Color Atlas of Veterinary Anatomy

Volume 1

The Ruminants
This book is intended for veterinary students and practising veterinary surgeons. Important features of topographical anatomy are presented in a series of full-colour photographs of detailed dissections. The structures are identified in accompanying coloured line drawings, and the nomenclature is based on that of the Nomina Anatomica Veterinaria (1992); Latin terms are used for muscles, arteries, veins, lymphatics and nerves, but anglicized terms are used for all other structures. When necessary, information needed for interpretation of the photographs is given in the captions. Each section begins with photographs of regional surface features taken before dissection, and complementary photographs of an articulated bovine skeleton illustrate the important palpable bony features of these regions. All dissections and photographs have been specially prepared for this book.

The cattle (two cows and four calves) were all Jerseys and the three goats were of the British Saanen breed. The specimens were embalmed, for the most part, in the standing position using methods routinely employed in the Department of Anatomy at the Royal Veterinary College. Every effort was made to ensure that the final position corresponded to that of normal level standing. In most cases red neoprene latex was injected into the arteries. The dissections follow the pattern of prosections used for teaching at the Royal Veterinary College for many years. The photographs of the adult bulls were taken at the Milk Marketing Board’s cattle breeding centre at Bletchley.

The aim of these dissections and photographs is to reveal the topography of the animal as it would be presented to the veterinary surgeon during a routine clinical examination. Therefore, lateral views predominate and we have, as far as possible, avoided photographs of parts removed from the body or the use of views from unusual angles, or of unusual bodily positions. It is our earnest hope that this book will enable students and veterinary surgeons to see, beneath the outer surface of the animals entrusted to their care, the muscles, bones, vessels, nerves and viscera that go to make up each region of the body and each organ system.

A significant difference between this edition of the volume and previous editions is the addition of new radiographs in Chapter 10. A second major difference is the inclusion of clinical notes at the beginning of each main chapter. These notes highlight the areas of anatomy which are of particular clinical significance. We feel that these additions to the book add considerably to its usefulness especially to the aspiring veterinary surgeon.
ACKNOWLEDGEMENTS

The dissections and photography for this book were carried out at the Royal Veterinary College, University of London. We are grateful to the Department of Anatomy for the provision of specialized facilities, without which this work could not have been possible. In particular we would like to thank Susan Evans, MIST, Chief Technician in Anatomy, for advice and assistance with the dissections and photography. The task of preparing and caring for the specimens before and during dissection was undertaken by Douglas Hopkins and Andrew Crook, both of whom also assisted with the dissections. We are also grateful to Gareth Hateley and Tony Andrews for their contributions to the clinical comments, and to Gayle Hallowell for providing us with the radiographs for Figures 10.4, 10.5, 10.15, 10.16 and 10.17. Dr Lizza Baines provided the remaining radiographs and we are grateful for her help with the new chapter on radiographical imaging.

The programme of prosections of the cow used in this book has been based on that developed over several years in this Department of Anatomy, by Harry Merlen, MRCVS; he also prepared the dissections of the abdomen of the goat.

The idea of producing an atlas of ruminant anatomy based on our yearly teaching programme of prosection of cow and calf, resulted from discussions within Gower Medical Publishing. We are very grateful to the project editor, designer and illustrators for their hard work and for sustaining us with their optimism and enthusiasm.

Our wives have been somewhat neglected at times while we picked at the carcases and puzzled over transparencies. We would like to thank them for their forbearance and understanding.

RRA
SD
Numerous original papers have been consulted during this work but our studies have mainly been supported by a range of anatomical textbooks. We would especially acknowledge our debt to the following, which have been our constant companions throughout the preparation of the specimens and the text:

Ashdown RR 2006 Functional, developmental and clinical anatomy of the bovine penis and prepuce. CABI Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 1 No: 021, 1–29
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>xi</td>
</tr>
<tr>
<td>The head</td>
<td>1</td>
</tr>
<tr>
<td>The neck</td>
<td>27</td>
</tr>
<tr>
<td>The forelimb</td>
<td>41</td>
</tr>
<tr>
<td>The thorax</td>
<td>61</td>
</tr>
<tr>
<td>The abdomen</td>
<td>89</td>
</tr>
<tr>
<td>The hindlimb</td>
<td>135</td>
</tr>
<tr>
<td>The foot</td>
<td>161</td>
</tr>
<tr>
<td>The pelvis</td>
<td>183</td>
</tr>
<tr>
<td>The udder, scrotum and penis</td>
<td>219</td>
</tr>
<tr>
<td>Radiographic anatomy of the head, manus and pes</td>
<td>239</td>
</tr>
<tr>
<td>Index</td>
<td>253</td>
</tr>
</tbody>
</table>
INTRODUCTION

The range of the Veterinary Curriculum is continually expanding, and in many subjects its depth is continually increasing, yet the overall length of the course remains constant. As a result, there is pressure to allocate less and less time to some subjects, of which Anatomy is a notable example. Furthermore, within departments of Anatomy the desire to give greater emphasis to functional and applied aspects of the discipline, to radiological anatomy, and to teratology makes it increasingly difficult to allocate adequate time to personal dissection of each species by each student. An obvious solution to this problem is to rely more and more upon prepared dissections for the teaching of topographical anatomy. This saves much student time, but has several major disadvantages. Firstly the student loses the chance to gain manipulative skills, and is unable to see and feel the structures as they are progressively revealed by scalpel and scissors. Secondly, it means that the student must rapidly and in quick succession master complexities that were more surely understood by the leisurely methods of thirty years ago. Nothing can fully compensate for the lack of personal dissection by the skilled dissector supplemented by the intelligent use of graphic methods to record the work as it progresses. However, our experience at the Royal Veterinary College over more than fifteen years has convinced us that the work of the skilful prosector, carefully studied, recorded and annotated, can be more useful than personal dissections of large animals carried out hurriedly by a group of inexpert students. One problem in the teaching of topographical anatomy from prepared specimens has been the difficulty of providing students with enough good preparations of a full range of dissection stages of specific regions. It is our sincere hope that this photographic atlas of dissections will help to compensate for this deficiency in prepared specimens. For those students who are able to carry out their own detailed dissections, this atlas will provide a permanent reminder of what they saw, or should have seen, during each stage (often transitory) of the dissection.

The sequence of dissections presented in this volume is an expanded version of that used by us for a series of twelve three-hour sessions on the topographical anatomy of ruminants. Each stage of the work has been photographed in order to show many more stages of each major dissection than can be shown in our practical demonstration classes. We hope that this will compensate for the loss of the third dimension that is inevitable in photographs of dissections. We have tried to present the progression of required dissections as they occurred. Where the specimen was ‘unusual’ or where we were not completely successful in demonstrating all of the structures as planned, we have not substi-
Clinical importance of the head

For the diagnosis of many important ruminant disorders and disease, the head is extremely important. In these days of minimal examination the head of the livestock under our care is the most accessible site of inspection. Rapid examination of the head of an individual or group is often enabled as animals raise their heads to inspect us as we inspect them. They rarely present their foot for us to examine easily.

The anatomy of the ox, sheep and to a lesser extent goat is also important in that inspection of carcasses and viscera is essential in food inspection to ensure safety of the human population from zoonotic disease through Food Safety Agencies. Secondly, pathological material has also to be prevented from entering the food chain. Thirdly, and of most importance for veterinarians, inspections in the abattoir enable us to monitor the occurrence of enzootic (naturally-occurring) and of most importance for veterinarians, inspections in the abattoir enable us to monitor the occurrence of enzootic (naturally-occurring) and epizootic (foreign animal) diseases in animal populations under our care.

Superficially, how the head is carried, the use of the ears and the brightness of eye may give us a sense of the animal’s well-being.

There are a variety of important skin conditions including dermatophyties (particularly important over the back), lice and mites, warts (often found on the head), urticaria, photosensitization and cancer-eye (squamous-cell carcinoma) that are often particularly relevant in the head. These latter two are a consequence of mucosal penetration, and are palpable as swellings. Jaw fractures and abscesses may also occur as a result of their chewing habits and inoculation of bacteria through foreign bodies causing mucosal injuries. All of the mouth structures can be examined and facilitated by use of a gag.

Teeth can be examined as an aid to age estimation (often required for classification for cattle shows, particularly for estimation of temporary or permanent dentition). Fluorosis may also be seen by examination of teeth, as can the degree of tooth wear and its effects on the animal’s body condition.

Disorders of the central nervous system may be seen through abnormalities of the head. In the calf, some may be inherited (cerebellar abiotrophy, ataxia, hypoplasia, aplasia etc). Others follow entry through the buccal mucosa and then along the trigeminal pathways (e.g. listeriosis) or from septicaemias such as E. coli, Histophilus somni. Similarly, BSE may be the result of infection from the alimentary mucosa and subsequent spread via nerves or lymphatics. Cattle also suffer occasionally from protozoal infections such as toxoplasmosis and sarcocytosis.

The infectious diseases may produce one or more of four different syndromes (cerebral, cerebellar, vestibular or ponto-medullary) depending on the area affected. The most important are the exotics such as Aujeszky’s disease (shown as excitement, pruritis or aggression) or rabies. Listeriosis associated with winter feeding of silage causes multiple cranial nerve defects due to lesions in the medulla, particularly in the trigeminal nucleus (paralysis of cheek muscles, decreased facial skin sensation, facial palsy and tongue paralysis). Similar lesions can occur when the facial branches (buccal) of cranial nerve V are traumatised by direct injury.

Sub-mandibular oedema, although rare in cattle, is another important clinical sign in the head. This may be a rare feature in anthrax or may result from marked hypoproteinaemia such as occurs in chronic fascioliasis (liver fluke) or severe hepatitis and in heart disease.

The so-called subcutaneous (theoretically palpable) lymph nodes of the head are the parotid and sub-mandibular glands. They are not easily palpable in the normal animal but may be palpable in generalised infectious diseases, local infections or lymphosarcoma. They
are particularly important in abattoir inspections, together with the medial and lateral pharyngeal lymph nodes, in the diagnosis of bovine tuberculosis. Similar lesions occur in head nodes in actinobacillosis, actinomycosis and lymphosarcoma.

The bovine or ovine ear may be damaged by trauma. Occasionally, there may be otitis media (difficult to diagnose in cattle) or otitis externa.

A basic knowledge of the anatomy of the bovine brain is essential to identify at gross post-mortem, and on subsequent histological examination, the occurrence of many brain abnormalities. Individual diseases are beyond the scope of this short introduction but would include hydrocephalus, cerebellar hypoplasia, familial cerebellar ataxia, progressive ataxia, ‘weaver disease’ in Brown Swiss cattle, ‘shaking head’ in Hereford cattle, lysosomal storage diseases, spastic paraparesis (locomotary problem) and mannosidosis to name but a few.

The eye is subject to several clinical disorders including malignant catarrhal fever (MCF), uveitis and retinopathies, and trauma particularly to eyelids. Vitamin A deficiency (anophthalmia and microphthalmia etc) should not be a problem with modern nutrition. The exception is bovine infectious keratoconjunctivitis associated with *Moraxella bovis*. Nystagmus and strabismus do occur, but congenital palpebral defects are rare in cattle. One more common condition is ‘cancer-eye’ which is a squamous cell carcinoma of the eyelid. It occurs in white breeds of cattle (e.g. Hereford) where ultra-violet exposure on skin with little pigment appears to be required to start the condition. Diseases of the lens and congenital cataract are common. Colomboma is an absence of part of the eye. It used to be common in Charolais but now is no longer found. One of the surgical interventions that may be required in the ox is enucleation of the eye under general anaesthesia.

Developmental abnormalities of the skeleton of the head are uncommon. There may be abnormal lengths of the upper and lower jaws (undershot or overshot jaws) and these are more common than cleft palate, harelip or *epitheliogenesis imperfecta*. Osteopetrosis (metaphyseal dysplasia) with small size, shortened mandibles, protruding tongue, impacted and mis-shapen molar teeth, mis-shapen mandibles and open fontanelles, is occasionally seen. Poor positioning of the front teeth is quite common, especially in Herefords.

The nasal cavity of the ruminants is rarely affected but may be invaded by tumours. Malignant catarrhal fever may affect the nasal cavity in cattle. Infectious bovine rhinotracheitis which primarily affects the trachea may also seriously involve the eyes and nose causing severe conjunctivitis and rhinitis.

Disbudding is a very routine treatment in dairy cattle. It involves a conventional block of the cornual nerve (zygomaticotemporal branch of maxillary V). It is more difficult in goats, which have additional innervation of the horn (as shown in Fig. 1.43) and a closer proximity to the brain as the sinuses are much smaller. Here general anaesthesia is preferred. The cornual artery runs parallel with the cornual nerve and may bleed.

Dehorning of adult cattle is now comparatively rare. A standard cornual block is sufficient, using a large volume of a local anaesthetic and sufficient time lag for it to be allowed to work. A ring-block of the horn is required if it is very large, as it may be innervated in its caudal aspect by the superficial rami from cervical nerves I and II. A saw or embryotomy wire is best for cutting the horn, followed by haemostasis of cornual vessels by twisting or torsion. The larger vessels are ventral and rostral. Secondary haemorrhage is unlikely and sinusitis is also unlikely if an antiseptic dusting powder is used. All dehorning should be carried out in winter when there is minimal chance of fly-strike. Treatment of sinusitis in the extensive bovine sinuses is not easy.

Cerebrospinal fluid is often collected at post-mortem examination of animals suspected of having CNS conditions, particularly meningitis. In living animals this is a procedure which may cause risk to the patient and to those trying to collect the sample, so lumbar puncture is the method of choice.

For details of bovine medicine in this chapter and others, the reader is advised to consult Andrews, Blowey, Boyd and Eddy (2006), Bovine Medicine; for sheep, Diseases of Sheep, edited by Aitken (2007); for goats, Diseases of Goats by Harwood (2006), and for all species; Radostitis *et al*., Veterinary Medicine, 10th Edition.
Fig. 1.1 Palpable surface features of the bovine head, in left lateral view. The hair covering the palpable surface features was shaved off before embalming commenced.

Fig. 1.2 The skull and first five cervical vertebrae. Palpable features shown in fig. 1.1 are coloured red.
Fig. 1.3 Surface features of the nostril. Compare this figure with that of the goat shown in fig. 1.41.

Fig. 1.4 Surface features of the mouth.

Fig. 1.5 Surface features of the incisor teeth. The wear on the occlusal surfaces is clearly visible in this cow which was six years old at death. Compare this figure with that of the young goat shown in fig. 1.42.

Fig. 1.6 Surface features of the eye. The eye of the goat is shown in fig. 1.40.
Fig. 1.7 **Superficial structures of the head, in left lateral view.** Further details of selected areas are given in figs. 1.8, 1.9 and 1.10. The vascular notch in the ventral border of the body of the mandible in the sheep and goat contains only the facial vein. In these species the transverse facial artery is large and the parotid duct crosses the surface of the masseter muscle as illustrated by the broken blue line. The dotted lines highlight the palpable bony prominences.
Fig. 1.8 Superficial structures of the head – relationships of the infraorbital foramen. The levator labii maxillaris muscle has been slightly depressed to reveal the infraorbital foramen.

Fig. 1.9 Superficial structures of the head – relationships of the mental foramen. An oval hole has been cut in the depressor labii mandibularis muscle to reveal the mental foramen.
Fig. 1.10 Superficial structures of the parotid region. The auriculotemporal (mand. V) and auriculopalpebral (VII) nerves are not shown, but they are both present in fig. 1.32.
The structures lying deep to the parotid gland. The lateral retropharyngeal lymph node lies too far rostral in this specimen to be visible at this stage of the dissection. It often protrudes from the caudal edge of the mandibular gland (see figs. 1.15 and 1.32).
Fig. 1.12 The mandible and caudal buccal wall. The facial vessels and parotid duct occupy a distinct notch in the ventral border of the mandible. The mandible has been sawn ready for removal as shown in fig. 1.13.

Fig. 1.13 The structures lying medial to the mandible. The lateral pterygoid muscle covers the lingual nerve (mand. V) and this nerve is therefore not visible (see fig. 1.14).
**Fig. 1.14** The structures lying deep to the pterygoid muscles. The sternocephalicus and brachiocephalicus muscles have been entirely cut away to reveal the deeper structures of the neck region. The muscular wall of the pharynx rostral to the stylohyoid bone has been partly removed in order to expose the palatine tonsil.

**Fig. 1.15** The lateral and medial retropharyngeal lymph nodes. By displacing the mandibular gland, the lateral retropharyngeal lymph nodes are exposed and their position relative to the stylohyoid bone can be compared with that of the medial node.
Fig. 1.16 The maxillary cheek teeth and the muscles of the pharynx. The mandibular gland, ventral neck muscles and buccal wall have been removed. The veins have also been cut away to permit a clearer presentation of additional structures.
Fig. 1.17 The sublingual salivary gland and the sublingual fold. The sublingual fold and its papillae mark the line of the orifices of the ducts of the polystomatic part of the sublingual gland. The duct of the monostomatic part, like that of the mandibular gland, opens at the rostral extremity of this fold.

Fig. 1.18 Surface features and muscles of the tongue.

Fig. 1.19 The muscles of the tongue.
The hyoid apparatus, pharynx and larynx. The stylohyoid and epihyoid bones have been removed. After reflecting the linguofacial artery, the caudal and middle constrictor muscles of the pharynx and part of the hyoid apparatus have been removed to expose the caudal part of the stylopharyngeal muscle and the dorsal edge of the thyroid cartilage.
Fig. 1.21 *The pharynx and larynx*. The lateral wall of the nasopharynx and laryngeal pharynx has been removed. The corniculate process of the arytenoid cartilage is unusually dark in colour. The border of the mandible is shown by a blue dotted line, but it should be remembered that its relationships are greatly changed in life during flexion and extension of the atlantooccipital articulation.

Fig. 1.22 *The oral, nasal and laryngeal parts of the pharynx.*
Figs. 1.23–1.26 Surface features and bones of the cornual region in a dehorned cow.

Fig. 1.23 Frontal, temporal, cornual and auricular regions.

Fig. 1.24 Skull, mandible and cervical vertebrae. Palpable features shown in fig. 1.23 are coloured red.

Fig. 1.25 Frontal, temporal, cornual and auricular regions in cranial view.

Fig. 1.26 Skull and cervical vertebrae. Palpable features shown in fig. 1.25 are coloured red.

Fig. 1.27 Nerves and blood vessels of the right cornual region. Dissections of this region in immature and horned ruminants are shown in figs. 1.33 and 1.43. The cornual artery is relatively larger in horned individuals. The fine branches of the frontal nerve (oph. V) that run parallel and caudal to the infratrochlear nerve, could not be identified, and the auriculopalpebral nerve (VII) is not shown.
Fig. 1.28 The frontal and maxillary paranasal sinuses, in right lateral view. Further details of these sinuses are shown in figs. 1.29, 1.30 and 1.31.
The maxillary paranasal sinus in right craniolateral view. Part of the lacrimal bone surrounding the nasolacrimal duct has been removed and the position of the duct is shown by a white wire. The palatine extension of the sinus is often considered to be a separate sinus.

The maxillary paranasal sinus in cranial view. The sinus extends caudally into the lacrimal bulla to reach the level of the zygomaticofrontal process (see fig 1.39).
Fig. 1.31 The maxillary and frontal paranasal sinuses in cranial view. The specimen was freeze-dried before being photographed for this figure.
Fig. 1.32 Superficial structures of the head in the bull calf—parotid, masseteric and facial regions. This calf was about one week old.
Fig. 1.33 Superficial structures of the head in the bull calf—temporal, frontal and cornual regions. As in fig. 1.27, the fine branches of the frontal nerve (oph. V) could not be identified.
Fig. 1.34 The frontal and maxillary paranasal sinuses of the calf at one week of age: left craniolateral view. The longitudinal dorsal skin incision has been made just to the right side of the midsagittal plane.

Fig. 1.35 The paranasal sinuses and nasal cavity of the calf: left craniolateral view. A space labelled ‘nasal septum’ has been excavated within the cartilage of the septum. Lateral to this, the dorsal nasal meatus has been exposed. The cavity of the dorsal nasal concha lies lateral to the meatus and has not been opened.
Fig. 1.36 The left mucosal surface of the nasal septum in the calf. The left nasal cavity has been cut away by a paramedian sagittal incision to show that the highly vascular mucosa of the nasal septum conforms closely to the shape of the conchae which are related to it. The vascular enlargements of the septal mucosa are divided by grooves, labelled here as ‘septal grooves.’

Fig. 1.37 The cartilaginous nasal septum of the calf, in left lateral view. The mucosa of the nasal septum, shown in fig. 1.36, has been removed to expose the perpendicular septal plate of the ethmoid bone which is entirely cartilaginous in this young calf.

Fig. 1.38 The right nasal conchae in the calf after removal of the nasal septum: left lateral view. Comparison of this figure with fig. 1.36 shows the close correspondence between the anatomy of the mucosa of the nasal septum and that of the nasal conchae related to it.
Fig. 1.39 The nasal cavity and associated structures of the calf, in left craniolateral view. The specimen is at the same stage of dissection as that shown in fig. 1.38, but is here viewed from a more cranial and dorsal aspect.
Fig. 1.40 **Surface features of the left eye of the goat.** The eye was photographed a few minutes after death.

Fig. 1.41 **Surface features of the nostrils and mouth of the goat.** The specimen was photographed a few minutes after death. Compare with fig. 1.3.

Fig. 1.42 **The deciduous incisor dentition of the young goat.** The specimen was photographed a few minutes after death. Compare with the permanent bovine incisor dentition shown in fig. 1.5.
Fig. 1.43 Nerves and blood vessels of the left cornual region in the male goat. This figure should be compared with fig. 1.27 (dehorned cow) and fig. 1.33 (bull calf). The fine branches of the frontal nerve (oph. V) could not be identified.
2. THE NECK

The structures in the neck of the ox, sheep and goat are not of such clinical significance as in the horse and dog or cat. The larynx is not a subject of surgical intervention and is only occasionally involved in infectious diseases in the ruminants. The laryngeal form of necrobacillosis (calf diphtheria) does cause problems.

Superficially, the neck may be involved in surface trauma and there may also be the skin lesions mentioned in chapter 1. One of the most important uses of the neck is for tuberculin testing, although other sites can be used. The test is carried out in the middle of the neck from mandible to rostral border of the scapula and in the vertical middle third of the neck. This area is also suitable for intramuscular injections as any complications following injection such as infections then take place in an area of muscle of relatively low economic value.

The submandibular region as previously noted is a site for oedema. Similarly, oedema may also accumulate in the lower neck superficial to the brisket.

The lymph nodes of the neck are not generally palpable (medial and lateral retropharyngeals, cranial, middle and caudal cervical lymph nodes) but may be enlarged in cases of tuberculosis, lymphosarcoma (enzootic bovine leucosis) and local infection. They may not be palpable even then but will be seen at post-mortem or meat inspection. In any case, these nodes particularly the pharyngeal should be examined at meat inspection for tuberculosis. The major lymph node of the neck is the superficial cervical (formerly known as the pre-scapular) which is important in draining the whole of the front leg including the foot and also the caudal neck, withers and shoulder regions. It may be present as a single node or as a chain of nodes along the rostral border of the supraspinatus muscle.

The jugular vein is important for providing an easily accessible, large, subcutaneous vein for the collection of blood samples, and administration of drugs and anaesthetics and intravenous supportive therapy. For small volumes of blood, the coccygeal vein is a more practical method of obtaining samples. The appearance of a jugular pulse is a normal phenomenon in many cattle. However, the presence of an exaggerated pulse may also aid diagnosis of cardiovascular disease, especially pericarditis. Jugular stasis may occur when there are space-occupying lesions in the cranial mediastinum such as mediastinal abscesses, tuberculosis or lymphosarcoma.

The oesophagus is the organ most often causing problems in the neck. Occasionally there may be ulcers (mucosal disease and malignant catarrh) and an extension of calf diphtheria. Vomiting very rarely occurs in cows and may be associated with the ingestion of toxic or poisonous material such as laurel or rhododendron. False vomiting may occur in acute bloat and acidosis or in actinobacillosis of the rumen or traumatic reticulitis. Dilation and diverticulae may also occur in the lower cervical portion of the oesophagus when muscle weakness has occurred and there may be an accumulation of food in such a diverticulum. Lesions of trauma may occur if there is careless use of a probang or stomach tube or after giving a bolus. Stenosis may occur as a result of external pressure from enlarged lymph nodes such as in tuberculosis. Squamous cell carcinoma of the upper alimentary tract including the oesophagus may occur in the areas where bracken occurs.

The major clinical problem in the neck is choke, in which a foreign body is impacted in the oesophagus. Reverse peristalsis, which is important for regurgitation in the normal process of ‘chewing the cud’, will tend to help removal of objects from the oesophagus. Always remember the clinical signs of choke and rabies are similar in cattle – beware when poking your hand down a cow’s gullet in a country where rabies is endemic.

Choke can occur at three points – at the larynx, the thoracic inlet (first rib level) or in the thoracic oesophagus.

The blockage causes the head and neck to be extended and because saliva has nowhere to drain, excessive saliva flows from the mouth.

Choke follows feeding of root crops in particular. Salivation and bloat follows. In many cases, the administration of a simple spasmolytic may relax the oesophagus sufficiently for the stuck object to be passed. If stuck in the cervical oesophagus, it can be felt from the outside and may be massaged back to the nasopharynx. If fixed in the thoracic oesophagus, the object can be pushed into the rumen by probang, but if stuck completely at this site it may have to be removed through a rumenotomy. A ruminal cannula may be placed (to prevent bloat) until the blocking vegetable has macerated.

The great strength and high elasticity of the ligamentum nuchae is extremely important for raising the head from the ground. The head is lowered by muscular action of the ventral strap muscles.
Fig. 2.1 Surface features of the neck in left lateral view. The first rib, which demarcates the caudal boundary of the neck, is palpable medial to the major tuberosity of the humerus. The cranial border of the scapula is covered by muscles and is not clearly palpable.

Fig. 2.2 Cervical vertebrae and scapula. The palpable features shown in fig. 2.1 are coloured red.
Fig. 2.3 Superficial structures of the neck.
This figure shows the details of the boundaries of the jugular groove. The external jugular vein has collapsed and no longer fills this groove.
Fig. 2.4 The superficial cervical lymph node. The omotransversarius muscle has been sectioned to show the position of the superficial cervical lymph node, deep to the omotransversarius muscle, on the cranial border of the supraspinatus muscle.
Fig. 2.5 The contents of the carotid sheath and the muscles of the neck. The brachiocephalicus, sternocephalicus and cervical trapezius muscles have been removed. The carotid artery and the vagosympathetic trunk have been freed from the carotid sheath which normally encloses them.
Fig. 2.6 The caudal part of the neck and the brachial plexus. The forelimb has been removed, and the thorax dissected as shown in fig. 4.10.

Fig. 2.7 The lateral relationships of the first rib. The nerves of the brachial plexus have been reflected dorsally, and the axillary artery and vein have been tucked deep to the sternomandibularis muscle to show the lymph nodes and the relationships of the first rib to the muscles, nerves and artery.
Fig. 2.8 The thymus gland in the neck. The dorsal scalenus muscle has been removed and the fascia holding the thymus has been loosened to show the cranial and caudal parts of the cervical thymus. This cow was about six years of age.
Fig. 2.9 Nerves, arteries, veins and visceral organs of the neck. The external jugular vein and the ‘strap muscles’ of the neck have been removed.
Fig. 2.10 The ligamentum nuchae and the epaxial muscles of the neck. Removal of the splenius and rhomboideus muscles reveals the nuchal ligament, which is seen more fully in figs. 2.11 and 2.12.
Fig. 2.11 The nuchal ligament and deep epaxial muscles of the neck. Removal of the semispinalis capitis muscle reveals the nuchal ligament and the short segmental muscles of the neck, including those of the atlas and axis.
The Neck

Fig. 2.12 The nuchal ligament, vertebral artery and cervical nerves. The elastic nuchal ligament is fully revealed by removal of the epaxial muscle mass on the left side. The continuity with the supraspinous ligament is shown in fig. 2.10.
**Fig. 2.13** **Superficial structures of the neck in the calf.** The course of the dorsal branch of the spinal accessory nerve is unusual: the nerve usually lies deep to the cervical trapezius muscle.

**Fig. 2.14** **The spinal accessory nerve and the thymus gland in the neck of the calf.** Removal of the brachiocephalicus and sternocephalicus muscles exposes the cervical thymus gland, which is large at one week of age. Compare with fig. 2.8.
Fig. 2.15 The visceral and associated structures in the neck of the calf. Removal of the external jugular vein displays the contents of the carotid sheath.
Fig. 2.16 The cervical vertebrae, vertebral artery and ligamentum nuchae of the calf. This dissection was performed on the right side, but the figure has been reversed to allow comparison with figs. 2.13, 2.14 and 2.15. The entire epaxial musculature has been removed from this side to display the nuchal ligament.
As in most domestic animal species, the major conditions affecting a limb are in the foot. That is the region that touches the ground where the major hazards are and these will be dealt with in chapter 7. The forelimb can be subjected to trauma from hedges, gates etc causing skin wounds. Generalised wasting conditions affecting fat and muscles will also affect the forelimb and also the conditions of the skin described in the head section.

There are a few generalised skeletal conditions which may be observed in the forelimbs. Achondroplasia of calves such as the Dexter breed fall into this group (short limbs, short faces, flattened skulls).

Many of the central nervous system disorders, particularly the acute and convulsive disorders, affect both the front and hind legs. Signs include hyperaesthesia, circling, muscular weakness, aggression, collapse and convulsions. A long list could follow but the major conditions are BSE, acute hypomagnesaemia, ketosis, hepatic encephalopathy, meningitis (including listeriosis and *Histophilus somni*) infections), lead poisoning and tetanus.

Occasionally there may be damage to peripheral nerves following trauma. Any or all of the brachial plexus nerves may be affected by excessive abduction of the limbs and it is also possible to have specific trauma to the point of the shoulder affecting the suprascapular nerve. Any of the superficial nerves of the lower limb, e.g. radial and ulnar can also be damaged by surface trauma. These nerves may also be used, albeit rarely in the ox, for nerve blocks for anaesthesia. Of more importance at post-mortem and at meat inspection are the joints which can easily be affected following navel ill in the neonatal calf in which a septicaemic spread occurs. Any of the joints (shoulder, elbow, radiocarpal, carpo-metacarpal, metacarpo-phalangeal and phalangeal joints) may become infected following septicaemia, local trauma or penetrating foreign bodies. As in all other domestic species, there is no articulation between the forelimb and the spine, but in the case of the ox this can be important because of the sheer weight of the thorax supported on the front legs by the trapezius, rhomboids, pectoral muscles and especially the ventral serrate muscles. In some cases there may be a neurogenic atrophy of these muscles.

Occasional fractures of limb bones occur, usually requiring euthanasia, but sometimes muscle action so fixes these that they are not found until slaughter or post-mortem examination. The front leg has only two lymph nodes – the superficial cervical (may be single or a chain) takes most of the drainage, and the small axillary lymph node takes some drainage from the chest wall and medial aspect of the limb. Both need to be checked at meat inspection for signs of tuberculosis or abscessation.
Fig. 3.1 Surface features of the shoulder and forelimb, in left lateral view. The palpable bony prominences have been shaved.

Fig. 3.2 Bones of the shoulder and forelimb. The palpable features shown in fig. 3.1 are coloured red.

Fig. 3.3 Surface features of the forelimb, in left lateral view. In normal level standing, the olecranon lies superficial to the costochondral junction of rib 5. There is a divergent hair whorl in the white hair immediately caudal to the olecranon, but it is not visible in this figure because of the hair colour.

Fig. 3.4 Bones of the forelimb. The palpable features shown in fig. 3.3 are coloured red.
Fig. 3.5 Superficial muscles of the left scapular, brachial and antebrachial regions: (1). The strong omobrachial and brachial fasciae which cover the muscles of these regions have been almost entirely removed.

Fig. 3.6 Superficial muscles of the left scapular, brachial and antebrachial regions: (2). The more cranial parts of this dissection are shown in fig. 2.5.
Fig. 3.7 Muscles of the scapular, brachial and antebrachial regions in the detached limb: lateral view. The relationship of this limb to the thoracic structures is shown in fig. 4.12. The acromial part of the deltoideus has been removed and its scapular part cut, in order to show the tendon of insertion of the infraspinatus muscle.
The Forelimb

Fig. 3.8 Superficial muscles and nerves of the antebrachium and carpus: lateral view. The dense antebrachial fascia has been removed. The common digital extensor muscle has two tendons; that part of the muscle associated with the medial tendon is sometimes referred to as m. extensor digiti III proprius. The ulnar nerve runs superficially between the extensor carpi ulnaris and flexor carpi ulnaris muscles; it has been slightly displaced to reveal its position.
Fig. 3.9 Muscles, vessels and nerves of the scapular and brachial regions: medial view. The muscles that join the limb to the trunk have been cut, but their attachments to the scapula and humerus have been preserved. In this figure and fig. 3.10 no attempt has been made to display the axillary vessels and nerves in their topographical positions; these are shown in a separate series of dissections (figs. 3.25–3.28).
Fig. 3.10 Muscles, vessels and nerves of the scapular, brachial and antebrachial regions: medial view. Details of the nerves of the brachial plexus are exposed on cutting away the muscles joining the limb to the trunk. Removal of the limb makes it impossible to preserve the true topographical relationships of the nerves and blood vessels in the axilla, but these are shown in a separate series of dissections (figs. 3.25–3.28).
Fig. 3.11 Muscles of the antebrachium and carpus, in lateral view: (1). The extensor carpi radialis and extensor carpi ulnaris muscles have been incised in preparation for removal as shown in the 2nd, 3rd and 4th dissections in this series (figs. 3.13–3.15). The extensor carpi ulnaris muscle is often called the m. ulnaris lateralis.
Fig. 3.12 Muscles, vessels and nerves of the antebrachium and carpus, in medial view. The cut proximal ends of the ulnar median and radial nerves have fallen down into this figure and can be seen in the top right hand corner. Further dissections, shown in medial view, can be seen in figs. 3.16 and 3.17.
Fig. 3.13 Muscles of the antebrachium and carpus, in lateral view: (2). The extensor carpi ulnaris muscle has been removed to expose the digital flexor muscles.
Fig. 3.14 Muscles of the antebraclium and carpus, in lateral view: (3). The part of the extensor carpi radialis muscle that originates from the lateral epicondylar crest of the humerus has been removed to show the brachialis muscle more clearly.

Fig. 3.15 Muscles of the antebraclium and carpus, in lateral view: (4). The part of the humeral head of the extensor carpi radialis muscle that originates from the intermuscular septum between the extensor carpi radialis and the common digital extensor muscle has now been removed to show more clearly the component originating from the radial fossa of the humerus.
Fig. 3.16 Muscles, vessels and nerves of the antebrachium and carpus, in medial view: (1). The m. pronator teres has been removed to display the artery, vein and nerve at the cubital region more completely. The humeral origins of the carpal flexors have been incised in preparation for removal as shown in fig. 3.17. An earlier stage of this dissection is shown in fig. 3.12.
Fig. 3.17 Muscles, vessels and nerves of the antebrachium and carpus, in medial view: (2). Removal of the humeral origins of the carpal flexors exposes further details of the cubital region and two heads of the deep digital flexor muscle. Further details of this muscle are shown in the third dissection in this series (fig. 3.22).
Fig. 3.18 Muscles, vessels and nerves of the carpal and metacarpal regions: (1), dorsal view. The superficial ramus of the radial nerve was seen at antebrachial level in fig. 3.8. Its medial branch was seen in figs. 3.16, 3.17 and 3.21 and now its dorsal branch is seen as the third common dorsal digital nerve.

Fig. 3.19 Muscles, vessels and nerves of the carpal and metacarpal regions: (2), lateral view. The origin of the fourth common dorsal digital nerve from the dorsal branch of the ulnar nerve is shown by dotted lines. This origin is clearly revealed in fig. 3.8 but in all subsequent dissections has been removed.
Fig. 3.20 Muscles, vessels and nerves of the carpal and metacarpal regions: (3), palmar view. This figure should be compared with other views of the dissection, shown in figs. 3.18, 3.19 and 3.21.

Fig. 3.21 Muscles, vessels and nerves of the carpal and metacarpal regions: (4), medial view. The medial branch of the superficial ramus of the radial nerve (n. cutaneus antebrachii lateralis) seen below carpal level in this dissection, also includes fibres derived from the musculocutaneous nerve (n. cutaneus antebrachii medialis) (see fig. 3.12). Radial and musculocutaneous nerves combine to supply the dorsal aspect of the skin at carpal, metacarpal and digital levels.
Fig. 3.22 Muscles of the antebrachium and carpus, in medial view. Removal of the superficial part of the superficial digital flexor has exposed the deep part of this muscle and all three heads are now visible. The union between the tendons of superficial and deep parts of the superficial flexor muscle has been cut; it is located just proximal to the fetlock region.
Fig. 3.23 Superficial features of the right manus, in dorsal view. The saw cut used for the sagittal section in fig. 3.24 passes through the axis of the fourth digit and then through the axis of the limb in metacarpal, carpal and antebrachial regions.

Fig. 3.24 Bones and muscles of the right manus seen in sagittal section. The detailed anatomy of the manus and pes is dealt with in a separate chapter. This figure is included here to show the insertions of some of the muscles dealt with in the forelimb, and the tendons of the digital flexor muscles in the carpal canal.
Fig. 3.25 The left axilla and brachial plexus in the 4-month bull calf: medial view. Earlier stages of this dissection are shown in figs. 4.29–4.34. The left rib cage and the ventral serrate muscle have been removed to display the normal topographical relationships of the axillary structures on the left side in the standing animal.

Fig. 3.26 The left axilla to show nerves of the forelimb in the calf: medial view. The nerves supplying the muscles of the synsarcotic union (long thoracic, thoracodorsal and pectoral nerves) have been removed together with the lateral thoracic nerve. Note that the main trunk of the thoracodorsal nerve supplies branches to the teres major (axillary nerve) and subscapular (subscapular nerve) muscles.
Fig. 3.27 Vascular structures of the axillary and brachial regions in the calf: medial view. Removal of most of the pectoral muscle mass exposes the medial brachial structures. The muscles and nerves of the region are shown in fig. 3.28. Compare the relationships of the structures in these dissections with those seen in the excised limb (fig. 3.10) where the correct topographical relationships cannot be preserved.

Fig. 3.28 Muscles and nerves of the axillary and brachial regions in the calf: medial view. Removal of the remainder of the ascending pectoral muscle completes the dissection of this region with the limb still attached to the trunk.
4. THE THORAX

The thorax of the full grown adult cow is not easily accessible for clinical diagnosis because the rostral part of the chest cavity is covered by the forelimb. In addition, the ribs are flat and wide and thereby prevent easy auscultation before any considerations of the depth of muscle covering (latissimus dorsi, ventral serrate etc). The process of clinical examination is of course much easier in the calf.

With up to 80% of clinical practice being concerned with problems of respiratory and alimentary disease and with reproduction, it is not surprising that a number of diseases and disorders affect the chest, including the general body conditions and skin conditions described in previous chapters. Little is palpable of the thoracic vertebrae but the costal arch is extensive, and occasionally ribs are broken but usually heal without any problems. Calves produced as a result of difficult births, often involving manual manipulation, may be damaged during the process and be found to have broken ribs.

Clinical signs of respiratory disease are relatively simple to understand. Sneezing is an indication of problems affecting the nasal cavity, coughing originates from obstruction or irritation in the trachea or main bronchi, and dyspnoea or difficulty in breathing is due to pathology in the bronchioles and alveoli. Little of the lung volume lies caudal to the forelimb and by the 9th or 10th rib the caudal lobe itself is very thin. Note the close apposition of right lung to left chest wall. Damage to the lung tissues produces cytokines. These then act centrally to prevent easy auscultation before any considerations of the depth of muscle covering (latissimus dorsi, ventral serrate etc). The process of clinical examination is of course much easier in the calf.

Dyspnoea may also cause severe respiratory problems. Bacterial pneumonia particularly associated with Mannheimia and Pasteurella, often follow viral infections (PI3, RSV, IBR, BVD) and, especially if accompanied by pleurisy, are extremely painful in the early stages before effusion has developed. Atypical interstitial pneumonia (fog fever) may also cause severe respiratory problems.

Thrombo-embolic pericarditis is a common sequel to traumatic reticulitis when a penetrating foreign body inoculates the liver with bacteria. Chronic vegetative endocarditis is a much more gradual process compared with traumatic pericarditis. The lesions usually result in a poor exercise tolerance and the lesions are usually right-sided. The full range of respiratory conditions may include acute exudative pneumonia, chronic suppurative pneumonia, aspiration pneumonia, pleur pneumonia, bovine farmer’s lung, diffuse fibrosing alveolitis, tuberculosis and infectious bovine rhinotrachitis and parasitic bronchitis and malignant catarrhal fever. Parasites may be found in the trachea and bronchi in parasitic bronchitis.

Cardiovascular complications in the thorax are not uncommon in cattle. Endocarditis and pericarditis from septicemias or extensions from traumatic pericarditis occur. Bacterial endocarditis is an important differential diagnosis of traumatic reticulitis (see abdomen) and is characterised by pain, rigidity of stance, shallow respiratory movements and a shifting lameness. Empyema which is generalised microabscessation (pus formation) may occur in the chest after mastitis or metritis.

A wide variety of cardiovascular defects may be found in the newborn calf. They range from the extreme such as ectopia cordis where the heart is outside the thoracic cavity usually in the lower neck, through ventricular septal defects usually high up in the septum of the ventricles, to small atrial defects. In the severe range may also be found the multiple cardiac defects. These include the Tetralogy of Fallot (ventricular septal defect, pulmonary stenosis, dextroposed aorta and associated right ventricular hypertrophy) and the Eisenmenger complex which is similar but without pulmonary stenosis. Other defects might include double aortic arches, double outlet to the right ventricle, patent foramen ovale, patent ductus arteriosis, aortic stenosis, and a persistent right aortic arch which may or may not cause pressure obstruction of the oesophagus.

The foramen ovale normally closes at about 7–10 days of age. The patent ductus arteriosis normally closes by the end of the first day, but in all cases by day 5 unless it is defective.

The thoracic lymph nodes are not generally important clinically but have to be examined carefully both at post-mortem and at meat inspection at slaughter. They may indicate sepsis and tuberculosis in particular. They are not always found in every animal. Sometimes they are only very small, embedded in fat and difficult to find, but in response to infectious stimuli they increase in size and are important indicators of pathology. There are five sets in the thorax and these are: sternal (cranial and caudal) mediastinal (cranial, middle and caudal which are larger); tracheobronchial (apical, right, left and middle); intercostal; and aortic, both series of which are generally small. The caudal mediastinal lymph nodes have clinical importance: when
enlarged they may press on the vagus nerves and be responsible for vagal indigestion.

In the neck section it was mentioned that foreign bodies may be trapped in the oesophagus and cause choke. It is worth remembering that in the thorax this may occur where the oesophagus is crossed by the aortic arch, as dilatation is limited at this point.

The last important clinical feature to note in the chest is the relationship of the heart, pericardium, lungs and diaphragm to the liver and reticulum/rumen in the abdomen. This is extremely important because of the possibility of foreign bodies being passed through the wall of the reticulum into the liver or diaphragm and pericardium with subsequent extension of purulent processes in the chest.
The Thorax

Fig. 4.1 Surface features of the neck, shoulder and thorax, in left lateral view. The hair over the palpable surface features was shaved before embalming commenced. The surface projections of the thoracic and cervical vertebrae, cupola of the diaphragm and diaphragmatic line of pleural reflection are based on the dissection shown in fig. 4.15.

Fig. 4.2 Scapula, humerus, thoracic vertebrae and costal arch. The palpable features shown in fig. 4.1 are coloured red.
**Fig. 4.3** Surface features of the caudal neck and shoulder regions, in left lateral view.

**Fig. 4.4** Scapula, humerus and caudal cervical vertebrae. The palpable features shown in fig. 4.3 are coloured red.
Fig. 4.5 Superficial features of the neck, shoulder and thorax, in left lateral view. Muscles of the antebrachium are labelled in fig. 4.7.

Fig. 4.6 Muscles of the shoulder and elbow, in left lateral view. For further details of the anatomy of the forelimb, Chapter 3 should be consulted.
Fig. 4.7 The left thoracic wall after removal of the latissimus dorsi muscle. The caudal border of the triceps muscle is the cranial limit of the area of auscultation and percussion.
Fig. 4.8 The caudal neck and shoulder region in craniolateral view. The axillary vessels have been displaced to reveal the lymph node more clearly. The rostral dissection of the neck is shown in fig. 2.5.
Fig. 4.9 The long thoracic and lateral thoracic nerves. The right forelimb has been removed with a part of the ventral serrate muscle. This figure has been laterally reversed to facilitate comparison with fig. 4.8.
Fig. 4.10 The rib cage and muscles of the left thoracic wall. The left forelimb has been removed.

Fig. 4.11 The left lung in situ. The intercostal muscles, pleura and endothoracic fascia of the intercostal spaces have been removed.
Fig. 4.12 Topography of the left lung and forelimb. The dissected left forelimb, which was removed in fig. 4.10 has been replaced to show the relationships between thoracic and appendicular structures (see also fig. 4.11). This figure shows the restricted region available in the standing animal for pulmonary auscultation and percussion.
Fig. 4.13 Thoracic viscera in situ, in left lateral view. The ribs have been removed close to their costochondral junctions except for three important ‘marker’ ribs (1, 3 and 6) and those parts that do not enclose the left pleural cavity.
Fig. 4.14 The left lung: lobation, lobulation and topography. Removal of ribs 1, 3 and 6 shows the lung and the cranial mediastinum more clearly.
Fig. 4.15 Thoracic structures after removal of the left lung. For further details of the structures found in the left side of the mediastinum figs. 4.16, 4.19 and 4.20 should be consulted. The phrenic nerve has been displaced in figs. 4.15–4.17 and 4.19; its true course is shown by the dotted lines in these figures, and by the dissections shown in figs. 4.29 and 4.30.
Fig. 4.16 Thoracic vessels, nerves and lymph nodes, in left lateral view. The phrenic nerve is displaced but its true course is shown by the dotted lines.
**Fig. 4.17 The heart: topography in left lateral view.** Ribs 1, 3 and 6, which were removed in fig. 4.14, have been replaced to show their relationships to the dissected structures of the thorax. The true course of the phrenic nerve is shown by the dotted lines.
Fig. 4.18 The positions of the left atrio-ventricular and pulmonary heart valves. Red latex, injected into the common carotid artery, has filled the left ventricle but not the left atrium. The pulmonary valve is just visible at the orifice of the pulmonary trunk.
The vessels and nerves of the cranial mediastinum. This is a closer view of the dissection shown in fig. 4.16. The true course of the phrenic nerve is shown by the dotted lines.
Fig. 4.20 The dorsal part of the caudal mediastinum. This is a closer view of the dissection shown in fig. 4.16.
Fig. 4.21 The rib cage with the right lung in situ: right lateral view. This dissection of the right side corresponds with that of the left shown in fig. 4.11.

Fig. 4.22 Right lung: lobation, lobulation and topography. This dissection of the right side corresponds with that of the left shown in fig. 4.13.
Fig. 4.23 The right side of the mediastinum after removal of the right lung. The right azygos vein is not always present in the ruminants. The mediastinum has not yet been dissected, but it has suffered some damage to the dorsocaudal part, which is very thin, during dissection to the left side.
Fig. 4.24 Thoracic structures after removal of the right lung: right lateral view. This dissection of the right side corresponds with that of the left side shown in fig. 4.17.
Fig. 4.25 The cavity of the right atrium. The lateral wall of the atrium has been removed, but the general topography of this part of the thorax can be seen in fig. 4.24.

Fig. 4.26 The right atrioventricular valve. This is a dorsolateral view of the dissection shown in fig. 4.25. The parietal cusp and its associated great papillary muscle arise from the outer wall of the ventricle and are therefore not visible in either figure.
Fig. 4.27 The diaphragmatic line of pleural reflection in the calf: left lateral view. Compare this figure with fig. 4.28.

Fig. 4.28 The diaphragmatic line of pleural reflection in the calf: right lateral view. In this and the preceding figure the diaphragmatic lines of pleural reflection were carefully defined; note the differences between left and right sides in this individual.
Fig. 4.29 The thoracic surface of the diaphragm of the calf; oblique craniolateral view. Figs. 4.29–4.34 show a series of dissections in which the left thoracic wall was removed to provide a medial view of the axilla. The dissections of the forelimb in this series are shown in figs. 3.26–3.29.
Fig. 4.30 The thoracic wall of the calf, in medial view (1). In this figure, the pleura and endothoracic fascia are shown lining the thoracic wall. The course of the phrenic nerve is topographically correct (compare with fig. 4.15 et seq.).

Fig. 4.31 The thoracic wall of the calf, in medial view (2). Removal of fascial and muscular layers from some intercostal spaces reveals the structures of the thoracic wall. The external intercostal muscle is shown in the first intercostal space. The internal intercostal muscle is shown in the second space, and both muscles have been removed from the fourth space.
Fig. 4.32 Structures of the axilla of the calf, in medial view. The left thoracic wall and the ventral serrate muscle have been removed to show the contents of the axilla.

Fig. 4.33 Nerves of the thoracic wall and brachial plexus in the calf: medial view. The removal of the dorsal scalenus muscle exposes the nerves of the brachial plexus. Further dissections of the forelimb are shown in Chapter 3 (figs. 3.26–3.29).
Removal of both left and right sides of the thorax shows the costal and sternal attachments of the diaphragm, and permits a full cranial view of the diaphragm.

Fig. 4.34 The thoracic surface of the diaphragm of the calf: cranial view.
5. THE ABDOMEN

The bovine abdomen is one of the major areas of veterinary clinical work, as one would expect from an animal that grazes regularly on any material it can.

The dairy calf is very prone to digestive disturbances as it quickly moves from a milk-based diet to the forage based diet of a ruminating adult. The transition is usually natural in suckler cows and their suckled calves. Otherwise, in dairy cattle production there is a disruption of the process by man interfering with the normal process by early weaning to conserve the milk for production.

There are a whole variety of agents which may cause diarrhoea including coccidia, rotavirus, coronavirus, astrovirus, Calicivirus, Breda virus, E. coli, cryptosporidia, salmonellae of several serotypes, bovine virus diarrhoea and a whole variety of disorders associated with bacterial toxins or plant toxins. Quite often there is no diagnosis. Herb problems may occur in the form of winter dysentery, salmonellosis, Johne’s disease and diarrhoea of nutritional origin, such as acidosis.

Endoparasites are a quite severe problem, especially in animals in their first season at grass. Large numbers of infective larvae are ingested by cattle and parasitic gastroenteritis results when susceptible cattle graze a contaminated area. Large numbers of parasites are found in the abomasum and small intestines, particularly Cooperia and Nematodirus. Ostertagiasis type I may occur in calves at grass and type II in yearlings in late winter or spring following a first season of grazing. Nutritional abnormalities may be associated with spring grass or rapid changes of diet.

Calves may also suffer from poor abomasal milk clotting, oesophageal groove dysfunction, Actinobacillus infections of the oesophageal groove, ruminal bloat caused by oesophageal groove flux and acidosis caused by high level concentrate feeding. In the abomasum, there is erosion of the abomasal wall and possibly burst ulcers.

In the calf abdomen there is also the possibility of an umbilical hernia and navel abscess. Navel infections may provide a source of infection for liver abscesses.

Liver abscession is a common feature of ‘barley beef’ production and a wide range of signs may be seen. Higher yielding cows may develop hepatic lipidosis when high energy diets are introduced too quickly. The most serious hepatic problem affecting both sheep and cattle is liver fluke which is spreading due to a combination of mild winters and wet conditions. Serious liver disease will also produce hepatic encephalopathy.

The lumbar musculature is sometimes the seat of infection with clostridia leading to clostridial myositis such as Blackleg (Clostridium chauvoei). Lameness, stiffness and muscle contractions are a feature in these cases.

The ox suffers from ascending urinary infections. Uraemia is a more common finding than other abnormalities. Contagious bovine pyelonephritis is characterised by blood-stained urine being passed, acute colic, loss of condition, and urine containing blood and debris including pus. Palpation of kidneys or pressure over the loins induces a pain response.

There are few other important conditions of the urinary system in the cow. Cystitis does occur often as a result of ascending infections and enzootic haematuria is seen in those areas where bracken is found.

The diaphragm may be subjected to either hernias or ruptures. The diaphragm is an essential organ for respiration but can be seriously damaged by penetration in traumatic reticulitis (necrotising myositis may result), it may also be affected by rupture with abdominal contents (usually reticulum or the liver, sometimes the omasum) passing into the thorax. Occasionally in the calf, rapid, shallow breathing may also be seen as a sign of nutritional muscular dystrophy associated with vitamin E and selenium deficiency.

The following conditions of the alimentary tract are important:

**Bloat – gaseous** – Caused by lesions of the oesophageal groove in calves e.g. abscesses or actinobacillosis. There can be physical obstruction of the groove, or the oesophagus. Gaseous bloat may also occur in acidosis. It may be caused by pressure of lymph nodes on the oesophagus, and is seen in tetanus and milk fever. Prolonged lateral recumbency may also cause gaseous bloat.

**Bloat – frothy** is more common, and often several animals are affected, particularly on pasture with clover or alfalfa which contain saponins.

A wide range of abdominal disorders are associated with the fore-stomachs in the adult and these are listed below. It is said that acute abdominal distension is caused by the 7 Fs: fat, foetus, fluid, flatus, faeces, food or foreign bodies. Colic is rare in the cow, but indigestion is common. All ruminal disorders produce inappetance, reduced milk yield and failure to thrive. Indigestion may follow the introduction of new diets, wet grass, frosted feeds, spoiled feeds. Minor changes in ruminal pH will cause atony of the rumen. The motto is always change diets slowly over a period of 10–14 days if possible.

Ruminal acidosis can occur if the grain store is attacked or too much fed ad-lib suddenly. Excess carbohydrate rapidly ferments leading to lactic acidosis which is a big problem; acute dehydration and depression then follows. Subacute ruminal acidosis is a very common problem in high yielding dairy herds.

**Tympany** – Acute abdominal distension by gas in various parts of the digestive tract is a quite common problem.
Reticulum – Traumatic reticulo-peritonitis is also known as ‘wire or hardware’ disease. Usually it is caused by pieces of wire 5 to 10 cm long from tyres used to weigh down plastic sheets used to cover silage clamps. As many as 50% of cows have metal in reticulum/rumen. The clinical signs may vary in extent and severity. Sometimes cows have no clinical signs from lots of wire or signs are very mild with a depressed appetite, reduced rumination, sub-normal milk yield and varying degrees of pain. The signs depend on how many other structures (diaphragm, liver, spleen, lung, pericardium and heart) are affected and the extent of peritoneal abscessation. Extensive adhesions may result and a reticular grunt may follow. Diaphragmatic hernia may follow ‘wire disease’. It may take several weeks to develop. Since the pericardium is in contact with the diaphragm, which is frequently penetrated, there may be thoracic signs as well as abdominal signs. Multiple heart sounds and fluid noises will confirm pericarditis.

Rumen – Dietary ruminal impaction is seen in store cattle fed on straw or hay with limited access to water, and can also be caused by excess intake of grain. Massive ruminal impaction has to be differentiated from ‘wire disease’. Shortage of water is the key factor in ruminal impaction. Acute ruminal tympany can occur following clover or kale consumption, but it also occurs in frothy bloat and choke with foreign body.

Omasum – Impaction is very rare.

Abomasum – Torsion causes acute gas obstruction. It can be displaced left or right which can then lead to left or right dilatation. Impaction can occur; most cases are probably associated with vagus indigestion.

Left displacement of the abomasum occurs mainly in dairy cattle and is diet-associated. It occurs in high yielding cows in early lactation. Atony of the abomasum in an animal that suddenly has a lot of space in the abdomen, is the major factor. A lot of gas with a gravid uterus leads to displacement. Dilation and displacement also occurs in the right flank. Ulceration and impaction may also occur.

Caecum – Torsion of the caecum occurs in early lactation and in bulls. High levels of volatile fatty acids in the caecum may be the cause, or high levels of starch are fermented, which produce atony and gas accumulation. It may also be associated with torsion of colon, ileum or mesentery, and is twisted on the common mesentery. It is a serious, usually fatal, complication of fermentation, and produces massive right-sided distension. The differential diagnoses of these cases depend on the demeanour of the animals, rectal examination, pulse rate and progress in the case.

Strangulated mesenteric hernia occurs in which the intestines prolapse through the mesentery. Intussusception may occur; it can sometimes be felt per rectum as a hard sausage in the right upper abdomen. Usually, the small intestine is involved, or the small intestine may involute into the caecum through the ileo-caeco-colic valve. In calves it is a sequel to profuse diarrhoea but this is not necessarily so in adults. Obstruction of the ileum by a lipoma can also occur. Fermentation colic occurs and usually gets better.

‘Vagal indigestion’ can be found as a complication of wire entrapment that results in adhesions. It often involves the medial wall of reticulum and the cranial sac of rumen, interfering with vagus nerve receptors in the walls, and can also follow oesophageal actinobacillosis, abscessation, tuberculosis or rupture of the diaphragm.

Peritonitis follows traumatic reticulitis, metritis, mastitis or dystocia or retained afterbirth. Acute diffuse peritonitis results from ‘wire’. It can have a wide range of causes. Penetration of the uterus or vaginal fornix by catheter may occur, or the cranial vagina may be damaged at service. Perforation of abomasal ulcers can also occur. Peritonitis can develop following abdominal surgery.

The uterus is an abdominal structure and it can also contribute to abdominal distension in the form of hydrops ammon and allantois which cause very marked abdominal distension. Diagnosis of these conditions is facilitated by rectal examination. There may also be uterine torsion.

Intestinal obstruction due to intussusception is relieved by removal of just the intussuscepted portion. Sometimes the intussusception can be pulled apart without having to resort to surgery.

Umbilical hernias occur in all shapes and sizes. Small hernias need not be repaired. Larger ones often contain omentum, not viscera, and unless huge, need not be surgically corrected. There is always the possibility of abscessation within the hernia.

When parturition has not proceeded normally and the calf cannot be delivered through the birth canal, either intact or in pieces following embryotomy, then a Caesarean under epidural or paravertebral anaesthesia is required.
Fig. 5.1 Surface features of the abdomen, in left lateral view. The palpable bony prominences have been shaved.

Fig. 5.2 Bones related to the abdomen, in left lateral view. The palpable bony prominences shown in fig. 5.1 are coloured red.
Fig. 5.3 The boundaries of the left paralumbar fossa. The palpable prominences have been shaved. The transverse process of the first lumbar vertebra is palpable only in thin animals; that of the sixth is hidden by the tuber coxae.

Fig. 5.4 Bones related to the left paralumbar fossa. The palpable bony prominences shown in fig. 5.3 are coloured red.
Fig. 5.5 The cutaneous nerves of the lateral abdominal wall. A flap of skin and cutaneous muscle has been reflected ventrally and the cutaneous nerves in the superficial fascia have been traced. This dissection, and those shown in figs. 5.6–5.8 were made on the right side, but the photographs have been laterally reversed.
Fig. 5.6 The external oblique abdominal muscle. The cutaneous muscle of the trunk has been removed (see fig. 5.9) and the cutaneous nerves are shown emerging from the deep fascia.
Fig. 5.7 The left internal oblique abdominal muscle. In this and the following figure, the full ventral extent of the straight abdominal muscle is not displayed (see figs. 5.11 and 5.12).
**Fig. 5.8 The left transverse abdominal muscle.** The abdominal viscera lying deep to this muscle, caudal to the last rib, are shown in fig. 5.16.
The Abdomen

Fig. 5.9 The cutaneous muscle of the trunk in the 1-week old bull calf, in right lateral view. The cranial muscle of the prepuce is more clearly seen in fig. 5.10. The surface of the cutaneous muscle is obscured by remnants of the dermis. Figs. 5.10–5.15 show further dissections of the abdominal wall of this calf.

Fig. 5.10 The right external oblique abdominal muscle in the bull calf. The origins from ribs 10 and 11 are covered by the latissimus dorsi muscle but the interdigitations with the serratus ventralis muscle at ribs 7, 8 and 9 are visible.
Fig. 5.11 The right internal oblique and straight abdominal muscles in the bull calf. The full extent of the straight muscle is shown in this figure and should be compared with fig. 5.7, in which only the lateral part of the muscle is displayed.

Fig. 5.12 The right transverse abdominal muscle, the rectus sheath and the nerves of the abdominal wall in the bull calf. The middle portion of the straight muscle has been removed, showing the thin aponeurosis of the transverse abdominal muscle which forms the medial lamina of the rectus sheath. The abdominal viscera lying deep to the right transverse abdominal muscle are shown in fig. 5.54.
The Abdomen

Fig. 5.13 Cutaneous nerves of the left abdominal and thoracic wall in the bull calf. The cutaneous branches of the thoracic and lumbar nerves emerge from the deep fascia in three oblique rows; only the last thoracic components have been labelled in each of the rows.
Fig. 5.14 The course of the last thoracic nerve and its cutaneous branches in the bull calf: left lateral view. The muscles of the abdominal wall have been cut just caudal to the costal arch and displaced in order to demonstrate the course of a typical segmental nerve supplying the trunk. The details of the full series of nerves in the right abdominal wall can be seen by referring to figs. 5.10 and 5.12.

Fig. 5.15 The thoracic and lumbar nerves of the left paravertebral region in the bull calf. The ventral rami of the third and fourth lumbar nerves are not visible because they run longitudinally across the deepest parts of the intertransverse spaces. The abdominal viscera lying deep to the left transverse abdominal muscle are shown in fig. 5.46.
The Abdomen

Fig. 5.16 The abdominal viscera caudal to the costal arch, in left lateral view. The dorsal part of the external oblique abdominal muscle has been removed to reveal the muscle belly of the internal oblique muscle. The subiliac lymph node, which lies in the superficial fascia, is now in contact with the internal oblique muscle. This lymph node is displaced cranially from the cover of the tensor muscle of the fascia lata.

Fig. 5.17 The abdominal viscera after removal of the rib cage and diaphragm, in left lateral view. The stomach has been moderately inflated to imitate its shape and position in life.
Fig. 5.18 The relationships of the reticulum, in left lateral view. This figure has been taken from a slightly more cranial position than fig. 5.17 in order to show the liver more clearly.

Fig. 5.19 The abdominal viscera after removal of the spleen, in left lateral view. The view is from a slightly cranial angle, to show the small part of the liver that extends into the left half of the abdomen. The right lung has been removed.
Fig. 5.20 The interior of the rumen, in left lateral view. The dorsal part of the rumen has been stitched to the abdominal roof to preserve the topographical relationships. A small part of the cavity of the reticulum is also displayed. The solid contents have been entirely removed but a puddle of fluid remains in the ventral sac of the rumen.
Fig. 5.21  The ruminal pillars and compartments in dorsocranial view. The specimen is at the stage of dissection shown in fig. 5.20.

Fig. 5.22  The interior of the rumen and reticulum showing the cardia and the reticular groove; caudal view. The dissection is at a similar stage to that shown in figs. 5.20 and 5.21, but more of the cranial wall of the reticulum has been removed.
The Abdomen

Fig. 5.23 The interior of the rumen and reticulum, in left lateral view. Removal of the ventral part of the wall of the ruminal atrium and ventral sac reveals the relationships of the abomasum to the left abdominal wall, reticulum and rumen.

Fig. 5.24 The abdominal viscera after removal of the dorsal and ventral ruminal sacs: left lateral view. Part of the right longitudinal ruminal groove remains, and its attachment to the deep leaf of the great omentum is just visible.
Fig. 5.25 The abdominal viscera after removal of the entire rumen, in left lateral view. The liver is related to the right surfaces of the omasum and the reticulum, but it has been removed during dissection of the right abdomen (fig. 5.31).
Fig. 5.26 The arteries and veins of the abdominal viscera after removal of the entire rumen: left lateral view. The right diaphragmatic crus is held in place by a fine wire. Arrows indicate the direction of flow of ingesta in the colon. The vessels shown here are also seen in right lateral view at a slightly later stage in the dissection, in fig. 5.34.
Fig. 5.27 **The caecum, in left lateral view.** The small intestine has been displaced to show the unusual position of the caecum. In the adult, non-pregnant cow, this organ usually occupies a right dorsal position with its apex pointing caudally towards the pelvis as shown in fig. 5.39. However in this individual the caecal apex is ventral and points cranially towards the left. On the right side its body was situated ventrally (see fig. 5.34). This topography is reminiscent of that usually seen in the calf.

Fig. 5.28 **The omasoabomasal orifice and the arteries and veins of the digestive tract after removal of the entire rumen: left lateral view.** The angle of the free edge of the omasal pillar, visible in this figure, is a consequence of the rather oblique orientation of the omasum (seen in right lateral view at a later stage of dissection in fig. 5.34).
Fig. 5.29 The abdominal viscera lying caudal to the costal arch: right lateral view.

Fig. 5.30 The abdominal viscera after removal of the rib cage and diaphragm: right lateral view. No remnants were found of the falciform ligament or the round ligament (umbilical vein) of the liver; these ligaments can be seen in the calf, fig. 5.54. The umbilical notch for the round ligament is visible in this figure.
Fig. 5.31 The abdominal viscera after removal of the liver: right lateral view. The liver was separated from the adherent caudal vena cava, and the coronary attachment to the diaphragm is not recognisable. The attachment of the lesser omentum is preserved. The vessels severed at the hepatic porta are shown in fig. 5.33.
The Abdomen

Fig. 5.32 The abdominal viscera after removal of the liver, lesser omentum and part of the great omentum: right lateral view. The blood vessels are shown in fig. 5.33 and the large intestine is shown more completely in fig. 5.34. Arrows indicate the direction of flow of ingesta in the large intestine. The visceral surface of the liver in a foetal calf is shown in fig. 5.60.
Fig. 5.33 The branches of the coeliac artery and tributaries of the hepatic portal vein, in right lateral view. This figure shows part of the dissection from fig. 5.32. Parts of the autonomic plexi surrounding the branches of the artery are visible, but only the hepatic plexus is labelled. The autonomic nerves are shown more completely in fig. 5.57.
Fig. 5.34 The abdominal viscera with parts of the colon exposed and the omasum opened: right lateral view. The entire rumen has been removed, and the dissection is at the stage shown in fig. 5.26. The caecum, usually visible in this view, is displaced ventrally so that it appears in the dissection of the left side shown in fig. 5.27. The normal topography of the caecum in adult cattle is shown in fig. 5.39. The omasal groove, normally vertical in the living animal, is oblique in this dissection, probably because the viscera tend to drop ventrally after preservation and dissection in the standing position. Arrows indicate the direction of flow of ingesta in the large intestine.
Fig. 5.35 The interior of the omasum, in right lateral view. This is a closer view of part of the dissection shown in fig. 5.34.

Fig. 5.36 The cranial mesenteric artery and associated structures, in right lateral view. This is a further dissection of a part of the region shown in fig. 5.34. Arrows indicate the direction of flow of ingesta within the large intestine.
Fig. 5.37 The abdominal cavity of a bull calf (aged 4 months) in dorsal view. Vertebrae, ribs, thoracic viscera and caudal vena cava have been removed. On the left side, the parietal peritoneum has been partly removed. The diaphragm remains but its lumbar attachments have been cut.
Fig. 5.38 The abdominal viscera of the 4-month calf, in dorsal view. This figure is a further stage of the dissection shown in fig. 5.37.

Fig. 5.39 The abdominal viscera lying cranial to the pelvis in the 4-month calf: dorsal view. The aorta and the kidneys have been removed to display the intestine. The colon and duodenum have been displaced laterally to show the caecum; this should be compared with the unusual position shown in figs. 5.27 and 5.34. Fig. 5.45 shows a cranial view of this dissection with colon and duodenum in situ. The sequence of these dissections of the abdomen of a 4-month calf continues with cranial views of the viscera, beginning at fig. 5.40.
Fig. 5.40 The abdominal viscera of the 4-month calf, after removal of the diaphragm: cranial view. Fig. 4.34 shows this specimen before removal of the diaphragm. The spleen is enlarged by barbiturate euthanasia; the approximate outline of the spleen in life is indicated by a broken blue line (compare with figs. 5.17 and 5.47).
Fig. 5.41 The abdominal viscera of the 4-month calf after removal of the spleen, liver and kidneys: cranial view. The omasum, shown in fig. 5.42, is too small in this young calf to be distinguished until the lesser omentum has been removed.
Fig. 5.42 The abdominal viscera of the 4-month calf and the distribution of the coeliac artery: right cranial view. Removal of the lesser omentum reveals the small omasum. The cranial part of the great omentum has been removed to display the apex of the supraomental recess. The large right ruminal branch of the coeliac artery is not displayed (see figs. 5.26 and 5.53).

Fig. 5.43 The pancreas and the caudal omental recess of the 4-month calf, in cranial view. The caudal omental recess has been displayed by cutting the superficial leaf of the great omentum away from the duodenum and reflecting it laterally. The pancreatic duct is too far caudal to be seen (see fig. 5.32).
Fig. 5.44 The abdominal viscera of the 4-month calf after removal of the great omentum and pancreas: cranial view. The lateral and cranial walls of the supraomental recess have been removed to expose the intestines, but the caudal roof of the recess, formed by the mesoduodenum, remains intact.

Fig. 5.45 The intestine within the supraomental recess of the 4-month calf, in cranial view. Removal of the mesoduodenum and descending duodenum has exposed the large intestine lying dorsally in the supraomental recess of the peritoneal cavity. Blue arrows indicate the direction of flow of ingesta in the various parts of the colon. Compare with the dorsal view (fig. 5.39) and with the lateral view of the adult cow (fig. 5.34).
The Abdomen

Fig. 5.46 The abdominal viscera caudal to the diaphragm, in the 1-week bull calf: left lateral view. The spleen is enlarged; in life it does not extend caudal to the last rib.

Fig. 5.47 The abdominal viscera in the 1-week calf, after removal of the rib cage: left lateral view. The diaphragm and the caudal lobe of the left lung have also been removed. The spleen is enlarged after barbiturate euthanasia; this obscures most of the abdominal cavity cranial to the costal arch. This figure should be compared with fig. 5.17, but it should be noted that the adult cow was put down with chloral hydrate and does not show splenic enlargement.
Fig. 5.48 The oesophageal hiatus of the diaphragm and associated structures of the thorax and abdomen in the 1-week calf: left lateral view. The hiatus has been exposed by reflecting the crura of the diaphragm with a glass rod (compare with fig. 5.47).

Fig. 5.49 The aortic hiatus of the diaphragm and associated structures in the 1-week calf: left lateral view. The hiatus has been exposed by depressing the spleen with a glass rod (compare with fig. 5.47).
The Abdomen

Fig. 5.50 The abdominal viscera in the 1-week calf after removal of the spleen: left lateral view. The dorsal sac of the rumen has been reflected laterally to reveal the left kidney and the intestine within, and caudal to, the supraomental peritoneal recess.
Fig. 5.51 The aortic hiatus and associated structures in the 1-week calf after removal of the spleen: left lateral view. A deeper dissection of this region is shown in fig. 5.53.
Fig. 5.52 The interior of the reticulum and the dorsal ruminal sac in the 1-week calf: left lateral view. This calf had been milk-fed, with access to hay and straw.
Fig. 5.53 Nerves, blood vessels and lymph nodes of the aortic and oesophageal hiatauses in the 1-week calf: left lateral view. This is a closer view of a part of the dissection shown in fig. 5.52. A more superficial view of this region, prior to removal of the spleen, is shown in fig. 5.49.
Fig. 5.54 Superficial abdominal viscera of the 1-week calf, in right lateral view. The abdominal wall, ribs, diaphragm and caudal lobe of the right lung have been removed. Compare this figure with the similar dissection of the cow (fig. 5.30).
Fig. 5.55 Vessels, lymph nodes and nerves of the caudal mediastinum in the 1-week calf: right lateral view. This is a closer view of a part of the dissection shown in fig. 5.54.
**Fig. 5.56** The abdominal viscera and mesenteries after removal of the liver in the 1-week calf: right lateral view. The superficial and deep leaves of the great omentum are both visible, and the vestibule and caudal recess of the omental bursa are clearly shown. Fig. 5.57 shows a further stage in the dissection. The visceral surface of the liver in a foetal calf is shown in fig. 5.60.
Fig. 5.57 Arteries and nerves of the stomach in the 1-week calf: right lateral view. The abomasum has been displaced ventrally.
Fig. 5.58 Viscera and blood vessels of thorax and abdomen in a female bovine foetus (aged about 230 days), in left lateral view. The left lung and all of the abdominal viscera except liver, kidneys and urinary bladder have been removed. Note the relative sizes of left and right ventricles, and compare with those seen in the adult cow (fig. 4.17). Further details are shown in figs. 5.59 and 5.60.
Fig. 5.59 **The base of the foetal heart to show components of the foetal circulation: left lateral view.** The tubular foramen ovale has been filled with a plug of cotton wool to show the rather irregular orifice leading into the left atrium from the caudal vena cava. This orifice undergoes anatomical closure 2 or 3 weeks after birth.

Fig. 5.60 **The visceral surface of the foetal liver to show the connections between umbilical, portal and caudal veins: left lateral view.** The veins have been dissected out from the liver parenchyma. In the ruminants, the ductus venosus persists until birth.
Fig. 5.61 Abdominal viscera of a billy goat, aged 6 months, in left lateral view. The abdominal and thoracic walls, diaphragm and caudal lobe of the left lung have all been removed. The position of this animal during embalming is described in the legend to fig. 5.65.

Fig. 5.62 Abdominal viscera of the goat after removal of the great omentum: left lateral view. The superficial leaf of the great omentum has been removed to display the full extent of the rumen.
Fig 5.63 Abdominal viscera of the goat, in right lateral view. The dissection carried out on the left side (fig. 5.61) showed the attachment of the superficial leaf of the great omentum to the stomach. This dissection shows its attachments on the right side. The dotted blue line shows where the superficial leaf was cut and removed at the next dissection, in fig. 5.64.

Fig. 5.64 The omental bursa of the goat, in right lateral view. Removal of the superficial leaf of the great omentum has opened up the entire caudal recess of the omental bursa, which lies between superficial and deep omental leaves. The dotted blue line shows where the deep leaf was cut and removed at the next dissection, in fig. 5.65.

Fig. 5.65 Abdominal viscera of the goat, showing the supraomental peritoneal recess and the great omentum: right lateral view. This goat was embalmed while lying on its left side with the hind quarters elevated. The intestinal mass within the supraomental peritoneal recess has been displaced cranially. The apex of the caecum, which usually lies near the pelvic inlet has also been displaced as is shown by the arrow. Compare this figure with the dissection of the left side of the adult cow (fig. 5.27).
The hind leg is subject to the same superficial traumas and skin disease as the rest of the body. Wire or even rubber hoses or bands wrapped around limbs are not uncommon. In addition, there is the possibility of muscular damage associated with clostridial infections such as blackleg. In some breeds (South Devon, Limousin and Belgian Blue), there is also ‘double muscling,’ and it is particularly evident in the hindquarters and may contribute to dystocia, especially in heifers. It varies from breed to breed and produces a well-rounded rump with pronounced intramuscular septae. The other major muscular condition affecting the hind limb is spastic paresis with extension of the stifle and tarsal joints of one or both limbs which progressively worsens from several weeks of age. The condition is associated with contraction of the Achilles tendon, gastrocnemius and superficial flexor tendons. The joints of the hind leg may also be susceptible to joint-ill resulting from navel-ill in the calf or from septicaemias in older animals.

Rupture of the gastrocnemius, adductor group and cranial tibial muscles can occur, particularly when a cow tries to rise postpartum. Arthrogryphosis is usually in the forelimb but occasionally also the hindlimbs. Hindlimb tendons also tend to be severed in machinery injuries rather than those of the forelimbs.

Fractures can occur in the hindlimb and are usually comminuted. Proximal limb fractures have a very poor prognosis whereas distal ones have a better prognosis. Excessive traction to remove calves during dystocia may lead to growth plate separation of the long bones and sometimes even to fractures of the vertebrae at T12 and T13.

Femoropatellar luxation may occur dorsally, medially and laterally but is uncommon in any direction. Subluxation of the femorotibial joint occurs as a result of cranial cruciate injury due to heavy weight, ‘bulling injuries’ or at service with heavy bulls. It is often associated with meniscal damage and very soon secondary osteo-arthritis changes can occur.

Deep-seated infections may also be seen in the form of osteomyelitis (young cattle with salmonellosis or *A. pyogenes* infection), or tarsal cellulitis (caused by trauma against concrete surfaces) or ‘capped hock injuries’.

Osteochondrosis is a disturbance of normal endochondral ossification at the cartilaginous growth plate between the epiphysis and the metaphysis with flaps of cartilage and clefts in the damaged cartilage. It can be seen in the coxofemoral, femoropatellar, femorotibial and tibiotalarsal joints of the hindlimb.

Nerve damage associated with trauma can also occur in the hindlimb. The femoral nerve emanating from roots L4–L6 ramifies in the iliopsoas and quadriceps. It can be damaged with the birth of oversized calves of large framed breeds when the femoral nerve is pushed against the pelvic brim. There is usually perineural haemorrhage and oedema at the site of damage.

There is also the possibility of damage to the obturator nerve during dystocia due to foetal oversize or foeto-maternal disproportion. This can be unilateral or bilateral and is again caused by pressure.

Damage to the tibial nerve is rare but can be caused by damage from infections in the muscle such as clostridial infections. The fibular nerve is derived from L6–L2 sacral nerves. Over the lateral aspect of the stifle joint the nerve lies relatively close to the skin surface and is often damaged at calving.

The sciatic nerve L6, S1–S2 is sometimes damaged in prolonged unilateral recumbency. The damage usually occurs close to the medial aspect of the greater trochanter of the femur. It rarely occurs following femoral neck or pelvic fractures or from septic infections.
Fig. 6.1 Surface features of the pelvic regions, in left lateral view. The palpable features have been shaved.

Fig. 6.2 Bones of the pelvic regions, in left lateral view. The bony features shaved in fig. 6.1 have been coloured red. The tail has been mounted too low in this skeleton.

Fig. 6.3 Surface features of the hindlimb, in left lateral view (1). The palpable features have been shaved. The patella is marked by an incision through which it was nailed to the femoral trochlea to fix the stifle joint.

Fig. 6.4 Bones of the pelvic, femoral, crural and tarsal regions, in left lateral view. The features shaved in fig. 6.3 have been coloured red except for the tuberculum of the femoral trochlea. The right stifle joint is superimposed on that of the left limb. The relative positions of patella and tuberculum vary with movements of the joint.
Fig. 6.5 Surface features of the hindlimb, in left lateral view (2). The palpable features have been shaved. The patella is marked by an incision.

Fig. 6.6 Bones of the femoral, crural, tarsal, metatarsal and digital regions, in left lateral view. The features shaved in fig. 6.5 have been coloured red except for the tuberculum of the trochlear of the femur. Further details of the bones of the pes are given in figs. 7.10–7.12.
Fig. 6.7 Superficial muscles of the pelvis and hindlimb, in left lateral view. The deep gluteal fascia and the fascia latae have been removed. A window has been excised in the deep crural fascia. The cutaneous nerves are shown in fig. 6.27.
Fig. 6.8 Deeper structures of the gluteal and femoral regions, in left lateral view. Removal of the gluteobiceps and tensor fasciae latae muscles exposes the vessels and nerves in the lateral femoral region.
Fig. 6.9 The ischiatic and gluteal nerves, in left lateral view. Removal of the gluteobiceps and middle gluteal muscles exposes the course of the ischiatic nerve from the greater ischiatic foramen to its termination. The semitendinosus muscle has also been removed.
Fig. 6.10 The sacroiliac articulation and deep structures of the gluteal region, in left lateral view. The wing of the ilium has been removed to show the sacroiliac joint. The broad sacrotuberous ligament has also been partly removed.

Fig. 6.11 The medial musculature of the femoral region, in left caudolateral view. The dissection is at a slightly later stage than that shown in figs. 6.9 and 6.10. The semimembranosus muscle has been transected and displaced ventrally to reveal the adductor and gracilis muscles. The transected ischiatic nerve (see fig. 6.12) is reflected ventrally.
Fig. 6.12 Nerves of the hindlimb, in left lateral view. The iliopsoas muscle and the iliac fascia have been removed to display the vessels and nerves running immediately cranial to and medial to the ilium. The sciatic nerve has been transected and its spinal origins have been displayed.
The Hindlimb

Fig. 6.13 Superficial structures of the hindlimb, in left lateral view. The leg has been removed from the body. The contributions of the hamstring muscles and crural fascia to the common calcaneal tendon are shown in figs. 6.20 and 6.28. The term ‘fibular’ is used throughout in preference to ‘peroneal’.

m. vastus lateralis
lateral femoropatellar ligament of stifle
tibial tuberosity
m. tibialis cranialis
m. tibialis longus
m. extensor digitorum laterralis
m. fibularis tertius
m. extensor digitorum longus
v. saphena lateralis
v. tibialis cranialis
n. fibularis superficialis
proximal extensor retinaculum
distal extensor retinaculum
n. digitals dorsalis communis III
v. digitals dorsalis communis III
n. digitals dorsalis communis IV
m. extensor digitorum lateralis
n. fibularis communis
m. adductor
n. tibialis
m. semimembranosus
v. saphena lateralis
m. semitendinosus
m. triceps surae
m. gastrocnemius (caput laterale)
m. soleus
n. cutaneus surae caudalis (n. tibialis)
m. tibialis caudalis
m. flexor digitorum superficialis
m. flexor digiti I longus
n. tibialis
calcaneus, tuberosity
v. saphena lateralis
r. caudalis
fibula, lateral malleolus
m. flexor digitorum profundus
m. interosseus
m. flexor digitorum superficialis
a. digitalis plantaris communis IV
v. digitalis dorsalis communis IV

143
Fig. 6.14 Superficial structures of the hindlimb, in caudolateral view. Removal of the third fibular and long digital extensor muscles exposes the cranial tibial muscle. Further dorsal views are shown in figs. 6.16 and 6.21.
Fig. 6.15 Deeper structures of the hock, in dorsal view. Removal of the third fibular and long digital extensor muscles exposes the cranial tibial muscle. Further dorsal views are shown in figs. 6.16 and 6.21.
Fig. 6.16 Structures of the hindlimb, in dorsal view. Further details of the more distal part of this dissection are shown in fig. 6.21.
Fig. 6.17 Structures of the hindlimb, in medial view (1) After removal of the limb from the trunk, the broad gracilis muscle has been cut away. The medial plantar artery, which extends as far as the digits, has been cut short at the hock. The specimen is at the same stage of dissection as that shown in Fig. 6.13.
Fig. 6.18 Structures of the hindlimb, in medial view (2). The sartorius and semitendinosus muscles have been removed. Removal of the superficial medial saphenous structures exposes more clearly the course of the tibial nerve.
Fig. 6.19 Structures of the hindlimb, in medial view (3). The medial gastrocnemius and third fibular muscles have now been removed.
Fig. 6.20 Deep structures of the hindlimb, in medial view. The stage of dissection is that shown in figs. 6.22 and 6.16. Removal of the heads of the gastrocnemius muscle reveals the tendinous structure of the superficial digital flexor muscle.
Fig. 6.21 Structures of the hock and metatarsus: (1), dorsal view. This is a closer view of a part of the dissection shown in fig. 6.16. Figs. 6.21–6.26 show features of the pes, but the structures of the digits (manus and pes) are dealt with in chapter 7.
Fig. 6.22 Structures of the hock and metatarsus: (2), left lateral view. The third fibular and long extensor muscles have been removed and the superficial flexor exposed by removal of the gastrocnemius muscle.
Fig. 6.23 Structures of the hock and metatarsus: (3), medial view. Dorsal and lateral views of the specimen at this stage of the dissection are shown in figs. 6.21 and 6.22. The tarsal canal has been exposed by transecting the flexor retinaculum, and the course of the medial plantar nerve by removing part of the long plantar ligament.
Fig. 6.24 Vessels and nerves of the hock and metatarsus, in dorsolateral view. The tendons of the common digital extensor and cranial tibial muscle have been displaced medially to reveal the cranial tibial vessels and the deep fibular nerve. The superficial digital flexor muscle has been removed.
Fig. 6.25 Caudal muscles of the tibia, in dorsocaudal view. The superficial digital flexor muscle has been removed to display the deep digital flexor and the popliteus muscles. On the medial side, the tendon of the long digital flexor muscle has been exposed as shown in fig. 6.23.
Fig. 6.26 Median section through the right pes: medial view. The plane of sectioning in the digital region is shown in fig. 7.14. In the metatarsus, the bending of the saw cut in order to pass through the axial plane of the tarsus has scorched the specimen. The digital region of the medial side of this specimen is shown in fig. 7.28.
Figs. 6.27–6.29 show dissections of these regions in a calf in which the hindlimb was rather flexed at embalming. The nerves and blood vessels in the superficial fascia of the hindlimb are shown in detail in figs. 7.33–7.36.
Fig. 6.28 Pelvic and femoral regions of the calf to show the tibial and fibular nerves, in left lateral view. The gluteobiceps muscle has been removed. The middle gluteal muscle still hides the main part of the sciatic nerve. The lesser ischiatic foramen is visible.
Fig. 6.29 The ischiatic and gluteal nerves of the calf, in left lateral view. Removal of the middle gluteal muscle exposes the structures emerging from the greater ischiatic foramen. Fig. 6.30 shows the structures lying medial to the tensor muscle of the fascia lata.
Fig. 6.30 Structures lying medial to the tensor muscle of the fascia lata of the calf: craniolateral view. The origin of the muscle from the tuber coxae has been cut and the muscle has been reflected ventrally onto the vastus muscles.
Lameness is a very big problem in dairy herds and in nearly all cases involves the foot. Few other conditions produce as much pain and lameness as problems concerning the foot. A considerable amount of time is also spent by farmers trying to sort out these problems and for the enterprise as a whole, foot problems may cause considerable economic loss.

There are three main components to the foot. Firstly, the epidermal hoof which has five parts: periople, wall, sole, white line and heel; secondly, the corium, which is the modified dermis, providing nerve and vascular supplies; and thirdly, bone and associated structures.

The distal phalanx, distal sesamoid (navicular) bone and distal interphalangeal joint are all contained within the hoof. The deep digital flexor tendon attaches to the flexor tuberosity of the distal phalanx and, within the heel, is separated from the distal sesamoid bone by the navicular bursa. The suspensory apparatus of the distal phalanx supports the caudal edge of the bone.

In a normal foot, the weight is taken on the heel, the abaxial wall and to a lesser extent on the white line and 10–20 mm of adjacent sole and on the axial wall running from the toe caudally along the first third of the axial space. The rest of the axial surface of the claw should be non-weight bearing.

Hoof overgrowth occurs at the toe which pushes the toe up and the pedal bone rotates backward, puts pressure on the rear edge and risks sole ulcers. Hoof overgrowth occurs in the lateral wall and the sole.

Hoof trimming is an important veterinary activity with the primary objective of returning the foot to the normal shape. There are normally differences in the sizes of the two hooves. The lateral hoof is bigger in the hind foot and in the front foot the medial hoof is usually larger. The aim is to reduce any toe overgrowth first, then the excess from the sole and then the axial overgrowth, and the last cut trims the two claws back to approximately the same size with the lateral 4–5 mm larger for the hind foot.

The majority of the conditions causing lameness are in the foot and particularly the hind foot. Sole ulcers and white line defects are quite commonly found. Other hoof problems include foreign body penetration, horizontal and vertical fissures and severe conditions of the skin. These include digital dermatitis (which is very common), inter-digital necrobacillosis, inter-digital hyperplasia, mud fever, slurry heel, vertical fissures, foot rot and foul in the foot. Disorders of the distal phalanges and navicular bones include fracture and apical necrosis of the distal phalanx and deep pedal infections.

One serious foot condition is laminitis (coriosis or inflammation of the corium). This condition is associated with parturition, excessive standing and post-calving comfort, cubicle design, the nutrition, wet hoof, poor floor surfaces, rough handling and hoof wear. It is usually seen as a chronic or subacute problem and is partly responsible for sole ulcers and white line problems.

Other causes of foot lameness include hoof disorders, skin disorders and bone and joint disorders. Genetic defects are rarely seen in the feet and limbs. Congenital flexure of the proximal interphalangeal joints is seen in most breeds, usually affecting the forefeet, and most animals recover.

Arthrogryphosis is congenital folded joints. They are usually bilateral and particularly affect the front feet. It is most common in Charolais where it is associated with a recessive gene.

Severe trauma to the hoof may require amputation of a digit or claw. Solar ulceration with infection of the flexor tendons and pedal bone is the major reason and the removal must take place early. Sedation and intravenous regional anaesthesia or local nerve block are necessary before surgery.
Fig. 7.1 Surface features of the left carpus, in craniolateral view. The palpable position of the radiocarpal joint has been shaved. The constituent bones can be seen in fig. 7.4. The dorsum of the carpus is directed somewhat laterally in normal level standing, and the medial surface of the carpus is markedly convex.

Fig. 7.2 Surface features of the left manus, in lateral view. Two palpable features have been shaved. The bones can be seen in fig. 7.5. The lateral rotation of the ‘toe’, mentioned in fig. 7.7, reveals the interdigital cleft from a lateral view in normal level standing.

Fig. 7.3 Surface features of the left manus, in caudolateral view. One palpable feature has been shaved. The bones can be seen in fig. 7.6. A palmar view of the hoof is shown in fig. 7.20.
Fig. 7.4 Bones of the left and right carpus, in left and craniolateral view. One palpable feature shown in fig. 7.1 has been coloured red. The bones of the digits are shown in craniolateral view in fig. 7.10.

Fig. 7.5 Bones of the left manus, in lateral view. The two features shaved in fig. 7.1 are coloured red.

Fig. 7.6 Bones of the left manus, in caudolateral view. The feature shaved in fig. 7.3 is coloured red.
Fig. 7.7 Surface features of the hindlimbs, in left craniolateral view. The position of the pes in normal level standing, and the action of the foot during locomotion, are variable. When the udder is large, the limb is abducted and the ‘toes’ of the hooves tend to be rotated laterally at all stages of the step. The bones are shown in fig. 7.10.

Fig. 7.8 Surface features of the left pes, in lateral view. Two palpable features have been shaved. The bones can be seen in fig. 7.11. Compare the angle of the main digits (dorsum of the hoof wall) with that seen in the forelimb (fig. 7.2).

Fig. 7.9 Surface features of the left pes, in caudal view. Two palpable features have been shaved. The bones can be seen in fig. 7.12.
The Foot

Fig. 7.10 Bones of the left and right pes, in left craniolateral view. The two features shaved in fig. 7.7 are coloured red. In life, the solar surface of the distal phalanx lies horizontal in level standing (see fig. 7.17). The talus is also called the astragalus or, more aptly, the tibial tarsal bone.

Fig. 7.11 Bones of the left pes, in lateral view. The two features shaved in fig. 7.7 are coloured red. The calcaneus is more aptly called the fibular tarsal bone.

Fig. 7.12 Bones of the left pes, in caudal view. The features shaved in fig. 7.9 are coloured red.
Fig. 7.13 Digital region of the right pes, in lateral view. The angle of the dorsum of the hoof wall should be compared with that of the manus (compare with fig. 7.17). The axial line of the coronet has been traced onto this drawing from fig. 7.15. The periople is continuous with the bulb of the heel, and there are good reasons for considering them as specialised parts of one structure.

Fig. 7.14 Digital region of the right pes, in cranial view. The saw cut made to display the axial structures of the digit (see fig. 7.15) is also shown.

Fig. 7.15 The interdigital region of the right pes, in lateral view. The interdigital cleft has been revealed by sectioning as shown in fig. 7.14. The medial half of the sectioned limb (containing the third digit) is viewed from the lateral aspect. The deeper structures are fully labelled in fig. 7.28.
The Foot

hair-bearing skin
periople and its corium
corium
middle phalanx
distal phalanx
distal sesamoid bone
m. flexor digitorum profundus
coronet of ‘heel’
bulp:
digital cushion
horny epidermis
corium

accessory digit V:
phalanges
horny epidermis

digit III of forelimb:
“toe” of larger, medial hoof
parts of hoof wall:
abaxial
axial
white zone
termination of hoof wall
approximate position of
distal sesamoid bone
interdigital cleft

digit II of forelimb:
parts of hoof wall
axial
abaxial

metacarpus

digit III of hind limb:
white zone
sole of hoof
axial groove
junction between sole and bulb
bulb of “heel”
hairless skin of
interdigital cleft
coronet at “heel”
digit II of hindlimb, sole of hoof

metatarsus

The limbs were fixed while the
cow was in the standing position.
During maximum weight bearing,
in life, the main digits are splayed
apart more than in these feet, and
the fetlock drops so that the
accessory digits may touch the
ground. The feet were scrubbed
and dried, but not trimmed. Note
that the so-called ‘white zone’ is,
in fact, darker than the sole and
wall. Its salient characteristic is
that it is laminar in structure.

Fig. 7.16 Solar surfaces of the
hooves of the right manus and pes.

Fig. 7.17 The hoof of the right manus, in sagittal section. This figure is a lateral view
of the fourth digit of the right manus and is a close-up of fig. 3.24. The deeper
structures are dealt with in fig. 7.27. The plane of sectioning is shown in fig. 3.23. The
dotted and broken blue lines show the position of the coronet on the axial and
abaxial aspects of the digit (see also figs. 7.13 and 7.15). Note that the deepest layer
of the wall of the hoof is white.
Fig. 7.18 Superficial digital structures of the left manus: (1), dorsal view. The superficial structures of the metacarpal region of the manus are shown in an earlier dissection (figs. 3.18–3.21). The relationships of the vessels and nerves of the manus to those of the more proximal regions of the limb are shown in the dissection of a calf limb (figs. 7.29–7.32).

Fig. 7.19 Superficial digital structures of the left manus: (2), lateral view. Figs. 3.19 and 7.30 (right forelimb of a calf) should also be consulted.
Fig. 7.20  Superficial digital structures of the left manus: (3), palmar view. Figs. 3.20 and 7.31 (right forelimb of a calf) should also be consulted. The axial palmar digital nerve IV was not given off from the ulnar nerve in this specimen, but it arose with the axial palmar digital nerve III from the median nerve.

Fig. 7.21  Superficial digital structures of the left manus: (4), medial view. Figs. 3.21 and 7.32 (right forelimb of a calf) should also be consulted.
Fig. 7.22 Digital muscles and ligaments of the left manus: (1), dorsal view. Figs. 7.22–7.26 show the deeper structures of the manus after removal of the nerves and vessels. The shining tendons of the common digital extensor muscle are enclosed by tendon sheaths. The dorsal surfaces of the fetlock joint capsules also reveal where they are overlain by the synovial bursae of the so-called ‘proper’ extensor tendons of digits III and IV.

Fig. 7.23 Digital muscles and ligaments of the left manus: (2), lateral view. The deep palmar fascia has been removed to reveal the flexor muscles except where its fibres are arranged transversely to form the annular ligaments of the digit. The ligaments of the accessory digit, which are parts of the deep palmar fascia, have been almost completely removed.
The annular ligaments have been dissected on the lateral digit (IV) and removed on the medial digit (III). The voluminous flexor tendon sheaths have not been completely removed proximally (blue lines). Distally the shiny surfaces of the flexor tendons have been exposed; the sheaths end just distal to the distal interdigital ligaments. The synovial structures of the digit are also shown in fig. 7.27.

Removal of the palmar annular ligaments exposes the manica flexoria of the superficial flexor which ensheaths the deep flexor muscle at the region of the fetlock joint.
Fig. 7.26 The interosseus muscle of the left manus, in caudomedial view. The specimen is at the stage of dissection shown in fig. 3.22. A glass rod has been inserted to display the interosseous tendons more clearly. The axial tendon of the interosseous muscle divides in the interdigital space and joins the extensor tendons as shown in fig. 7.22.
The Foot

Fig. 7.27 The fourth digit of the right manus, in sagittal section. This figure is a lateral view of the fourth digit of the manus and is a close-up of fig. 3.24. The integumentary structures are dealt with in fig. 7.17. The plane of sectioning is shown in fig. 3.23. Synovial structures are indicated by blue dotted lines.

Fig. 7.28 The interdigital region of the right pes, in median section. The plane of sectioning is shown in fig. 7.14. In this figure, the medial half of the sectioned limb is viewed from the lateral aspect. The integumentary structures are fully labelled in fig. 7.15. In the pes, the main arterial supply to the interdigital region is from the dorsal side. In the manus, however, most of the supply is from the palmar side; compare with figs. 7.18 and 7.20.
Fig. 7.29 Superficial veins and nerves in the right forelimb of a one-week old calf: (1), dorsal view. Figs. 7.29–7.32 provide a general view of the vessels and nerves to show how those of the manus are related to those in the more proximal regions of the limb.
Fig. 7.30 Superficial veins and nerves in the right forelimb of the calf: (2), lateral view.
Fig. 7.31 Superficial vessels and nerves in the right forelimb of the calf: (3), palmar view. In the distal metacarpus, the deep fascia has been partially removed to display the vessels and nerves, but the ligaments of the accessory digits have been preserved to demonstrate the fascial levels of the vessels and nerves.
Fig. 7.32 Superficial veins and nerves in the right forelimb of the calf: (4), medial view. In this specimen, the musculocutaneous nerve extends, as a distinct nerve, into the distal parts of the limb but appeared to play no major part in forming the second dorsal common digital nerve.
Fig. 7.33 Superficial veins and nerves of the right hindlimb of the calf: (1), dorsal view. Figs. 7.33–7.36 provide a general view of the vessels and nerves to show how those of the pes are related to those in the more proximal regions of the limb. Only the pes is included in this figure because the contour of the more proximal regions of the limb produces excessive foreshortening.
Fig. 7.34 Superficial veins and nerves of the right hindlimb of the calf: (2), lateral view. The crural fascia has been incised and pinned back to reveal the course of the lateral cutaneous sural nerve. The nerve is large in this specimen; when it is small, its territory is partly supplied by the caudal cutaneous sural nerve.
Fig. 7.35 Superficial vessels and nerves of the right hindlimb of the calf: (3), plantar view. The contour of the more proximal regions of the limb produces considerable foreshortening. The deep fascia has not been removed from the distal metatarsal region and only the superficial structures are visible (compare with fig. 7.31).
Fig. 7.36 Superficial vessels and nerves of the right hindlimb of the calf: (4), medial view. The course of the medial plantar nerve, artery and vein beneath the deep fascia, alongside the deep flexor tendon, is indicated by broken lines.
Fig. 7.37  Solar surfaces of the hooves of the right pes of a sheep. The limb was fixed in the standing position. The foot has been divided into lateral and medial halves by a median sagittal incision, and the lateral part (digits IV and V) has been clipped. Figs. 7.38 and 7.39 show further views of the lateral half of this specimen. This figure should be compared with that of the ox in fig. 7.16.

Fig. 7.38  Digital region of the right pes of a sheep, in lateral view. This is a lateral view of half of the foot shown in fig. 7.37 showing the fourth digit. The hair has been clipped to show the coronet region. This figure should be compared with that of the ox in fig. 7.13. The axial line of the coronet is shown by blue dots.

Fig. 7.39  The interdigital region of the right pes of the sheep, in median section. The interdigital cleft and interdigital region are revealed by the median sagittal incision (see fig. 7.37). This is a medial view of the clipped lateral half of the specimen showing the fourth digit. The interdigital sinus is not found in the ox (fig. 7.28) or in the goat.
The difficulties of collecting CSF from the foramen magnum in the live animal were noted in the chapter on the head. However, it is possible to collect CSF under local anaesthesia from cattle of all ages. The site is the mid-point of the lumbo-sacral space which is the mid-line depression between the last palpable lumbar dorsal spine (L6) and the first palpable sacral dorsal spine (S2). The secret is in recognising the differences in consistency of tissues and the lack of resistance when the needle enters the dorsal sub-arachnoid space from which the CSF is taken.

The pelvis is extremely important in bovine medicine, as it is the bony passage through which the foetus passes at birth, and since birth of a new calf is the single most important economic event and subsequently facilitates lactation, it is the principle area of interference in bovine medicine and reproduction. Fertility investigations involve a considerable amount of time.

Obviously veterinary assistance at calving in cases of dystocia is important. Traumatic injuries do not normally occur in normal parturition. Damage to uterine vessels or vaginal vessels may follow traction at calving. Pneumovagina or urovagina may sometimes occur and may need surgical intervention. Early investigation of calving cases can show whether an early caesarean section is required and this can save considerable damage to cow and calf post-partum. The genital tract involutes and by 10 to 14 days post-partum the entire genital tract is palpable per rectum. This process takes about 40 to 50 days to complete, when the uterus is back in the pelvis with horns of equal size and diameter. The uterine epithelium regenerates and any bacterial infections acquired at parturition are cleared and the ovarian cycle recommences. Any failure of normal involution, where there is either infection or abnormal ovarian function, causes sub-fertility which results in economic loss. The causes include retained foetal membranes, endometritis and cystic ovarian disease. Oestrus is usually detectable at about 30% of first and 70% of second ovulations following calving.

Unobserved oestrus is a serious problem after calving and has a multitude of causes including physiological anoestrus, true anoestrus, parturition damage, ovarian cysts and nutritional deficiencies. It may take the form of silent ovulation and unobserved oestrus. Rectal examination of the ovaries can be helpful in assessing the problems but only as a part of a reproduction programme that also includes proper herd records, histories, clinical examination to include body scoring at calving and drying off, milk analyses and so on. Normal cycling is investigated by palpation of the corpus luteum in the ovary. Palpation of ovarian structures more than 25 mm in diameter may indicate the presence of a follicular or luteal cyst.

Uterine prolapse is facilitated by uterine inertia post-partum. It can be replaced with the cow in sternal recumbency with the hind legs extended.

A common problem after calving, and one of the most important, is retained foetal membranes. It may develop to acute metritis, toxæmia and septicaemia, and can be fatal if unrecognised. The membranes are removed manually and treated conventionally thereafter. Vaginitis and acute puerperal metritis require aggressive treatment with fluid therapy, antibiotics and also uterine flushing with warm sterile saline.

A small proportion of these cases may lead to embolic pneumonia, polyarthritis or endocarditis. Endometritis can be an extremely expensive exercise in that there is reduced fertility, much reduced milk yield and expensive, often long-term, treatment.

Unsuccessful service may be related to ovulation failure, fertilisation failure, or the loss of the conceptus. Embryonic death is associated with a return to oestrus within 21 days, late embryonic death occurs at between three and six weeks and foetal death after six weeks.

There are a variety of infectious causes of foetal loss but they nearly all have a degree of placentitis. Viral causes include bovine virus diarrhoea and in particular Bovine Herpesvirus-1,2, which causes infectious pustular vulvovaginitis in cows and infectious pustular balanoposthitis in bulls. This virus will cause abortion and endometritis in any cows served by such an infected bull. Bacterial causes may include brucellosis, leptospirosis, *Bacillus licheniformis*, *Listeria*, salmonellae and *Campylobacter*. Protozoal causes include trichomoniasis and neosporosis, *Chlamydia*, rickettsia and also mycotic abortion when feeding poorly-made winter silage associated with wet conditions in the growing season.

A wide range of infectious agents are also responsible for infertility in cattle and may be transmitted by natural mating or AI (FMD, IBR, BVD, EBL, Rinderpest, bluetongue, Akabane virus, bovine genital campylobacteriosis, brucellosis, tuberculosis, leptospirosis, Q fever and trichomoniasis). *Neospora* can cause abortion in cattle and particularly around five to six months. Foetuses can be born alive or weak or may die in utero and be mummified or resorbed.

Bull infertility can be caused by a wide range of problems which fall into four major groups. The first of these is failure to mount (may be related to age, genetic factors, season, social factors, overwork, nutrition and orthopaedic abnormalities). The second is failure of active intromission (penis cannot be protruded sufficiently), failure to locate the vulva due to balanoposthitis, short penis, rupture of corpus cavernosum penis, persistent frenulum, psychogenic problems, and penile problems such as fibropapilloma, venous drainage defects and deviations. Failure to thrust and ejaculate is also a reason for bull infertility.
Poor pregnancy rate with normal service behaviour can also occur. This may be due to age, overwork, testicular hypoplasia, testicular atrophy, testicular degeneration and atrophy, scrotal sac disruption, orchitis or epididymitis and systemic illness or medicinal usage. Strangled intestine in a scrotal hernia is also a rare possibility.

It is convenient to regard the urinary system as part of the pelvis. Most of the diseases of the urinary tract are associated with haemorrhage. The haemorrhage could be a result of systemic disease including bracken poisoning and also pyelonephritis which causes pus, debris, and haemorrhage in the urine. ‘Red water’ could be haematuria or myoglobinuria. Haemoglobinuria can be associated with theileriosis (*Babesia divergens*). Bacillary haemoglobinuria is associated with *Clostridium haemolyticum* (*Cl. noyvi* type D). Occasionally kale or rape feeding will cause haemoglobinuria, and the condition may be associated post-partum with root and straw feeding. Urolithiasis (urinary stones), both calculi and inorganic, occurs as a result of a predisposing diet in both sexes but it generally causes problems only in males. The stones most commonly lodge at the sigmoid flexure of the penis, with the region of the ischial arch the second most common site. Bladder rupture and urethral rupture can also occur, and when this occurs the pain goes immediately and toxaemia and uraemia follow. It is possible to do a urethrotomy distal to the ischial arch to remove these stones. After doing so, feed adjustments should be made.

Trauma to the pelvis may be a rare occurrence. The tuber coxae can be damaged during passage through a narrow doorway or by a sudden fall. In a calving situation there may be damage to the pelvic symphysis caused by excessive traction. Dislocation and subluxation do occur, particularly the hip joint (coxo-femoral) in two to five year old cows, associated with parturition and early post-partum due to ligament relaxation; 80% occur in a cranio-dorsal direction. Sacro-iliac sub-luxation also occurs when there is excessive ligament flaccidity.
The Pelvis

Fig. 8.1 Surface features of the pelvic regions, in left lateral view. In older cattle, the first caudal vertebra may fuse with the sacrum. The first moveable joint caudal to the sacrum is then the first intervertebral joint of the tail.

Fig. 8.2 Pelvis, vertebrae and proximal femur, in left lateral view. The palpable bony features shown in fig. 8.1 are coloured red. Note also that in this skeleton the tail is not sufficiently elevated. The caudal border of the sacrotuberous ligament is attached to the dorsal and transverse processes of the sacrocaudal junction, and the dorsal tuberosity of the tuber ischiadicum.

Fig. 8.3 Surface features of the pelvic regions, in caudolateral view. Strictly, the escutcheon is the region in which the hairs lie in a dorsal direction. The skin of the perineum is said to lie between the anus and the scrotum. However, it is difficult to define in female ruminants because the scrotal swellings of the foetus are not incorporated into the perivulvar region but gradually disappear in the inguinal region. Therefore, the udder forms the ventral boundary of the perineum in the female.

Fig. 8.4 Pelvis and vertebrae, in caudolateral view. The palpable bony features shown in fig. 8.3 are coloured red. The caudal border of the sacrotuberous ligament is attached to the dorsal and transverse processes of the sacrocaudal junction and the dorsal tuberosity of the tuber ischiadicum.
Fig. 8.5 Superficial muscles of the left lateral pelvic wall. The cutaneous nerves and superficial lymph nodes of the region are shown in fig. 8.29.
Fig. 8.6 Deeper muscles of the left lateral pelvic wall. Removal of the large gluteobiceps muscle reveals part of the sacrotuberous ligament caudal to the medial gluteal muscle.
Fig. 8.7 The broad sacrotuberous ligament and its foramina, in left lateral view. Removal of the middle gluteal muscle reveals the full extent of the sacrotuberous ligament, the two foramina and the vessels and nerves that traverse them.
Fig. 8.8 The pelvis after partial removal of the left lateral pelvic wall. The wing of the ilium and most of the broad sacrotuberous ligament have been removed. This figure shows the nerves and arteries of the pelvic cavity surrounded by massive adipose deposits as in life. A further dissection is shown in fig. 8.11.
Fig. 8.9 The median caudal artery and ischiorectal fossa: left lateral view. In fat animals the ischiorectal fossa is occupied by a large adipose mass and externally this forms a bulge rather than a concavity.

Fig. 8.10 Superficial muscles of the perineal region and the ischiorectal fossa: left caudolateral view. The fascia of the urogenital diaphragm, which forms the medial wall of the ischiorectal fossa, has been dissected away to reveal the retractor muscle of the clitoris.
The Pelvis

Fig. 8.11 Nerves and blood vessels of the pelvis, in left lateral view. The caudal cutaneous femoral nerve enters the pelvis through the lesser sciatic foramen and joins a branch of the pudendal nerve; this union is not shown here but can be seen in figs. 8.31–8.33. The origin of the pelvic nerve can be seen in figs. 8.13 and 8.33.

Fig. 8.12 Nerves and blood vessels at the pelvic inlet, in left lateral view. This is a close up of part of fig. 8.11 after removal of the abdominal wall and the iliacus and rectus femoris muscles.
Fig. 8.13  Nerves and arteries of the pelvis, after removal of the limb: left lateral view. The origin of the pudendal nerve from SIV has been cut and reflected to reveal the pelvic nerve.
Fig. 8.14 Pelvic viscera before removal of the left side of the bony pelvis. The adipose tissue of the pelvic wall has been removed together with the coccygeus muscle to show the positions of the viscera. A more complete topographical display is seen in fig. 8.15.
Fig. 8.15 Pelvic viscera after removal of the left bony pelvis. The paramedian saw cut passes through the obturator foramen; the intrapelvic part of the obturator muscle remains in situ. Figs. 8.17 and 8.18 show the uterus and ovary at this stage of the dissection from a more cranial view.

Fig. 8.16 Pelvic viscera after removal of the left bony pelvis and the obturator muscle. Comparison with the usual text book accounts shows the contracted urinary bladder in this cow to be rotated dorsally and to the left, while the uterus is displaced ventrally towards the right.
Fig. 8.17 Structures at the pelvic inlet, in left lateral view. This is a slightly more cranial part of the dissection shown in fig. 8.16. Further details of the ovary and the ovarian bursa are shown by another series of dissections in figs. 8.24–8.28.

Fig. 8.18 Structures at the pelvic inlet, in left craniolateral view. The tissues covering the right inguinal region in fig. 8.17 have been partially removed to expose the positions of the vessels and lymph node.
Fig. 8.19 The right inguinal canal and structures traversing it: left craniolateral view. This is a further dissection of part of the specimen shown in fig. 8.17, partly overlapping with that shown in fig. 8.18. The cranial and ventral borders of the deep inguinal ring are shown with a broken blue line. The medial and lateral borders of the superficial inguinal ring are shown with a line of blue dots; the lateral border is not very distinct.
Fig. 8.20 Structures of the right inguinal canal, in cranial view (1). In figs. 8.20–8.23 the anatomy of the superficial and deep inguinal rings and the disposition of the structures traversing the inguinal canal are shown by progressively reflecting the layers of the abdominal wall. The female reproductive tract has been displaced caudally into the pelvis.

Fig. 8.21 Structures of the right inguinal canal, in cranial view (2). Medial reflection of the right rectus abdominal muscle opens the deep inguinal ring.
Fig. 8.22 Structures of the right inguinal canal, in cranial view (3). Reflection of the ventral part of the internal oblique abdominal muscle removes the cranial border of the deep inguinal ring and exposes the cranial part of the superficial ring.

Fig. 8.23 Structures of the right inguinal canal, in cranial view (4). The ‘pelvic’ tendon of the external oblique abdominal muscle has been incised and the rest of the muscle has been reflected medially, leaving the pelvic tendon in situ. In this way the superficial inguinal ring is opened up.
Fig. 8.24 The pelvic inlet of a cow aged six years: cranial view. The trunk has been transected at fifth lumbar level and the incision continued ventrally, removing all but the floor of the abdominal wall. The figure shows the structures as they were when embalmed in the standing position. No part of the female tract (non-pregnant, but adult) lay in the abdomen and the empty bladder was entirely pelvic in position. Figs. 8.25–8.28 show further details.
Fig. 8.25 The descending colon at the pelvic inlet, in cranial view. Removal of a part of the large mass of adipose tissue, shown in fig. 8.24, reveals further details of the descending colon just cranial to the pelvic inlet. This view is taken from a slightly lateral angle to show the right side of the inlet.
Fig. 8.26 The ovary and associated structures at the pelvic inlet, in cranial view (1).
Removal of the sigmoid descending colon at its junction with the rectum now reveals the position of the right ovary and its associated structures in relation to the pubic brim.
Fig. 8.27 The ovary and associated structures at the pelvic inlet, in cranial view (2). The fimbriae of the infundibulum have been turned ventrally to expose the abdominal opening of the uterine tube and the surface of the ovary.

Fig. 8.28 The ovary and associated structures at the pelvic inlet, in cranial view (3). The fimbriae of the infundibulum have been replaced after filling the ovarian bursa with cotton wool. This cotton wool is clearly visible through the thin mesosalpinx which forms the wall of the bursa.
Fig. 8.29 Superficial muscles, nerves and lymph nodes of the pelvic regions in a bull calf aged one week: lateral view. The lymph nodes shown here are not always present in the ox.

Fig. 8.30 The perineal region and the root of the tail in the calf: left caudolateral view. The dissection is at the stage shown in the previous figure but the tail has been raised to show the median caudal artery and the related muscles more clearly.
Fig. 8.31  The lateral wall of the pelvis and associated structures in the calf: lateral view. Removal of the gluteobiceps and middle gluteal muscles exposes the structures that lie superficial to the broad sacrotuberous ligament.
Fig. 8.32 The greater and lesser ischiatic foramina of the calf, in lateral view. The broad sacrotuberos ligament has been incised (broken blue line) in preparation for partial removal to display the structures lying medial to it (see fig. 8.33). The incision passes round the borders of the ischiatic foramina without damaging them or the structures traversing them.
Fig. 8.33 Vessels and nerves related to the broad sacrotuberous ligament in the calf: left lateral view. Excision of a part of the ligament (as indicated in figs. 8.32 and 8.33 by a broken blue line) and removal of the ischiatic lymph node, reveals the course of the branches of the third and fourth sacral nerves and the internal pudendal artery. Their relationships at the lesser ischiatic foramen are also displayed.
The Pelvis

Fig. 8.34 Surface features of the anal, perineal and scrotal regions in a bull calf aged five months: caudal view. In this preserved specimen the contour of the scrotum differs from that in life. The escutcheon (in which the hairs lie pointing dorsally) is variable in size and includes the caudal scrotal wall. In this calf it was not extensive.

Fig. 8.35 Superficial structures of the perineal and scrotal regions in the calf: right caudolateral view. The skin has been removed from left and right sides but on the left side the superficial and deep fasciae have also been taken away. This calf was in prime condition at slaughter, and the adipose deposits in the superficial fascia, especially around the neck of the scrotum, were very large.
Fig. 8.36 Topography of the penis in the perineal region of the calf: left caudolateral view. The superficial and deep fasciae of the perineum and scrotum remain intact on the right side showing the depth within the perineum of the retractor penis muscle and the penile body (including the sigmoid flexure).

Fig. 8.37 Structures situated in the scrotum and at the scrotal neck in the calf: left caudolateral view. This figure is a closer view of a part of fig. 8.36.
Fig. 8.38 Contents of the left vaginal process within the left side of the scrotum of the calf: caudal view. The parietal tunica vaginalis has been incised to display the testis and epididymis suspended within the cavity of the vaginal process. Note the medial location of the body of the epididymis (compare with fig. 9.27).
Fig. 8.39 Muscles of the penile root in the perineal region: caudal view (1). The small flap of fascia left attached, but reflected from the surface of the bulbospongiosus muscle, emphasises the thickness and density of the deep fascia in the perineal region of the bull.

Fig. 8.40 Muscles of the penile root in the perineal region: caudal view (2). The origin of the retractor penis muscle from the coccygeal vertebrae is shown in fig. 8.49.
Fig. 8.41 The superficial inguinal ring of a male goat aged five months, in left lateral view. The left hind limb has been removed, and the superficial inguinal ring exposed by removal of the lateral lamina along the line indicated in blue. Further dissections of the pelvic regions and reproductive organs of this male goat are shown in figs. 8.42–8.50.
Fig. 8.42 The deep inguinal ring of the goat, in left lateral view. The external oblique abdominal muscle has been removed, with its superficial inguinal ring (see fig. 8.41). The caudal part of the internal oblique abdominal muscle was preserved when the abdominal viscera were displayed (see fig. 5.61). The deep inguinal ring lies caudal to the caudal border of the internal oblique muscle.

Fig. 8.43 Inguinal structures of the goat, in left lateral view. Removal of the caudal border of the internal oblique abdominal muscle displays the origin of the cremaster muscle and the transverse fascia of the inguinal region. The orifice of the vaginal process is shown in fig. 8.45.
The Pelvis

Fig. 8.44 The broad sacrotuberous ligament and the structures related to the iliac fascia in the male goat: left lateral view. This is a closer view of a part of the dissection shown in fig. 8.43.
Fig. 8.45 Nerves and blood vessels of the pelvis of the goat: left lateral view. The left pelvic bone has been removed, as shown in fig. 8.46. The damaged internal pudendal and caudal gluteal arteries are shown by broken lines.
Fig. 8.46 Relationships of the pelvic bone of the goat, in left lateral view. The left pelvic bone has been replaced, after the dissection shown in fig. 8.45, to show its relationships to the dissected structures.

Fig. 8.47 The right vaginal ring of the goat, in left lateral view. The specimen is at the same stage of dissection as that shown in fig. 8.48, but the abdominal contents have been pushed cranially to reveal the orifice of the vaginal process in the peritoneum of the right abdominal wall.
Fig. 8.48 The reproductive organs of the male goat, in left lateral view. Removal of the bony pelvis and the parietal structures now displays the major organs. Further details of the reproductive organs in this dissection are shown in figs. 8.49 and 8.50.
Fig. 8.49 Pelvic viscera of the goat, in left lateral view. The left side of the bony pelvis has been removed, as shown in fig. 8.46, and the vessels and nerves of the pelvis removed. Note also that the dorsal and medial part of the ischiocavernosus muscle has been removed to display the bulbourethral gland more completely. Three black pins in the wall of the rectum mark the caudal limit of the peritoneal cavity.
Fig. 8.50 The penis and scrotum of the goat, in left lateral view. The sigmoid flexure is effaced to a considerable extent and therefore the apex of the penis lies at the preputial orifice. When the tonus of the retractor penis muscle is raised the apex of the penis can be retracted to scrotal level; this draws out the prepuce into an integumentary sheath of considerable length.
Parturition is the single most significant event in bovine medicine, but a lactation is a 305 day event. Therefore a lot of veterinary time is invested in the maintenance of the health of the udder. Pregnancy includes rapid growth of the udder. The fully lactating udder may weigh about 50 kg.

Support is provided by lateral suspensory ligaments which spread ventrally over the udder and converge inwards to join paired medial ligaments which form a vertical partition separating the left gland from that on the right. Septae of interlobular connective tissue traverse the glands between the lateral and medial ligaments and support the heavy lobules. The medial ligaments contain more elastin than the lateral ligaments so the full udder drops in the mid-line and the teats become splayed outwards. The blood supply is extensive, particularly the external pudendal artery through the inguinal canal. There is also a supply cranially from the superficial epigastric artery and caudally via the vaginal artery. The base of the udder has a long circular vessel which is drained by three trunks: the subcutaneous abdominal wall, the external pudendal vein and the perineal vein. The first may be easily traumatised because it is so exposed. The nerve supply to the udder is from the fourth and fifth lumbar nerves through the inguinal canal. Contributions from the lumbar 1 and 2 branches supply the cranial part of the udder and the caudal part of the udder is supplied by sacral 1 and 2.

The skin receives a sensory supply but the deeper tissue does not.

The teat is important as it is not just designed for a milking machine but it protects against mechanical trauma during suckling or milking and also protects against ascending infection. The streak canal itself is a mechanical barrier with antimicrobial substances found in the teat canal and in the mammary secretions. A huge number of defence mechanisms are employed principally lymphocytes, immunoglobulins and phagocytic cells but it is still relatively easy for udder infections to occur.

There are a large number of potentially pathogenic agents (e.g. *Staphylococcus aureus*, *Streptococcus dysgalactiae*, *Streptococcus agalactiae* and *S. uberis*, *Arcanobacterium pyogenes* and coliforms and mycoplasmas). Summer mastitis, which is particularly dangerous in heifers, is associated with *A. pyogenes*. A variety of viruses will cause lesions on teats and these include bovine herpes mammillitis, pseudocowpox, cowpox and FMD and vesicular stomatitis.

It is, however, important to realise that a tremendous influence on the occurrence of mastitis is the milking machine and milking machinery hygiene and milking technique. The counts of cells and bacteria in milk are good guides to the effectiveness of these factors. Non-infectious lesions on teats are also quite common because there are four of them and they stick out even though they are protected by abdomen and hind legs. Teats get caught on barbed wire, equipment, trodden on by their owners or other cows, damaged by chemicals, teat dips, sunburn or frost, and attract flies and other insects. As a result, they may have calluses or patches of hyperkeratosis. If they are lacerated severely they can be repaired surgically. Most events are emergencies and cannot be left to the dry period. Inserting a cannula is a way of drawing milk and not allowing pressure to build up.

The contractile dartos tunic of the scrotum helps to maintain fertility by controlling intratesticular temperatures. Palpation of the scrotum is important for the diagnosis of abnormalities, especially testicular hypoplasia in young bulls and testicular degeneration in older bulls. Developmental failure of organs derived from the embryonic mesonephric ducts can sometimes be diagnosed by palpation of the epididymis. The cauda is easily seen and felt in the scrotal fundus. The caput is more difficult to palpate, though it lies laterally. The corpus lies medially, in contact with the scrotal septum, and is difficult to palpate. The ampullae and seminal vesicles are palpated per rectum.

Bulls with pendulous preputial orifices, deficient in sphincteric control, may evert a short length of prepuce while grazing. Preputial prolapse, however, is irreversible, leading to fibrosis near the cranial end of the prepuce. At the caudal end of the prepuce, the preputial attachment to the penile integument may be torn during service, leading to fibrosis if not treated surgically. Fibrous lesions of the penis and prepuce are serious because extreme mobility is needed for protrusion at service.

A mass of tissue in the umbilical region may depress the protruded penis on mounting. This may affect the bull’s success in breeding under ‘range’ conditions. Enormous pressures (14 000 mmHg) are generated by the ischiocavernosus muscles within the corpus cavernosum penis (CCP) of the bull during erection. The penis elongates significantly and this is enhanced by the relaxation of the retractor penis muscles and elimination of the sigmoid flexure. Rupture of the CCP at the distal bend of the flexor manifests itself cranial to the scrotum. Less frequently, rupture may occur caudal to the scrotum, distal to the root of the penis. Failure of erection (impotence) in the bull may result from abnormal venous drainage of the CCP into the dorsal veins of the penis. Impotence may also result from fibrous occlusion of the canal through which blood should be pumped from the crura into the body of the CCP.

The bovine penis frequently spirals after intromission, during ejaculation. Right ventrolateral deviation is the first stage in this anti-clockwise spiralling. This normal deviation results from the fibro-architecture of the tunica albuginea and penile prepuce of the intromittent organ. Premature spiral deviation prevents intromission. Deviation that occurs while the penis is still in the prepuce hinders or prevents protrusion through the preputial orifice.
Fig. 9.1 Surface features of the udder and hindlimb, in left lateral view. The dissection of the udder is covered in figs. 9.1–9.18; the rest of the chapter deals with the dissection of the scrotum. The lateral fold of the flank is also called the ‘knee’ fold because of its proximity to the stifle joint. This Jersey cow was almost at the end of her lactation, but the ‘milk vein’ was clearly visible in life. The hind legs are positioned in normal level standing, and the udder shows good dairy conformation.

Fig. 9.2 Bones of the pelvis and hindlimb related to the udder: left lateral view. The palpable bony prominences which are shaved in fig. 9.1 are coloured red. Note, however, that the tuberculum of the trochlea of the femur, lying dorsomedial to the patella, has not been coloured.

Fig. 9.3 Surface features of the udder and hindlimb, in caudolateral view. The shape of the escutcheon and the extent of the hair feathers (penna pilorum) vary greatly between individuals and attempts have been made to relate this to variations in milk production. Supernumerary teats may be seen on the caudal surface of the udder, but these are generally removed from calves destined for use as dairy cows.

Fig. 9.4 Bones of the hindlimb related to the udder: caudolateral view. The palpable prominences which are shaved in fig. 9.3 are coloured red.
The superficial and deep fasciae of the udder after removal of the left hindlimb: lateral view. This stage of the dissection is slightly earlier than that shown in fig. 8.13. The superficial inguinal (mammary) lymph nodes lie deep to the deep fascia, in the transverse plane of the acetabulum and the caudal teat.
Fig. 9.6 The left lateral suspensory lamina of the udder, in lateral view. This ligament is continuous with the yellow abdominal tunic. Its attachment to the prepubic and symphyseal tendons is shown, but the details of the origins of the adductor muscles (pectineus, gracilis, adductor) from these tendons are not shown.

Fig. 9.7 The ‘milk vein’ and nerves of the ventral abdominal wall, in left lateral view. The abdominal wall is traversed by the ventral cutaneous branches of the thoracic nerves. Where the ‘milk vein’ also uses a nerve canal, the palpable superficial foramen becomes greatly enlarged and is called a ‘milk well’. In this cow, only that of ThX is utilised. Further details of the internal course of the milk vein are shown in figs. 9.8 and 9.9.
Fig. 9.8 The left ‘milk well’ and the structures traversing it: left dorsolateral view. The subcutaneous abdominal, or ‘milk’, vein pierces the oblique and straight abdominal muscles. The xiphoid cartilage, transverse fascia and transverse abdominal muscle have been removed from a paramedian sagittal incision on the left side; this reveals the course of the vein and its accompanying artery as it runs in a cranial direction within the abdominal and thoracic wall. Further details of the course of these vessels are shown in fig. 9.9.

Fig. 9.9 The abdominal and thoracic course of the left cranial epigastric vessels: right dorsolateral view. The epigastric vessels do not pierce the transverse muscles of the trunk. Their caudal connections, as seen from the left side, are shown in fig. 9.8; fig. 4.16 shows the cranial connections.
Fig. 9.10 The lateral suspensory lamina of the udder and the superficial inguinal ring, in left lateral view. The attachments of the suspensory lamina to the abdominal wall, prepubic tendon and symphyseal tendon have been incised to reveal the position of the superficial inguinal ring (the outer limit of the inguinal canal).
Fig. 9.11 The superficial inguinal (mammary) lymph nodes, in left lateral view. The ‘pelvic’ tendon of the external oblique abdominal muscle has been incised. The lateral suspensory lamina of the udder has been reflected ventrally. In this way the structures which traverse the inguinal canal are exposed; their pathway through the canal is shown better in fig. 9.13.

Fig. 9.12 The dorsal surface of the udder, in craniolateral view. This figure shows a closer view of a part of the dissection seen in fig. 9.11. The dorsal surface of the udder is supported from the deep fascia of the abdominal wall by numerous connective tissue lamellae in which run small blood vessels and nerves.
Fig. 9.13 The inguinal canal and associated structures, in left lateral view. Reflection of the ‘pelvic’ tendon of the external abdominal muscle opens up the inguinal canal. The dorsal border of the ‘abdominal’ tendon is now visible; this forms the medial rim of the superficial inguinal ring. The cranial rim of the deep ring, formed by the dorsocaudal border of the internal oblique muscle, can also be seen. The genitofemoral nerve (the most caudal of the ventromedial cutaneous branches of the lumbar spinal nerves) and associated vessels traverse the abdominal wall by way of the inguinal canal. In males, the vaginal process persists and also traverses the canal (see fig. 9.27).
Fig. 9.14 The yellow abdominal tunic and ventromedial cutaneous nerves, in left lateral view. The ventromedial cutaneous branches of LI, LII, traverse the abdominal wall in the same way that the ventromedial cutaneous branches of LIII, LIV (the genitofemoral nerve) traverse the inguinal canal. This dissection is a closer view of fig. 9.15, but at a slightly earlier stage of dissection.

Fig. 9.15 The arteries and veins of the udder, in lateral view. The superficial inguinal lymph node of the left side has been cut away from its union with that on the right side. The paths of dorsal venous trunks in the substance of the udder have been dissected to show the three venous drainage routes.
Fig. 9.16 Internal structure of the left forequarter of the udder: lateral view. An incision has been made through the axis of the teat, slanting obliquely and laterally through the lateral part of the forequarter. The cut also passes through the parenchyma of the hindquarter. There is no visible demarcation in the udder parenchyma between fore and hindquarters, but the two glands do not intercommunicate.

Fig. 9.17 Internal structure of the left half of the udder: lateral view. A second cut passes through the lateral part of the left hindquarter. The two cuts do not define the extent of each gland system; there is no clear demarcation between fore and hindquarters. Left and right halves of the udder are distinctly separated by the medial suspensory laminae (see fig. 9.18).
Fig. 9.18 The left medial suspensory lamina after removal of the left half of the udder: lateral view. Left and right laminae arise from the yellow abdominal tunic near the midline of the abdominal wall. A small caudal elastic lamina often arises from the symphysis tendon as indicated by the broken blue lines, but it was not recognisable on this specimen.
Fig. 9.19 Caudal abdominal and pelvic regions of a week-old bull calf, in right lateral view. The male structures occupying the same regions as the udder are displayed in figures 9.19 to 9.27. This facilitates comparisons between the two sexes. In female ruminants the foetal scrotum regresses in the inguinal region, just caudal to the udder. In male ruminants the mammary gland persists, just cranial to the scrotum. Scrotum and udder are both components of the escutcheon and the two regions are strictly comparable.
The Udder, Scrotum and Penis

Fig. 9.20 The ischiatic foramina and femoral ring of the bull calf, in right lateral view. This is a closer view of a part of the dissection shown in the previous figures, but the rectus femoris muscle has been shortened slightly.

Fig. 9.21 Superficial inguinal structures of the bull calf, in right lateral view. The structures traversing the inguinal canal are discernible through the thin lateral suspensory lamina immediately ventral to the superficial inguinal ring (see figs. 9.22 and 9.23).
Fig. 9.22 The superficial inguinal ring of the bull calf: right lateral view (1). The lateral suspensory lamina has been partially removed to reveal the structures that traverse the inguinal canal, and those at the neck of the scrotum.
Fig. 9.23 The superficial inguinal ring of the bull calf: right lateral view (2). The remaining part of the lateral suspensory lamina (see figs. 9.21 and 9.22) has been reflected to reveal the superficial ring and its traversing structures more clearly. It should be stressed that the clear-cut lateral rim of the superficial inguinal ring seen in figs. 9.22–9.27 is an artefact. It is merely the line along which the deep fascia of the lateral suspensory lamina has been cut. The ventral border of the ‘pelvic tendon’ of the external oblique abdominal muscle is the true lateral rim of the ring.
Fig. 9.24 Fasciae and vessels of the inguinal and scrotal regions in the bull calf: right lateral view. Lateral and medial scrotal and mammary fasciae of the bull are readily comparable with the mammary suspensory laminae of the cow (see figs. 9.5 and 9.18). The dartos tunic is formed by adherence of the lateral lamina to the scrotal skin. The dartos septum is the direct continuation of the medial lamina into the scrotum.

Fig. 9.25 The prepuce and preputial orifice of the bull calf, in right lateral view. A flap of skin has been reflected from the region immediately dorsal to the preputial orifice and the umbilicus. The specimen is at the stage of dissection shown in fig. 9.21.
**Fig. 9.26** The scrotum of the bull calf, in right lateral view. The fascial layers of the scrotum can be subdivided in a more complex fashion, but for practical purposes the simple arrangement shown in this dissection and those preceding it is adequate.

**Fig. 9.27** The scrotal contents of the bull calf, in right lateral view. The wall of the vaginal process has been incised and pinned out to show the contents of the peritoneal vaginal cavity. In this specimen the body of the epididymis is not so medial in position as is usual because the testis has rotated on its long axis (see fig. 8.38).
Fig 9.28 Ventral abdominal wall, preputial orifice and umbilical region of a Simmental bull. Right lateral view. The terminal part of the prepuce (long arrow) is moderately pendulous in this bull. The orifice can be elevated and constricted by m. preputialis cranialis (Fig. 9.25). The umbilical region (short arrow) is insignificant.

Fig 9.29 Preputial orifice and umbilical region of a Hereford bull with protruded penis while mounting the teaser. Right lateral view. The pars libera penis (short black arrow) and part of the prepuce (long black arrow) are protruded through the relaxed preputial orifice. The umbilical region (white arrow) is large in this bull.

Fig 9.30 Sussex bull mounting the teaser, showing right ventrolateral penile deviation. Right lateral view. This deviation is abnormal, causing infertility. It may result from injury. However, it is also the first stage of the full spiral deviation that often follows normal intromission. In this bull, deviation of the penis hindered penile protrusion and therefore the position of the sigmoid flexure of the erect organ (arrow) is visible cranial to the scrotum and the teats.
Fig 9.31  **Scrotum, escutcheon and hocks of a Guernsey bull.** Caudal view. Ventral to the escutcheon (long white arrow), the narrow scrotal neck contains the spermatic cords (Fig. 8.38). In the scrotal fundus (short white arrows), on each side, lie the tails of the epididymides. The heads of the epididymides lie laterally, near the scrotal neck (Figs 8.38, 8.50). The bodies of the epididymides lie medially, where the scrotal septum is just visible (see Fig. 8.38) and may be difficult to palpate. At the hock, the common calcaneal tendon attaches to the calcaneal tuberosity (Figs 6.18–6.20).

Fig 9.32  **A second Sussex bull mounting the teaser, showing normal protrusion.** Right ventrolateral view. Ventral deviation of the tip of the penis, as in this bull, is normal. The protruded part is covered by its penile integument (short black arrow) and a part of the prepuce (long black arrow). The testes have been retracted from the scrotum by the m. cremaster (Fig. 8.42). The scrotal skin is wrinkled by contraction of the smooth muscle bundles of the tunica dartos (Fig. 8.38). The distal bend of the sigmoid flexure is just visible, cranial to the teats.
Clinical considerations for radiography

Radiography is a very useful diagnostic tool in ruminant medicine, particularly for the skull and the distal limbs, although higher powered equipment will enable images of the spine, proximal limbs and pelvis to be made also. Knowledge of normal radiological anatomy is necessary for the correct interpretation of radiological abnormalities. The distal limbs of ruminants are not too complex, but superimposition of the two digits can create difficulties, as can bones of the accessory digits. In contrast, the skull is extremely complex and so it is of paramount importance to have an atlas of normal radiological anatomy or a ‘normal’ radiograph for comparison when attempting interpretation of this area.

The commonest clinical indication for radiography is lameness and the commonest causes of lameness in ruminants are infections of the bone marrow (osteomyelitis) and septic arthritis which often results from blood-borne infection (haematogenous). Both infection and trauma may result in a fragment of bone becoming separated from the surrounding tissue (sequestrum). At least two views of the affected area should be taken at right angles to each other (orthogonal projections). For the limbs, the opposite limb may also be radiographed for comparison. In cases of foot lameness, a lateromedial view showing only the affected claw can be achieved if the film, in a light-proof envelope or in a cassette, is pushed through the interdigital cleft. This removes superimposition due to the unaffected digit and greatly assists in the diagnosis of fractures.

The presence of cartilaginous epiphyseal (or growth) plates must be remembered when interpreting radiographs of the limbs of young animals. For domestic ruminants, gross anatomical studies suggest that in the manus and pes, after birth, the proximal epiphysis of the middle phalanx is the first to fuse completely (c. 1–2 years for ox; c. 6 months for sheep and goat). Epiphyses participating in the fetlock joint may still be separate at c. 2 years in the ox; fusions are slightly earlier in the sheep and goat. Epiphyses that articulate with the proximal rows of carpal or tarsal bones may still be separate at over 3 years in the ox; fusions are slightly earlier in the sheep and goat. The calcaneal tuberosity is also late in fusing (c. 3 years in ox, sheep and goat). By radiography, fusion between epiphysis and diaphysis can be divided into a sequence of stages. The age at which ‘complete radiological fusion’ occurs may differ from that based on gross or microscopic anatomical investigations.
Fig. 10.1 The head of the cow: lateral view.
Fig. 10.2 *The head of the goat: lateral view.* The frontal sinus extends into the horns.
Fig. 10.3 The head of the sheep: lateral view.
Fig. 10.4 The carpus of the goat: lateral view.

Fig. 10.5 The carpus of the goat: dorsopalmar view.
Fig. 10.6 The carpus of the skeletally immature goat: lateral view. The accessory carpal bone can be clearly seen.

Fig. 10.7 The fetlock, digits and foot of the skeletally immature goat: lateral view.
Fig 10.8 The manus of the skeletally immature goat: dorsopalmar view. The wide spaces at the carpometacarpal joint are due to thick articular cartilage. Thick metacarpal growth plates are also seen.
Fig. 10.9 The digits and foot of the cow: lateral view. The two digits are superimposed on this view.

Fig. 10.10 The digits and foot of the cow: dorsopalmar view. The interdigital cleft is well demarcated.
Radiographic Anatomy of the Head, Manus and Pes

distal epiphyses of metacarpal bones III, IV
proximal sesamoid bones
vestigial digits II, V
proximal epiphyses of phalanges
growth plate
proximal phalanges
proximal interphalangeal joints
proximal epiphyses of middle phalanges
growth plate
middle phalanges
distal sesamoid bone
distal interphalangeal joints
distal phalanges

distal interphalangeal joints
distal phalanges

Fig. 10.11 The fetlock, digits and foot of the skeletally immature calf: lateral view. The two digits are superimposed on this view.

Fig. 10.12 The fetlock, digits and foot of the skeletally immature calf: dorsopalmar view. The sesamoid bones of the metacarpophalangeal joints are clearly visible.
**Fig. 10.13** The fetlock, digits and foot of the cow: oblique view. The bones of an accessory digit are shown in this projection.

**Fig 10.14** Superficial structures of the left manus of the cow: lateral view. This shows the lateral accessory digit. (From Fig. 7.19; Fig. 7.17 shows the bones.)
Fig. 10.15 The fetlock, digits and foot of the goat: dorsopalmar view. The digits are abducted from the axis of the limb.
Fig. 10.16 The hock of the cow: lateral view.

Fig. 10.17 The hock of the cow: dorsoplantar view.
Fig. 10.18 The hock of the skeletally immature calf: lateral view. Growth plates of the distal tibia and the calcaneus are seen. The bones appear rounded and soft in outline due to the presence of relatively large amounts of cartilage which has not yet undergone endochondral ossification.

Fig. 10.19 The hock of the skeletally immature calf: dorsoplantar view.