 marks)**

c. Identify the structures labelled A-K on the axial MRI image below. Indicate laterality where applicable. **(2 marks)**

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



Question 4 cont

RCB

A patient is having radiotherapy for squamous carcinoma of the tonsil. Treatment was prescribed to 70Gy in 35 fractions over 7 weeks. After 6 weeks the patient has an unscheduled treatment break of 5 days.

a. Explain radiobiologically why increasing treatment time would reduce tumour control probability. **(1 mark)**

b. List strategies that could be used to compensate for the treatment break. **(1 mark)**

c. Explain what is meant by “double-trouble” and which type(s) of tissue it affects most. **(1 mark)**

d. Draw labelled cell survival curves on the same axes for late responding tissue and for squamous carcinoma of the tonsil. **(3 marks)**

PATH

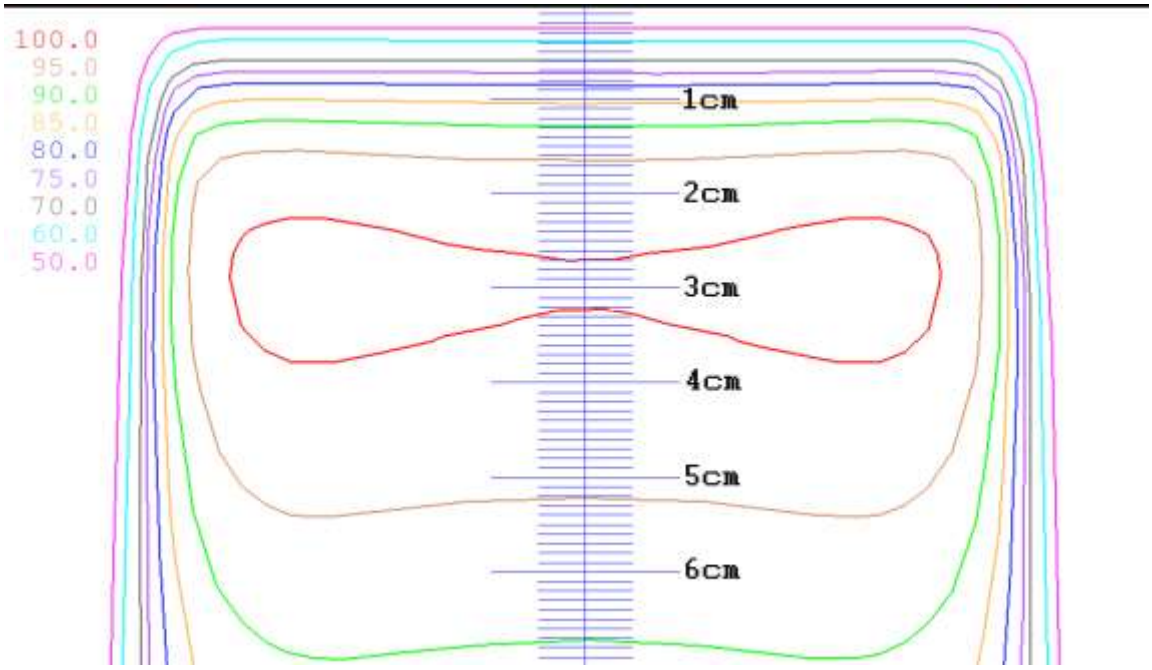
a. Describe the nuclear morphology of anaplastic cells. **(1 mark)**

b. Define the term aneuploidy. **(1 mark)**

Question 4 cont

PHY

The isodose chart below illustrates the dose fall off for an 18MV photon beam 10cm x 10cm field at 100cm Source Surface Distance (SSD), measured in a water equivalent phantom. In this diagram, the thick black line indicates the interface between air and water equivalent phantom.



One centimetre of water equivalent bolus is added to the surface of the phantom.

a. What is the new dose at the phantom's surface (in percentage relative to prescribed dose) using data from this isodose chart? **(1 mark)**

b. Describe what happens to depth of Dmax? **(1 mark)**

c. Describe what is meant by a fixed Source Axial Distance (SAD) in physical terms? **(1 mark)**

d. Explain the advantage of prescribing to a fixed SAD rather than a fixed SSD for multi field treatments. **(1 mark)**

e. Explain the physical basis of what happens to the depth of Dmax when radiotherapy is prescribed with a fixed SAD of 100cm compared to a fixed SSD of 100cm. **(2 marks)**

Question 5

ANA

a. List the subsites of the oropharynx. **(1 mark)**

b. Describe the structures anatomically related to the tonsil. **(2 marks)**

c. Describe the lymphatic drainage of the oropharynx according to anatomical subsite, including major nodal stations. **(3 marks)**

RCB

a. List the patient, tumour and treatment related factors to be taken into account when considering re-irradiation. **(3 marks)**

b. When re-irradiating, discuss how normal tissue complication probability can be reduced by modifying re-irradiation dose and fractionation. Comment on how these modifications may impact on tumour control probability. **(3 marks)**

PATH

a. Describe the role of the following cells in the immune response to tumours:

i. Cytotoxic T cells **(1 mark)**

ii. NK Cells **(1 mark)**

Question 5 cont

PHY

For a 10 x 10cm megavoltage photon beam:

a. Draw central axis depth dose curves to show how dose distribution changes with: **(2 marks)**

i. Increasing energy

ii. Increasing field size

b. Explain the physical basis separately for each of these effects. **(2 marks)**

c. Describe the impact on percentage depth dose for a 6MV photon beam if a patient develops massive weight loss. Explain the physical basis for this. How is the impact different for superficial (eg. head and neck) relative to deep (eg. prostate) targets? **(2 marks)**

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Candidate Number: _____

FRANZCR Examination

Phase 1 Radiation Oncology

Paper 2

8 September 2017

2:00pm

Time Allowed: 2.5 Hours

INSTRUCTIONS

- There are a total of FIVE questions numbered 6 – 10.
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Question 6

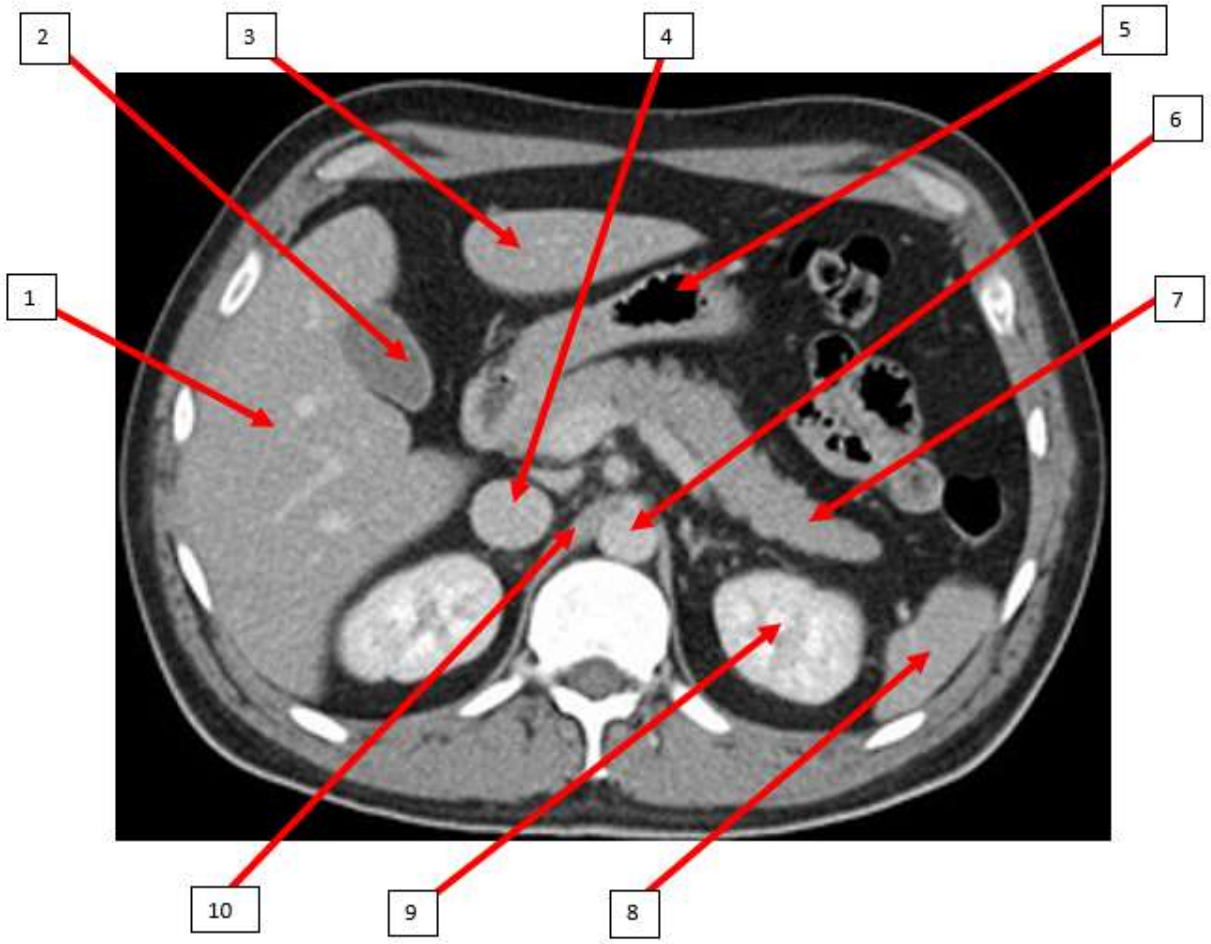
ANA

a. Draw diagrams of the liver from anterior and posterior views to illustrate the segments of the liver including key delineating structures. **(3 marks)**

b. Briefly describe the blood supply of the liver. **(1 mark)**

c. Name the structures numbered 1-10 on the axial CT image of a normal upper abdomen. Indicate laterality where applicable. **(2 marks)**

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



Question 6 cont

RCB

Radiation therapy can induce changes in the tumour microenvironment beyond cellular cytotoxicity to evoke an immune response.

a. How does radiation therapy activate the immune system? **(2 marks)**

b. List FOUR (4) immunological factors that are up-regulated by radiation therapy. **(2 marks)**

c. Discuss TWO (2) immune checkpoints targeted by immunotherapy and state how these may enhance the effects of radiation therapy when used in combination. **(2 marks)**

PATH

Radiation therapy is targeted to tumour cells but can also impact surrounding normal tissue.

a. List FOUR (4) patient-related factors that are known to affect normal tissue damage. **(1 mark)**

b. For TWO (2) factors listed above describe how they impact on normal tissue effects from fractionated radiation therapy. **(1 mark)**

Question 6 cont

PHY

Radiation therapy can be delivered with curative or palliative intent. A variety of 3D conformal and modulated techniques are used in practice to achieve the desired clinical endpoint(s).

a. Draw a labelled diagram of the expected dose distribution using an equally weighted 10x10cm parallel opposed pair of 6 MV photon beams prescribed to mid plane and comment on TWO (2) aspects of the dose distribution. **(3 marks)**

b. Define the term 'VMAT' and discuss how it differs from 3D conformal radiation therapy (3DCRT). **(3 marks)**

Question 7

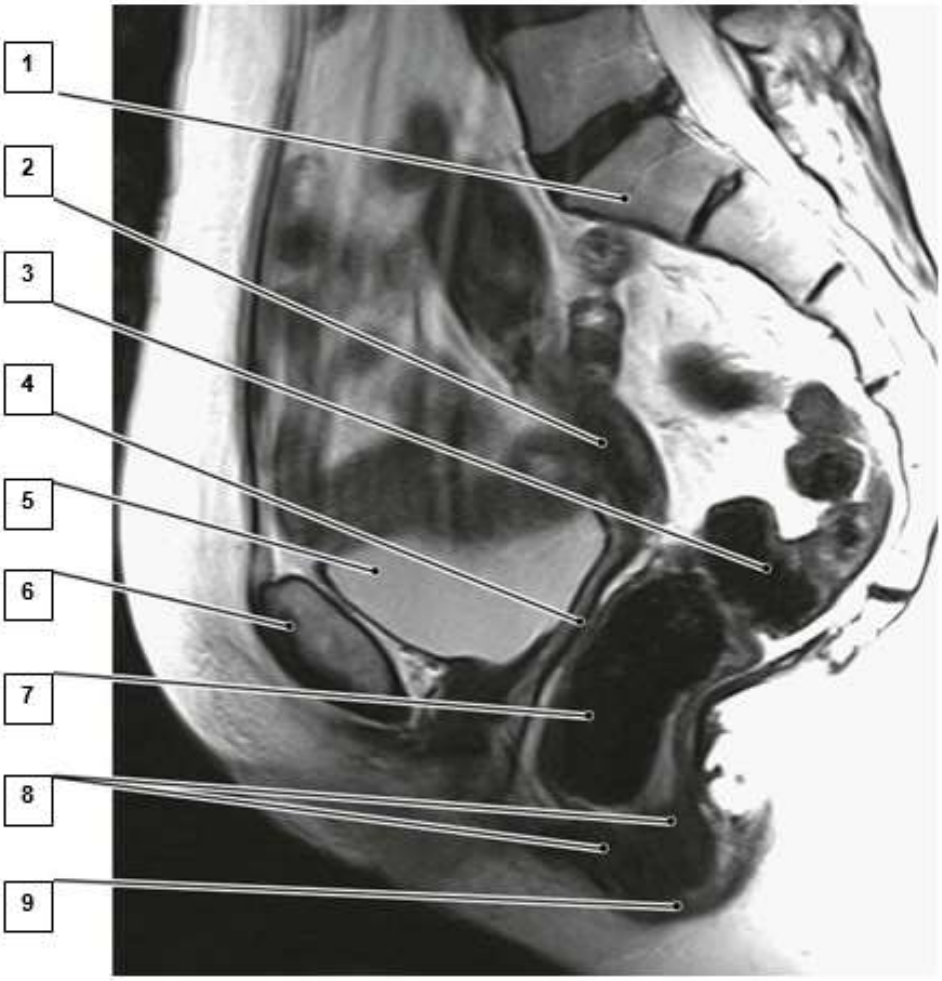
ANA

a. Describe the lymphatic drainage of the anatomical regions of the uterus. **(2 marks)**

b. State the relations of the uterus? **(2 marks)**

c. Identify the structures labelled 1-9 in the sagittal MRI image of a female pelvis. **(2 marks)**

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



Question 7 cont

RCB

LET (Linear Energy Transfer) is a measure of the density of ionisation along the track of a charged particle.

a. Define the term Relative Biological Effectiveness (RBE). Discuss how RBE changes as a function of LET. **(3 marks)**

b. **(3 marks)**

i. Define oxygen enhancement ratio (OER).

ii. Describe the relationship between LET and the OER. Illustrate your answer with a diagram.

PATH

A malignant tumour can invade locally and/or metastasise.

a. Describe the underlying mechanism of invasion and the development of metastasis. **(2 marks)**

Question 7 cont

PHY

a.

i. How do the physical properties of a proton differ from electrons and photons? **(1 mark)**

ii. Use a diagram to illustrate the dose deposition of a mono energetic proton beam. **(1 mark)**

b. The dose prescription point for a radiation plan is critical to the subsequent dosimetry that is achieved. Compare and contrast the dose prescribing and reporting for each of the following radiation therapy techniques: **(4 marks)**

i. Single megavoltage photon field

ii. 3-Dimensional Conformal Radiation Therapy

iii. Intensity Modulated Radiation Therapy

iv. Stereotactic Body Radiation Therapy

Question 8

ANA

a. List the compartments of the mediastinum and state how the mediastinal compartments separated from each other? **(2 marks)**

b. List the contents of the middle mediastinum. **(2 marks)**

c. Label the structures A – J from the below CT slice. Indicate laterality where applicable. **(2 marks)**

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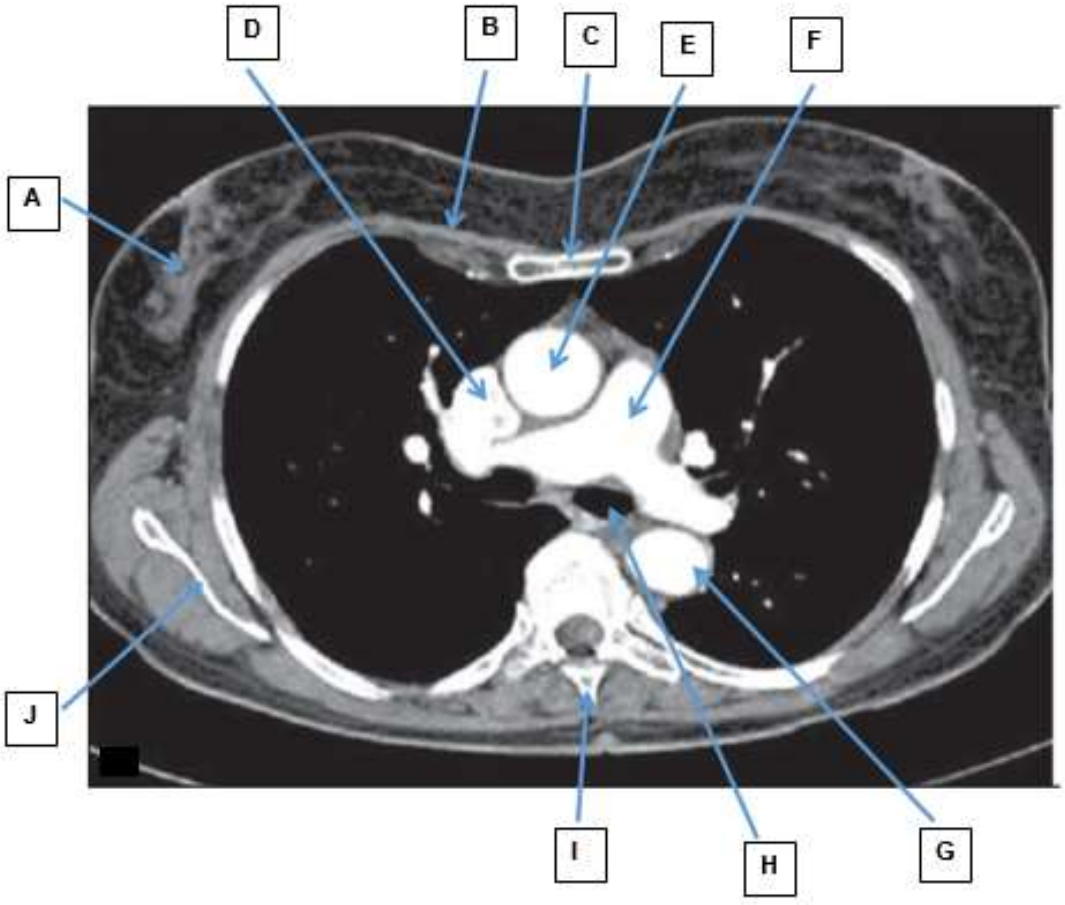


Question 8 cont

RCB

a. List FOUR (4) modes of cell death. **(1 mark)**

b. Describe the activation pathways for apoptosis. Include named examples of specific factors or proteins involved in these pathways. **(4 marks)**

c. List the morphological features in the cell associated with apoptotic cell death. **(1 mark)**

PATH

The Ras gene is a proto-oncogene.

a. Draw a simple flow diagram of TWO (2) intra-cellular signalling pathways of which the Ras gene is a usual component, including at least TWO (2) other proteins in each pathway. **(1 mark)**

b. Describe a type of mutation that results in a proto-oncogene becoming an oncogene and outline the result of this change. **(1 mark)**

PHY

a. Draw a central axis depth dose curve for a 6 MeV electron beam with a 10x10cm cone. On this diagram label the Dmax and R50 for this beam. **(2 marks)**

b. Due to the natural contours of the body, at some anatomical sites an electron beam will not enter the body perpendicular to the skin but rather at an oblique angle.

i. Define the angle of obliquity. **(0.5 mark)**

ii. At oblique beam incidences, describe how the percentage depth dose characteristics of electron beams deviate from perpendicular beam incidences. Draw a graph illustrating your answer for beam incidences of 0^o, 30^o and 60^o. **(3.5 marks)**

Question 9

ANA

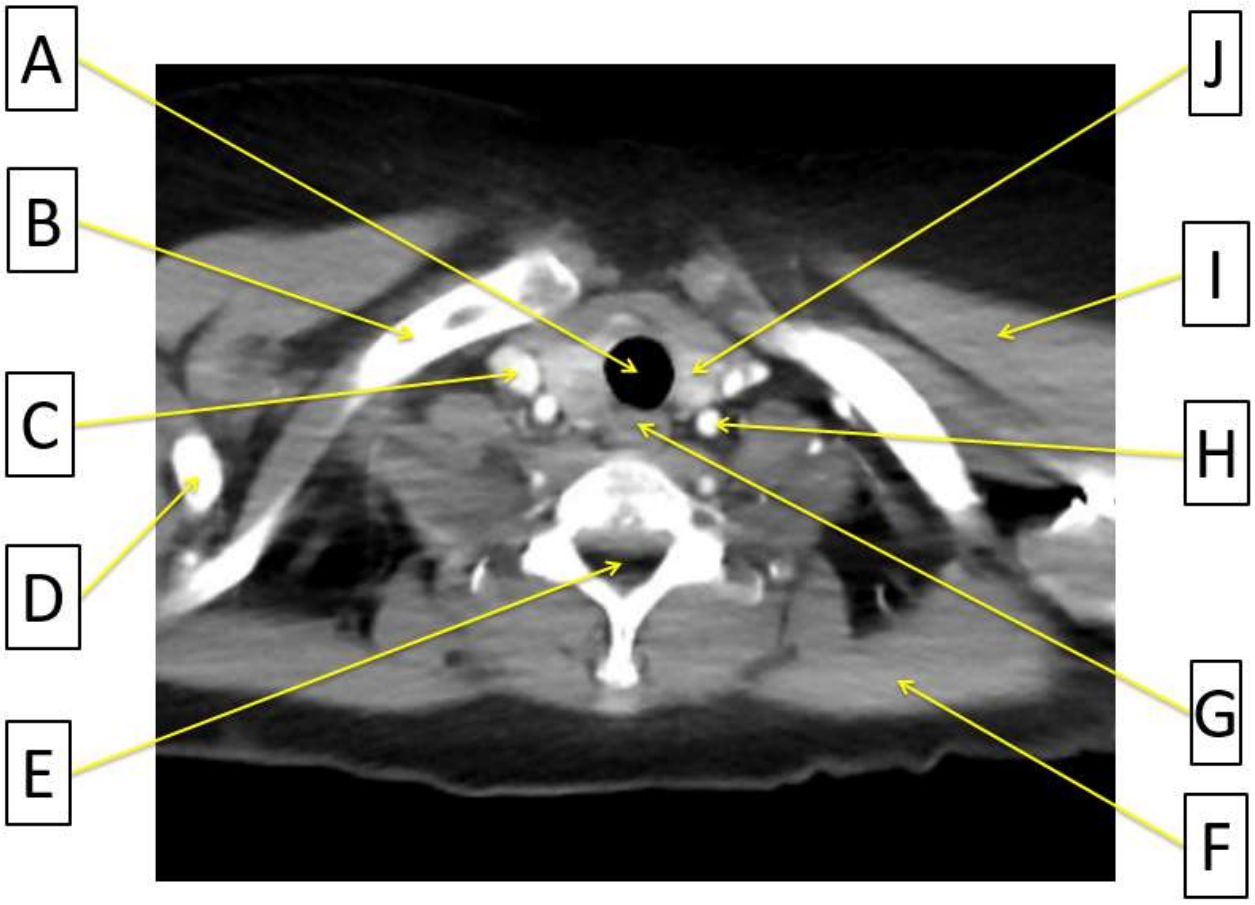
A 55 year old heavy smoker is diagnosed with squamous cell carcinoma of the oesophagus.

a. List the microscopic layers of the oesophagus, starting from innermost layer to outermost layer. **(1 mark)**

b. Describe the lymphatic drainage of the oesophagus. **(3 marks)**

c. Name the structures labelled A to J on the axial CT slice below. Indicate laterality where applicable. **(2 marks)**

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



Question 9 cont

RCB

a. Draw a labelled diagram of the mammalian cell cycle, illustrating the main phases and the relative duration of each phase (assuming a total cell cycle time of 24 hours). **(1 mark)**

b. Describe the relative radiosensitivity of cells in the different phases of the cell cycle and include a labelled cell survival curve to illustrate your answer. **(2 marks)**

c. In response to DNA damage from ionising radiation exposure, THREE (3) main cell cycle checkpoints are activated. For **EACH** of these checkpoints: **(3 marks)**

i. Name the checkpoint.

ii. Briefly describe its function.

iii. Name the cyclin-dependent kinases and cyclins (if applicable) involved in its regulation.

PATH

One year after treatment for oesophageal cancer, the man is found to have an oral cavity squamous cell carcinoma.

a. Describe the concept of field cancerization. **(1 mark)**

b. Describe the histologic features of squamous dysplasia. **(1 mark)**

Question 9 cont

PHY

Field junctions may be required in some radiation therapy treatments. Two adjacent radiation fields (with parallel central axes, size 10cm x 10cm and at 100cm source surface distance) are junctioned at the skin surface in the following TWO (2) scenarios:

a. Both are 6 MV photon fields. **(3 marks)**

b. One is a 9 MeV electron field and the other is a 12 MeV electron field. **(3 marks)**

For each scenario:

i. Draw a labelled isodose chart to illustrate the dosimetric features encountered with the junction. Include a hot spot, 100%, 80% and 50% isodose lines.

ii. Briefly explain why the dosimetric features seen in (i) occur.

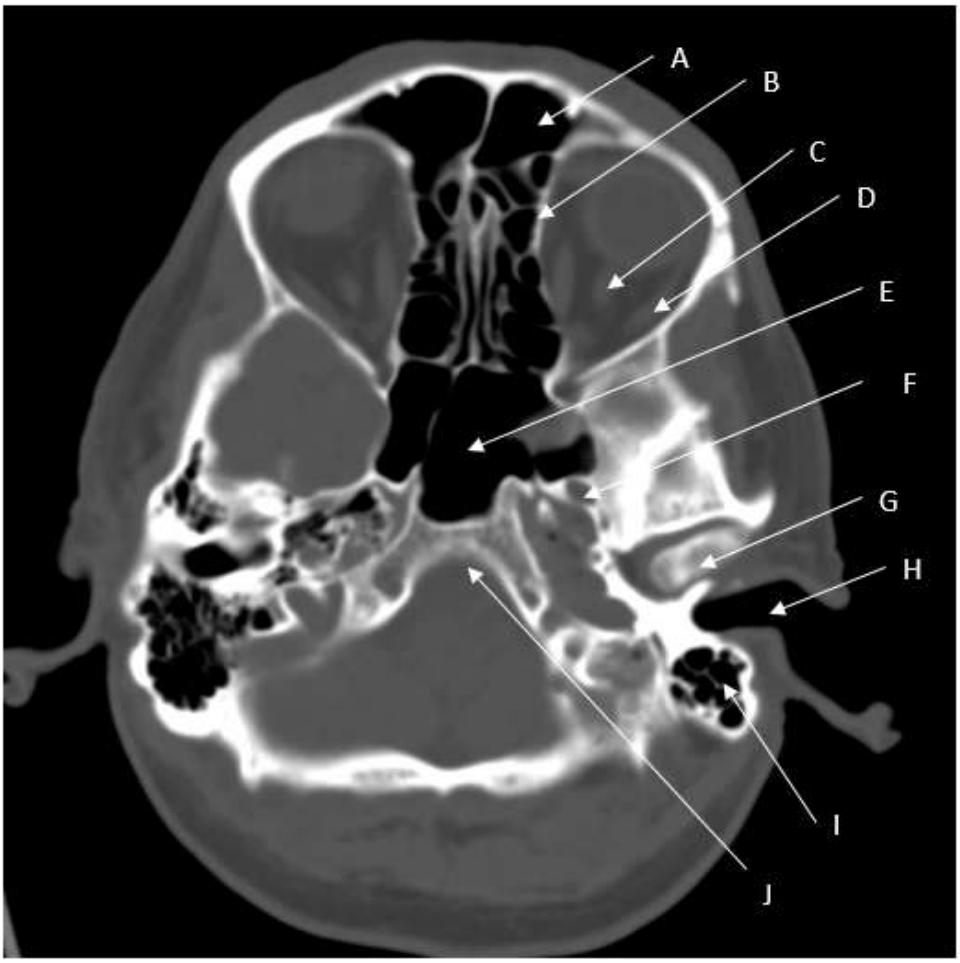
Question 10

ANA

a. Describe the relations of the maxillary sinus. **(4 marks)**

b. Name the structures labelled A to J on the CT slice below. **(2 marks)**

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



Question 10 cont

RCB

a. State the formula for the linear-quadratic (LQ) model of cell kill. Include a definition of each term in the equation. **(2 marks)**

b. Briefly explain SIX (6) potential limitations of the LQ model in clinical use. **(3 marks)**

c. State the α/β values typically used when considering: **(1 mark)**

i. Early responding tissues

ii. Late responding tissues

PATH

a. Describe the role of IHC in histopathological assessment of tumour tissue. **(1 mark)**

b. Briefly describe the steps in the process of immunohistochemical (IHC) staining using the indirect method. **(1 mark)**

Question 10 cont

PHY

Low dose rate (LDR) brachytherapy is an effective treatment for early stage prostate carcinoma.

a. Using a table compare iodine-125 (^{125}I) and palladium-103 (^{103}Pd) in terms of: **(3 marks)**

i. Spectra and energy of radiation emitted

ii. Physical half-life

iii. Specific activity

b. Explain how the physical properties of ^{125}I seeds make them a suitable sealed source for prostate brachytherapy. **(3 marks)**