CHAPTER 21

Magnetic resonance imaging (MRI)

Answers to revision questions

1. A carbon-12 nucleus has six protons and six neutrons – both its atomic number and atomic mass number are even numbers. Hence a carbon-12 nucleus has 0 net spin and no associated magnetic field. It does not respond to the external magnetic field and will not absorb or release radio waves, and hence does not contribute to MR image formation.
2. (a) There are more parallel alignments than anti-parallel alignments. At a magnetic field strength of 1.5 T, there is approximately one extra parallel alignment for every 100 million nuclei aligned.

   (b) Anti-parallel alignments have a slightly higher energy level compared to parallel alignments.

   (c) The parallel alignments can absorb externally applied pulses of radio waves to move into the anti-parallel alignments.

   (d) The hydrogen nuclei that have changed their alignments will later return to their original (parallel) alignments. They will re-emit the already absorbed radio waves and the returning radio waves can then be used for MR image reconstruction.
3. (a) Precession is the movement where the rotational axis of a spinning object revolves around another central axis.

   (b) MRI relies on the absorption and re-emission of radio waves by the aligned nuclei. Nuclei will only absorb radio waves if the radio wave frequency corresponds to their Larmor frequency; the Larmor frequency is the frequency at which the nuclei precess about the magnetic field lines.
4. Locating signals along the longitudinal axis of the body is achieved by the use of a gradient coil that produces a gradient magnetic field along the *z*-axis (the longitudinal axis of the body). This gradient magnetic field augments the main magnetic field to result in distinct Larmor frequencies for the hydrogen nuclei that situate at different locations along the *z*-axis of the body. Consequently, the re-emitted radio waves will have frequencies that are position specific.
5. - The hydrogen density.
   - T1 or T2 weighting.
   - The level of pre-saturation.
   - The use of a contrast agent.
6. (a) T1 relaxation is related to the returning of the M vector to its starting parallel position. T1 relaxation time is defined as the time taken for the M vector to return to 63% of its original value.

   (b) T2 relaxation is the loss of precession coherence of the nuclei which is accompanied by a reduction in the induced MR signals. T2 relaxation time is defined as the time for the nuclei to decay to 37% of their initial precession coherence.
7. To produce T1 weighted images, a short repetition time and a short echo delay time are used. Tissues with a short T1 will appear bright on T1 weighted images – for instance, fat tissues.

8. To produce T2 weighted images, a long repetition time and a long echo delay time are used. Tissues with a long T2 will show up bright – for example, free water.

9. (a) Strong magnet, radio frequency oscillator, radio receiver and powerful computer.

(b)
- The ability to produce very powerful magnetic fields and at the same time minimise the amount of energy loss as heat.
- Smaller in size.

(c) No unsecured metal objects should be allowed inside the scan room.

10. (a) MRI produces high-resolution images and has the ability to differentiate the grey matter from the white matter, and therefore is the investigation of choice for viewing the central nervous system. CT is inferior in terms of resolution and grey and white matter differentiation.

(b) MRI examinations are time-consuming.

(c) No, this is a contraindication for a MRI scan. The strong magnetic field of MRI will affect the pacemaker of the heart and hence the heart beats, which can be fatal.

(d) A negative MRI means that structural conditions of the central nervous system may be excluded. The next step is to look for functional pathologies. Simple investigations such as an EEG (electroencephalogram) may be ordered to study the brain activities. Ultimately, a functional brain scan, such as a PET scan, may be warranted.

11. (a) Yes. Although plain X-ray films cannot visualise soft tissues, such as a torn ligament, they are useful for excluding bone conditions associated with this injury. This includes fractures as well as malalignment of the knee joint due to its ligament disruption. (Note that the role of the ligaments is to stabilise the joint.)

(b) Ultrasound does not have the penetration to reach the deep structures of the knee. Furthermore, the low resolution and poor soft tissue contrast make the visualisation of the ligaments difficult.

12. MRA stands for magnetic resonance angiogram. It is a type of pulse sequencing used by MRI to selectively reconstruct blood vessels, therefore it is excellent for studying the vascular anatomy. Conditions of, or inside, the blood vessels such as thrombus, leakage, aneurysm or stenosis may be diagnosed.

13. See Chapter 21.

See also the *Higher verb questions* on this CD for support in constructing your answer.