CHAPTER 19

# X-rays, CAT and endoscopy

## Answers to revision questions

1. (a) The EMR (electromagnetic radiation) spectrum is a family of different types of electromagnetic radiation with different frequency ranges and hence different physical properties.

   (b) X-rays are positioned at the high frequency end of the EMR spectrum, between UV and gamma rays.

2. (a) Hard X-rays refer to X-rays that have higher frequencies. Soft X-rays are X-rays that have lower frequencies.

   (b) Hard X-rays are more penetrative and produce higher resolution images due to their higher frequencies and therefore are preferred for medical imaging.

3. X-rays used for medical imaging are produced in an X-ray tube. The X-rays are created either via the conversion of electrons' kinetic energy as they strike the anode, known as bremsstrahlung radiation, or ionisation of the atoms that constitute the anode, known as characteristic radiation.

4. The principle of X-ray imaging is that as the X-rays pass through the body, they are attenuated by the tissues in the body differently. They then expose the X-ray film to create a shadow of the target organs.

5. (a) After a fall, a fracture of the elbow may be suspected. The purpose of ordering the X-ray was to examine the bones around the elbow to look for fractures. X-rays can produce high-resolution images of the bone. They are the investigation of choice for assessing fractures.

   (b) Ultrasound scans are not useful for bone pathologies. However, they may be ordered later if the X-ray images show negative findings, in order to assess soft tissue injuries around the elbow.

6. Many pathologies will show up clearly on a chest film as they disrupt the normal aeration of the lungs. One of them is lung infection (pneumonia), which is what the doctors should be looking for in this case.

7. See Chapter 19.

8. CT scans use a computer to re-analyse the attenuated X-rays as they pass through the body and use these data to electronically reconstruct the images of the target organs. Since CT scans rely on computer reconstructions, they are more sensitive in distinguishing small differences in the attenuation of the X-rays, hence allowing differentiation of different types of soft tissue organs. Soft tissues are not well differentiated on plain X-ray films.

9. See Chapter 19. The answer should include the production and transmission of the X-rays inside the gantry, the rotation of the X-ray tube, and the detector and the movement of the bed, as well as the computed reconstruction of the images from the X-ray attenuation data.

**10.** (a) Brain tumour.

(b) The brain and its pathologies can be visualised well by CT because its computer system is able to analysis the small differences in the attenuation of the X-rays as they pass through the brain substances. These differences are otherwise too small to be differentiated on the plain X-ray film. Furthermore, for X-ray imaging, most of the incident X-rays will be blocked by the skull bone. Therefore the skull bone will overshadow the brain, making the brain difficult to see on the X-ray film.

(c) No, the adult brain cannot be visualised by using ultrasound. This is because at the bone and tissue interface, significant amounts of ultrasound waves are reflected, leaving only a small proportion to reach the brain.

**11.** (a) CT scans can visualise soft tissues and intra-abdominal organs much better than X-ray imaging as a result of their computed image reconstruction using the X-ray attenuation data. CT abdominal scans can be performed without using a contrast medium, whereas contrast is essential for abdominal X-ray. Nevertheless, the visualisation of certain organs or certain diseases can be further enhanced by using the contrast medium.

(b) Ultrasound may be used for diagnosing intra-abdominal pathologies in a limited number of clinical settings. Ultrasound is good for detecting gallstones. Ultrasound may also be used to assess the size of liver, spleen and kidneys. However, due to its low resolution and poor penetrating power, it does not produce quality images of the abdominal organs.

**12.** (a) (i) Detecting lung pathologies such as malignancies.

(ii) Detecting muscle tears as well as tendon or ligament ruptures.

(b) A CT scan exposes the patient to more X-rays than a plain X-ray film (approximately 40 times), and thus is more likely to do harm.

**13.** (a) Refraction occurs when light travels from one medium to another and the change in its speed as it is doing so is accompanied by a change in its direction. When light travels from a less dense medium to a denser medium, or when its speed reduces as it passes from one medium to another, its pathway bends towards the normal. The opposite happens when light travels from a denser medium to a less dense medium or when its speed increases.

(b) The critical angle is the size of the incident angle such that when refraction occurs, the angle of refraction is $90^{o}$ to the normal.

(c) Total internal reflection occurs when the incident angle is greater than the critical angle such that the angle of refraction now exceeds $90^{o}$. As a consequence, no light will enter the second medium and it is all reflected at the boundary back into the first medium.

**14.** See Chapter 19.

**15.** A coherent bundle is one in which the individual optical fibres are kept parallel to each other so that they are in the same relative positions at the ends. Therefore a coherent bundle is able to maintain the light pattern (image integrity) as the light travels through the fibres. An incoherent bundle is one in which individual optical fibres are randomly placed alongside each other so that the fibres are not in the same relative positions at the ends. An incoherent bundle distorts the light pattern.

**16.** (a) A colonoscope would allow a direct view of the bowel as well as biopsies of tissues if required. It is more accurate and reliable than CT in determining the extent of the cancer. Tissue biopsies will allow the doctors to determine the pathological nature of the cancer which will guide treatment.

(b) The air channel allows air to be pumped into the bowel to cause inflation so that the bowel can be examined more easily. Water can be pumped through the water channel to gently flush the bowel lumen to help with the examination.

(c) The instrument channel can be used to insert various instruments to perform small operations while the colonoscope is inside the bowel. The instruments include forceps, biopsy scissors, diathermy and many more.

**17.** See Chapter 19 for descriptions of the functions of different types of endoscopes.

**18.** (a) 'A key-hole surgery to remove the gall bladder' refers to removing the gall bladder under the view of a laparoscope using instruments inserted into the abdomen through very small cuts.

(b) The major advantages of performing key-hole surgeries are lower level of post-operative pain as well as faster recovery time.

**19.** Performing an endoscopic examination is invasive and carries risks.