VETERINARY RADIOGRAPHY

A Workbook for Students

Suzanne Easton

BUTTERWORTH HEINEMANN
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PREFACE

This workbook is aimed at individuals working towards the Royal College of Veterinary Surgeons' Certificate in Veterinary Nursing, but will hopefully be useful for other courses involving veterinary radiography. The workbook aims to provide a useful source of activities to help with revision and enhance learning during the initial course.

Each chapter has a variety of activities related to a certain aspect of radiography. Key points are provided to introduce the area and these are then supported by crosswords, puzzles, self-assessment questions, activities relating the topic to everyday practice, and general revision. The activities will also encourage exploration of the topic in greater detail to ensure that radiography can be applied to the clinical situation.

Thanks go to my husband Jake, Claire Cave, Lindsay Crane and Tracey Lear for their enthusiasm and support, and to the second year students of 2005 and Lois Daniels at Norton Radstock College for letting me try out the activities on them.

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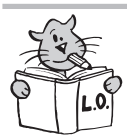
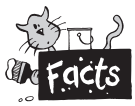
1

BASIC PHYSICS



LEARNING OBJECTIVES

- Atomic structure
- Periodic table
- Variations in atomic structure
- Current



FACTS ABOUT BASIC PHYSICS

- Every structure is made up of elements.
- Elements can join together to make compounds.
- The smallest particle of a compound is a molecule.
- The nucleus of the element contains protons and neutrons.
- Electrons orbit the nucleus in shells.
- The details of all elements are given in the periodic table.
- Electricity is generated when electrons flow through a conductor.

ATOMIC STRUCTURE

Key Points

- The number of electrons will equal the number of protons.
- The electrons fill the shells or orbits surrounding the nucleus.
- The shells will fill from the innermost point first then out towards the outer shells.
- Any odd electrons are found in the outer shell.
- Protons have a positive charge, electrons are negatively charged and neutrons are neutral.
- If there are more protons than electrons the atom will be positively charged; if there are more electrons it will be negatively charged.

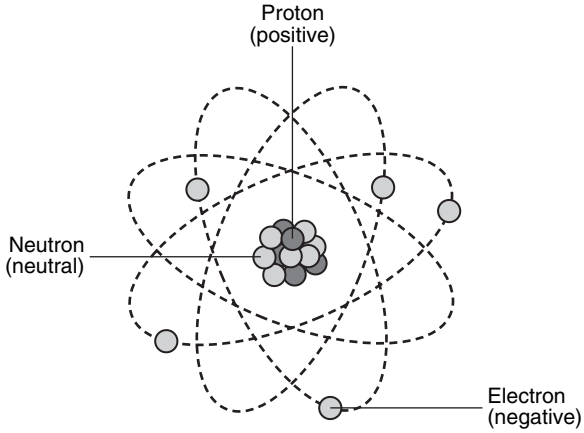


Figure 1.1 Diagram of an atom.

ACTIVITY

Exercise 1.1 The electron shells fill from the innermost point first. Each shell has a designated letter and a number of electrons essential to fill the shell. Using your knowledge complete the table.

Shell number	Shell symbol	Number of electrons
1	K	2
2	(b)	8
3	M	(d)
(a)	(c)	32

ACTIVITY

Exercise 1.2 Using the table completed for Exercise 1.1 draw in the missing electrons for the aluminium atom below. Aluminium has 13 electrons in its orbit.

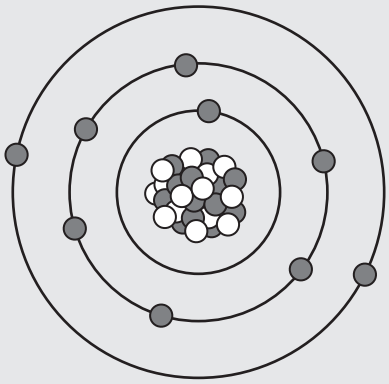


Figure 1.2 Diagram of an aluminium atom.

PERIODIC TABLE

Key Points

- The periodic table gives details of all elements.
- The table gives the chemical symbol of the element (X).
- (X) always starts with a capital letter and may have a second letter.
- The atomic number (Z) gives the number of protons.
- The mass number (A) describes the number of neutrons and protons in the atom.

Mass number — A

X — Chemical symbol

Atomic number — Z

ACTIVITY

Exercise 1.3 Identify the carbon, oxygen, barium and silver atoms below. State the number of protons, neutrons and electrons found in each element.

1	**2**	**3**	**4**
12	138	107	16
C	Ba	Ag	O
6	56	47	8

LOOK IT UP

Find a copy of the periodic table and identify as many elements as you can that are used in radiography. Where and why are they used?

VARIATIONS IN ATOMIC STRUCTURE

Key Points

- Electrons will always occupy the innermost shell first.
- Electrons in the outer shell will have less energy holding them in place than the inner electrons.
- Odd electrons will always fill the outer shells.
- Some atoms of the same element will have the same atomic number as each other but a different mass number and neutron number.
- These atoms are known as isotopes.

ACTIVITY

Exercise 1.4 Iodine is found in two forms, Iodine 127 and Iodine 131. Iodine 127 is normal iodine whereas iodine 131 emits radiation and is used in the treatment of thyroid cancer in cats.

Look at the details for the two forms and work out what the difference in electrons, protons and neutrons is for each.

1	**2**
127	131
I	I
53	53

CURRENT

Key Points

- Free electrons are the odd electrons in the outer shell, which is incomplete.
- These electrons will make the atom unstable.
- Insulators such as plastics have full outer shells and no free electrons.
- Conductors such as copper have incomplete outer shells.
- If a length of wire such as copper has a positive and negative charge applied, which is known as a potential difference, the free electrons will move around the wire.
- This will always be from the negative end to the positive end.
- This is how a current forms.

ACTIVITY

Exercise 1.5 On the diagram below show the direction of flow of the electrons within the wire.

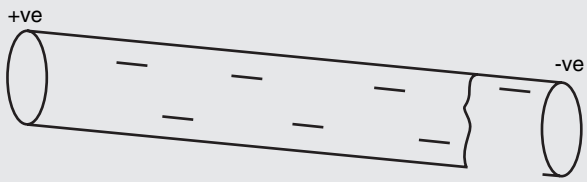


Figure 1.3 Flow of electrons within a wire.

GENERAL REVISION

Multiple Choice Questions

Exercise 1.6

1. The nucleus of an atom contains:
   a) protons and nucleons
   b) electrons and neutrons
   c) protons and neutrons
   d) electrons and protons.

2. The innermost shell of the atom contains a maximum of how many electrons:
   a) 1
   b) 2
   c) 4
   d) 8.

3. An atom with an incomplete outer shell is described as:
   a) reactive
   b) stable
   c) unstable
   d) negatively charged.

4. Metals are described as:
   a) conductors
   b) insulators
   c) charged
   d) isotopes.

5. A charged atom can be produced by:
   a) removing an electron
   b) adding an electron
   c) a) and b)
   d) neither a) nor b).

6. The difference between two isotopes of the same atom is the number of:
   a) neutrons
   b) protons
   c) photons
   d) electrons.

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2

ELECTROMAGNETIC SPECTRUM

LEARNING OBJECTIVES

- Electromagnetic spectrum
- Wavelengths and frequency
- Inverse square law
- Ionising radiation

FACTS ABOUT THE ELECTROMAGNETIC SPECTRUM

- The electromagnetic spectrum is made up of a range of energy forms.
- These forms all move at the speed of light.
- All these forms will move in a straight line.
- The wavelengths of these forms are all different.
- The inverse square law describes the relationship between the distance of the X-ray beam or energy source and the detector and the change in intensity.
- Ionising radiation is the term used to describe a radiation form that can remove an electron from an atom (X-rays and gamma (γ) rays).

ELECTROMAGNETIC SPECTRUM

Key Points

- The electromagnetic spectrum is made up of a range of energy forms.
- These forms have a range of wavelengths and frequencies.
- The electromagnetic spectrum ranges from cosmic rays and X-rays through visible light to microwaves and radio waves.
- These waves all move at the same speed; the difference is in their wavelengths and frequencies.

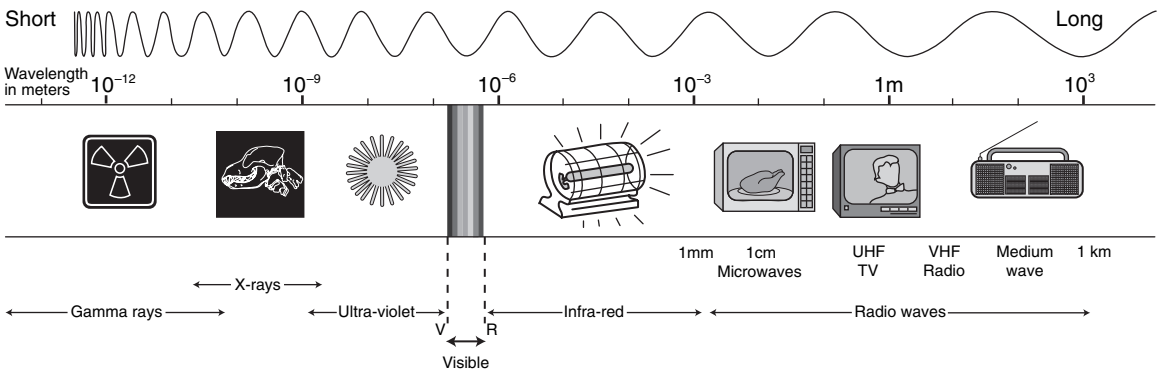
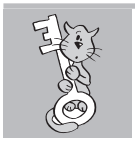


Figure 2.1 The electromagnetic spectrum.

ACTIVITY

Exercise 2.1 Put the following energy forms in order starting with the shortest wavelength first.

X-rays	Radio waves
Microwaves	Gamma rays
Infrared	Cosmic rays
Ultraviolet	Visible light



WAVELENGTHS AND FREQUENCY

Key Points

- The wavelength is the distance between any two consecutive peaks formed during the movement of a wave.
- The frequency is the number of cycles passing a fixed point per second.
- This is measured in hertz.
- The smaller the wavelength the higher the frequency or energy of the wave.

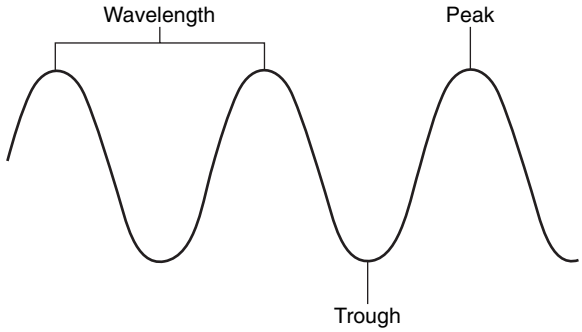


Figure 2.2 Wavelength.

FILL IN THE GAPS

Exercise 2.2

A (1)_____ wave has a long wavelength and a (2)_____ frequency.

X-rays have a (3)_____ wavelength and a (4)_____ frequency.

X-rays that have a short wavelength will (5)_____ more easily than those with a (6)_____ wavelength.

INVERSE SQUARE LAW

Key Points

- The greater the distance between the source and the patient or film the lower the intensity of the primary beam.
- As the distance between the source and the patient increases, the intensity of the primary beam decreases, but the size of the primary beam coverage increases.
- Decrease the distance and the size of beam coverage decreases but the intensity increases.
- This is important in radiation safety.

ACTIVITY

Exercise 2.3 Think about what happens to the intensity and size of the beam from a torch when it is shone against a wall. As you move towards the wall and away from the wall, what happens to the intensity and size of the light beam? How does this relate to the inverse square law?

IONISING RADIATION

Key Points

- Ionising radiation describes a type of radiation that is able to remove an electron from an atom.
- In radiography, these types of radiation are X-rays and gamma rays.
- The process of removing the electron from the atom is known as ionisation.
- Ionisation requires energy.
- The energy of an X-ray is known as a photon of energy.

LINK THE WORDS

Exercise 2.4 Match the words in the first column with the definitions in the right column.

Photon	The distance between two peaks of a wave
Ionisation	The number of wavelengths passing a set point per second
Excitation	Package of X-ray energy
Electromagnetic spectrum	Removal of an electron from an atom
Wavelength	Collection of energy types that all move in waves
Frequency	Movement of an electron from one energy level to another

GENERAL REVISION

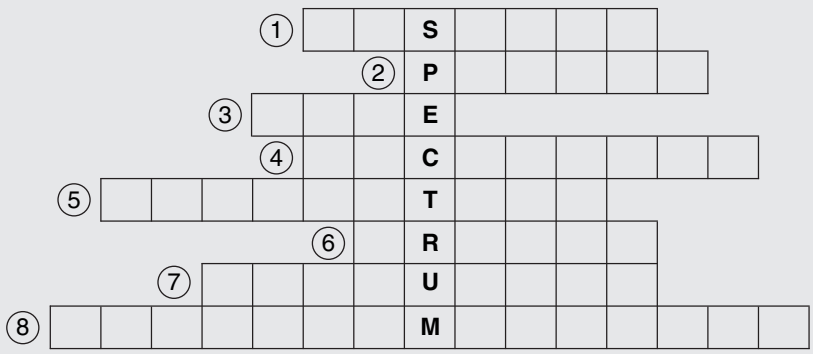
True or False?

Exercise 2.5

1. Visible light is part of the electromagnetic spectrum.
2. X-rays have a longer wavelength than gamma rays.
3. The light and heat energy given off from an electric heater are not part of the electromagnetic spectrum.
4. The wavelength is the number of cycles of energy per second past a fixed point.
5. A package of energy is known as a proton.
6. The removal of an electron from an atom is called ionisation.
7. If the source of radiation is moved closer to the patient the intensity of radiation reaching the patient is decreased.
8. Laser lights are part of the electromagnetic spectrum.

WORD CHART

Exercise 2.6



Clues

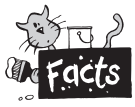
1. Energy from the electromagnetic spectrum that we use to see everything with.
2. A package of X-ray energy.
3. Movement of energy.
4. Used for cooking fast food.
5. Removal of an electron from an atom.
6. Bottom part of an energy wave.
7. Measurement of the movement of a wave.
8. Spectrum containing cosmic rays.

3

X-RAY TUBE

LEARNING OBJECTIVES

- X-ray tube
- Cathode
- Focussing cup
- Anode
- Tube surround



FACTS ABOUT THE X-RAY TUBE

- The X-ray tube consists of the cathode and anode.
- The cathode is negatively charged and the anode is positive.
- The cathode and anode are supported in a glass tube containing a vacuum.
- The cathode produces electrons.
- The anode is where the X-rays are produced.
- A small glass window allows the X-rays to exit the X-ray tube.

X-RAY TUBE

Key Points

- High-tension cables provide the electric supply at either end of the X-ray tube.
- Timers are present to ensure the exposure time is correct and controlled.
- A mains voltage compensator prevents fluctuations in the power supply to the tube.
- Interlocks prevent an exposure being made if there is a chance of damage to the tube.

ACTIVITY

Exercise 3.1 In the diagram below, name the parts of the X-ray tube that are related to electrical supply and safety.

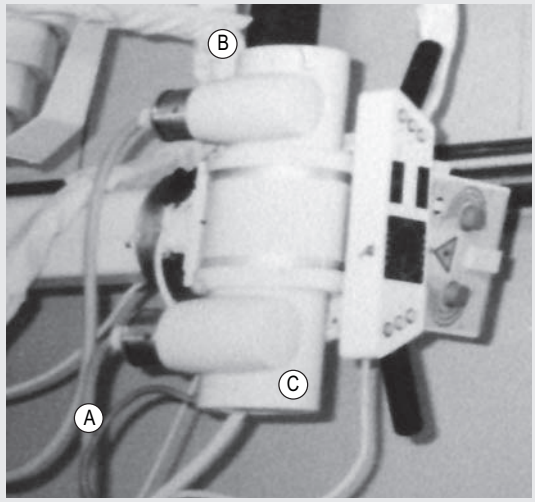
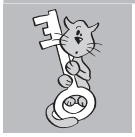


Figure 3.1 An X-ray tube.



CATHODE

Key Points

- The cathode is a small wire made of tungsten.
- The cathode produces electrons when it is heated.
- The number of electrons produced will depend on the milliamperes (mA) applied.
- The higher the mA, the hotter the cathode becomes and therefore the more electrons produced.

STUDY

Some X-ray tubes have two filament wires at the cathode. Find out why some machines have two filament wires and what the benefits may be.

FOCUSSING CUP

Key Points

- The focussing cup surrounds the cathode.
- As electrons move towards the anode they will diverge.
- This gives a large area of electrons striking the anode, which is not ideal.
- The focussing cup is negatively charged and will make the electrons flow in a tight stream towards the anode.
- This ensures that the electrons strike one very small spot on the anode.

ACTIVITY

Exercise 3.2 The diagrams below show a cathode without the focussing cup and a cathode with a focussing cup. Draw the path of the electrons from the cathode to the anode on both diagrams to show the effect of the focussing cup on the electron divergence.

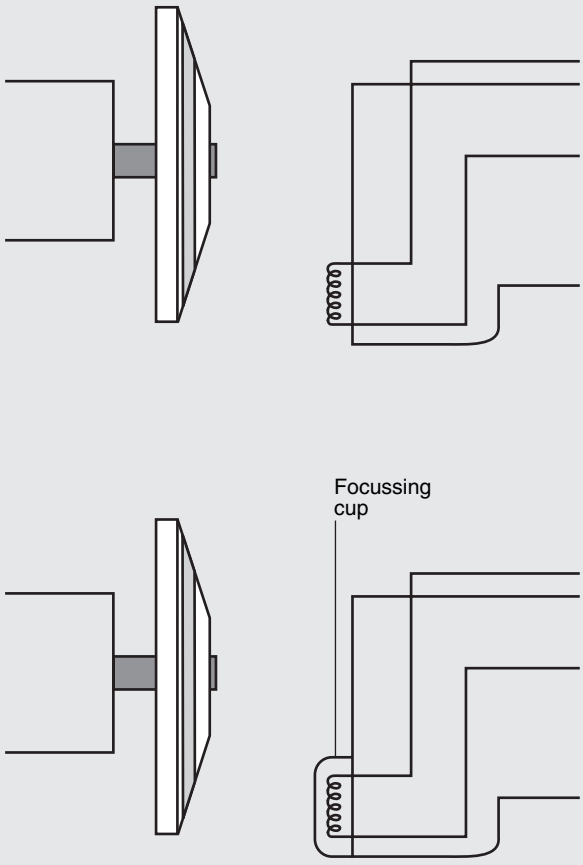


Figure 3.2 A cathode without a focussing cup (A) and with a focussing cup (B). (Adapted with permission from Bushong 1997 Radiological Science for the Technologist, 6th edn. Mosby Inc, St Louis)

ANODE

Key Points

- The anode is also known as the target.
- This is where the electrons strike.
- It is made of tungsten embedded in copper with a molybdenum stem.
- The tungsten is in a disk around the edge of the anode.
- The anode rotates to minimise the number of electrons striking one spot and causing damage.

FILL IN THE GAPS

Exercise 3.3

The anode of the X-ray tube (1)_____. This ensures that the (2)_____ strike a point that is always changing. This prevents the anode from (3)_____. If electrons strike the (4)_____ spot all the time the surface can be damaged. This is known as (5)_____. The target is made from (6)_____ embedded in (7)_____, which is supported on a (8)_____ stem. To reduce heat further the anode is (9)_____. This (10)_____ the area that the electrons can strike while keeping the spot where the (11)_____ strike to a (12)_____.

TUBE SURROUND

Key Points

- The cathode and anode are encased in a glass tube.
- A layer of oil to remove heat from the tube surrounds this glass tube.
- As the oil heats it compresses a set of bellows, which will prevent exposure being made if the tube is too hot.
- The tube also has a layer of lead that allows only useful X-rays to leave the tube.
- All of this is encased in an aluminium shell.
- All layers have a small window called the tube port to let the useful beam exit the tube.

ACTIVITY

Exercise 3.4 The diagram below shows the layers of the X-ray tube surround. Name the layers.

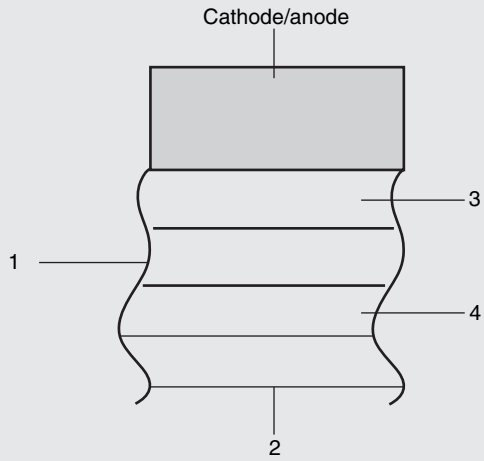


Figure 3.3 Layers within the tube casing that surrounds the vacuum containing the cathode and the anode.

GENERAL REVISION

Exercise 3.5 In the diagram below, name all the parts of the X-ray tube. Write a statement about each part.

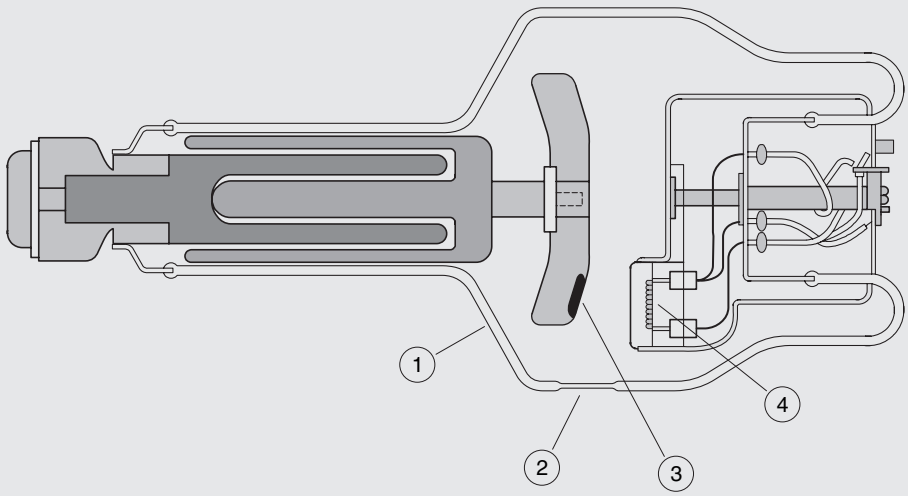
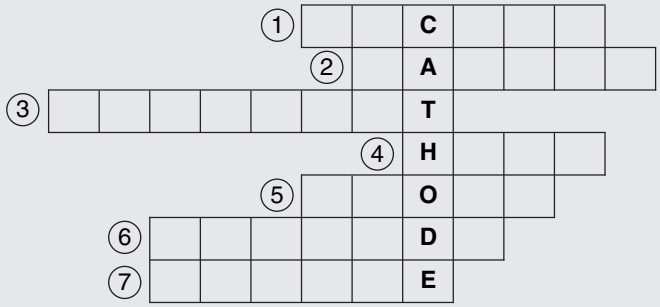


Figure 3.4 An X-ray tube. (Adapted with permission from Bushong 1997 Radiological Science for the Technologist, 6th edn. Mosby Inc, St Louis)

WORD CHART

Exercise 3.6



Clues

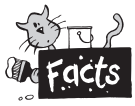
1. This is present in the glass tube.
2. This is where the electrons strike.
3. This is where electrons are produced.
4. Lots of this is produced in the X-ray tube.
5. This is supported on a molybdenum stem.
6. This is the negative part of the X-ray tube.
7. The anode does this.

4

X-RAY PRODUCTION

LEARNING OBJECTIVES

- X-ray production
- Interactions
- Attenuation



FACTS ABOUT X-RAY PRODUCTION

- X-rays are produced at the anode as the electrons strike the target.
- 99% of the energy is converted to heat and 1% is converted to X-rays.
- The X-rays produced at the anode have specific characteristics determined by the tungsten in the target.
- This is known as characteristic radiation.
- When X-rays interact with atoms they can cause luminescence, biological effects and photographic effects.
- Some X-rays will be scattered and some will be absorbed.
- The combination of scatter and absorption is known as attenuation.

X-RAY PRODUCTION

Key Points

- Electrons are formed at the cathode through the heating of the filament wire.
- The milliampere (mA) selected will heat the wire.
- The electrons are collected in the focussing cup.
- A potential difference is applied between the anode and cathode.
- The electrons are accelerated towards the anode.
- As the electrons collide with the anode they are converted to heat (99%) and X-rays (1%).

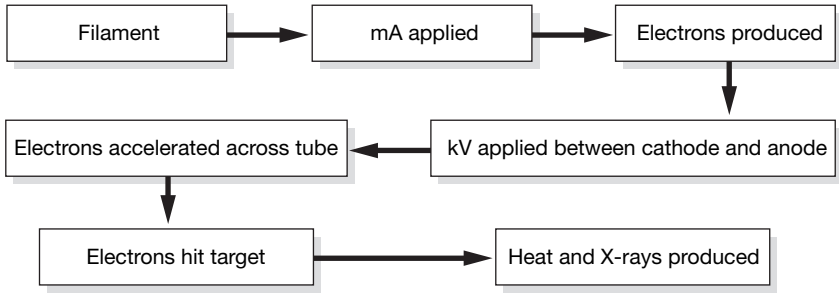


Figure 4.1 The production of X-rays.

ACTIVITY

Exercise 4.1 Using the flow diagram in Figure 4.1, copy the stages, cut them out and see if you can put them back in the correct order. Use this as a quick revision test.

INTERACTIONS

Key Points

- Low energy X-rays will interact with atoms, medium energy X-rays with electrons and high energy X-rays with the nucleus.
- X-rays may interact with the outer shell electrons of the tissues and cause ionisation. This results in the production of scattered radiation.
- X-rays can be totally absorbed if they interact with the electrons in the inner shells.
- As the kilovoltage (kV) increases this is less likely to happen as the X-ray will penetrate the tissue and not be absorbed.

STUDY

Look at an X-ray and work out the areas where the primary beam has been absorbed and scattered. What effects do these interactions have on the quality of your radiograph?

ATTENUATION

Key Points

- Attenuation describes the changes that interactions make on the primary beam.
- This is made up of the absorption of the beam within the patient and the amount of scatter.
- If there is lots of scatter and absorption there will be a small amount of the primary beam left to reach the film and attenuation is described as high.

Attenuation = absorption + scatter

FILL IN THE GAPS

Exercise 4.2

As the (1)_____beam passes through the patient it will interact in some way with the (2)_____ present. If the atoms have a (3)_____atomic number or (4)_____ the X-ray may pass straight through with (5)_____ interactions. This will cause (6)_____ on the film. This occurs when an X-ray passes through a (7)_____ area of (8)_____. If an X-ray passes through tissue with a higher density or atomic number it will interact either by being totally (9)_____ or being (10)_____. As (11)_____ interactions occur within the patient the (12)_____ of the tissues will (13)_____. (14)_____ radiation will occur when the X-ray interacts with the (15)_____ in the (16)_____ shell of the atom. (17)_____ will occur if the X-ray interacts with the (18)_____ shell electrons. (19)_____will have high attenuation compared to (20)_____ with lower attenuation.

GENERAL REVISION

Multiple Choice Questions

Exercise 4.3

1. The production of X-rays results in 1% X-rays and 99%:
   a) electrons
   b) heat
   c) interactions
   d) ionisation.

2. As the mA increases so does the number of electrons produced at which part of the tube:
   a) anode
   b) cathode
   c) vacuum
   d) target.

3. A vacuum is present to prevent:
   a) scatter
   b) absorption
   c) damage to the tube
   d) interactions in an incorrect place.

4. As the electrons reach the target, they produce X-rays by:
   a) absorption
   b) scatter
   c) sudden braking
   d) heating.

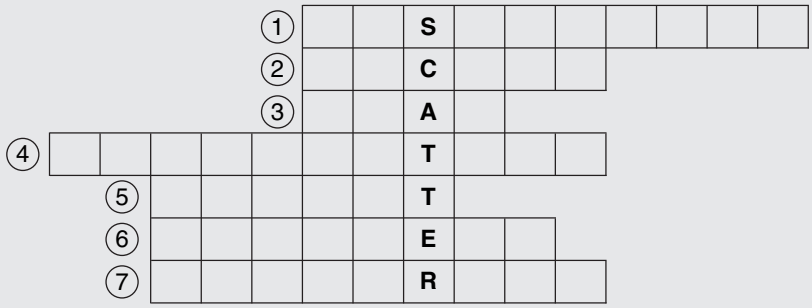
5. As the density of a tissue increases, the amount of scatter produced:
   a) increases
   b) stays the same
   c) decreases
   d) doubles.

6. An X-ray that interacts with an inner electron will produce:
   a) scatter
   b) attenuation
   c) absorption
   d) luminescence.

7. When compared with bone, the attenuation of lung tissue is:
   a) higher
   b) lower
   c) similar
   d) identical.

WORD CHART

Exercise 4.4



Clues

1. When an X-ray interacts with an inner electron.
2. Prevent unwanted interactions occurring in the X-ray tube.
3. Produced at the same time as X-rays.
4. Composed of scatter and absorption.
5. Area on anode where X-rays are made.
6. Part of tube where electrons are made.
7. Produced when the cathode is heated.

5

EXPOSURE FACTORS

LEARNING OBJECTIVES

- Effects of exposure factors
- Distance alteration
- Milliampere (mA) alteration
- Kilovoltage (kV) alteration
- Other factors affecting the image
- Exposure charts

FACTS ABOUT EXPOSURE FACTORS

- Exposure factors will need altering to accommodate different sizes between species, breeds and ages.
- An image must be produced that shows all the relevant areas with adequate contrast and density to be diagnostic.
- The mA needs to be as high as possible to keep time minimal, reducing the time period that a patient could move.
- Distance should be kept constant with alteration only being necessary when a new examination table or X-ray machine is introduced.
- Exposure charts are essential to ensure reproducible exposure factors, increasing radiation safety.

EFFECTS OF EXPOSURE FACTORS

Key Points

- The kV is the voltage applied across the tube.
- The kV controls the penetrating power of the primary beam.
- The kV will affect the contrast of the radiograph.
- The mA is the amount of current applied to the filament.
- The mA controls the number of electrons produced and therefore the number of X-rays produced.
- This will determine the density of the resultant image; if the mA is high more electrons will be produced at the cathode.

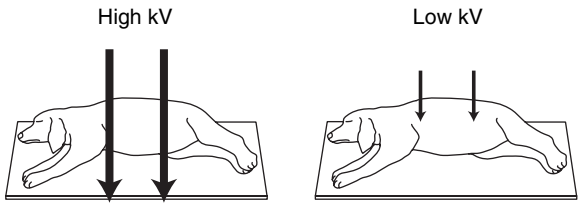


Figure 5.1 The effect of kV.

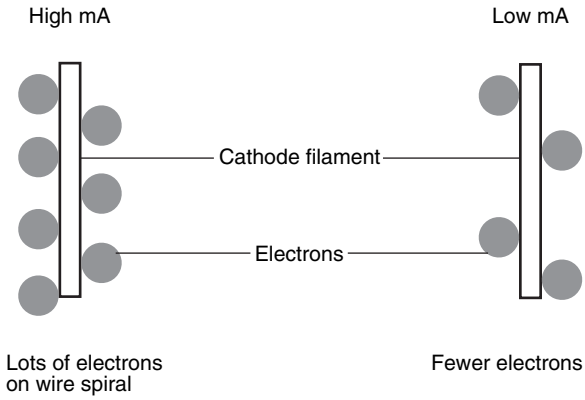


Figure 5.2 Changes to the number of electrons produced at the cathode with alteration of the mA.

- The time over which the exposure will occur can be altered.
- This will also control the quantity of X-rays produced.
- The time should be kept to a minimum to prevent movement, causing blurring of the image.
- The effect of the exposure is calculated using mA × time (mAs).
- If the mAs is doubled the exposure is doubled.
- The inverse square law controls the changes in exposure caused by alterations in distance.
- If the distance from the tube to the object is increased slightly, the overall exposure to the film will decrease greatly.

LINK THE EFFECTS

Exercise 5.1

kV	Density
mA	Intensity of beam reaching the patient Penetrating power
Time	The number of X-rays produced Density
Distance	Penetrating power Contrast

ALTERING THE DISTANCE (FOCAL-FILM DISTANCE)

Key Points

- The focal-film distance (FFD) is the distance from the focal spot of the X-ray tube to the film.
- This distance should remain constant during all radiographic examinations.
- If this distance is altered, the inverse square law can be applied.

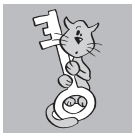
- As the distance decreases, the number of X-rays reaching the patient with suitable energy increases.
- To compensate for this the mAs needs to be decreased, lowering the number of electrons produced.

$$\text{Old mAs} \times \frac{\text{new distance}^2}{\text{old distance}^2} = \text{new mAs}$$

CALCULATE THE mAs

Exercise 5.2

1. What will be the new mAs if the FFD is changed from 75 cm to 100 cm and the original mAs was 25?
2. What will be the new mAs if the FFD is changed from 75 cm to 90 cm and the original mAs was 30?



ALTERING THE mAs

Key Points

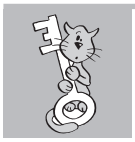
- The mAs is the milliamperes applied to the tube multiplied by the time that this takes place.
- In the ideal world the mA should be as high as possible with a short time.
- This will reduce movement blur from respiration or movement from the animal.

$$\text{mAs} = \text{mA} \times \text{time (seconds)}$$

CALCULATE THE mAs

Exercise 5.3

1. If the mA is 60 and the time is 0.5 seconds, what mAs is being used?
2. If an mA of 20 and a time of 0.2 seconds are used to radiograph a dog carpus with a kV of 53, what exposure factors are used?



ALTERING THE kV

Key Points

- Alteration in the kV will alter the penetrating power of the primary beam.
- From a starting exposure, increasing the kV by 10 will require half the original mAs to give a radiograph of similar density.

60 kV	4 mAs	70 kV	2 mAs
80 kV	1 mAs	90 kV	0.5 mAs

FILL IN THE GAPS

Exercise 5.4 If the starting exposure is 80 kV and 4 mAs, what will the exposure factors be to produce a similar image?

80 kV	4 mAs
(1)____	2 mAs
100 kV	(2)____
(3)____	16 mAs

ALTERING OTHER FACTORS

Key Points

- As the part being radiographed increases in size, so the kV will need to increase to allow adequate penetration.
- If a grid is used the mAs should be multiplied by the grid factor (given on the grid) to compensate for the primary beam absorbed within the grid.

mAs with grid = old mAs × grid factor

Wherever possible dressings should be removed, however the following acts as a guide:

Fibreglass/vet wrap and bandaging	1.5 × mAs
Plaster of Paris	2 × mAs
Wet plaster of Paris	4 × mAs

CALCULATE THE EXPOSURES NEEDED

Exercise 5.5

1. An exposure of 70 kV and 25 mAs is needed to radiograph a dog's chest without a grid at 100 cm. If a grid with a grid factor of 4 is used, what mAs and FFD is needed to produce a similar image?
2. You are asked to radiograph a cat's elbow following surgery and a vet wrap bandage has been applied. What exposures would be used if your original exposures were 45 kV and 8 mAs?
3. A radiograph is taken of a dog's abdomen using 55 kv and 12 mAs. If this was to be repeated using a grid, with a grid factor of 3, what mAs would now be needed to produce a diagnostic image?

EXPOSURE CHARTS

Key Points

- All exposures made should be recorded.
- A chart or book of suitable exposures should be kept to ensure exposures are kept to a minimum and repeats due to incorrect exposure are avoided.
- Charts should take into consideration the differences in breed, age and weight.

STUDY

Look at the exposure chart in your practice and see how the exposure factors vary from breed to breed and between species. If you do not have an exposure chart, start one to help yourself when working in the X-ray room.

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6

X-RAY FILM

LEARNING OBJECTIVES

- Film structure
- Types of film
- Film care
- Film speed and sensitivity

FACTS ABOUT X-RAY FILM

- There are two types of film – duplitised film which has two emulsion layers and single-sided film with one layer of emulsion.
- The film is made up of a number of layers:
  - film base
  - subbing layer
  - emulsion
  - supercoat
  - anti-halation/curl layer.
- Radiographic film may be used with intensifying screens and this type of film is called screen film. Other films must be used without intensifying screens and this film is known as non-screen film.
- Film should be stored in a dry, cool environment with no exposure to light, radiation or processing chemicals.
- A latent image is formed as the silver halide crystals react to radiation or light. When processed this latent image forms the visible image.
- Different types of film will react to different wavelengths of light and the crystals of some film emulsions will react more quickly to light or radiation. This is known as sensitivity and speed.

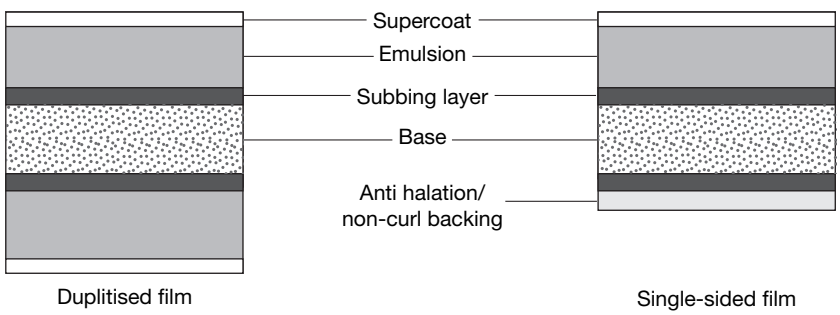


Figure 6.1 Cross-section through duplitised and single-sided emulsion film.

FILM STRUCTURE

Key Points

Film base

- The film base gives support for the emulsion.
- It is transparent to allow light to pass through.
- It maintains its shape despite changes in temperature and moisture levels.
- Polyester is usually chosen because it is:
  - strong
  - flexible
  - chemically inert.

Subbing layer

- The subbing layer is made of gelatine and a reactive ester salt.
- It forms an adhesive for the emulsion.
- It stops the emulsion becoming a sludge in the processor.

Emulsion

- Emulsion is an active part of the film.
- It is made of gelatine containing small crystals of silver halides.
- Gelatine can exist in a number of forms.
- It is liquid for application.
- It is semi-liquid during processing.
- Gelatine becomes hard and solid for storage.

Silver halide grains

- Silver halide grains are tabular or globular.
- Globular grains are monochromatic and are sensitive to blue light.
- Tabular grains are orthochromatic and are sensitive to blue or green light.
- The size of the grains will enhance image quality.
- They will react to light and radiation to form a latent image.

Supercoat

- The supercoat is a thin layer of gelatine.
- It provides protection for the film during processing.
- It is semi-matt to help the movement of the rollers in the processor.

Anti-halation/curl layer

- This only applies to single-sided film
- Processing of the film makes the emulsion swell.
- If there is only one emulsion layer the film will curl.
- This layer prevents the curl.

ACTIVITY

Copy the diagrams of single-sided and duplitised film in Figure 6.1. Cut them into layers and reassemble the layers. For each layer write a statement about the function.

LINK THE WORDS

Exercise 6.1

Film base	Made of gelatine
Subbing layer	Made of polyester
Emulsion	Stops the film from curling
Silver halide grains	Protects the emulsion
Supercoat	React with light and radiation
Anti-curl	Acts as an adhesive

EMULSION AND FILM TYPE

Key Points

- Single-sided film will have one layer of emulsion on the back of the film.
- Duplitised film will have emulsion on both sides of the base.
- Duplitised film is used with intensifying screens.
- The image is formed mainly as a result of the light emitted from the intensifying screen.
- Two screens will improve efficiency but single screens will give increased quality.
- Non-screen film uses a direct exposure and gives good detail but the increased exposure means it can only be used for dental and nasal radiography.
- Very high exposures are needed to form a diagnostic image.
- Radiation monitoring film uses a film similar to non-screen film and is designed to record exposure accurately.
- Polaroid film is used in the field mainly for equine work.
- It works in a similar way to conventional Polaroid photography.

WHAT AM I?

Exercise 6.2

1. I like to be exposed with just radiation. To make an image I need very high exposures. I like to go in the mouth of your patient.
2. I use light and radiation to form an image. I give good detail and am ideal for extremities and feline patients. I must be used the right way round otherwise there will be no image.
3. I can be used in a remote field. I give a picture that is the reverse of a normal radiograph. All you need is the special chemical pouch and the machine to squidge the chemicals over the film.
4. I am exposed mainly with light. I have emulsion on both sides of my base. I can be used for most radiography.

FILM CARE

Key Points

- The film should not be exposed to light, radiation or dampness before use.
- Film should be stored upright in the packaging until needed; there should be no direct pressure on the film.
- Orders should be made regularly in small amounts.
- The oldest film should always be used first and the expiry date should be checked.
- The film should be stored away from the X-ray room and away from the processing chemicals and the fumes they emit.

ACTIVITY

Exercise 6.3 Look at the following statements and decide what factor might be influencing the film.

1. This will cause the emulsion to swell and alter in consistency.
2. This will fog the film, causing a silver halide reaction.
3. This will fog the film in a similar way to light.
4. This will make the emulsion swell and absorb moisture.
5. This might cause a reaction similar to processing.
6. This might make the film appear grey and fogged.

FILM SPEED AND SENSITIVITY

Key Points

- Different films are sensitive to different colours of light from the spectrum and the colour is usually blue or green for radiographic film.
- This is controlled by the manufacturer who adds dye to alter the sensitivity of the film.
- Some films may be sensitive to all light including UV and red light.
- Film speed is the sensitivity of the film to light or radiation.
- This will be determined by the size and shape of the silver halide grains.
- Fast films require less exposure to give a similar image to that of a slow film.
- Fast films are ideal where a high exposure may be needed to provide a diagnostic image.
- Exposure factors will need to be adjusted depending on the film speed selected.

STUDY

Look at the films in your practice. Are they stored correctly? What is the speed and sensitivity of your film; if no one knows how could you find out? When do you use each of the film types that you stock?

GENERAL REVISION

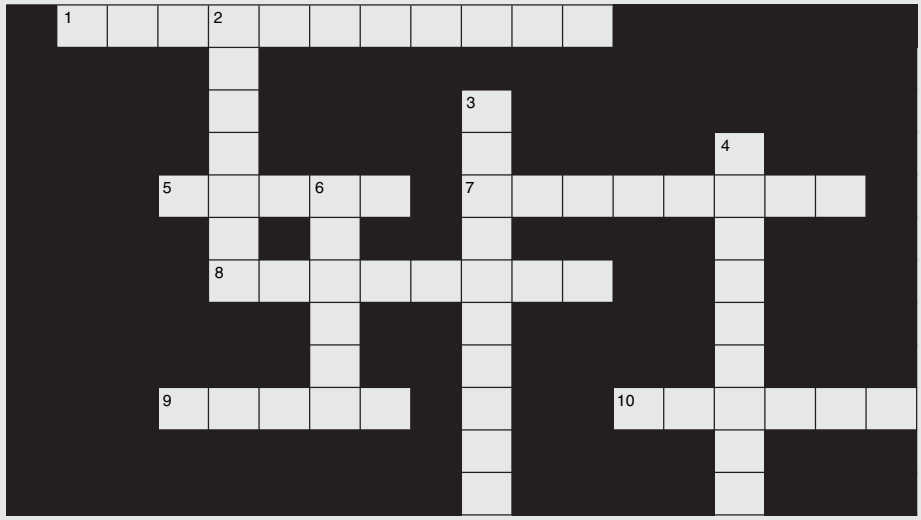
True or False

Exercise 6.4

1. X-ray film contains gelatine.
2. The subbing layer is found on both sides of single-sided film base.
3. Non-screen film can be used for extremities.
4. If X-ray film is stored in a box stacked in a pile, fogging may occur.
5. High humidity will cause the emulsion to swell and damage the film.
6. Green sensitive film will react to red light.
7. A fast film will require a lower exposure to produce a similar image to a slow film.
8. The silver halide grains react to form the latent image.
9. Film that has passed its expiry date should not be used.
10. Fogging is an overall grey appearance on the film before processing.

CROSSWORD

Exercise 6.5

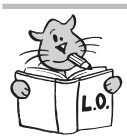


Clues

1. Film speed is determined by the _____ of the film to light and radiation.
2. Adhesive layer of film.
3. Film with two layers of emulsion.
4. Material used to form base.
5. Provides the majority of exposure on screen film.
6. Combined with silver to form the active part of the emulsion.
7. Film used without access to a conventional processor.
8. Material used to form the emulsion layer.
9. X-ray film is sensitive to blue and which other colour of light?
10. A film, which is exposed but not processed, has this type of image.

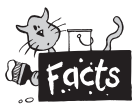
7

INTENSIFYING SCREENS, CASSETTES AND GRIDS



LEARNING OBJECTIVES

- Intensifying screens
- Film screen combinations
- Care of screens
- Cassette construction
- Grids



FACTS ABOUT INTENSIFYING SCREENS, CASSETTES AND GRIDS

- The intensifying screen is made up of four key components:
  - protective coating
  - phosphor layer
  - reflective layer
  - base.
- The phosphor crystals within the intensifying screen emit light when they are exposed to radiation.
- The light emitted forms the image on the film.
- The use of intensifying screens will reduce the exposure needed to form a diagnostic image.
- The cassette contains the screens and holds the film in contact with the screens.
- The cassette is hard wearing, light and liquid tight.
- Films and screens must be compatible.
- A grid is used to reduce the effects of scattered radiation.
- The grid will absorb lower energy X-rays while still allowing the primary beam to pass through to the film.

INTENSIFYING SCREENS

Key Points

- The intensifying screen has a reactive layer containing phosphor grains.
- These grains absorb radiation and emit light.
- This is known as fluorescence.
- The phosphor will emit hundreds of photons of light for each X-ray that it has contact with.
- The light given off reacts more easily with the X-ray film and provides an image for a lower amount of radiation.

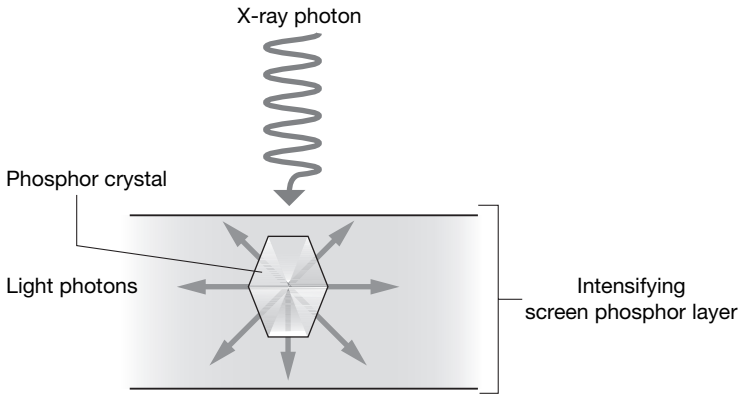


Figure 7.1 Luminescence.

LOOK IT UP

Find out more about fluorescence and how it can be used to reduce patient exposure.

FILM SCREEN COMBINATIONS AND SCREEN SPEED

Key Points

- Screen light emissions must match the sensitivity of the film.
- A film may be sensitive to either blue or green light and the screen emission must be selected appropriately.
- There are two types of screen types – rare earth and calcium tungstate.
- Rare earth screens emit green light and are suitable for most general radiographic work.
- Calcium tungstate screens emit blue light and are ideal for higher exposure examinations such as chests.
- Screens may be fast, medium or slow depending on the magnification of the exposure that can occur.
- Speed is altered by phosphor size, thickness of the phosphor layer or the presence of a reflective layer.

ACTIVITY

Exercise 7.1 For each of the examinations below select a film screen combination.

1. Dog chest
2. Dog abdomen
3. Dog skull
4. Cat chest
5. Tooth
6. Dog extremity
7. Dog pelvis
8. Cat skull
9. Cat extremity
10. Nasal chambers

Choice of combination:
Fast tungstate
Rare earth
Non-screen
Single screen

CARE OF INTENSIFYING SCREENS

Key Points

- Screens cannot be repaired and if one is damaged both will need to be replaced.
- Damage can occur with excessive dust, moisture and handling.
- Screens should be cleaned regularly and the date of each clean recorded.
  1. A soft cloth should be used, *not* cotton wool
  2. The cloth should be moistened with a little screen cleaner
  3. The screen should never become wet
  4. The screen should be wiped clean using a dry cloth or gauze
  5. The cassette should be left standing up and open to allow the screen time to dry.

ACTIVITY

Design a poster to show the stages involved in cleaning a screen. Put it up where screen cleaning takes place in your practice so that it can be performed correctly.

CASSETTES

Key Points

- The cassette contains the film and intensifying screens and protects both from damage and dust accumulation.
- The cassette will maintain film screen contact as well as preventing light reaching the film.
- The front of the cassette is made of a material that will not alter the X-ray beam passing into the cassette. This is usually carbon.
- The back is similar to the front but is lined with lead to prevent scatter.
- Closure must be good and the cassette is usually bowed slightly to ensure tight closure.
- Cassettes should be handled carefully; they are heavy and can be damaged if dropped.

ACTIVITY

Exercise 7.2 Look at the X-ray image below and think about what has happened to the cassette to cause this fault.

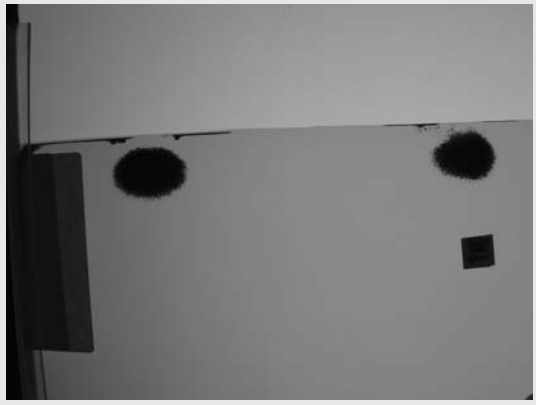


Figure 7.2 X-ray image.

GRIDS

Key Points

- A grid will absorb scattered radiation while still allowing the primary beam to pass through to form a latent image on the film.
- A grid is made up of four key components:
  - lead strips
  - radiolucent interspace
  - radiolucent protective cover
  - reinforced edge.
- The lead strips will absorb the scattered radiation and the radiolucent interspace will allow the primary beam to pass through.
- There are a number of different types of grid from the most basic which is a parallel grid through to the most expensive which is built into the X-ray table.

ACTIVITY

Exercise 7.3 Match the name of the grid to the correct diagram and description.

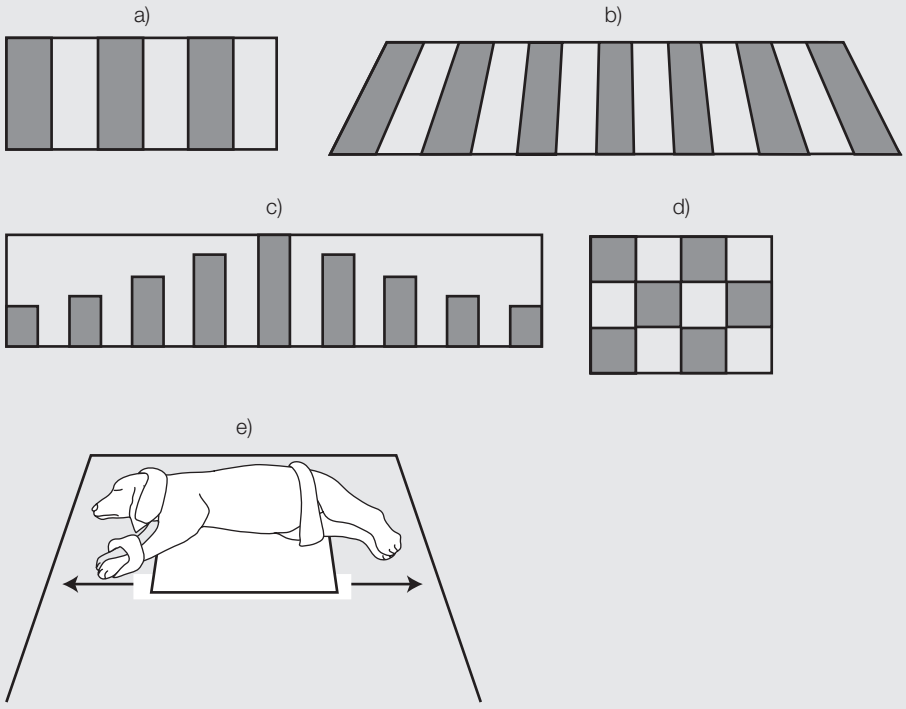


Figure 7.3 Grid types.

1. Parallel	Ideal for large animal work
2. Focussed	Grid of choice but expensive
3. Pseudo-focussed	Must be used at the correct FFD
4. Cross-hatched	Built into the X-ray table, moves to remove grid lines
5. Moving grids (Potter bucky)	Most versatile

GENERAL REVISION

Multiple Choice Questions

Exercise 7.4

1. The intensify screen is used to:
   a) increase film quality
   b) reduce patient dose
   c) replace X-rays
   d) convert electrons to light.

2. The position of an intensifying screen on a single screen cassette is:
   a) on the back
   b) on the front
   c) inside the back
   d) inside the front.

3. Intensifying screens should not be cleaned with:
   a) cotton wool
   b) lint-free gauze
   c) screen cleaner
   d) detergent.

4. A single screen cassette and film combination is ideal for:
   a) feline nasal chambers
   b) canine extremity
   c) canine chest
   d) canine shoulder.

5. Damage to a cassette corner will result in:
   a) film damage
   b) screen damage
   c) film fogging
   d) poor film screen contact.

6. Which type of grid moves to blur out the grid lines?
   a) parallel
   b) focussed
   c) Potter bucky
   d) cross-hatched.

WORD SEARCH

Exercise 7.5 Find 8 words in the grid below and then match them into pairs.

F	L	U	O	R	E	S	C	E	N	C	E
S	I	T	Y	U	B	C	G	G	G	A	N
B	U	C	K	Y	H	E	B	F	X	R	C
L	M	N	H	U	O	E	B	V	I	B	F
Y	F	D	S	E	W	N	C	D	D	O	F
C	A	S	S	E	T	T	E	O	Y	N	D
E	L	H	F	A	K	M	F	E	S	G	G
B	J	B	P	A	R	A	L	L	E	L	R
U	S	D	T	N	E	M	R	V	O	M	I
C	A	L	C	I	U	M	K	U	M	H	D
K	S	G	Y	H	W	C	D	D	G	V	N
Y	D	A	V	G	R	S	X	D	B	G	T
D	C	T	N	E	M	E	V	O	M	F	B
C	D	T	E	W	V	F	J	B	N	M	E
C	S	S	W	M	O	C	E	C	R	W	B
S	F	T	U	N	G	S	T	A	T	E	J
S	C	R	E	E	N	Y	P	F	D	C	A

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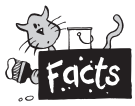
8

PROCESSING CYCLE

LEARNING OBJECTIVES

- Developer solution
- Fixer solution
- Washing and drying
- Precautions



FACTS ABOUT THE PROCESSING CYCLE

- There are four key stages to developing film:
  1. development
  2. fixing
  3. washing
  4. drying.
- Developer reduces the silver halide grains that have been exposed to metallic silver.
- Fixer stops the effects of the developer and removes the remaining silver halides.
- Unexposed crystals remain.
- The whole cycle is complete once the film has been washed in running water and dried.

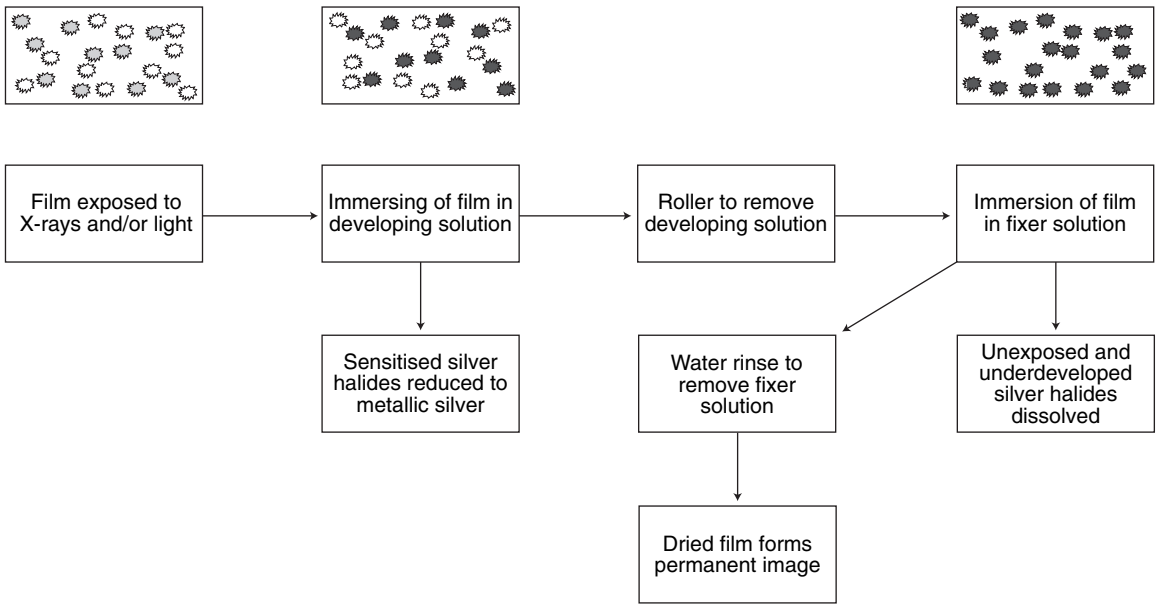
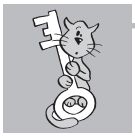


Figure 8.1 The processing cycle.

ACTIVITY

Exercise 8.1 Using the flow diagram in Figure 8.1, copy the stages, cut them out and see if you can put them back in the correct order. Use this as a quick revision test.



DEVELOPER

Key Points

- Silver halide grains are reduced to metallic silver.
- Unaffected silver halides will not change.
- Developer donates ions to the silver halide.
- If the film spends too long in the developer it might become fogged.
- Developer splashes before processing will always appear black on the processed radiograph.

Table 8.1 Components of developer and their functions

Component	Function
Solvent	Water. Allows chemicals to be soluble and penetrate the emulsion
Other additives	Hardener reduces swelling and allows softening of emulsion
	Fungicide prevents fungal growth
	Wetting agent stops bubbles and froth forming
Accelerator	Ensures the solution is alkali at pH 9.6–10
Preservative	Slows the oxidation of the developer
Restrainers	Makes the developer more accurate, preventing fogging
A buffer	Maintains the pH
Developing agents	The active part of the solution
Sequestering agent	Stops a build-up of sludge formed during the developing process

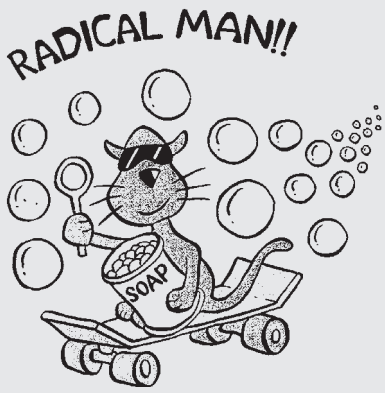
LINK THE WORDS

Exercise 8.1 In the table below, match the components of developer with the correct functions.

Component	Function
Solvent	Ensures the solution is alkali at pH 9.6–10
Other additives	Stops a build-up of sludge formed during the developing process
Accelerator	Maintains the pH
Preservative	Makes the developer more accurate, preventing fogging
Restrainers	Water. Allows chemicals to be soluble and penetrate the emulsion
A buffer	Slows the oxidation of the developer
Developing agents	Hardener reduces swelling and allows softening of emulsion
	Fungicide prevents fungal growth
	Wetting agent stops bubbles and froth forming
Sequestering agent	The active part of the solution

MNEMONIC

To remember what the contents of developer are, use 'SOAPRADS' (see the first letter of each component of developer in Table 8.1).



FIXER

Key Points

- Fixer stops the continuation of development.
- Acid stops the developer from working.
- Fixer removes silver halides from the emulsion.
- Unexposed crystals remain.
- Fixer hardens the film and protects it during washing, drying and storage.
- Pre-processing splashes of fixer will always appear white on processed radiographs.

STUDY

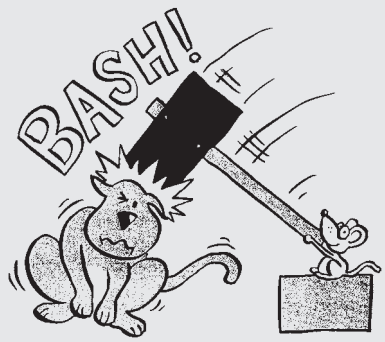
Find out why fixer has its distinctive smell. How does fixer actually work and why does it make white splash marks when spilt on X-ray film before processing?

Table 8.2 Components of fixer and their functions

Component	Function
Preservative	Stops fixer decomposing
Acidifier	Stops development
Fixing agents	Stop development and provide a permanent image
Buffer	Sodium acetate. Maintains pH within 0.2
Anti-sludging agent	Stops the products of the hardener forming a layer of sludge in the tank
Solvent	Water. Dissolves into emulsion taking processing chemicals with it
Hardener	Prevents damage to film and allows drying

MNEMONIC

To remember what the components of fixer are, use 'PAFBASH' (see the first letter of each component of fixer in Table 8.2).



WASHING AND DRYING

Key Points

- Water must be running.
- Water removes chemicals from the film surface.
- The final wash removes residue fixer and silver compounds.
- Film may turn the colour of sepia over time if not washed for long enough.
- Drying will remove surface water and water held in the emulsion.

PRECAUTIONS WHEN HANDLING PROCESSING CHEMICALS

Key Points

- The precautions for handling processing chemicals fall under Control of Substances Hazardous to Health (COSHH) guidelines.
- Processing chemicals can be harmful.
- Mask and gloves should be worn during processor cleaning and replenishment.
- The room around a processor should be well ventilated.
- Chemicals should be stored in the containers supplied by manufacturers.
- The chemicals should remain in these containers until placed in the processor.
- The containers should be disposed of carefully.
- They should not be kept and re-used.
- Chemistry should be returned to a recycling unit after use.
- Collection should be in specially provided containers and these should be returned when they are full.

GENERAL REVISION

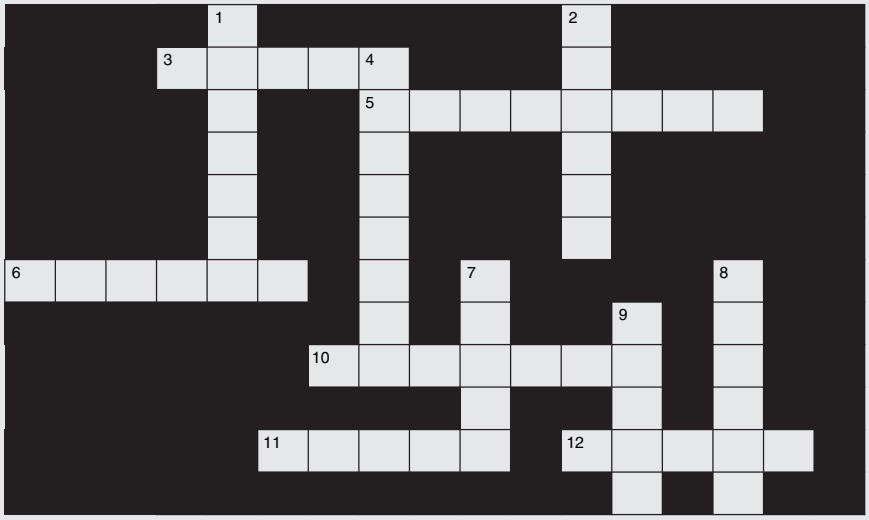
True or False

Exercise 8.3

1. Developer is acidic.
2. Developer splashes will appear black on a processed film.
3. Water is used as the solvent in processing because it is cheap.
4. Fixer contains sodium acetate.
5. Fixer provides protection for the film surface.
6. If the film is not developed for long enough it will appear a sepia colour.
7. Developer reduces the sensitised silver halides to bromine.
8. Over-washing can make the film brittle.
9. All processing chemicals should be recycled.
10. Protection should be worn when cleaning a processor.

CROSSWORD

Exercise 8.4



Clues

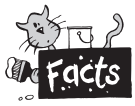
1. Too long in the developer will cause this.
2. This metal is formed through the reduction of silver halides.
3. The regulations adhered to when cleaning the processor.
4. This will ensure the emulsion is not damaged when handled.
5. pH of developer.
6. This can form during processing.
7. This dissolves the fixer solution and the by-products of processing.
8. Maintains alkalinity.
9. Inadequate washing will make the film change to this colour over time.
10. Too high a temperature will cause this effect.
11. This stops development.
12. A splash on a film is white – what has caused this?

9

PROCESSORS AND THE DARKROOM

LEARNING OBJECTIVES

- Manual processing
- Automatic processing
- Replenishment and silver recovery
- The darkroom
- Safelights



FACTS ABOUT PROCESSORS AND THE DARKROOM

- Manual and automatic processing involve placing the film into each of the tanks of developer, fixer and wash in turn for a set period of time.
- Manual processing is more time consuming than an automatic processor.
- The automatic processor will move the film from tank to tank.
- Chemicals used in processing should be replenished on a regular basis with a full change of chemistry every month.
- Processors should be cleaned regularly.

MANUAL PROCESSING

Key Points

- Manual processing is used when there is no automatic processing.
- It involves manual immersion of films into tanks of chemicals.
- It is more time consuming than automatic processing.
- The equipment needed includes tanks, film hangers, a thermometer, stirring rod, timer and protective clothing.

ACTIVITY

Exercise 9.1 Place the following stages of manual processing in order.

Place film into fixer solution
Move film to wash for 10 seconds
Film ready for storage
Film left to dry in a dust-free environment
Switch on safelights
Place film into film hanger
Leave film in solution for double the clearing time
Mix developer
Enter darkroom
Put film into developer and set timer
Film in to wash for 30 minutes
Switch off machine and cover developer
Expose film to light and radiation
Check developer temperature

AUTOMATIC PROCESSOR

Key Points

- The processor uses a series of rollers to carry the film through the tanks.
- The chemistry is pressed onto the emulsion as the film passes through the rollers.
- Excess chemistry is squeegeed off the films before the film passes into the next tank.
- The processor will be set up to provide a film with adequate time in all of the key stages.

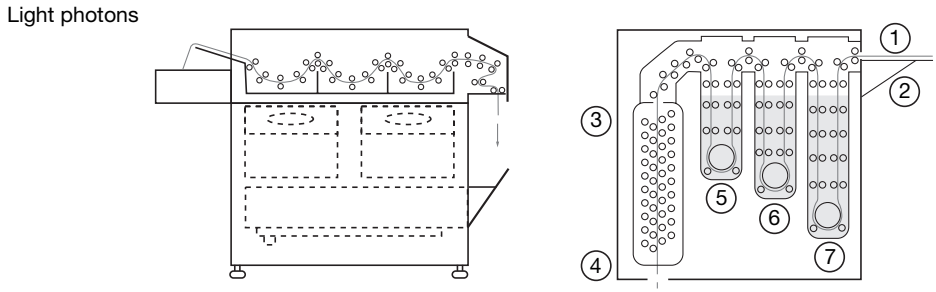
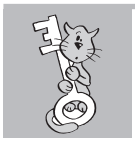


Figure 9.1 Processors. 1 Film entry; 2 feed tray; 3 dryer; 4 film exit; 5 wash; 6 fixer; 7 developer.

ACTIVITY

Take the lid off your processor and look inside. What do you see? Identify the tanks, the entry roller, the squeegee rollers and the dryer. Find out how your practice looks after your processor.



REPLENISHMENT AND SILVER RECOVERY

Key Points

- Replenishment is the removal of a small amount of tired chemistry and the introduction of an equal amount of fresh chemistry.
- This is triggered every time a new film enters the processor and ensures that chemistry is kept as fresh as possible.
- Total replenishment should occur every 4 weeks.
- Silver can be obtained from used fixer solution or old film.
- This is carried out by a specialised recycling company.
- Environmentally this should be encouraged.

THE DARKROOM

Key Points

- The darkroom is specifically designed for the processing and handling of radiographs.
- Space is essential to provide room for film handling.
- It should be easily accessible.
- It should be dry and warm (but not hot).
- It should be away from sources of radiation.
- It should have reliable ventilation.
- It should have an adequate source of fresh running water.

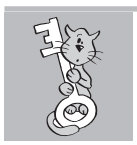
ACTIVITY

Exercise 9.2 Match the statement for darkroom design to the features.

Room dimensions	Removes any fumes present
Floors	Single door must be light tight and lockable from the inside
Walls and ceilings	Non-slip
Ventilation	Easily cleaned and maintained
Doors	Double doors are ideal, but need room
	Easy to keep clean
	Accidental entry must be avoided
	Light coloured
	Oil-based paint
	Non-porous
	Improves working environment
	Over-heating and high humidity will alter the way the chemicals function
	Adequate floor space
	If there is to be wet processing there should be a tiled splashback to allow cleaning
	Light coloured
	Minimum of 10 m^2
	Painted to reflect light

ACTIVITY

Look at your darkroom. Does it fulfil the criteria in Exercise 9.2?



SAFELIGHTS

Key Points

- A safelight prevents light affecting the film.
- It comprises a box containing a maximum 25 watt pearl light bulb.
- There should be a red filter over the bulb area.
- The filter is a layer of gelatine dyed to the correct colour and positioned between two sheets of glass.

ACTIVITY

Exercise 9.3 Look at the diagrams and colour in the arrows to represent the components of white light. Then colour in the arrows emerging after the light has passed through the safelight filter. Will the film be affected?

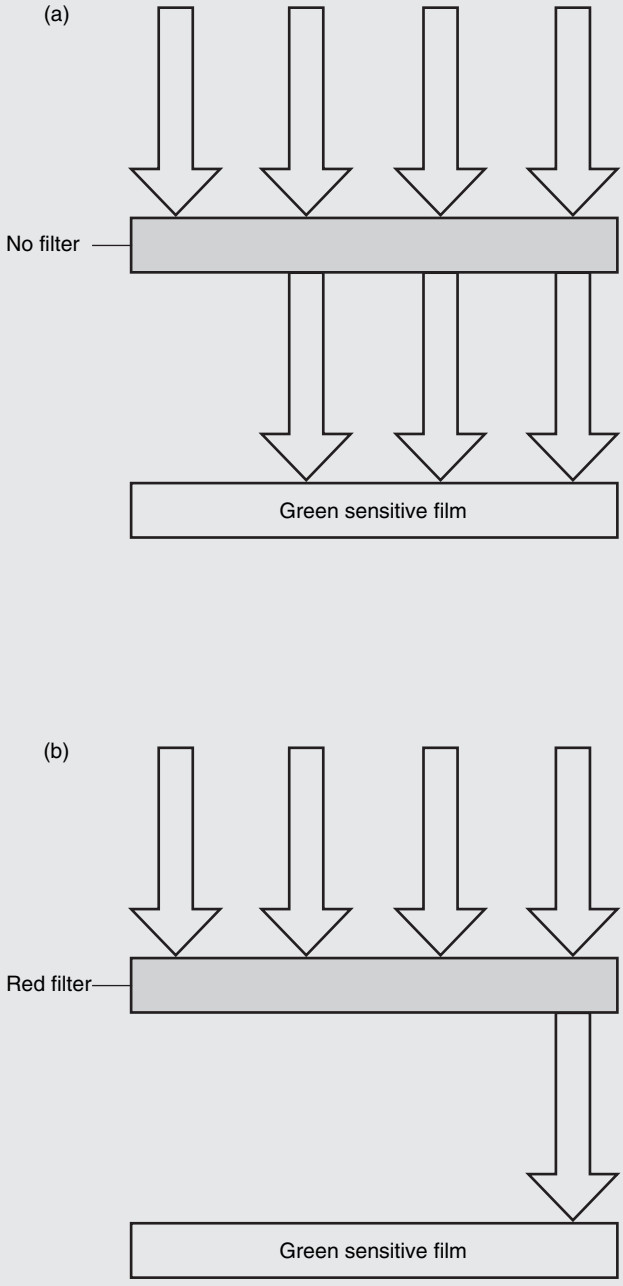


Figure 9.2 Safelight filters.

GENERAL REVISION

Multiple choice questions

Exercise 9.4

1. The first stage of processing is:
   a) fixing
   b) developing
   c) washing
   d) drying.

2. The wash tank in a manual processor:
   a) removes excess chemicals
   b) is the final stage of processing
   c) prevents contamination
   d) last for 20 minutes.

3. The darkroom walls must be painted with:
   a) emulsion
   b) paint for humid and damp environments
   c) specialist paint
   d) yellow paint.

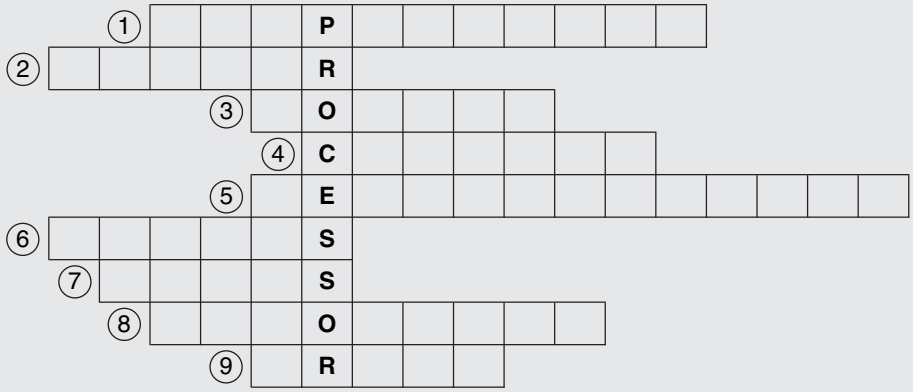
4. The safelight bulb must have a maximum wattage of:
   a) 15
   b) 25
   c) 30
   d) 60.

5. In manual processing a stirring rod is used to prevent:
   a) streaks from unmixed developer
   b) spots of fixer
   c) algae forming
   d) static formation.

6. When used with conventional X-ray film, safelight filters should be:
   a) green
   b) blue
   c) red
   d) yellow.

WORD CHART

Exercise 9.5



Clues

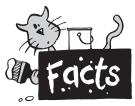
1. This must be at the correct level before processing starts.
2. This holds the film for manual processing.
3. This carries film from tank to tank.
4. This should reflect light.
5. Replacing chemicals on a constant schedule.
6. These should be non-porous and easily cleaned.
7. This holds the chemicals.
8. A processor that does the work for you.
9. The last part of the processor.

10

IMAGE QUALITY

LEARNING OBJECTIVES

- Density
- Contrast
- Factors affecting contrast and density
- Sharpness
- Magnification and distortion



FACTS ABOUT IMAGE QUALITY

- Density describes the amount of blackening on an X-ray film.
- Contrast describes the difference in blackening between adjacent structures.
- Sharpness is essential to ensure the radiograph is diagnostic.
- Magnification can occur if the object and film are not in close contact.
- Distortion can occur if the primary beam, patient and film are not all parallel to each other.

DENSITY

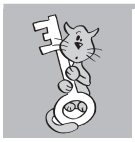
Key Points

- Density describes the amount of blackening on the film.
- Denser parts of the patient (e.g. bone) absorb more of the radiation, stopping X-rays from reaching the film.
- This gives an area of high density.
- In practice the image should not be so dark that soft tissue cannot be seen, but not so light that the film is not diagnostic.
- Bone trabeculae should be visible.

MATCH THE TISSUE TYPES AND PUT THEM IN ORDER

Exercise 10.1 Match the tissue types listed to the appearance you would expect on a radiograph. Then put them in order with the highest density tissue first.

Tissue type	Appearance
A Bone	1 Pale/white image
B Kidney	2 Black image
C Bladder with Urine	3 Slightly darker than soft tissue
D Lungs	4 Grey image



CONTRAST

Key Points

- Contrast is used to describe the difference in density between two adjacent structures.
- Film is said to have high contrast if there is very limited grey but lots of distinct black and white areas.
- Low contrast film is very grey in appearance.
- In practice there should be a good range of grey with some black and some white areas.

ACTIVITY

Exercise 10.2 Look at the three X-rays and decide which has high contrast, which has low contrast and which is an acceptable diagnostic image.

Figure 10.1a

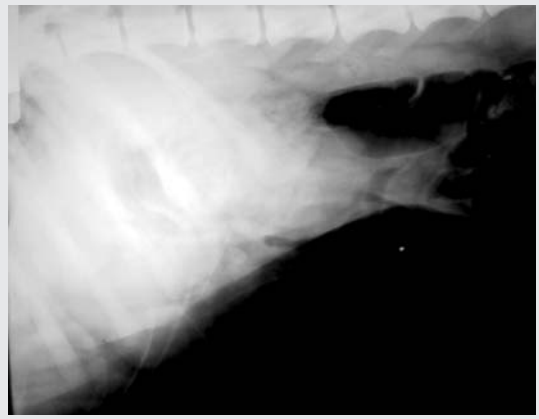


Figure 10.1b

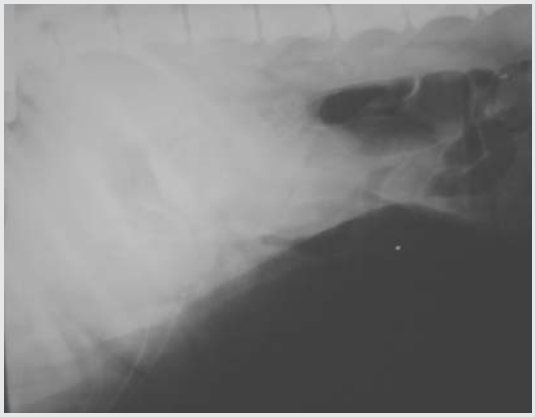


Figure 10.1c

FACTORS AFFECTING CONTRAST AND DENSITY

Key Points

- As kilovoltage (kV) increases, the contrast will also increase.
- High kV produces a film with a large range of grey.
- Low kV produces an image with limited greys but lots of black and white.
- If an area is very thin the contrast will be greatly reduced.
- This is a problem in abdominal radiographs of very thin patients.
- The abdomen may appear grey with no differentiation of structures.

SHARPNESS

Key Points

- There should be no evidence of movement blur on a radiographic film.
- Penumbra is caused by divergence of the primary beam, this can lead to unsharpness around the edges of the image.
- A small focal spot results in less divergence.
- A large focal spot results in more divergence.
- A large focal spot gives a blurred image.

ACTIVITY

Exercise 10.3 On the diagram, label the areas of penumbra. Explain why increased penumbra can make an image appear blurry.

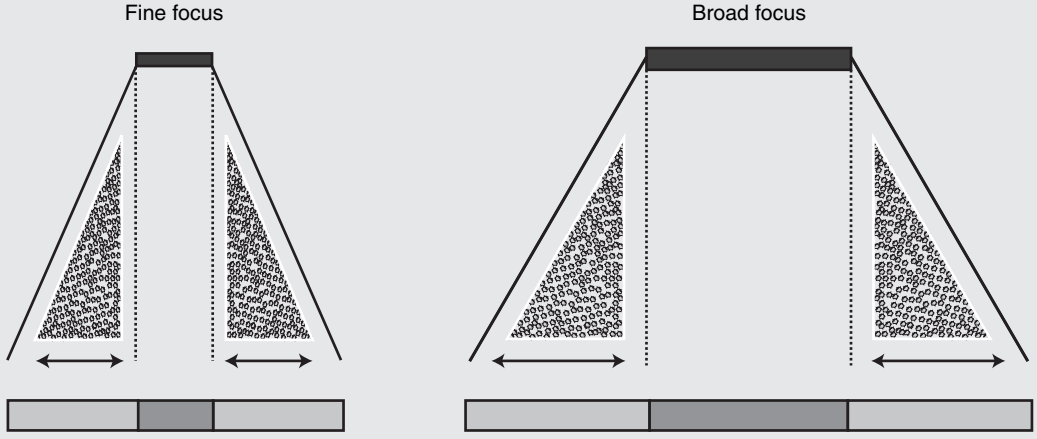


Figure 10.2 Penumbra.

MAGNIFICATION AND DISTORTION

Key Points

- If the distance between the object and the film is large, magnification will occur.
- This is due to divergence after the primary beam has passed through the animal.
- The image will appear larger.
- Controlled magnification is known as macroradiography.
- Distortion occurs if the patient and primary beam are not parallel.
- The image will appear shorter than it actually is.
- Distortion can be minimised if the patient is suitably sedated and restrained.

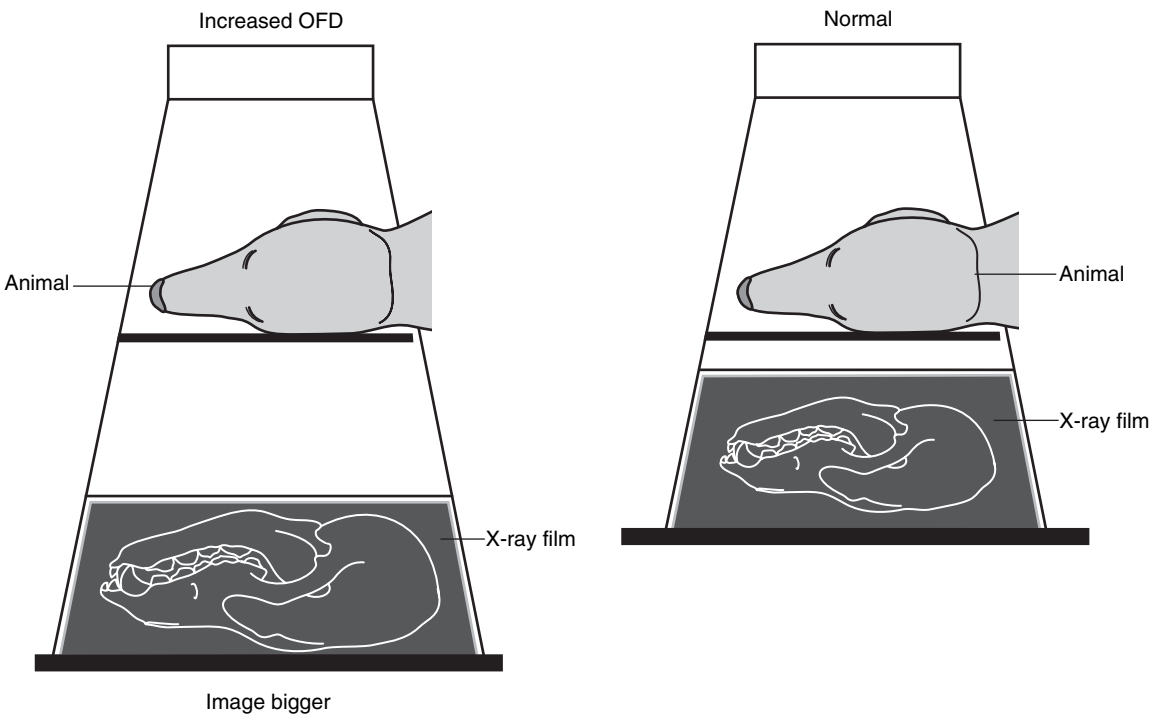


Figure 10.3 Magnification.

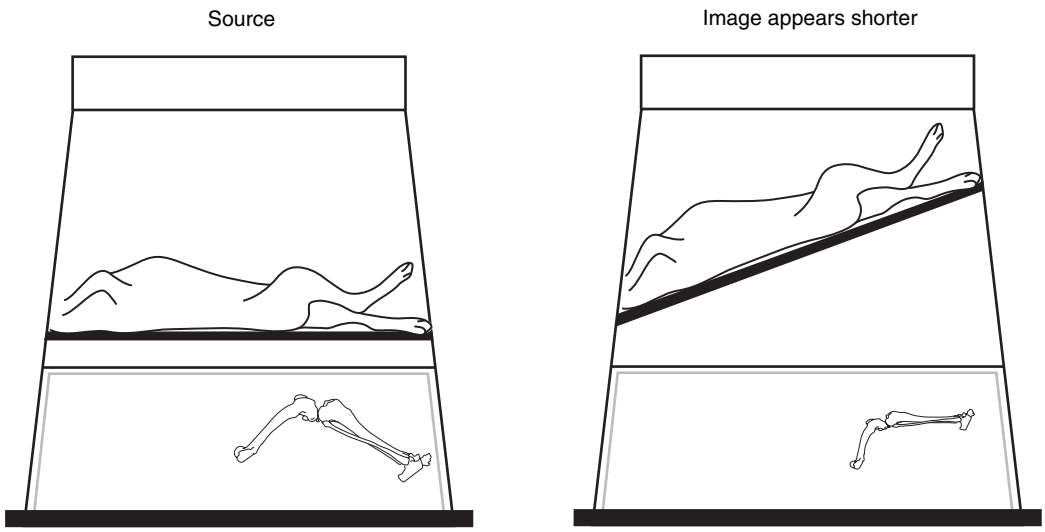


Figure 10.4 Distortion.

STUDY

Write a list of the benefits and disadvantages of having a magnified or distorted image. When could magnification be detrimental to a patient's treatment?

GENERAL REVISION

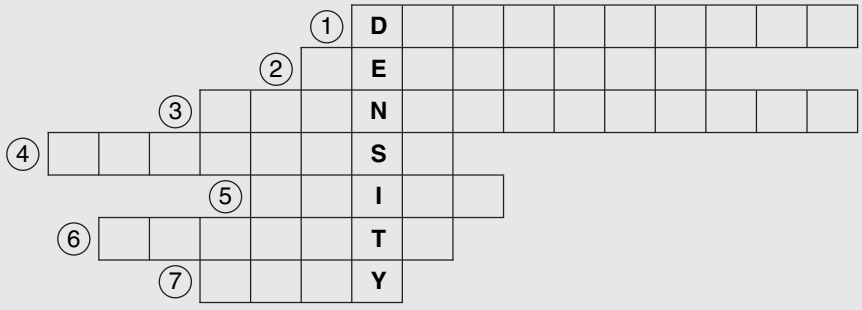
True or False

Exercise 10.4

1. Density describes the degree of blackening of a film.
2. A high contrast image is very grey.
3. The ideal humerus radiograph will show the structure of the bone.
4. Soft tissue is white on a radiograph.
5. The lungs appear black on a radiograph.
6. Penumbra should be minimal.
7. Penumbra increases as the focal spot size increases.
8. To minimise magnification the patient and film should be in contact.
9. Distortion can make a radiograph non-diagnostic.
10. Magnification can result in incorrect prosthesis size selection.

WORD CHART

Exercise 10.5



Clues

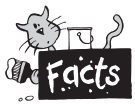
1. This is the result if the patient is not parallel to the film.
2. Blurring caused by divergence of the primary beam.
3. When something appears bigger than it is.
4. The difference between two adjacent structures.
5. The appearance of bone on an X-ray.
6. The degree of blackening of a film.
7. The kidney may have this appearance.

11

FILM FAULTS

LEARNING OBJECTIVES

- Patient film faults
- Technique film faults
- Equipment film faults
- Exposure factors
- Processing faults
- Miscellaneous faults



FACTS ABOUT FILM FAULTS

- Film faults are avoidable.
- Care should be taken to ensure optimal images are produced with every exposure.
- Repeat radiographs increase potential X-ray exposure to the radiographer.
- Adequate time and adequate patient and room preparation will ensure high quality radiographs are produced.

PATIENT FILM FAULTS

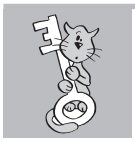
Key Points

- Patient film faults are all related to patient preparation.
- Bedding and mattresses should be dry and radiopaque.
- The patient should not be wet, covered in mud or have a matted coat, as this will all be visible on the radiograph.
- Leads and collars should be removed from the area of interest.
- The patient should be suitably restrained and sedated.

MATCH THE DESCRIPTIONS

Exercise 11.1 Look at the descriptions below and match them to the cause of the fault.

Grey or white streaks	Collar not removed
Lumpy appearance across radiograph	Patient movement during exposure
Line across thorax region with a loop of metal	Wet coat
Studs around neck	Lead not removed
Blurred image	Patient not starved before examination
Large area of mottling in colon and stomach	Wet bed under or over patient



TECHNIQUE FILM FAULTS

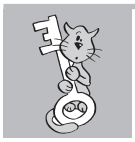
Key Points

- The area of interest should be parallel with the film and centrally placed when possible.
- Positioning should be performed before centering and collimation to prevent missing the area of interest.
- Collimation should be to the area of interest with a small amount of primary beam either side to ensure nothing is missed from the image.
- The collimation should be no bigger than the dimensions of the cassette.
- Collimation will improve image quality and radiation safety.

ACTIVITY

Exercise 11.2 Look at the image of the stifle. What has been done wrong and how could it be corrected?

Figure 11.1



EQUIPMENT FILM FAULTS

Key Points

- Films are rarely a source of faults. However, poor storage and handling can cause pressure marks on the films.
- Care should be taken when loading the cassette to ensure the film is in the correct orientation and is not folded.
- Intensifying screens can become sources of film faults. They will collect dust and dirt.
- Regular cleaning should be performed to remove dust.
- Poor film screen contact will introduce film faults due to a loss of contact and increased blurring on the film.
- Grids should always be used with correct orientation at the defined focal film distance.

ACTIVITY

Exercise 11.3 Look at the radiograph. What has caused this fault? Why does it have this very distinct appearance? How can it be prevented?

Figure 11.2

EXPOSURE FACTORS

Key Points

- To remember over and under exposure:
  - If it is too dark there is too much exposure or processing and the image appears burnt, like toast.
  - Under exposed or under processed radiographs appear light, like undercooked toast (Figure 11.3).
- Overexposure – film too dark.
- Underexposure – film too light.

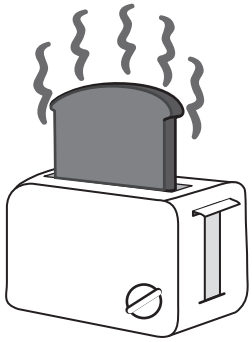


Figure 11.3a Overexposure.

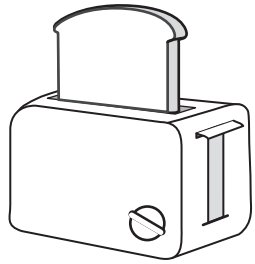


Figure 11.3b Underexposure.

ACTIVITY

Exercise 11.4 Place the faults below under the correct heading at the right.

	Film too dark/overexposed	Film too light/underexposed
Distance too short		
Milliampere (mA) too low		
Grid not used		
Distance too long		
Kilovoltage (kV) too low		
Cassette back to front		
Grid used without increasing exposure		
mA too high		
Time too long		
kV too high		
Time too short		

PROCESSING FILM FAULTS

Key Points

- With the introduction of automatic processors, film faults are less likely to occur.
- During manual processing splashes can occur.
- Fixer will cause white splash marks on the processed radiograph.
- Developer will cause white splash marks on the processed radiographs.
- Poor washing at the end of manual processing can result in the film becoming brown over time.
- Damage can be caused during automatic processing from the rollers, especially if the film is pulled out of the processor.
- If two films are fed into an automatic processor at the same time they may stick together resulting in some areas that are not developed or fixed correctly.

ACTIVITY

Exercise 11.5 Look at the radiographs and identify the film faults. Which fault is not demonstrated?

Faults to choose from: fixer splash, developer splash, light fogging, processor pressure marks.

Figure 11.4a

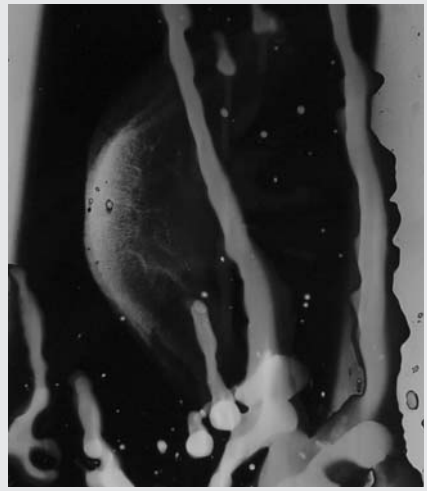
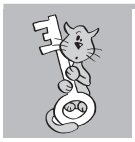


Figure 11.4b

Figure 11.4c



MISCELLANEOUS FAULTS

Key Points

- Labelling is essential on all radiographs.
- This must identify patient name, date or examination and give anatomical details.
- Care must be taken, however, to ensure that the labels do not encroach on the area of interest.
- Anatomical markers should be correct; make sure left is actually left.
- Patients' teeth may damage intra-oral film if they decide to bite down. The patient must be well anaesthetised to prevent bite marks.

ACTIVITY

Exercise 11.6 Look at the radiograph. What has caused this film fault? How could it be avoided?

Figure 11.5

GENERAL REVISION

FILM FAULTS

Exercise 11.7 Name the film faults in the radiographs.

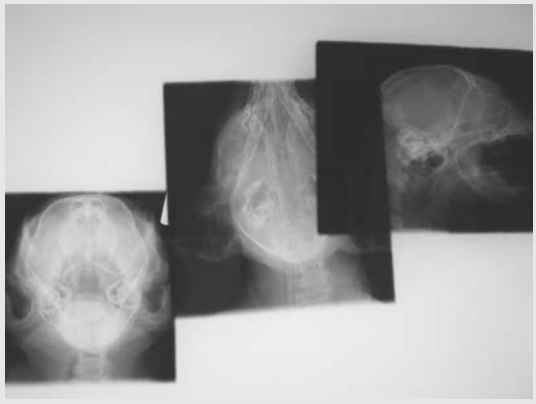


Figure 11.6a

Figure 11.6b

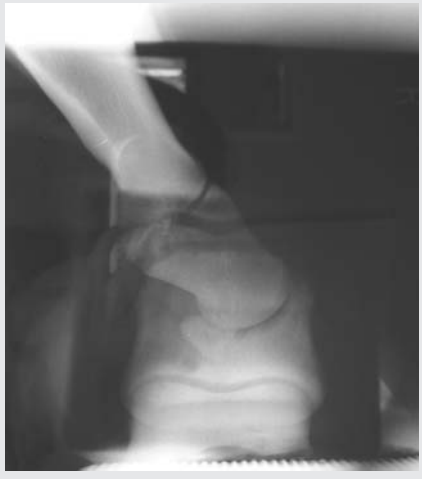


Figure 11.6c

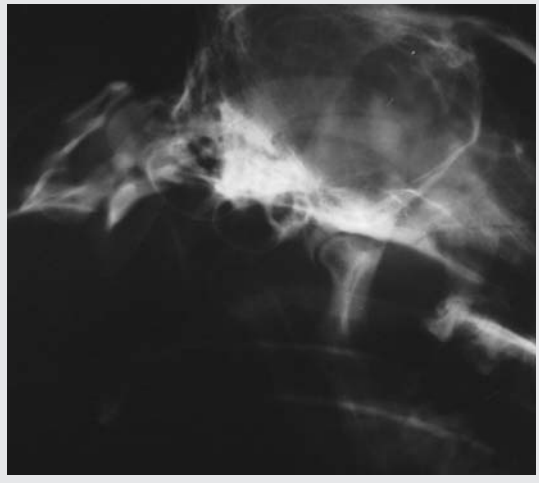


Figure 11.6d

Figure 11.6e

Figure 11.6f

Figure 11.6g

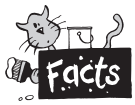
Figure 11.6h

12

RADIATION SAFETY

LEARNING OBJECTIVES

- Effects of radiation
- Regulations
- Radiation safety in practice
- Monitoring devices
- Protection.



FACTS ABOUT RADIATION SAFETY

- Dose limits should not be exceeded.
- Exposure of personnel to radiation should be minimal.
- Unnecessary procedures should not be performed.
- The ALARP principle should be followed.

ALARP	
A	As
L	Low
A	As
R	Reasonably
P	Practicable

- ALARP is important as it forms one of the regulations that must be adhered to in the Ionising Radiation Regulations 1999.
- Work carried out with radiation should be optimised to produce the highest quality radiographs with minimal exposure.

EFFECTS OF RADIATION

Key Points

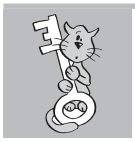
- Radiation will cause damage to cells and is not selective of cell type.
- Immature and rapidly dividing cells are more likely to be damaged by radiation.
- If the cell is developing when the dose is received the DNA may mutate.
- The effects of radiation can be categorised in two ways – biological and cellular:

Biological	*Cellular*
Heat	Somatic
Ionisation	Carcinogenic
Excitation	Mutations

WORD SEARCH

Exercise 12.1 Find seven different cell types in the grid below. Once found, put them in order of susceptibility to radiation starting with the cells most resistant to radiation.

N	E	R	V	E	T	I	S	S	U	E	L	A
N	Q	U	E	E	R	S	B	A	P	O	L	D
G	B	S	S	M	U	S	C	L	E	I	E	C
E	R	G	I	P	W	K	S	Y	I	T	T	P
E	A	H	O	Y	D	I	S	M	A	R	F	G
F	I	P	S	T	I	N	Y	P	L	E	E	R
L	N	T	S	K	A	W	Y	H	M	S	E	E
P	C	I	E	E	B	O	I	O	M	K	L	D
P	E	D	B	L	O	O	D	C	E	L	L	S
A	L	E	H	L	N	P	Z	Y	M	L	I	S
S	L	E	A	S	E	D	I	T	H	Y	S	T
C	S	P	W	S	E	R	H	E	J	K	C	Y
A	D	V	U	P	T	A	R	S	B	Q	P	H



REGULATIONS

Key Points

- The key regulations are the Ionising Radiation Regulations 1999.
- These give details of practice that should be followed to ensure maximum safety.
- The regulations are adapted to veterinary use in a book called *Notes for the Protection of Persons against Ionising Radiations arising from Veterinary Use*.
- All practices should have a radiation protection supervisor and radiation protection advisor.
- Local rules should be available detailing all radiation procedures within your practice.

LOOK IT UP

There should be a copy of the book *Notes for the Protection of Persons against Ionising Radiations arising from Veterinary Use* in your practice. Find your copy and have a look to see what should be happening to help protect the staff in your practice.

RADIATION SAFETY IN PRACTICE

Key Points

- Equipment should be maintained and serviced.
- Risk assessment should be carried out on all new equipment.
- Local rules should be adhered to.
- Clear systems of work should be available.
- Repeat radiographs should be kept to a minimum.
- Minimal numbers of people should be involved in a radiographic procedure.

WHO'S WHO AND WHAT'S WHAT?

Exercise 12.2 Can you put a name to the roles and guidelines?

1. A person from outside the practice who gives advice on radiation protection issues.
2. An individual in your practice who looks after the day-to-day radiation issues.
3. Guidelines specific to your practice relating to radiation safety and procedures.
4. Guidelines on how to perform your examinations.
5. Guidelines needed to ensure consistent exposure factors are used.

MONITORING DEVICES

Key points

- Monitoring is provided for most individuals working with radiation.
- You will receive your own badge, which only you should use.
- It should be worn on the trunk under protective clothing.
- There are two types – the film badge and thermoluminescent dosimeter (TLD).

FILL IN THE GAPS

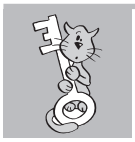
Exercise 12.3

Film badge

A small (1)_____ is placed in a plastic container. A number of (2)_____ have varying (3)_____ and (4)_____ of metal. When the film is developed the degree of (5)_____ on the film and the regions, which are blackened, will determine the dose received. The films are sent away for (6)_____ and they can only be used once making them (7)_____.

Thermoluminescent dosimeter (TLD)

The dosimeter is a similar size to the film badge. It contains (8)_____ of (9)_____, which has a similar (10)_____ to soft (11)_____. After the dosimeter has been (12)_____ and possibly (13)_____, it is (14)_____ and the amount of light (15)_____ is compared to a standard, known radiation (16)_____ by a specialised company. The dose received can then be (17)_____. This type of monitor can be (18)_____.



RADIATION PROTECTION

Key Points

- Patients should never be manually restrained.
- If it is essential to stay in the room, lead aprons should be worn and a distance of 2 m from the primary beam should be maintained.
- Gloves and sleeves should be used during contrast examinations.
- An attempt should be made to leave the room during any exposure.

SPOT THE MISTAKES

Exercise 12.4

Look at the picture below and find four mistakes.

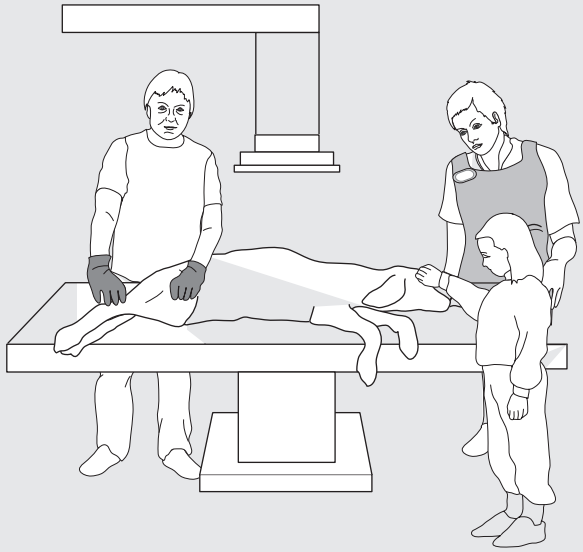


Figure 12.1

GENERAL REVISION

Multiple Choice Questions

Exercise 12.5

1. The tissues most susceptible to radiation damage are:
   a) muscles
   b) skin
   c) red blood cells
   d) bone.

2. The radiation protection supervisor is:
   a) a member of parliament
   b) an external advisor who holds the Diploma in Veterinary Radiology
   c) a principle or veterinary surgeon in practice
   d) the person who sends off the dosimeters to be checked.

3. The legal document, which covers the use of radiation, including veterinary radiography is:
   a) the local rules
   b) the Radiation Protection Act 1860
   c) the ionising radiation regulations 1985
   d) the ionising radiation regulations 1999.

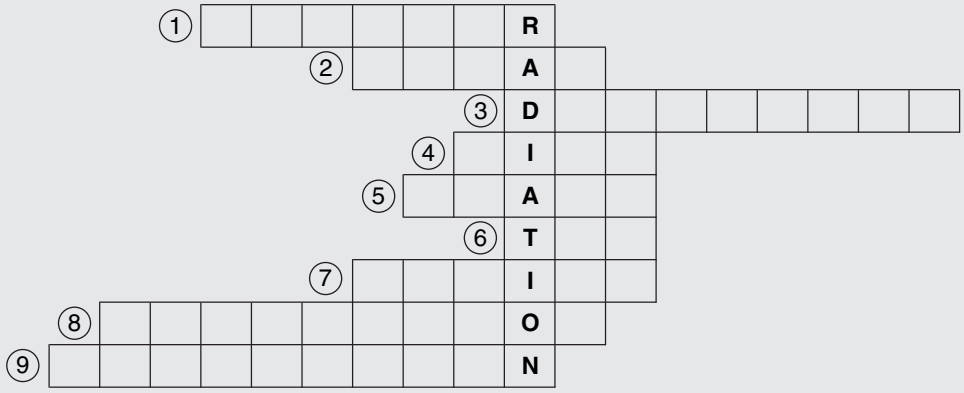
4. Safety instructions specific to each practice are called:
   a) local rules
   b) practice rules
   c) ionising radiation regulations
   d) systems of work.

5. Dosimeters should be worn:
   a) by the person it is issued to
   b) under lead protective aprons
   c) by personnel regularly involved in radiographic work
   d) all of the above.

6. Protective clothing used during radiography is only protective against:
   a) the primary beam
   b) thermionic emissions
   c) scatter
   d) all of the above.

WORD CHART

Exercise 12.6



Clues

1. Lead protection stops this from reaching the radiographer.
2. Rules specific to your practice.
3. A badge for monitoring radiation exposure.
4. This is used in expensive monitoring badges.
5. The principle that keeps exposure low.
6. Abbreviation for a thermoluminescent dosimeter.
7. Cells that do a lot of this are more likely to be damaged.
8. The person in the practice who looks after your radiation issues.
9. The aim of the ionising radiation regulations.

13

PRINCIPLES OF RADIOGRAPHIC POSITIONING

LEARNING OBJECTIVES

- Anatomical orientation
- Surface landmarks
- Principles of positioning

FACTS ABOUT THE PRINCIPLES OF RADIOGRAPHIC POSITIONING

- Set protocols should be adhered to at all times when describing the orientation of an animal.
- These allow discussion between individuals about specific cases which do not become confused.
- All animals however large or small have certain anatomical areas that can be used for positioning.
- These are known as surface landmarks.
- These landmarks are consistent in the majority of animals and have been related to specific internal organs and areas.
- Radiation safety guidelines must be followed at all times.
- Standard projections should always be taken in the first instance.
- Indexing and cross-referencing should be clear and concise to ensure radiographs can always be found.

ANATOMICAL ORIENTATION

Key Points

- The head is described as cranial and the bottom as caudal.
- Close to the body or joint a limb is described as proximal; as you move down the limb it is described as distal.
- The back of an animal is dorsal; the sternal and abdominal area are ventral.
- Lateral describes the outside edge of a limb and medial describes the inside edge.
- When describing a projection, the area the X-ray penetrates the patient is given first, followed by the last place the X-ray touches as it passes out of the patient.

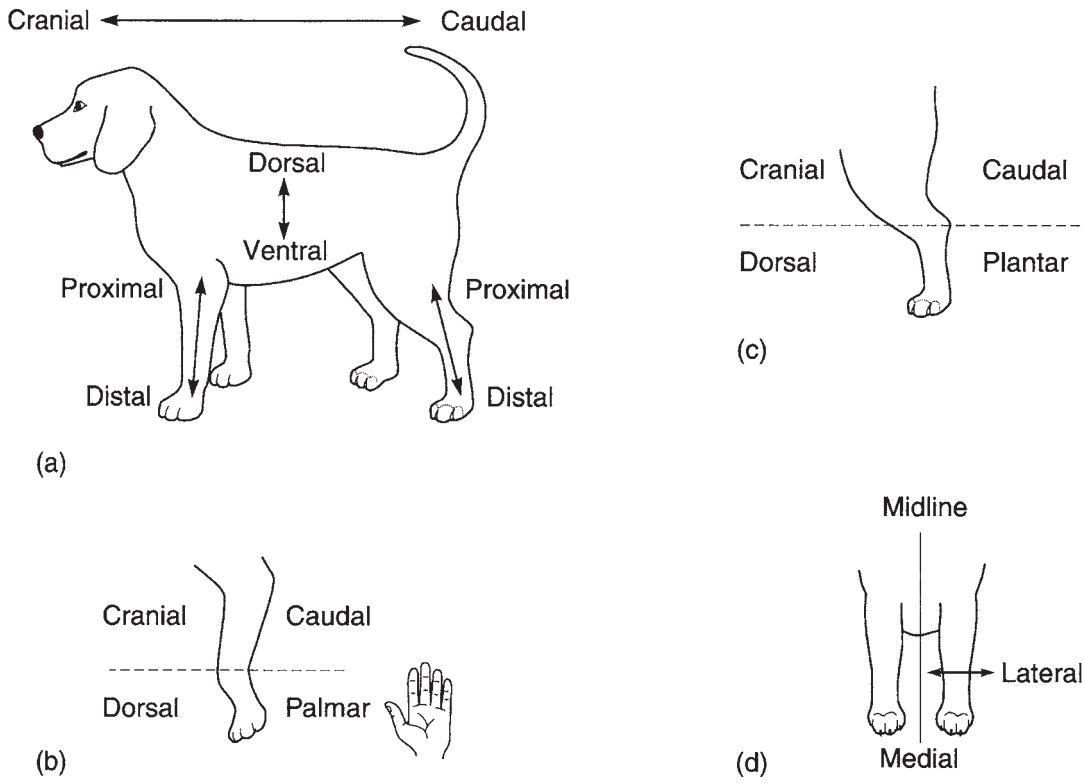


Figure 13.1 Anatomical orientation.

COMPLETE THE TABLE

Exercise 13.1 Look at the abbreviations below and write the full term used and the direction of the X-ray beam. Think about which projections each would be used to describe. Photocopy the completed table out and use it to help with descriptions when you are positioning.

Full description	Abbreviation	Direction of X-ray beam or description or area
1_____	L	
2_____	R	
3_____	D	4_____
Ventral	V	5_____
6_____	Cr	7_____
8_____	Cd	9_____
10_____	Ras	11_____
12_____	M	13_____
14_____	Lat	Outside edge of legs
15_____	Pr	16_____
Distal	Di	17_____
18_____	Pa or P	19_____
20_____	Pl	Back edge of the lower hind limb

SURFACE LANDMARKS

Key Points

- Surface landmarks are used to identify structures that cannot be seen from the surface of the animal.
- The landmarks are usually fixed points that do not move or change position.
- They are either bony protrusions or points between something fixed such as the eye or ear.
- Care should be taken to identify the landmark correctly to ensure accurate positioning (Fig. 13.2).

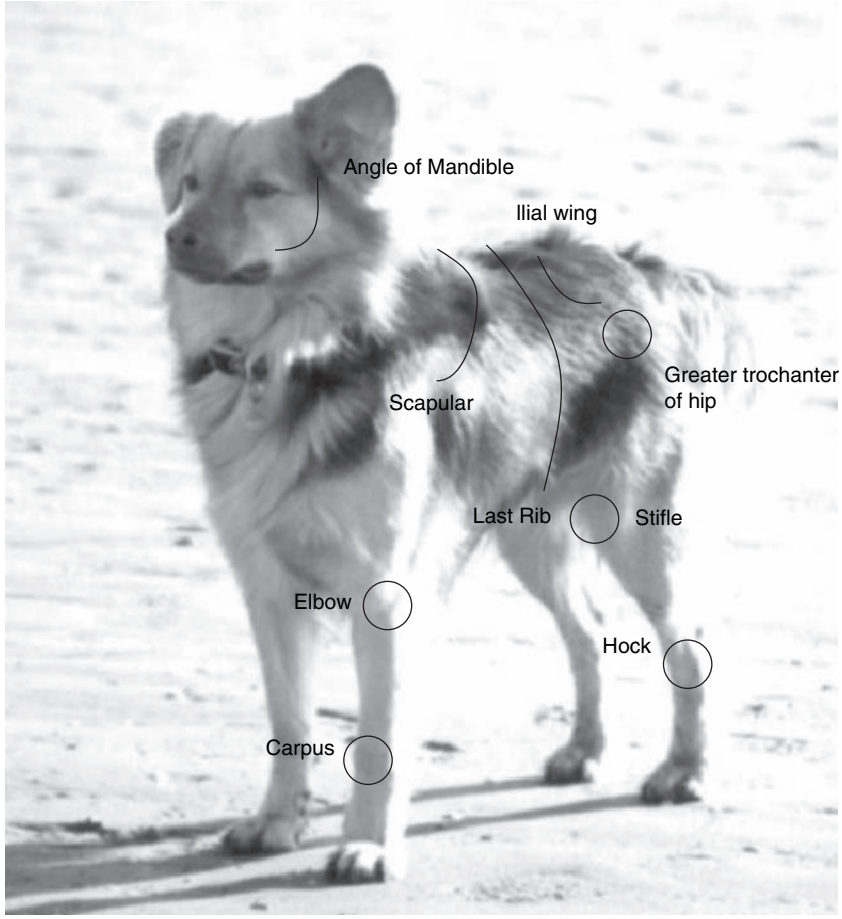


Figure 13.2 Some surface landmarks used in radiography. (Reproduced from Easton S 2002 Positioning aids for radiography. Veterinary Nursing 17(5): 172–175, with permission of British Veterinary Association.)

ACTIVITY

Using the illustration in Figure 13.2 and a willing volunteer, identify as many surface landmarks as you can. Try and match the list you have to projections and see if there are any you have missed. Do this every time you have a patient so you get used to feeling landmarks on different shapes, sizes and species of animal.

WORD SEARCH

Exercise 13.2 Find 10 surface landmarks in the grid below.

P	S	A	E	R	C	I	T	I	U	M	S	S
V	I	N	N	E	R	C	A	N	T	H	U	S
P	I	G	R	D	Q	U	C	I	S	S	S	C
P	A	L	T	E	L	S	R	I	O	T	T	A
A	U	E	S	S	D	G	O	K	A	I	E	P
T	R	O	C	H	A	N	T	E	R	L	R	U
E	L	F	N	N	F	M	W	T	T	I	N	L
L	M	M	U	I	L	O	I	P	P	U	U	A
L	Z	A	C	R	O	M	I	O	N	M	M	M
A	B	N	E	F	A	K	L	M	M	M	I	M
D	F	D	E	K	U	K	L	A	I	U	U	G
A	D	I	D	E	D	C	E	C	N	R	E	G
I	L	B	B	T	T	A	A	C	G	N	E	U
E	L	L	A	S	T	R	I	B	E	H	R	I
D	I	E	W	C	O	N	D	Y	L	E	T	N

PRINCIPLES OF POSITIONING

Key Points

- Radiographic positioning is much easier if you get into a routine and stick to it.
- Always position the patient with sandbags and pads before centering and collimating the primary beam.
- Label the film before exposure with x-rite tape and anatomical markers.
- The anatomical markers should be placed in close proximity to the area of interest without overlying important structures.
- Remember radiation safety at all times.

ACTIVITY

Think about your routine when you are taking a radiograph. Try and write down what you do. Is it an efficient process or can you make changes so that you do not forget to do things when you are busy?

WHAT AM I?

Exercise 13.3

1. I am the time you spend placing sandbags on the patient.
   During my time you will also put pads in the correct places and extend limbs.
   I will have no lights or collimators during my time.
2. I happen when all the pushing and pulling is done.
   I make sure the primary beam goes in the right place at the right size.
   If I am done first your radiograph will not be good.

GENERAL REVISION

True or False

Exercise 13.4

1. Film identification is added after processing.
2. Lesion orientated oblique (LOO) projections are used to demonstrate specific lesions.
3. Positioning involves the use of pads and sandbags to restrain the patient.
4. Manual restraint should be used whenever possible.
5. Collimation should be opened to include the whole of the film in use.
6. The tail can be used as a surface landmark.
7. The last rib is not suitable as a surface landmark.
8. The X-ray room should have the minimal number of people in it at all times to ensure safety and a calm environment for the patient.

PUT IT IN ORDER

Exercise 13.5 Look at the following statements and put them in the order you would use to position a patient.

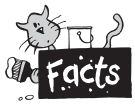
Make exposure
Place the patient on the table in suitable recumbency
Ensure examination is known
Double check exposure factors
Identify projections needed
Ensure the cassette is under the area of interest
Identify the patient
Turn on the light
Position the patient using sandbags and pads
Select the correct film screen combination and exposure factors
Centre and collimate the primary beam
Ensure everyone is protected.

14

RADIOGRAPHY OF THE FORELIMB

LEARNING OBJECTIVES

- Carpus
- Radius and ulna
- Elbow
- Shoulder



FACTS ABOUT RADIOGRAPHY OF THE FORELIMBS

- The forelimb extends from the shoulder to the foot.
- The limb includes the carpus, radius and ulna, elbow and humerus.
- All long bones should include the joints at either end during radiographic examination and joints should show a small amount of the long bone either side.
- Two projections should be taken of each area at 90° to each other.

CARPUS

Key Points

- The carpus is the joint at the base of the limb.
- Distal to the carpus are the phalanges and proximal to it are the radius and ulna.
- The carpus should always be demonstrated in the dorso-palmar and lateral projection.
- The central point of the joint is where the mid-carpal bones are located.

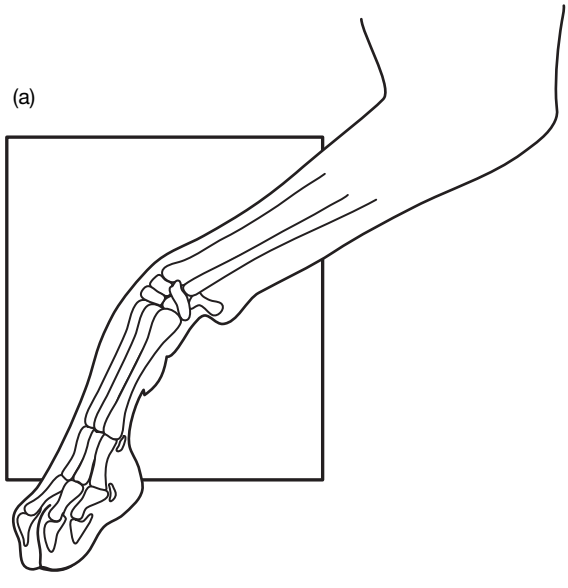


Figure 14.1a Lateral projection of the carpus.

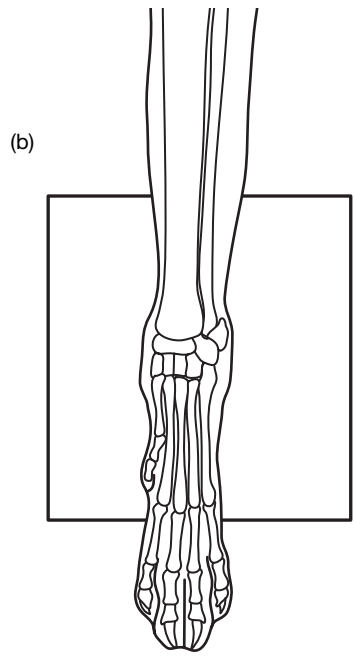


Figure 14.1b Disto-palmar projection of the carpus.

ACTIVITY

Exercise 14.1 What are the names of the parts of the anatomy labelled below?

Figure 14.2 Disto-palmar projection of the carpus.

RADIUS AND ULNA

Key Points

- The radius and ulna are the long bones between the elbow and the carpus.
- The radius and ulna form a loop so if one bone is broken the other may be fractured or dislocated as well.
- Two projections are needed of the radius and ulna to demonstrate all of the structures adequately.
- When taking an image of the radius and ulna the carpus and elbow should be included.

LOOK IT UP

Radiographic changes occur in the radius and ulna. Find out about some conditions that may be seen in the radius and ulna. How might your technique need to be adapted to accommodate these patients?

ELBOW

Key points

- The elbow is very difficult to get straight.
- For the ideal cranial–caudal projection the patient should be on the back with the limb extended down the side of the thorax.
- Centering is midway between the condyles for the CrCd and on the medial condyle for the lateral.
- Lateral projections should always be performed with the limb flexed.

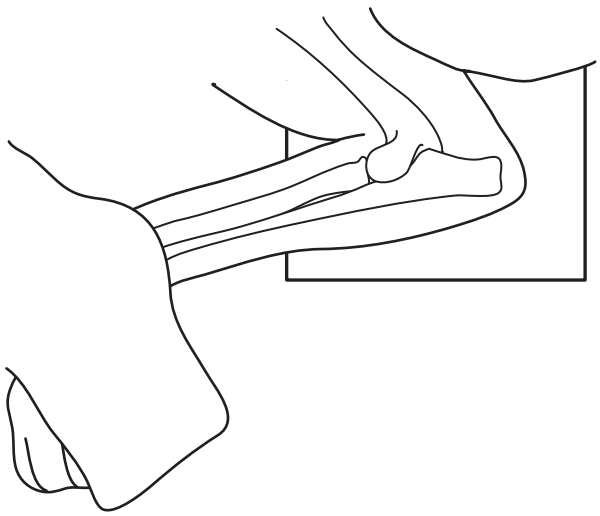


Figure 14.3a Lateral projection of the elbow.

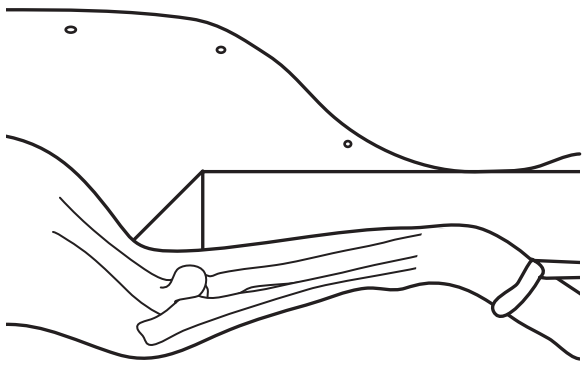


Figure 14.3b Cranio-caudal projection of the elbow.

ACTIVITY

Look at how you perform the CrCd projection of the elbow. On a dog used to being handled, try positioning the dog on its back for the elbow. What are the advantages and disadvantages of this positioning?

ACTIVITY

Exercise 14.2 What are the names of the parts of the anatomy labelled below? Which parts are used as the surface landmarks for positioning the elbow?

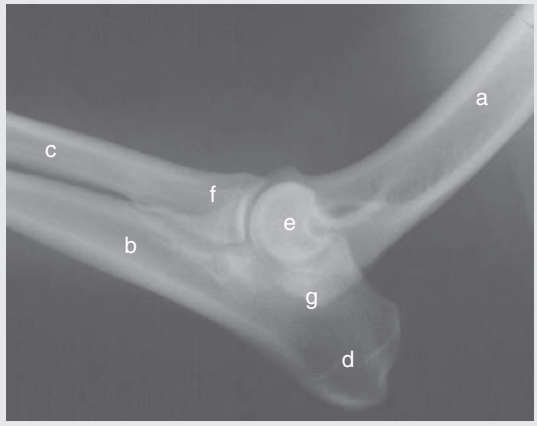


Figure 14.4 Lateral projection of the elbow.

SHOULDER

Key Points

- The shoulder is the joint that attaches the forelimb to the main part of the body.
- It is a ball and socket joint.
- When positioning a shoulder a number of key stages should be carried out.
- These ensure that the lateral projection is straight with all overlying tissue removed.

FILL IN THE GAPS

Exercise 14.3

(1)_____ *shoulder*
The patient is placed in (2)_____ recumbency with the limb being examined (3)_____ to the film.
The (4)_____ most leg is retracted onto the chest and secured with a (5)_____.
The head and neck are (6)_____.
The limb under examination is (7)_____.
The beam is centred at the level of and (8)_____ to the lateral (9)_____.

(10)_____ *shoulder*
The patient is placed in (11)_____ recumbency and supported with (12)_____ and (13)_____.
Slight rotation may be needed to remove the (14)_____ from the area of interest.
The limb under examination is drawn (15)_____, fully (16)_____ and secured with a (17)_____.
The beam should be centred level with the (18)_____.
A tie should only be used with (19)_____ animals.

GENERAL REVISION

Multiple Choice Questions

Exercise 14.4

1. Two projections should always be taken of the forelimbs. These should be orientated to each other at:
   a) 20°
   b) 45°
   c) 90°
   d) 120°.

2. The centering point for the lateral elbow is:
   a) over the olecranon
   b) over the calcaneum
   c) over the condyles of the humerus
   d) over the condyles of the femur.

3. The lateral elbow projection should demonstrate the joint:
   a) extended
   b) flexed
   c) rotated
   d) oblique.

4. The carpus is found in which part of the forelimb:
   a) proximal
   b) distal
   c) medial
   d) lateral.

5. The shoulder joint attaches the forelimb to the:
   a) thorax region
   b) abdomen region
   c) cervical spine
   d) scapula.

6. When taking a radiograph of the shoulder joint, the part of the anatomy that is extended is the:
   a) head
   b) neck
   c) head and neck
   d) thoracic spine.

7. Which type of restraint should not be used unless the patient is anaesthetised?
   a) sandbags
   b) ties
   c) pads
   d) troughs.

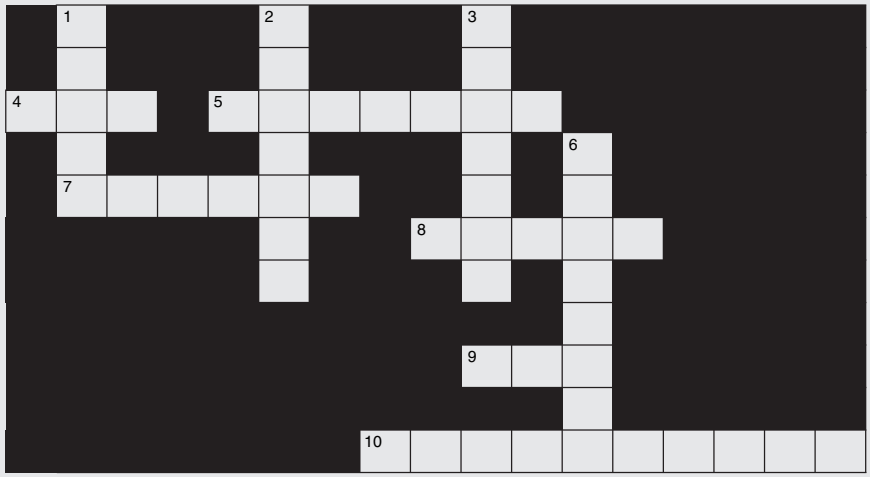
FILL IN THE GAPS

Exercise 14.5 The chart below gives two centering points for each projection of the forelimb. Fill in the gaps. Copy the chart, cut it into pieces and use it to learn the positioning points for the forelimb.

Lateral carpus	1._____	2._____
3._____	Carpal joint	Midline
Lateral elbow	Humeral condyles	Midway between skin surfaces
CC elbow	4._____	5._____
6._____	Level with	Lateral tuberosity
CC shoulder	7._____	8._____

CROSSWORD

Exercise 14.6



Clues

1. The amount of radius seen on a carpal radiograph.
2. The most distal bone of the forelimb.
3. The surface landmark used for the elbow.
4. Method of restraint in anaesthetised animals.
5. Rotation of the forelimb can be avoided by doing this to the apposing limb.
6. A ball and socket joint.
7. The position of the patient for a caudocranial shoulder radiograph.
8. A joint that should be flexed in the lateral projection.
9. An elbow may need this under the olecranon to keep it straight.
10. The surface landmark used when positioning a lateral shoulder.

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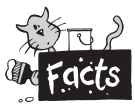
15

RADIOGRAPHY OF THE HIND LIMB

LEARNING OBJECTIVES

- Hock
- Stifle
- Pelvis



FACTS ABOUT RADIOGRAPHY OF THE HIND LIMB

- The hind limb extends from the foot to the pelvis.
- All joints should be examined to include a third of the long bone above and below.
- The long bones (femur, tibia and fibula) should demonstrate the joints at both ends.
- The pelvis should be positioned exactly when performing the examination for a kennel club hip score.

HOCK

Key Points

- The hock is composed of the tarsal bones and the calcaneum.
- The calcaneum extends over the base of the tibia and fibula.
- Centering should be on the tarsal bones and not the calcaneum.
- Collimation should include a small amount of the metatarsals and the tibia and fibula.

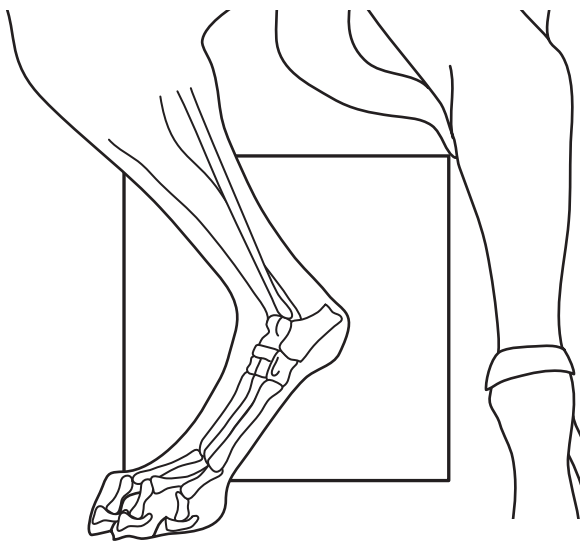


Figure 15.1a Lateral projection of the hock.

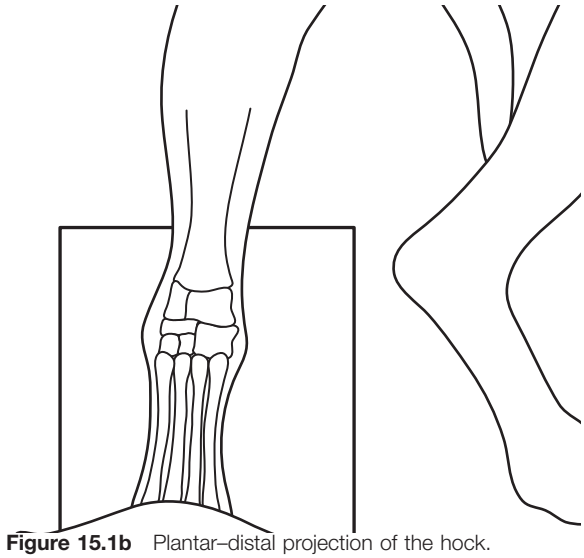


Figure 15.1b Plantar–distal projection of the hock.

ACTIVITY

Exercise 15.1 What are the names of the parts of the anatomy labelled below?

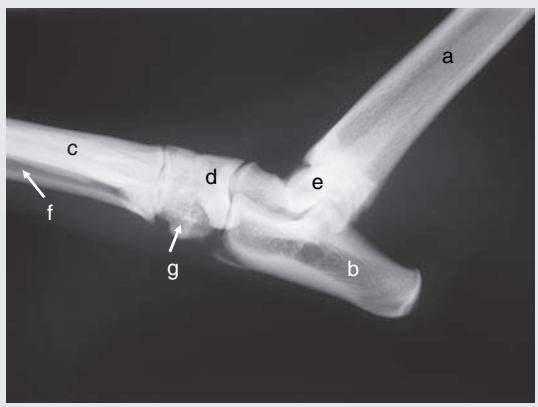


Figure 15.2 Lateral projection of the hock.

STIFLE

Key Points

- The stifle forms the joint between the tibia and fibula, and the femur.
- A lateral projection should always be performed with the joint flexed. Centering should be over the distal femoral condyle.
- The cranio-caudal projection should be performed with the leg extended as much as possible and maintained in a position parallel with the film.
- The primary beam should be centred over the patella.

ACTIVITY

Exercise 15.2 On the diagram and radiograph below, mark the lines you would use when centering the radiograph.

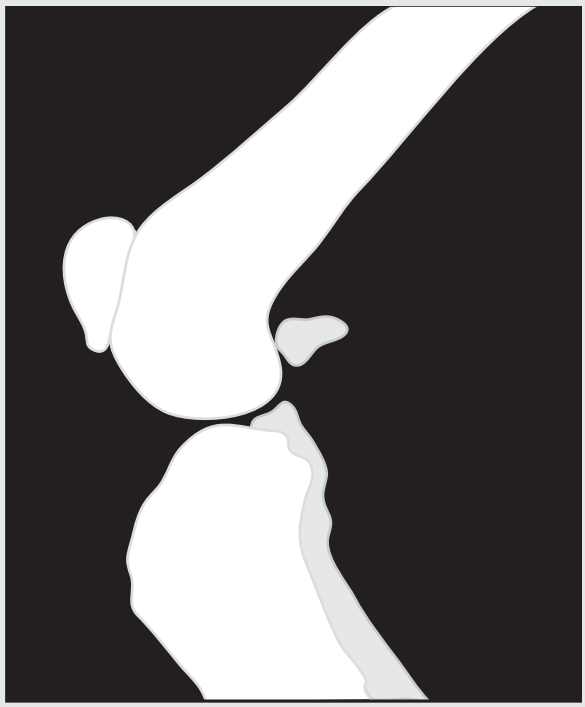


Figure 15.3a Caudo-cranial projection of the stifle.

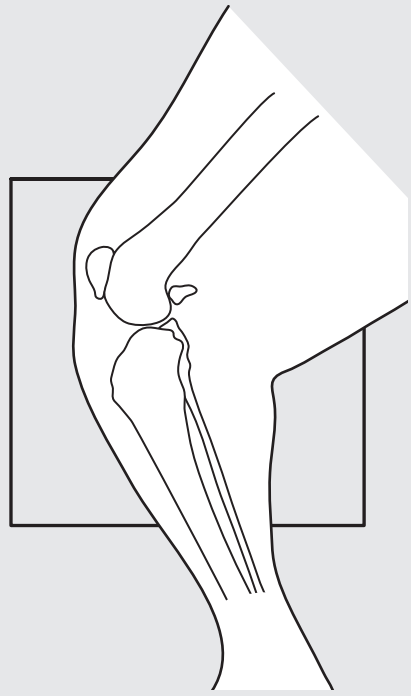


Figure 15.3b Lateral projection of the stifle.

PELVIS

Key Points

- The pelvis provides attachment for the hind limb to the spine.
- The pelvis forms a circular structure of bone.
- This protects a number of organs including the reproductive organs and the bladder.
- When imaging the pelvis the collimation should include the ilial wings and the proximal third of the femur.

FILL IN THE GAPS

Exercise 15.3

(1)_____ *pelvis*
The patient is placed in (2)_____ recumbency with the limb being examined (3)_____ to the film.
The pelvis is maintained in a true (4)_____ position through the use of (5)_____.
The (6)_____ is centred over the greater (7)_____.
The (8)_____ should include the wing of the (9)_____ and the (10)_____.

(11)_____ *pelvis*
The patient is placed in (12)_____ recumbency and supported with (13)_____ and (14)_____.
There should be no (15)_____ along the (16)_____ axis of the patient.
The hind limbs are (17)_____ so that the (18)_____ are parallel and rotated (19)_____.
The hind limbs are (20)_____ above the (21)_____ and secured with (22)_____.
The (23)_____ is centred at the level of the (24)_____ trochanter along the midline.
A (25)_____ should only be used with (26)_____ animals.

LOOK IT UP

The pelvis is used to determine the condition of the hips in dogs used for breeding. This is known as the kennel club hip score. Find out what this procedure entails and how the films are assessed.

GENERAL REVISION

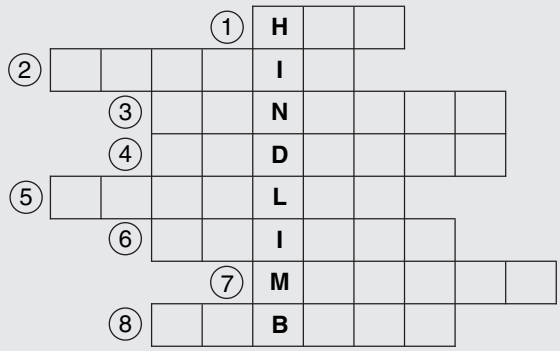
True or False

Exercise 15.4

1. The calcaneum is the centering point for the hock.
2. The caudo-cranial stifle is centred over the patella.
3. The pelvis radiograph should include the stifles.
4. The hind limb should be rotated internally to ensure the femora are in a true caudo-cranial position.
5. The opposing limb should be placed on the abdomen when positioning for a stifle radiograph.
6. The pelvis is kept in a true lateral position using pads.
7. The lateral stifle should be taken with the joint extended.
8. Ties can be used in heavily sedated patients.

WORD CHART

Exercise 15.5



1. A score of these is performed in breeding dogs over 1 year of age.
2. The proximal part of the hind limb.
3. Surface landmark for the stifle.
4. Centering point for a dorso-plantar projection of the hock.
5. This is used to position the stifle.
6. The joint joining the tibia and the femur.
7. Rotation needed on the femur to obtain a true position.
8. The bone found adjacent to the tibia.

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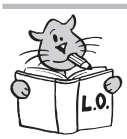
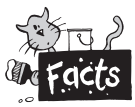
16

RADIOGRAPHY OF THE AXIAL SKELETON, CHEST AND ABDOMEN



LEARNING OBJECTIVES

- Chest
- Abdomen
- Skull
- Spine



FACTS ABOUT THE RADIOGRAPHY OF THE AXIAL SKELETON, CHEST AND ABDOMEN

- The chest and abdomen should be radiographed with the patient in right lateral recumbency.
- Chest radiographs should be taken on full inspiration.
- Abdominal radiographs should be taken on full expiration.
- Abdominal films should include the top of the liver and diaphragm.
- The skull and spine should only be taken with the patient fully anaesthetised to ensure the patient is not rotated.
- The spine should be taken in multiple small sections.

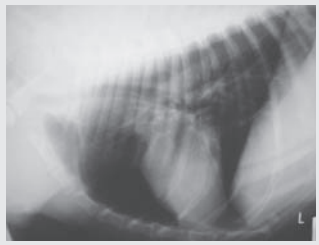
CHEST

Key Points

- The initial projection for the chest is a right lateral radiograph.
- This can be followed by a second projection if required.
- When looking at the lungs a ventro-dorsal projection should be used.
- When examination of the heart is required a dorso-ventral projection should be used.
- If it is known at the start that both projections are required the DV/VD projections should be performed before the lateral projection to prevent positional collapse of the lungs.

ACTIVITY

Exercise 16.1 Look at the radiograph and diagram of the chest. Mark the centering point on the radiograph based on the surface landmarks that are visible on the image. Where is your centering point?



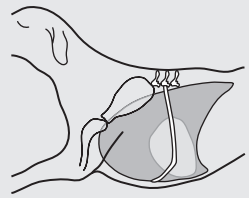


Figure 16.1 Lateral projection of the thorax.

ABDOMEN

Key Points

- Abdominal radiographs should be performed with the patient in right lateral recumbency.
- The last rib should be used as a surface landmark.
- The liver should be shown to include the cranial margins.
- A ventro-dorsal projection can be performed to demonstrate the abdominal organs without superimposition.

ACTIVITY

Exercise 16.2 What are the names of the parts of the anatomy labelled below?

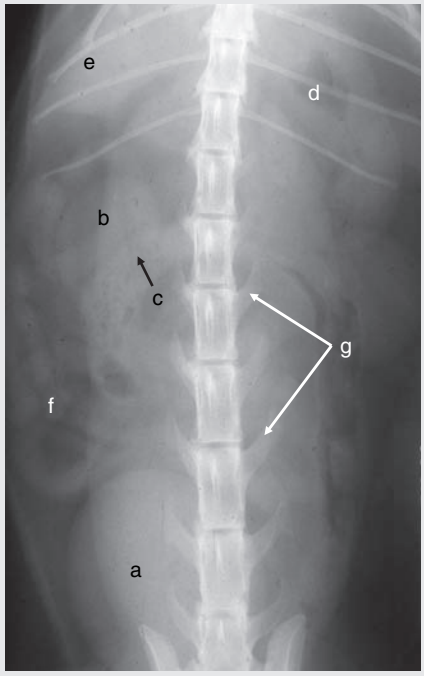


Figure 16.2 Ventro-dorsal projection of the abdomen.

SKULL

Key Points

- The most diagnostic projection of the skull is the ventro-dorsal.
- The hard palate should be maintained parallel with the cassette and film.
- The centering point should always be on the midline but will vary rostro-caudally depending on the area of interest.
- The nasal chambers can be imaged using a non-screen film placed in the mouth of the patient.

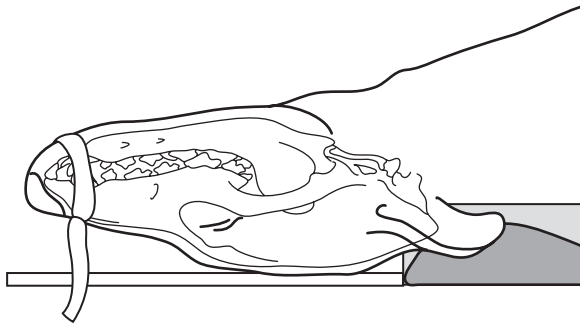


Figure 16.3 Ventro-dorsal projection of the skull.

ACTIVITY

Exercise 16.3 What are the names of the parts of the anatomy labelled below?

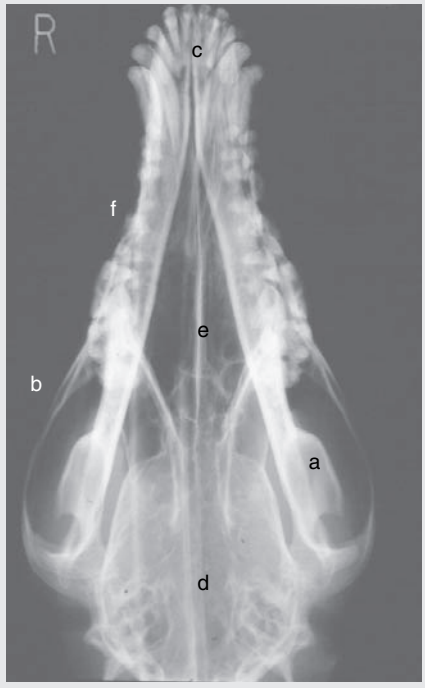


Figure 16.4 Ventro-dorsal projection of the skull.

SPINE

Key Points

- The spinal column should be imaged with the patient fully anaesthetised.
- Care should be taken when moving a patient with suspected spinal trauma.
- A full survey of the spine should be taken with the patient in lateral recumbency.
- Any suspicious areas can have further ventro-dorsal projections made of them.
- Each image should overlap at the top and bottom with previous and subsequent images.

LOOK IT UP AND DRAW

Exercise 16.4 The lumbar sacral junction has very specific centering landmarks. Look this up and then draw where the centering point should be below.

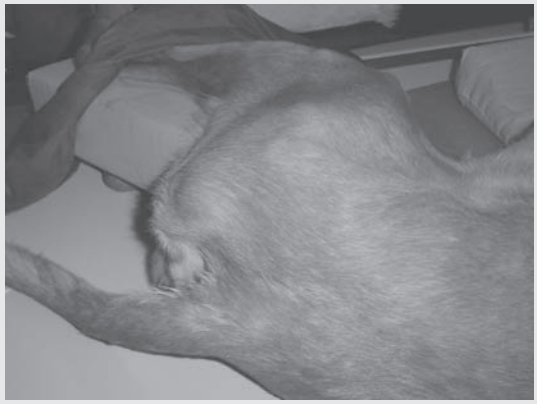


Figure 16.5 Positioning for the lumbar–sacral junction.

GENERAL REVISION

Multiple Choice Questions

Exercise 16.5

1. Thoracic radiographs should be taken on:
   a) inspiration
   b) expiration
   c) does not matter
   d) slight inspiration.

2. On an abdominal radiograph, the organ that must be seen on the top edge of the image is the:
   a) spleen
   b) stomach
   c) liver
   d) pancreas.

3. The part of the skull that must be parallel with the film in the ventro-dorsal projection is the:
   a) tympanic bullae
   b) soft palate
   c) hard palate
   d) zygomatic arch.

4. The best projection for imaging the nasal chambers is the:
   a) ventro-dorsal
   b) intra-oral
   c) rostro-caudal
   d) lateral.

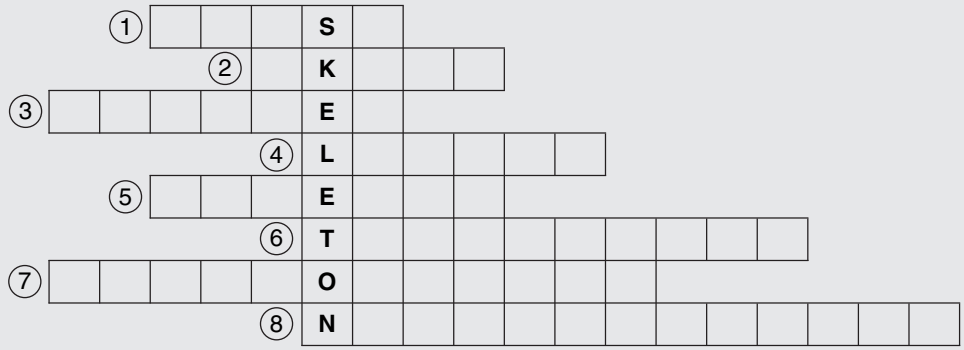
5. Which of the following is not a surface landmark used for thoracic radiographs:
   a) scapula
   b) last rib
   c) midline
   d) sternum.

6. In dogs with very deep chests, which of the following can be used to enhance the contrast of the caudal abdomen:
   a) grid
   b) lead sheet
   c) compression
   d) intensifying screens.

7. Rotation of the lumbar spine can be identified by looking at the alignment of the:
   a) spinous processes
   b) vertebral bodies
   c) intervertebral disc spaces
   d) transverse processes.

WORD CHART

Exercise 16.6



Clues

1. Radiographs of this must be taken on full inspiration.
2. Ventro-dorsal projections of this must have the hard palate parallel with the cassette.
3. Lateral surface landmarks for this region include the last rib.
4. An area containing seven vertebral bodies.
5. The initial projection of the chest.
6. These processes must be superimposed if the lumbar spine is straight.
7. The second projection of the abdomen.
8. This is demonstrated with a intra-oral, rostro-caudal projection.

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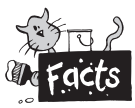
17

CONTRAST STUDIES

LEARNING OBJECTIVES

- Negative contrast mediums
- Barium sulphate solution
- Iodine-based contrast mediums
- Setting up for contrast medium examinations
- Antegrade and retrograde.



FACTS ABOUT CONTRAST STUDIES

- Contrast medium is used to enhance areas where contrast would otherwise be low.
- Positive contrast mediums have high atomic numbers.
- When using barium sulphate the kilovoltage (kV) should be increased.
- When using a negative contrast medium the kV should be reduced.

NEGATIVE CONTRAST MEDIUMS

Key Points

- Negative contrast mediums can be in the form of air or carbon dioxide.
- They appear black on the processed radiograph.
- They can be introduced into the bladder or rectum.
- They can be used in conjunction with positive contrast mediums to enhance the image further.

ACTIVITY

Exercise 17.1 Describe what you see on the final radiograph of a double contrast cystourethrogram of the male dog below. Why is the bladder demonstrated in this way?

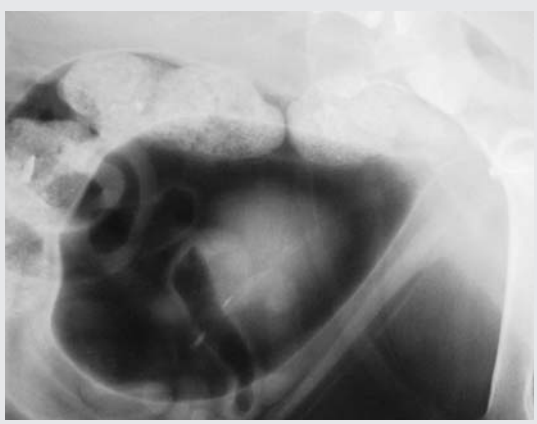


Figure 17.1 DC cystourethrogram.

BARIUM SULPHATE SOLUTION

Key Points

- Barium sulphate solution is a positive contrast medium.
- It is an inert substance that does not react with gastric acid.
- It coats the gastrointestinal tract and appears white on a radiograph.
- It should not be used if a perforation is suspected.
- Patients will need to be hydrated after the examination, as the barium will reduce water absorption and cause constipation.

FILL IN THE GAPS

Exercise 17.2 Fill in the gaps in the table below for barium studies of the canine patient. Copy the table and use it to help you remember what examination is needed for each part of the gastrointestinal tract.

Region	Study	Volume	Projections	Time
Oesophagus	1_____	5–20 mls	2_____	Immediate
3_____	Barium meal	4_____	4 views of abdomen	5_____
6_____	7_____	1–3 ml/kg	VD and lateral abdomen plus 4 views if pathology seen	8_____
Rectum	9_____	10ml/kg	10_____	Immediate

WATER SOLUBLE IODINE-BASED CONTRAST MEDIUM

Key Points

- Water soluble iodine-based contrast medium is a positive contrast medium.
- It is a clear and viscous liquid.
- It may be ionic or non-ionic.
- The non-ionic version is safer for use in sick or smaller patients and for spinal examinations.
- Ionic contrast medium causes more irritation on injection, but is ideal for bladder and sinus tract investigations.
- It is ideal for the demonstration of abdominal organs, the spinal column and other soft tissue structures.
- The amount of iodine in solution is described in mg/ml. This is the number part of the contrast medium name.

LINK THE WORDS

Exercise 17.3 Match the examination name to the organs demonstrated.

Intravenous urography	Salivary glands
Dacrocystorhinogram	Bladder and urethra
Retrograde vagino-urethrogram	Joint space
Sialogram	Nasolacrimal ducts
Double contrast cysto-urethrogram	Kidneys, bladder ureters
Arthrogram	Venous supply to liver
Myelogram	Female vagina, urethra and bladder
Mesenteric portal venogram	Spinal column

STUDY

Look at all the contrast medium you have in your practice and think about what it is, the concentration of iodine if it is iodine based, the examinations it can be used for, and the quantities used.

PREPARING FOR CONTRAST STUDIES

Key Points

- Preliminary radiographs should always be taken.
- The contrast medium should be prepared and the correct amount made ready for introduction away from the patient and examination table.
- Care should be taken not to spill any contrast medium.
- Any spilt contrast medium should be cleared immediately to prevent artefacts appearing on future radiographs.

ACTIVITY

Exercise 17.4 From the list of equipment below, select what you would prepare for an intravenous urethrogram, a myelogram and a barium follow-through examination.

1. 5 ml syringe
2. 10 ml syringe
3. Allis tissue forceps
4. Sample containers
5. Scrub kit for clean prep
6. Foley catheter
7. IV catheter
8. Bladder catheter
9. Non-ionic contrast medium
10. Barium sulphate solution
11. Spinal needle
12. Kidney dish
13. Gloves
14. Clippers
15. Head support
16. Stomach tube

ACTIVITY

Retrograde or antegrade?

Exercise 17.5 Match the description of antegrade and retrograde correctly, then decide which examinations are performed antegrade and which are performed retrograde.

1.

Retrograde	Before in time or position
Antegrade	Back or backwards

2.

Barium enema
Barium follow-through
Barium impregnated poly spheres
Urethrogram
Double contrast cystogram
Intravenous urography
Vagino-urethrogram
Cervical myelogram
Mesenteric portal venogram
Thoracic myelogram

GENERAL REVISION

Multiple Choice Questions

Exercise 17.6

1. When using negative contrast medium what should happen to your exposure factors?
   a) increase kV
   b) decrease kV
   c) decrease milliamperes (mAs)
   d) increase mAs.

2. Introduction of air into the bladder, followed by water soluble iodine-based contrast medium is known as:
   a) pneumocystogram
   b) vagino-urethrogram
   c) double contrast urethrogram
   d) double contrast cystogram.

3. Barium sulphate is ideal for examinations of the gastrointestinal tract because:
   a) it is inert
   b) it is heavier than air
   c) it fills the stomach
   d) it is white and shows up on X-rays

4. barium sulphate should not be used if a patient:
   a) has a suspected perforation
   b) has been sedated
   c) has a severe swallowing difficulty
   d) all of the above.

5. The contrast medium of choice for a myelogram is:
   a) barium sulphate suspension
   b) non-ionic iodine-based contrast
   c) ionic iodine-based contrast medium
   d) air.

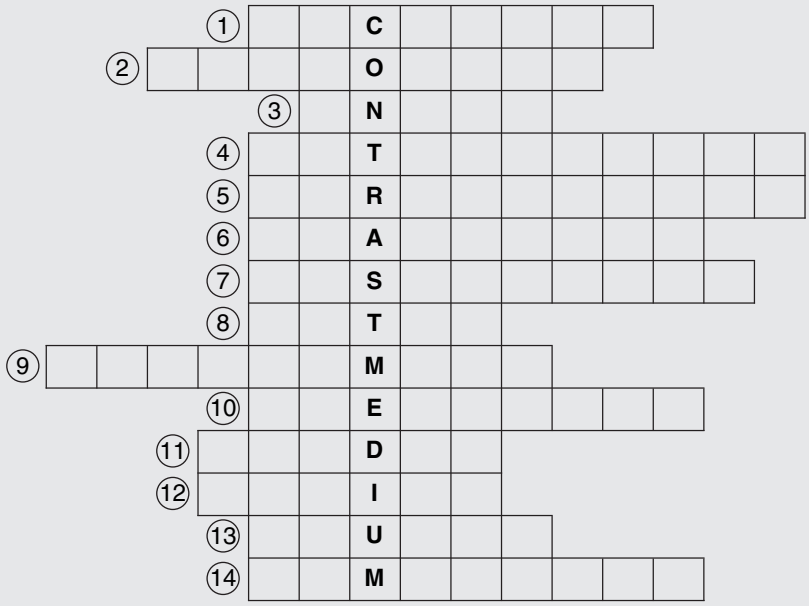
6. When performing an intravenous urethrogram the amount of contrast medium administered is:
   a) 2 ml/kg
   b) 1 ml/kg
   c) 0.5 ml/kg
   d) 5 ml/kg.

7. When setting up for a shoulder arthrogram, which technique should be employed?
   a) Alexander
   b) aseptic
   c) radiographic
   d) clean.

8. A sinogram will demonstrate:
   a) nasal chambers
   b) discharging sinus tract
   c) urethra
   d) salivary glands.

WORD CHART

Exercise 17.7



Clues

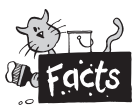
1. This is a necessary action on kV when using air.
2. This is what the bladder examination is called.
3. The introduction of barium sulphate into the rectum.
4. Method of introduction of contrast medium for a mesenteric portal venogram.
5. This is when not to administer barium sulphate.
6. This is what the examination of the salivary glands is called.
7. The presentation of barium sulphate.
8. This is used as a solution for iodine-based contrast medium.
9. This is a study for examining the stomach
10. This is what the examination of the spinal column is called.
11. The position of the bladder in the abdomen.
12. Injectable positive contrast medium.
13. Introduction of air and positive contrast medium.
14. The time after the introduction of contrast medium to first film in a barium follow-through.

18

ALTERNATIVE IMAGING MODALITIES

LEARNING OBJECTIVES

- Digital imaging
- Ultrasound
- Nuclear scintigraphy
- Magnetic resonance imaging
- Computerised tomography



FACTS ABOUT ALTERNATIVE IMAGING MODALITIES

- Alternative methods of imaging are becoming more common in veterinary practice as is the use of digital imaging and film storage.
- Ultrasound uses high frequency sound waves to form an image.
- Computerised tomography uses conventional X-rays with equipment designed to form an image on a monitor after manipulation.
- Magnetic resonance imaging utilises the effects of a very strong magnet and the interaction of radio waves.
- Nuclear scintigraphy involves injecting the patient with an isotope which emits gamma rays that are detected and transformed into an image.

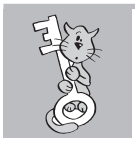
DIGITAL IMAGING

Key Points

- Digital imaging can be used for basic radiographic procedures and replaces the need for films.
- The image is produced using a cassette in the usual way, however the cassette contains digital plate instead of film.
- The image on the plate is processed by computer to give a digital image.

ACTIVITY

Find out more about digital imaging through the internet and manufacturers' information. Draw up a list of all the benefits and disadvantages you can think of that are involved in digital imaging.



ULTRASOUND

Key Points

- Ultrasound employs high frequency sound waves.
- The sound waves pass through the body and bounce back.
- A crystal in the transducer will be crushed by the wave causing an electrical impulse, which is amplified on a TV monitor.

A mode	Shows the depth into the patient of a tissue boundary
B mode	Lots of scan lines used to provide a two-dimensional cross-sectional image. This is the most common mode in use
M mode	Used in cardiology to freeze moving images, allowing comparison of an electrocardiogram (ECG) trace with the movement of the heart

ACTIVITY

Exercise 18.1 There are three very distinct stages in the preparation of a patient for ultrasound. Look at the pictures below and place them in order.

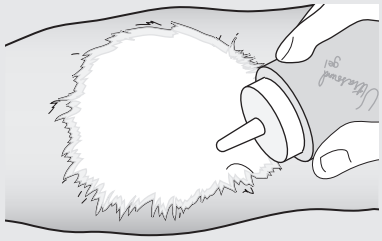


Figure 18.1 Spirit applied over the area.

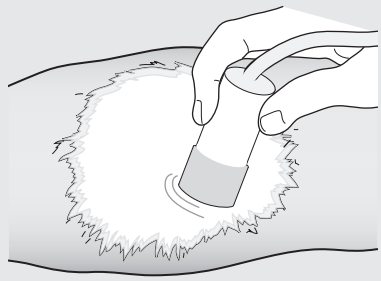


Figure 18.1 Gel placed on the skin surface and transducer to form a layer for the waves to pass through.

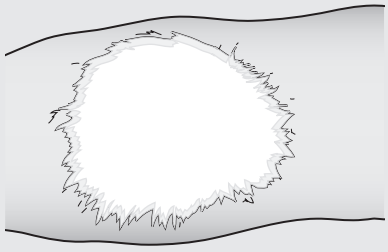


Figure 18.1 Clipped in the area of interest.

NUCLEAR SCINTIGRAPHY

Key Points

- Nuclear scintigraphy uses a radioactive isotope.
- The isotope is attached to a specific compound which will be taken up by the area of interest.
- The isotope is injected into the patient and will circulate in the blood, eventually passing into the area under examination.
- It will collect in this area and nowhere else, if bone is being examined it will go to bone only; active or damaged bone will have a greater concentration of the isotope.
- The isotope will emit gamma radiation from the animal and the gamma camera will detect the radiation.
- This radiation will be turned into an image.
- Care must be taken to ensure there is no spillage of the radioisotope in saliva or urine.

ACTIVITY

Exercise 18.2 Look at the radioisotope images below and identify the region under examination.

1.

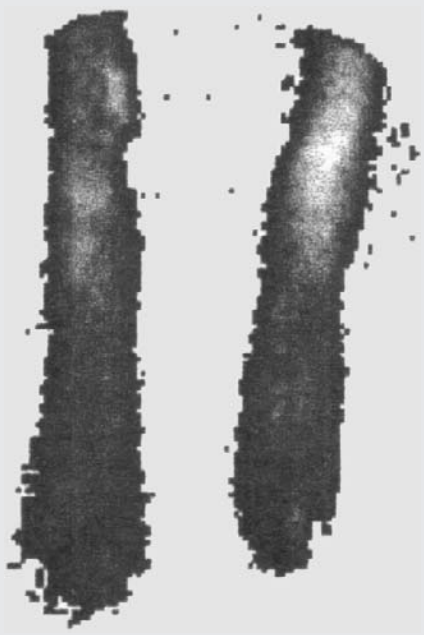


Figure 18.2a

2.

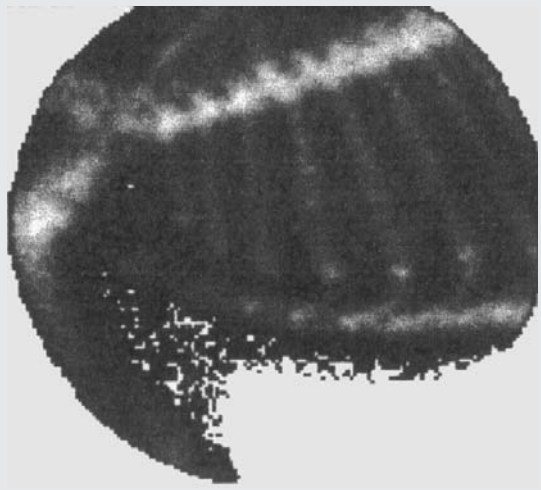


Figure 18.2b

3.

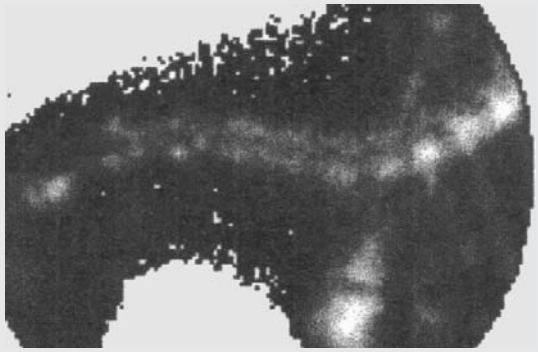


Figure 18.2c

4.

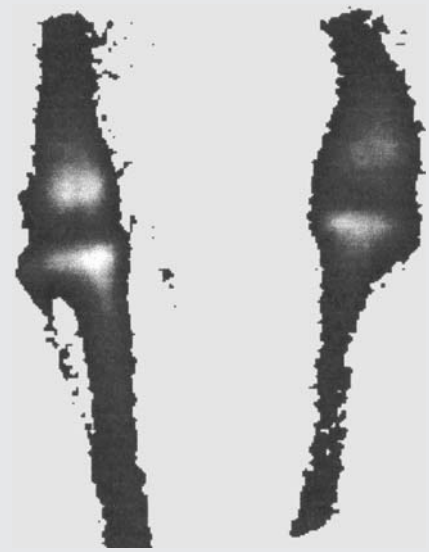
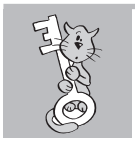


Figure 18.2d



MAGNETIC RESONANCE IMAGING

Key Points

- Magnetic resonance imaging (MRI) uses a magnetic field and the effects of a radio frequency on this field.
- The patient passes through a very narrow tunnel during the examination.
- The procedure is relatively expensive and very specialised.
- Nothing metallic/magnetic may be used in the room and any equipment for anaesthesia and patient care must be specially designed for use in the scanner.
- This technique gives excellent images of soft tissue structures, especially the spinal column and joints.

ACTIVITY

Exercise 18.3 MRI provides an image of the patient in three planes or projections. These are transverse, sagittal and coronal planes. Look at the diagram below and name the planes.

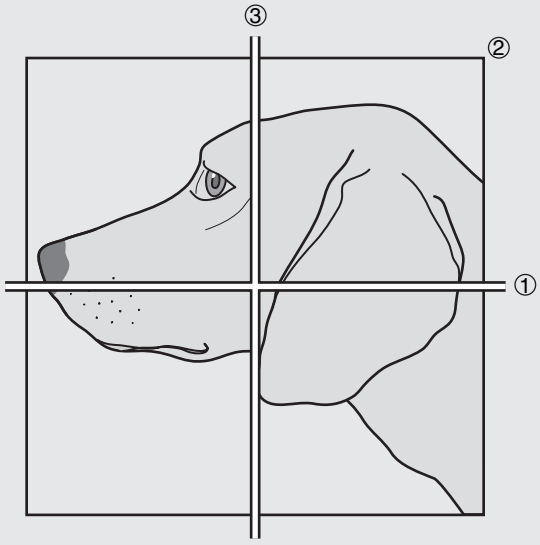
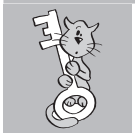


Figure 18.3 MRI head planes.



COMPUTERISED TOMOGRAPHY

Key Points

- Computerised tomography uses an X-ray tube that circulates around the patient in a spiral.
- Opposite the X-ray tube is a detector that collects the X-rays passing through the patient and reconstructs them into a digital image on a computer.
- The patient must remain still.
- Usual radiation safety procedures must be followed.
- The image obtained is cross-sectional, as if the animal has been cut through the middle many times like a sausage and the cut end is being examined.

ACTIVITY

Exercise 18.4 Look at the diagram of the CT scan image below and name the parts a–h.

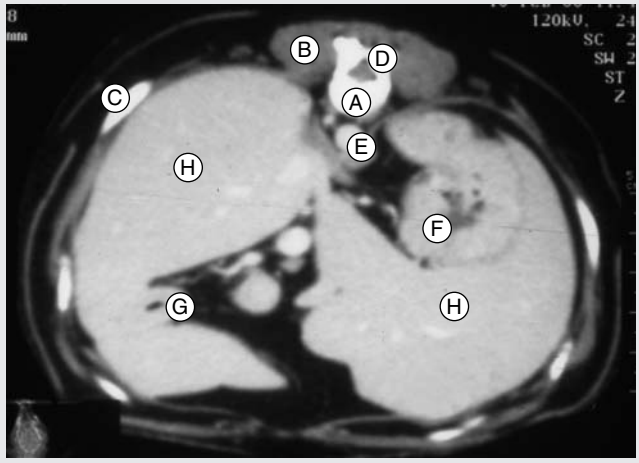


Figure 18.4 Diagram of an abdominal CT scan.

GENERAL REVISION

Multiple Choice Questions

Exercise 18.5

1. The technique that uses X-rays to produce an image is:
   a) computerised tomography
   b) magnetic resonance imaging
   c) digital imaging
   d) ultrasound.

2. The type of waves that ultrasound uses to form an image are:
   a) light
   b) gamma
   c) sound
   d) moving.

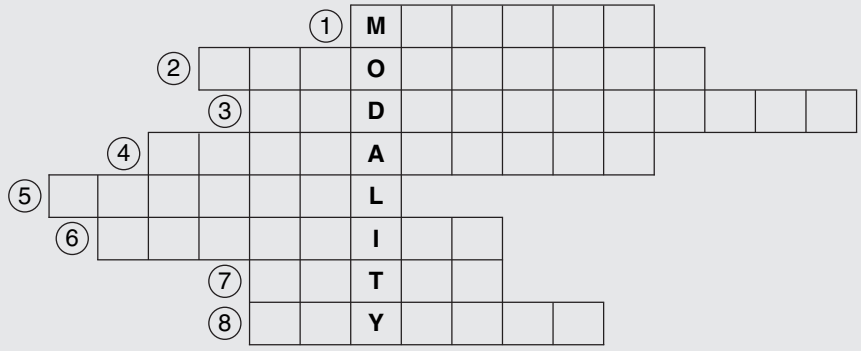
3. Prior to an ultrasound examination the patient is clipped, cleaned and a gel applied. This is done to:
   a) make sure the correct area is examined
   b) make the patient more relaxed
   c) increase the costs
   d) ensure good contact between the transducer and the patient.

4. Nuclear scintigraphy uses the emission of which part of the electromagnetic spectrum to form an image?
   a) microwaves
   b) gamma rays
   c) X-rays
   d) infrared.

5. Computerised tomography is not ideal for imaging:
   a) soft tissues
   b) brain tissues
   c) abdominal organs
   d) bone.

WORD CHART

Exercise 18.6



Clues

1. This is used to form an image in an MRI scan.
2. The movement of an X-ray tube around a patient.
3. This is injected into the patient in nuclear scintigraphy.
4. This is ideal for demonstrating soft tissue structures on animals with minimal sedation.
5. Modern technology producing a film-less X-ray department.
6. The first stage in the preparation of a patient for ultrasound.
7. The magnetic form of this must never be taken into the MRI examination room.
8. The soft tissue organ examined using nuclear scintigraphy.

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USEFUL READING

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Most editions of *Veterinary Nursing* in 2001–2005 contain radiography/imaging-related articles.

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ANSWERS TO EXERCISES

1 BASIC PHYSICS

1.1. **a** 4; **b** L; **c** N; **d** 16.

1.2. The ring nearest the nucleus should have 2 electrons; the next ring should have 8 electrons; the outer ring should have 3 electrons.

1.3. **1** Carbon: 6 protons, 6 electrons, 6 neutrons; **2** Barium: 56 protons, 56 electrons, 82 neutrons; **3** Silver: 47 protons, 47 electrons, 60 neutrons; **4** Oxygen: 8 protons, 8 electrons, 10 neutrons.

1.4. **1** 53 protons, 53 electrons, 74 neutrons; **2** 53 protons, 53 electrons, 78 neutrons.

1.5. The electrons should flow from the positive to the negative end of the wire.

1.6. **1** c; **2** b; **3** c; **4** a; **5** c; **6** a.

2 ELECTROMAGNETIC SPECTRUM

2.1. **1** Cosmic rays; **2** Gamma rays; **3** X-rays; **4** Ultraviolet; **5** Visible light; **6** Infrared; **7** Microwaves; **8** Radio waves.

2.2. **1** radio; **2** low; **3** short; **4** high; **5** penetrate; **6** long.

2.3. As you move towards the wall the torch light gets brighter and smaller. As the torch is moved away the beam gets bigger and less intense. This is an example of the inverse square law and shows how the intensity of the X-ray beam alters as the distance from the tube to the source alters.

2.4. Photon – Package of X-ray energy; Ionisation – Removal of an electron from an atom; Excitation – Movement of an electron from one energy level to another; Electromagnetic spectrum – Collection of energy types that all move in waves; Wavelength – The distance between two peaks of a wave; Frequency – The number of wavelengths passing a set point per second.

2.5. **1** True; **2** True; **3** False; **4** False; **5** False; **6** True; **7** False; **8** True.

2.6. **1** VISIBLE; **2** PHOTON; **3** WAVE; **4** MICROWAVE; **5** IONISATION; **6** TROUGH; **7** FREQUENCY; **8** ELECTROMAGNETIC.

3 X-RAY TUBE

3.1. **a** Insulated cables; **b** High tension cables; **c** Aluminium casing.

3.2. Without the focussing cup the electrons will spread out and miss the target; with the focussing cup they will all be directed on to the target.

3.3. **1** rotates; **2** electrons; **3** overheating; **4** same; **5** crazing; **6** tungsten; **7** copper; **8** molybdenum; **9** angled; **10** increases; **11** electrons; **12** minimum.

3.4. **1** Oil; **2** Black lead outer casing; **3** Pyrex tube; **4** Lead.

3.5. **1** Lead casing; **2** Window; **3** Target; **4** Filament.

3.6. **1** VACUUM; **2** TARGET; **3** FILAMENT; **4** HEAT; **5** ANODE; **6** CATHODE; **7** ROTATE.

4 X-RAY PRODUCTION

4.1. Refer to the flow diagram in Fig. 4.1 to see if you are correct.

4.2. **1** primary; **2** tissues; **3** low; **4** density; **5** minimal; **6** blackening; **7** normal; **8** lung; **9** absorbed; **10** scattered; **11** more; **12** attenuation; **13** increase; **14** Scattered;

15 electrons; **16** outer; **17** Absorption; **18** inner; **19** Bone; **20** soft tissues.

4.3. **1** b; **2** b; **3** d; **4** c; **5** a; **6** c; **7** b.

4.4. **1** ABSORPTION; **2** VACUUM; **3** HEAT; **4** ATTENUATION; **5** TARGET; **6** FILAMENT; **7** ELECTRONS.

5 EXPOSURE FACTORS

5.1. kV – penetrating power and contrast; mA – the number of X-rays produced and density; time – density; distance – intensity of beam reaching the patient and penetrating power.

5.2. **1** 44; **2** 43.

5.3. **1** 30; **2** 4 mAs 53 kV.

5.4. **1** 90 kV; **2** 1 mAs; **3** 60 kV.

5.5. **1** 100 cm FFD 100 mAs; **2** 45 kV 12 mAs; **3** 36 mAs.

6 X-RAY FILM

6.1. Film base – Made of polyester; Subbing layer – Acts as an adhesive; Emulsion – Made of gelatine; Silver halide grains – React with light and radiation; Supercoat – Protects the emulsion; Anti-curl – Stops the film from curling.

6.2. **1** Non-screen film; **2** Single-sided screen film; **3** Polaroid; **4** Duplitised film.

6.3. **1** Temperature; **2** Light; **3** Pressure; **4** Humidity; **5** Chemicals; **6** Radiation.

6.4. **1** True; **2** True; **3** False; **4** True; **5** True; **6** False; **7** False; **8** True; **9** True; **10** False.

6.5. **1** SENSITIVITY; **2** SUBBING; **3** DUPLITISED; **4** POLYESTER; **5** LIGHT; **6** HALIDE; **7** POLAROID; **8** GELATINE; **9** GREEN; **10** LATENT.

7 INTENSIFYING SCREENS, CASSETTES AND GRIDS

7.1. **1** Fast tungstate; **2** Rare earth; **3** Rare earth; **4** Single screen; **5** Non-screen; **6** Single screen; **7** Rare earth; **8** Single screen; **9** Single screen; **10** Non-screen.

7.2. Light fogging due to a broken cassette clip.

7.3. **1** Parallel – Most versatile, Fig. 7.3a; **2** Focussed – Must be used at the correct FFD, Fig. 7.3b; **3** Pseudo-focussed – Grid of choice but expensive, Fig. 7.3c; **4** Cross-hatched – Ideal for large animal work, Fig. 7.3d; **5** Moving grids (Potter bucky) – built into the X-ray table, moves to remove grid lines, Fig. 7.3e.

7.4. **1** b; **2** c; **3** a; **4** b; **5** c; **6** c.

7.5. GRID – PARALLEL; SCREEN – FLUORESCENCE; CASSETTE – CARBON; CALCIUM – TUNGSTATE.

8 PROCESSING CYCLE

8.1. Refer to the flow diagram in Fig. 8.1 to see if you are correct.

8.2. **1** Solvent – Water. Allows chemicals to be soluble and penetrate the emulsion; **2** Other additives – Hardener reduces swelling and allows softening of emulsion. Fungicide prevents fungal growth. Wetting agent stops bubbles and froth forming; **3** Accelerator – Ensures the solution is alkali pH at 9.6–10; **4** Preservative – Slows the oxidation of the developer; **5** Restrainers – Makes the developer more accurate, preventing fogging; **6** A buffer – Maintains the pH; **7** Developing agents – The active part of the solution; **8** Sequestering agent – Stops a build-up of sludge formed during the developing process.

8.3. **1** False; **2** True; **3** True; **4** True; **5** True; **6** False; **7** False; **8** False; **9** True; **10** True.

8.4. **1** FOGGING; **2** SILVER; **3** COSHH; **4** HARDENER; **5** ALKALINE; **6** SLUDGE; **7** WATER; **8** BUTTER; **9** SEPIA; **10** BRITTLE; **11** FIXER; **12** FIXER.

9 PROCESSORS AND THE DARKROOM

9.1. **1** Expose film to light and radiation; **2** Enter darkroom; **3** Check developer temperature;

4 Mix developer; **5** Switch on safelights; **6** Place film into film hanger; **7** Put film into developer and set timer; **8** Move film to wash for 10 seconds; **9** Place film into fixer solution; **10** Leave film in solution for double the clearing time; **11** Film in to wash for 30 minutes; **12** Film left to dry in a dust-free environment; **13** Film ready for storage; **14** Switch off machine and cover developer.

9.2. **Room dimensions** – Adequate floor space, Minimum of 10 m^2; **Floors** – Light coloured, Non-porous, Non-slip, Easily cleaned and maintained; **Walls and ceilings** – Painted to reflect light, Easy to keep clean, If there is to be wet processing there should be a tiled splashback to allow cleaning, Painted coloured, Oil-based paint; **Ventilation** – Removes any fumes present**,** Improves working environment**,** Over-heating and high humidity will alter the way the chemicals function; **Doors** – Accidental entry must be avoided, Double doors are ideal, but need room, Single door must be light tight and lockable from the inside.

9.3. A red safelight will only allow red light to pass through. The film is not sensitive to red light and so it will not be fogged. If any other colour of safelight is used the film will fog as the components of white light that the film is sensitive to (green and blue) will be able to pass through and fog the film.

9.4. **1** b; **2** c; **3** b; **4** b; **5** a; **6** c.

9.5. **1** TEM**P**ERATURE; **2** HANGE**R**; **3** **R**OLLER; **4** **C**EILING; **5** **R**EPLENISHMENT; **6** FLOOR**S**; **7** TANK**S**; 8 AUT**O**MATIC; **9** D**R**YER.

10 IMAGE QUALITY

10.1. A = 1, C = 3, B = 4, D = 2.

10.2. **a** diagnostic; **b** high; **c** low.

10.3. Penumbra are the shaded triangles on each image. Penumbra makes an image appear blurry as it is formed with the diverging beam and not the main part of the primary beam.

10.4. **1** True; **2** False; **3** True; **4** False; **5** True; **6** True; **7** True; **8** True; **9** True; **10** True.

10.5. **1** **D**ISTORTION; **2** P**E**NUMBRA; **3** MAG**N**IFICATION; **4** CONTRA**S**T; **5** WH**I**TE; **6** DENSI**T**Y; **7** GRE**Y**.

11 FILM FAULTS

11.1. Grey or white streaks – Wet coat; Lumpy appearance across radiograph – Wet bed under or over patient; Line across thorax region with a loop of metal – Lead not removed; Studs around neck – Collar not removed; Blurred image – Patient movement during exposure; Large area of mottling in colon and stomach – Patient not starved before examination.

11.2. The tail is over the stifle. The tail should be removed from the area of interest.

11.3. There is dirt on the screens. It has this distinct appearance because the dirt prevents light emitted from the screens from reaching the film. Screens should be carefully cleaned.

11.4. **Film too dark/overexposed** – kV too high, mA too high, Time too long, Distance too short, Grid not used; **Film too light/underexposed** – kV too low, mA too low, Time too short, Distance too long, Grid used without increasing exposure, Cassette back to front.

11.5. **a** Processor pressure marks; **b** fixer splash; **c** light fogging. Developer splash is the fault that is not demonstrated.

11.6. The markers are over the region of interest. This can be avoided by careful placement of markers.

11.7. **a** Poor film use; **b** Collar left on; **c** Double exposure; **d** Over exposure; **e** Rotated position; **f** Inadequate collimation; **g** Underexposure; **h** Wet coat.

12 RADIATION SAFETY

12.1. **1** MUSCLE; **2** BRAIN CELLS; **3** NERVE TISSUE; **4** BONE; **5** SKIN; **6** RED BLOOD CELLS; **7** LYMPHOCYTES.

12.2. **1** Radiation protection advisor; **2** Radiation protection supervisor; **3** Local rules; **4** Systems of work; **5** Exposure chart.

12.3. **1** film; **2** different ports; **3** thickness; **4** types; **5** blackening; **6** analysis; **7** expensive; **8** crystals; **9** lithium fluoride; **10** density; **11** tissues; **12** worn; **13** irradiated; **14** heated; **15** emitted; **16** dose; **17** calculated; **18** re-used.

12.4. **1** Manual restraint; **2** No lead protection for veterinary surgeon; **3** Child/owner in room; **4** Monitoring badge in wrong position.

12.5. **1** c; **2** c; **3** d; **4** a; **5** d; **6** c.

12.6. **1.** SCATTE**R**; **2.** LOCA**L**; **3.** **D**OSIMETER; **4.** F**I**LM; **5.** ALAR**P**; **6.** **T**LD; **7.** DIVI**D**E; **8.** SUPERVIS**O**R; **9.** PROTECTIO**N**.

13 PRINCIPLES OF RADIOGRAPHIC POSITIONING

13.1. **1** Left; **2** Right; **3** Dorsal; **4** Front of lower limbs or top of main trunk; **5** Underside of animal; **6** Cranial; **7** Towards the head; **8** Caudal; **9** Towards the tail; **10** Rostral; **11** Towards the nose; **12** Medial; **13** Inside of leg; **14** Lateral; **15** Proximal; **16** The higher end of an extremity or bone; **17** The part of a bone or limb furthest from the main body; **18** Palmar; **19** Back edge of the lower forelimb; **20** Plantar.

13.2. STERNUM; PATELLA; ANGLE OF MANDIBLE; SCAPULA; LAST RIB; ILIUM; INNER CANTHUS; CONDYLE; ACROMION; TROCHANTER.

13.3. **1** Positioning; **2** Centering and collimation.

13.4. **1** False; **2** True; **3** True; **4** False; **5** False; **6** False; **7** False; **8** True.

13.5. **1** Identify the patient; **2** Ensure examination is known; **3** Identify projections needed; **4** Select the correct film screen combination and exposure factors; **5** Place the patient on the table in suitable recumbency; **6** Ensure the cassette is under the area of interest; **7** Position the patient using sandbags and pads; **8** Turn on the light; **9** Centre and collimate the primary beam; **10** Double check exposure factors; **11** Ensure everyone is protected; **12** Make exposure.

14 RADIOGRAPHY OF THE FORELIMB

14.1. **a** Ulna; **b** Radius; **c** Growth plate; **d** Carpal bones; **e** Metacarpal bones; **f** Phalanges.

14.2. **a** Humerus; **b** Ulna; **c** Radius; **d** Olecranon; **e** Condyle of humerus; **f** Head of radius; **g** Medial condyle.

14.3. **1** Lateral; **2** lateral; **3** nearest; **4** upper; **5** sandbag; **6** extended; **7** drawn forward; **8** caudal; **9** tuberosity; **10** Caudocranial; **11** dorsal; **12** pads; **13** sandbags; **14** chest; **15** cranially; **16** extended; **17** tie; **18** acromion process; **19** anaesthetised.

14.4. **1** c; **2** c; **3** b; **4** b; **5** d; **6** c; **7** b.

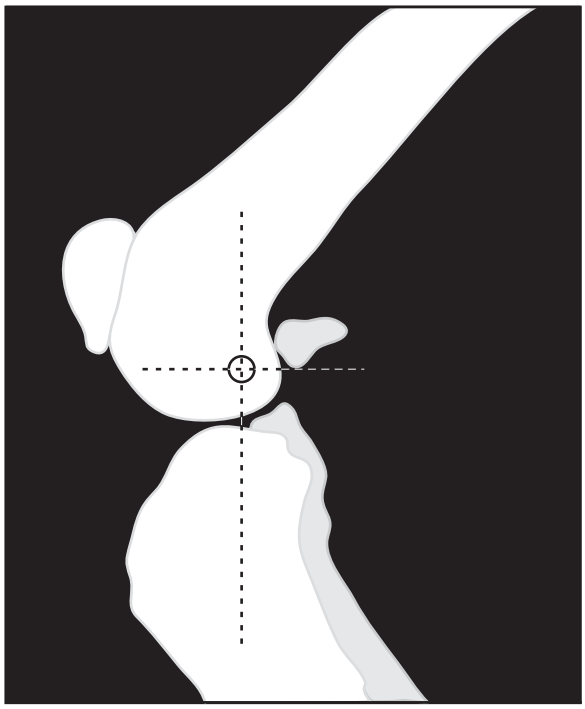
14.5. **1** Carpal joint; **2** Midway between skin surfaces; **3** DP carpus; **4** Humeral condyles; **5** Midline; **6** Lateral shoulder; **7** Midline; **8** Level with acromion process.

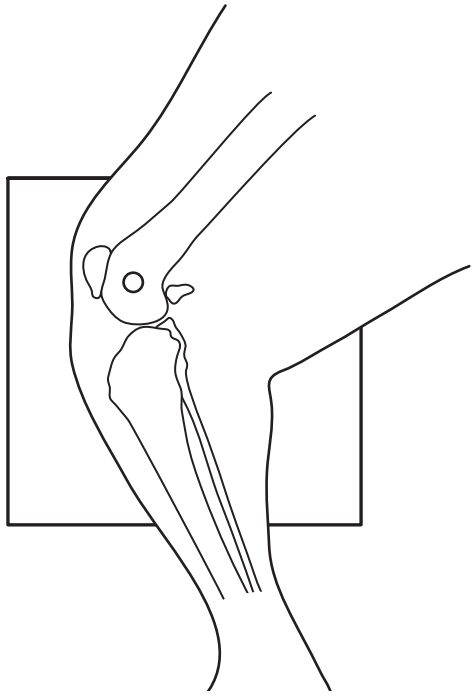
14.6. **1** THIRD; **2** PHALANX; **3** CONDYLE; **4** TIE; **5** RAISING; **6** SHOULDER; **7** DORSAL; **8** ELBOW; **9** PAD; **10** TUBEROSITY.

15 RADIOGRAPHY OF THE HINDLIMB

15.1. **a** Tibia; **b** Calcaneum; **c** Metatarsal bones; **d** Central tarsal bone; **e** Talus; **f** First metatarsal bone; **g** Fourth tarsal bone.

15.2.





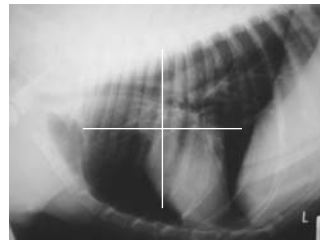
15.3. **1** Lateral; **2** lateral; **3** nearest; **4** lateral; **5** pads; **6** primary beam; **7** trochanter; **8** collimation; **9** ilium; **10** acetabulum; **11** Ventrodorsal; **12** dorsal; **13** pads; **14** sandbags; **15** rotation; **16** longitudinal; **17** extended; **18** femora; **19** medially; **20** tied; **21** stifles; **22** sandbags; **23** beam; **24** greater; **25** tie; **26** anaesthetised.

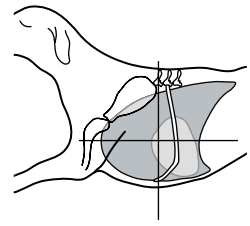
15.4. **1** False; **2** True; **3** False; **4** True; **5** True; **6** True; **7** False; **8** False.

15.5. **1** **H**IP; **2** PELV**I**S; **3** CON**D**YLE; **4** MI**D**LINE; **5** PATE**L**LA; **6** STI**F**LE; **7** ME**D**IAL; 8 FI**B**ULA.

16 RADIOGRAPHY OF THE AXIAL SKELETON, CHEST AND ABDOMEN

16.1.

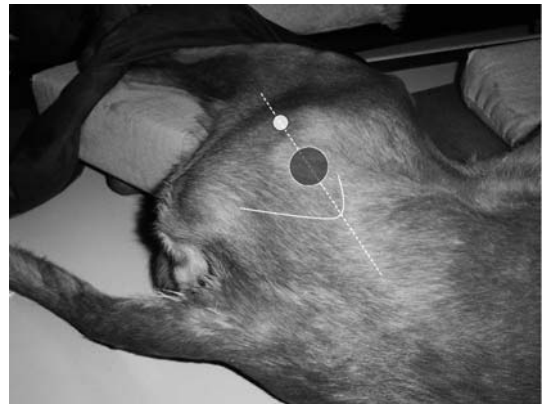




16.2. **a** Bladder; **b** Kidney; **c** Large intestine; **d** Stomach; **e** Liver; **f** Small intestine with gas; **g** Transverse processes of spine.

16.3. **a** Coronoid process of mandible; **b** Zygoma; **c** Incisors; **d** Cranium; **e** Nasal septum; **f** Pre-molars.

16.4.



16.5. **1** a; **2** c; **3** c; **4** b; **5** b; **6** b; **7** d.

16.6. **1** CHEST; **2** SKULL; **3** ABDOMEN; **4** LUMBAR; **5** LATERAL; **6** TRANSVERSE; **7** VENTRODORSAL; **8** NASAL CHAMBERS.

17 CONTRAST STUDIES

17.1. The bladder is seen in this way because it has contrast against the bladder wall with the bladder inflated with air, enhancing the wall.

17.2. **1** Barium swallow; **2** Lateral chest; **3** Stomach; **4** 1–3 ml/kg; **5** Immediate and as required; **6** Small intestine; **7** Barium follow through; **8** Immediate and 5, 10, 30 minutes plus as required; **9** Barium enema; **10** Lateral caudal abdomen.

17.3. **1** Intravenous urography – kidneys, bladder ureters; **2** Dacrocystorhinogram – nasolacrimal ducts; **3** Retrograde vagino-urethrogram – female vagina, urethra and bladder; **4** Sialogram – salivary glands; **5** Double contrast cysto-urethrogram – bladder and urethra; **6** Arthrogram – joint space; **7** Myelogram – spinal column; **8** Mesenteric portal venogram – venous supply to liver.

17.4. **1** myelogram; **2** intravenous urethrogram; **3** intravenous urethrogram; **4** intravenous urethrogram, myelogram; **5** intravenous urethrogram, myelogram; **6** intravenous urethrogram; **7** intravenous urethrogram; **8** intravenous urethrogram; **9** intravenous urethrogram, myelogram; **10** barium follow through; **11** myelogram; **12** intravenous urethrogram; **13** intravenous urethrogram, myelogram, barium follow through; **14** intravenous urethrogram, myelogram; **15** myelogram; **16** barium follow through.

17.5. **1** Retrograde – Back or backwards; Antegrade – Before in time or position; **2** barium enema – retrograde; barium follow through – antegrade; barium impregnated poly spheres – antegrade; urethrogram – retrograde; double contrast cystogram – retrograde; intravenous urography – antegrade; vagino-urethrogram – retrograde; cervical myelogram – antegrade; mesenteric portal venogram – antegrade; thoracic myelogram – antegrade or retrograde depending on injection site.

17.6. **1** b; **2** d; **3** a; **4** d; **5** b; **6** b; **7** b; **8** b.

17.7. **1** DECREASE; **2** CYSTOGRAM; **3** ENEMA; **4** INTRAVENOUS; **5** PERFORATION; **6** SIALOGRAM; **7** SUSPENSION; **8** WATER; **9** BARIUM MEAL; **10** MYELOGRAM; **11** CAUDAL; **12** IODINE; **13** DOUBLE; **14** IMMEDIATE.

18 ALTERNATIVE IMAGING MODALITIES

18.1. **1** Clipped in the area of interest; **2** Spirit applied over the area; **3** Gel placed on the skin surface and transducer to form a layer for the waves to pass through.

18.2. **1** Carpi; **2** Ribs; **3** Cervical spine; **4** Stifles.

18.3. **1** Transverse; **2** Sagittal; **3** Coronal.

18.4. **a** Vertebral body; **b** Lumbar muscle; **c** Rib; **d** Spinal column; **e** Aorta; **f** Stomach; **g** Intestine; **h** Liver.

18.5. **1** a; **2** c; **3** d; **4** b; **5** d.

18.6. **1** MAGNET; **2** TOMOGRAPHY; **3** RADIOISOTOPE; **4** ULTRASOUND; **5** DIGITAL; **6** CLIPPING; **7** METAL; **8** THYROID.