

Ovine Meat Inspection

2nd Edition

Anatomy, physiology and disease conditions

A Grist

CONTEXT

CONTENTS

Foreword to Second Edition
Craig Kirby

Foreword to First Edition
Alison Small B.V.M.&S., D.V.P.H.(M.H.), Dip.E.C.V.P.H., M.R.C.V.S., M.A.M.I

SECTION ONE	1
Anatomy / Physiology	1
Skeletal System	3
Introduction	3
The Structure of Bones	3
Bone Types	4
The Structure of Joints	4
The Skull	6
The Axial Skeleton	6
The Ribs	7
The Pelvis	7
The Appendicular Skeleton	8
Foreleg	8
Hindleg	9
Anatomy of the Foot	10
Muscle	12
Introduction	12
Skeletal Muscle	12
Anatomy of a Muscle	12
Fibres	13
ATP – Adenosine triphosphate	13
Contraction	14
Fibre Types	14
Nerve Supply	15
Rigor Mortis	15
Smooth Muscle	15
Respiratory System	17
Introduction	17
Distinctive Features	17
Nostrils and Nasal Passages	18
Larynx	19
Trachea	19
Bronchi	20
The Act of Respiration	21

Digestive System	22
Introduction	22
The Mouth	22
The Tongue	24
Oesophagus	25
Forestomachs	25
Rumen	26
Reticulum	26
Omasum	27
Abomasum	28
Rumination	28
The Intestines	29
Small Intestine	29
Duodenum	30
Jejunum	31
Ileum	31
Large Intestine	31
Caecum	32
Colon	32
Rectum	33
Intestinal Function and Digestion	33
The Liver	34
Appearance	34
Liver Structure	35
Bile	35
Functions of the Liver	35
Cardiovascular System	37
Introduction	37
Blood	37
Blood Vessels	37
The Heart	38
Appearance	38
Cardiac Muscle	39
Blood Circulation	40
Pulmonary System	40
Systemic Circulation	41
Portal Circulation	41
Blood Clotting	41
Lymphatic System	41
Lymph Vessels	41
Lymph	42
Lymph Nodes	42
Position of Nodes and Drainage Areas	43
Lymphoid Tissue	50
The Spleen	50

Urogenital System	52
Urinary Tract	52
Introduction	52
Kidney Structure	52
Function of the Kidneys	53
Ureters	53
Bladder	54
Urethra	54
Reproductive System	55
Female Reproductive System – Introduction	55
Ovaries	55
Uterine Horns	57
Cervix	57
The Vagina	58
Male Reproductive System – Introduction	58
Testes	58
Urethra and Penis	59
Mammary Glands	60
Nervous System	62
Introduction	62
Nerves	62
Nerve cells	62
Central Nervous System	63
Peripheral Nervous System	64
Endocrine Glands	65
Introduction	65
Thyroid Gland	65
Parathyroid Gland	65
Pituitary Gland	65
Thymus	65
Adrenal Glands	66
Pancreas	66
 SECTION TWO	 69
Diseases of Sheep	69
 Introduction	 71
Routes of Infection	71
Immunity	72
Skin/Mucous Membranes	72
Cellular Factors	73
Humoral Factors	73
Acquired Immune Response	73
Bacteria	74
Size and Structure	74

Energy, Nutrition and Growth	75
Toxins	77
Bacterial Identification	77
Viruses	78
Virus Types	79
Fungi	80
Prion Proteins	81
Diseases of Sheep	82
Actinobacillosis	82
Actinomycosis	82
Anthrax	84
Bacillary Haemoglobinuria	84
Black Disease	85
Blackleg	85
Bloat	86
Blue Tongue	86
Braxy	88
Brucellosis	88
Caseous Lymphadenitis	89
Contagious Agalactiae	90
Contagious Epididymitis	91
Enterotoxaemia	92
Enzootic Abortion	92
Foot and Mouth Disease	92
Foot Rot	94
Green Wool Disease	94
Haemorrhagic Enteritis	95
Jaagsiekte	95
Jöhne's Disease	96
Leptospirosis	98
Listeriosis	98
Louping Ill	99
Maedi-Visna	99
Malignant Oedema	100
Meliodosis	100
Orf	100
Ovine Infectious Keratoconjunctivitis	102
Pasteurellosis	103
Peste Des Petits Ruminants	103
Post Dipping Lameness	104
Pregnancy Toxaemia	104
Ringworm	104
Salmonellosis	105
Scald	106
Scrapie	106
Sheep Pox	107

Strawberry Foot Rot	107
Swayback	108
Tetanus	109
Tick Borne Fever	109
Tick Pyaemia	110
Tuberculosis	110
Ulcerative Dermatitis	112
White Liver Disease	113
White Muscle Disease	113
Yersiniosis	113
SECTION THREE	115
Parasites	115
Main Parasites of Sheep	117
Parasitism	118
Endoparasites	119
Endoparasite Groups	119
Host / parasite relationship	119
Infection	119
Individual Maintenance	120
Parasite Maintenance	120
Species Maintenance	120
Affects on the Host	120
Dog Tapeworm metacestodes	121
<i>Cysticercus ovis</i>	122
<i>Cysticercus tenuicollis</i>	126
Hydatidosis	131
<i>Coenurus cerebralis</i>	137
Lungworm	138
<i>Moniezia expanza</i>	146
<i>Haemonchus contortus</i>	148
<i>Ostertagia spp</i>	148
Protozoal Parasites	150
Coccidia	150
Babesiosis	151
Sarcocysts	152
Toxoplasma	154
Fascioliasis	155
<i>Paramphistomum cervi</i>	162
Ectoparasites	163
Fly strike	163
Ticks	166
Keds	169
<i>Oestrus ovis</i>	170

<i>Linguatula serrata</i>	172
Anomaly – A ‘parasitic’ foetus	173

SECTION FOUR	175
Neoplasia	175
Tumours	177
Introduction	177
Benign tumours	177
Malignant tumours	177
Metastasis	178
Characteristics of Neoplasia	179

SECTION FIVE	191
Conditions encountered at ovine post mortem inspection	191
Abscesses	193
Arthritis	202
Anaemia	202
Bacterial Necrosis	207
Bloodsplash	209
Caseous Lymphadenitis	210
Cholecystitis	214
Cirrhosis	215
Congestive Hepatitis	216
Cystitis	216
Enteritis	217
Fat Necrosis	219
Fever	220
Gangrene	223
Jaundice	224
Lymphadenitis	225
Mastitis	226
Melanosia	227
Metritis	229
Nephritis/nephrosis	229
Glomerulonephritis	231
Hydronephrosis	231
Haemoglobinuric nephrosis	233
Nephropylitis	233
Renal retention cysts	236
Renal Infarction	237
Toxic shock	239
Oedema and Emaciation	240
Pericarditis	245
Peritonitis	247

Pleurisy	250
Pneumonia	253
Pyæmia	253
Trauma	260
Trichobezoars	265
Uraemia	266
Urethral Calculi	267

SECTION SIX	269
Aide memoire - anatomy	

SECTION SEVEN	277
Aide memoire - disease and causative organisms	

SECTION EIGHT	285
Ante and Post Mortem Affections of specific parts	

SECTION NINE	301
Index	

DIAGRAM LIST

Section One - Anatomy/Physiology

Anatomy of a simple synovial joint	5
Basic anatomy of the foot	10
Muscle banding	13
Mechanism of muscle contraction	14
Blood circulation	40
Schematic of a nephron	53
Nerve cells	62

Section Two - Diseases of Sheep

Representative bacteria	75
Bacterial growth curve	76
Unenveloped virus	78
Enveloped virus	78
Replication cycle of a virus	79
Structure of a filamentous mould	80

Section Three - Parasites

Parasites of sheep	117
Generic lifecycle of canine tapeworms	121
Lifecycle of <i>Moniezia Ezpansa</i>	147
Lifecycle of the liver fluke <i>Fasciola hepatica</i>	158

1

ANATOMY/ PHYSIOLOGY



SKELETAL SYSTEM

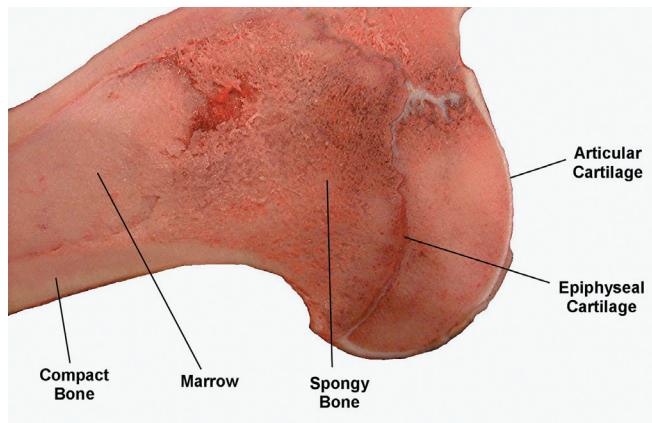
INTRODUCTION

The skeletal system provides structure, protection and a means of locomotion. Muscles are attached to the bones by ligaments or tendons and move the animal by contracting around a pivot or joint. In this section the basic structure, position and function of the bones is described. For this purpose the bones of the skeleton are divided into the skull, the axial skeleton and the appendicular skeleton (forelegs and hindlegs).

THE STRUCTURE OF BONES

Bone is a collagen matrix containing mineral salts, chiefly calcium phosphate, and various cells including osteoclasts and osteoblasts. The deposition of mineral salts within the matrix is controlled by osteoblasts. Mineral reabsorption and release of the minerals into the blood is attributed to the large, mononucleated osteoclasts. These cells work in balance, their activity being controlled by parathyroid hormone (PTH) secreted by the parathyroid gland in response to fluctuation in the serum- calcium level of the blood. If this level decreases, more hormone is released which has the effect of increasing the activity of the osteoclasts whilst decreasing the osteoblast activity and hence subsequently increasing the calcium in the blood. This deposition and reabsorption of mineral salts of the bone is a continual process.

Bones have a connective tissue membranous covering, the periosteum, which has bone-forming properties and, through fusion with muscular connective tissue, anchors the muscle to the bone. Under the periosteum is the dense, or compact bone, which in the long bones forms a hollow shaft containing marrow and spongy bone. Marrow occurs in two forms, red and yellow, and is a combination of blood vessels and connective tissue containing fat and blood producing cells. Red marrow produces blood cells such as erythrocytes and leukocytes; yellow marrow is formed mainly from fatty tissue. Spongy or cancellous bone is usually found at the extremities of long bones and is composed of thin intersecting layers of bone. The



Section through a humerus

articular cartilage has a bluish white colour and is also known as hyaline cartilage due to its glassy appearance. The epiphyseal cartilage represents the site at which bone growth increases the length of the long bones.

BONE TYPES

There are several classification systems used to describe bone types, the most common being the subdivision of bones into shapes, therefore the types encountered can be considered to be:

- Long bones, such as those of the humerus and femur.
- Short bones, such as the carpus and tarsus, roughly cuboid in shape.
- Flat bones, consisting of two layers of compact bone separated by a thin layer of spongy bone, as occurs in cranial bones and the scapula.
- Irregular bones, for example the vertebrae.

THE STRUCTURE OF JOINTS

The separate bones of the skeletal system are jointed together by systems that either fix the bone in relation to its neighbour or allow partial or free movement (articulation). Fibrous and cartilaginous joints between bones form fused or limited mobility joints, and synovial joints allow free movement between articulating bones.

Cartilaginous joints are found in areas such as between the vertebrae, at the pelvic symphysis and between the two halves of the mandible. Their structures vary and allow a small range of movement between the bones.

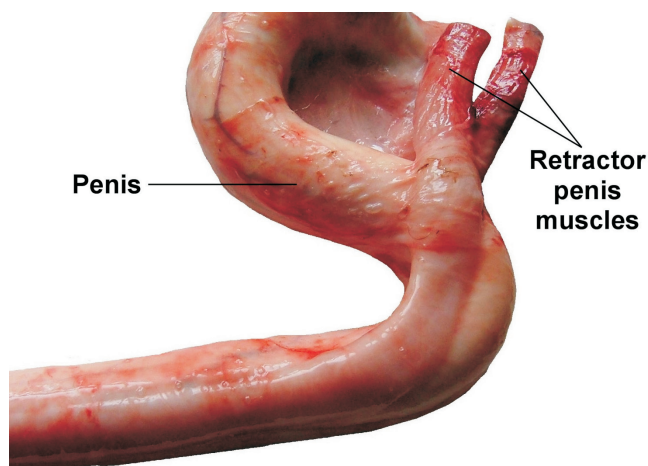
Fibrous joints immobily connect bones forming joints such as those fusing the flat bones of the skull at joints known as sutures.



The cartilaginous joints between the vertebrae

The penis proper is composed of three columns of tissue, with a rich arterial blood supply, that surround the hollow urethra. Contained within a fibrous tunic and roughly circular in section, the dorsal aspect of the penis is formed by the two fused *corpus cavernosae* with the urethra surrounded by the *corpus spongiosum*

carried in a ventral groove. The columns of *corpus cavernosae* terminate at the glans of the penis which is formed by the *corpus spongiosum*. In addition to the columns of erectile tissue the penis also contains a large proportion of connective tissue, and is characterised by the presence of a sigmoid flexure (an 'S' shaped portion) that straightens out when the penis becomes erect and is retracted, post copulation, by the retractor penis muscles following disgorgement of blood from the erectile tissue.



MAMMARY GLANDS

The mammary glands are modified sweat glands containing connective tissue, blood vessels, lymphatic vessels and glandular tissue. Alveoli within the gland tissue secrete and store milk which is then collected in ducts and delivered to the teats. Sheep possess two mammary glands; each with a teat, combined to form the udder. The udder is visibly separated into two halves along the median plane by the presence of suspensory sheets; the division between the two glands on each side of the separation is indistinct as the glandular tissue of one gland tends to fuse with that of the other. The milk produced collects in interconnecting ducts before entering the teat cistern. The teat contains a single duct, usually held closed by a combination of the naturally elasticity of the connective tissue of the teat, and an encircling layer of smooth muscle.

2

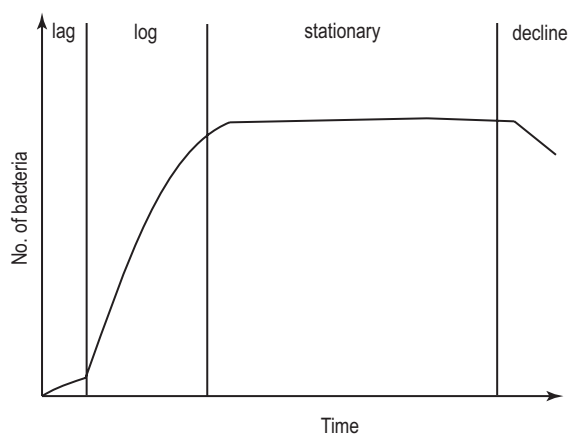
DISEASES OF SHEEP



Bacterial growth is by binary fission, where the internal contents of the bacterium halve, split and then reform into two matching bacterium, the doubling time varying from 20 minutes (*E.coli*) to 24 hours (tubercle bacilli). The process of binary fission means that one bacterium becomes two, two become four, four become eight, and eight become sixteen, and so on. Given balanced growth, where all required nutrients are available, the growth curve of bacteria follows distinct phases. After an initial lag phase, high-virulence exponential growth occurs during the log phase, followed by a stationary phase where the number of bacteria produced is equal to the number dying, which is in turn followed by the decline phase where the number dying is greater than the number produced as the available nutrients are used up.

Each bacterial species has varying requirements for optimum growth, including available nutrients, temperature, available moisture in the form of water activity (A_w), and the pH or hydrogen ion concentration of their growth medium.

Taking these factors in order, bacterial growth requires water-soluble nutrients, and high protein foods are favoured such as eggs, fish and meat. Food was historically salted to preserve it, which reduces moisture as well as preventing the osmotic diffusion of nutrients into bacterial cells.



Bacterial growth curve

In terms of temperature, the lower the temperature, the slower bacteria grow. Most disease causing bacteria (pathogens) cannot grow below 4°C and none can grow below 0°C, spoilage bacteria can grow at temperatures down to -5°C. As these are the only two groups of bacteria present on meat, at temperatures below -5°C all bacterial growth ceases.

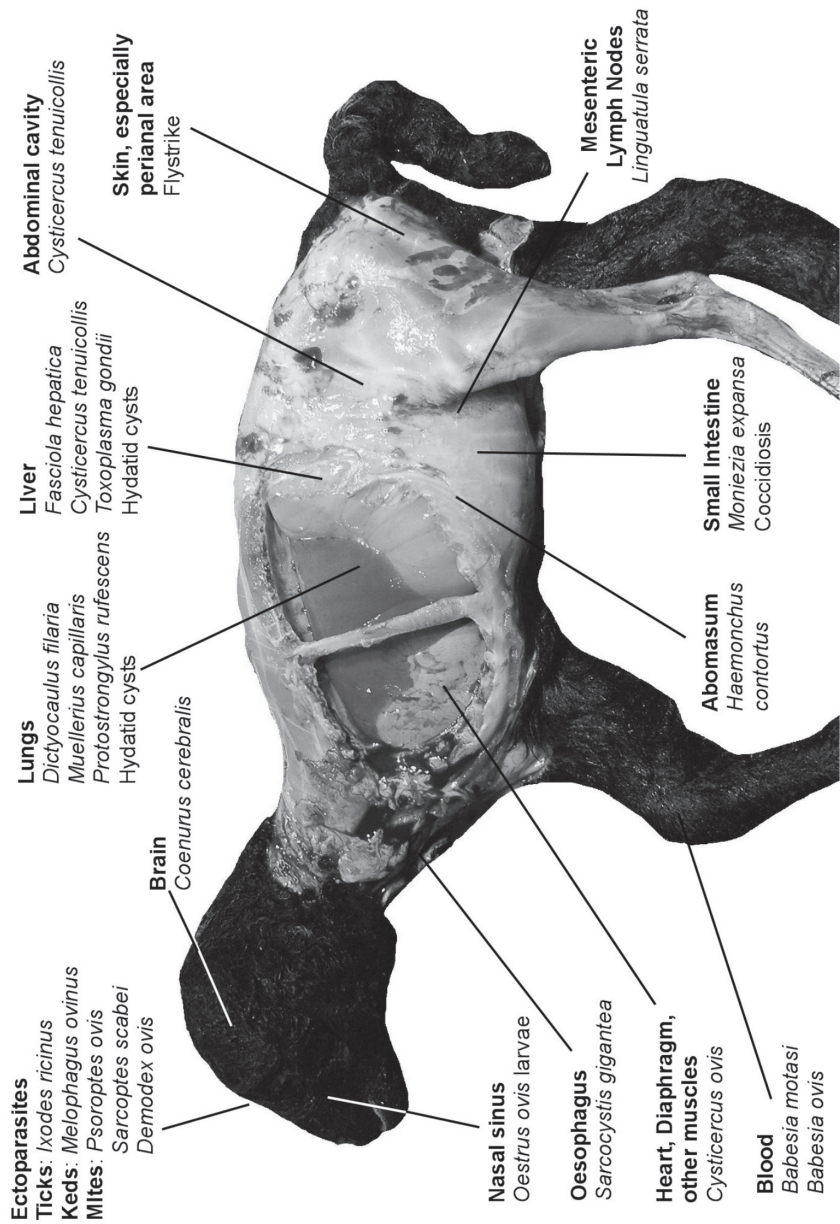
Each bacterial species has an optimum temperature for growth, as well as a temperature range in which they grow, it is generally accepted that there are four groups:

3

PARASITES



MAIN PARASITES OF SHEEP



PARASITISM

Parasites can be defined as plants or animals that live on or within another living organism at whose expense it gains some advantage whilst giving nothing in return. The host/parasite association can be complicated. The type of parasite encountered ranges from viruses (intracellular parasites) that can only reproduce in a living cell, to protozoa (single celled organisms) to intestinal worms and insects. Although they are parasitic, viruses are generally treated as a separate group, and we will only be considering parasites that are internal (endoparasites) and external (ectoparasites) that affect sheep.

During post mortem inspection of the ovine species, the presence of parasites and their affects on the host tends to be the most common condition encountered.

Parasites may have a direct or indirect lifecycle. A direct lifecycle means that the parasite can only complete the lifecycle by parasitizing the host. An indirect lifestyle involves at least one secondary (or intermediate) host. In the case of sheep, the ancestral association with canines both as control and predator has led to a number of parasites relying on the ingestion of parts of infected ovine carcasses by canines to complete their lifecycle. To this end the infective parasite stage in sheep forms infective hibernation stages, usually in the form of cysts, awaiting digestion by canids and their subsequent activation to evolve to their adult form.

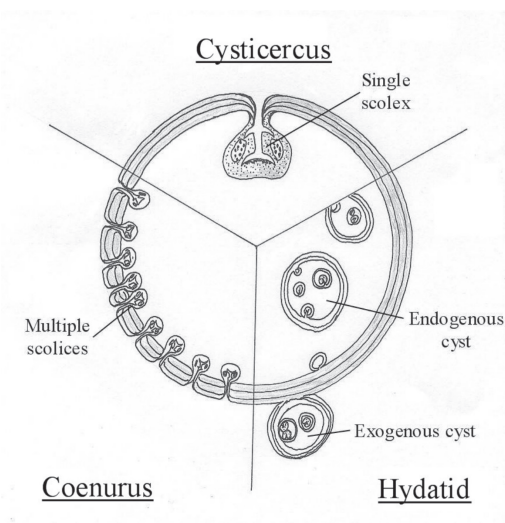
These cysts, or metacestodes, present in differing forms in preferred parts of the body known as predilection sites, some larvae having an affinity for musculature with a good blood supply such as the heart, diaphragm, others only maturing within the central nervous system. Once the larvae have reached this predilection site it develops into one of three metacestodes in sheep, a *cysticercus*, a *coenurus* or a hydatid.

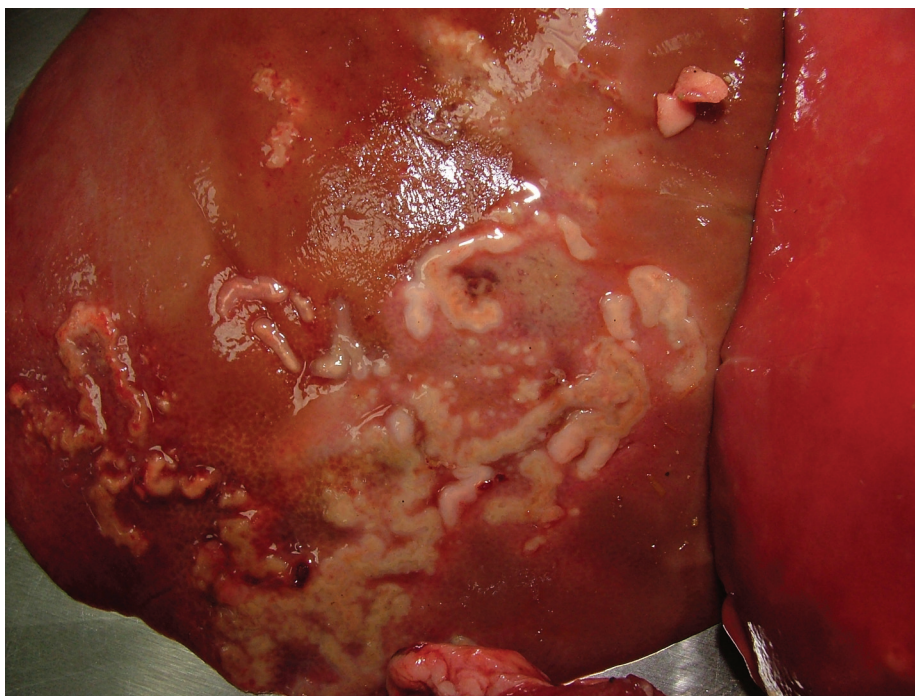
CYSTICERCUS

A cysticercus is a fluid-filled cyst containing a single protoscolex (the scolex is the attachment organ of the tapeworm, in this case infolded within the structure of the cysticercus).

COENURUS

A fluid filled cyst containing numerous protoscolices.





Scarred tracking in a liver



The single scolex is clearly visible in this cyst.

4

NEOPLASIA



TUMOURS

INTRODUCTION

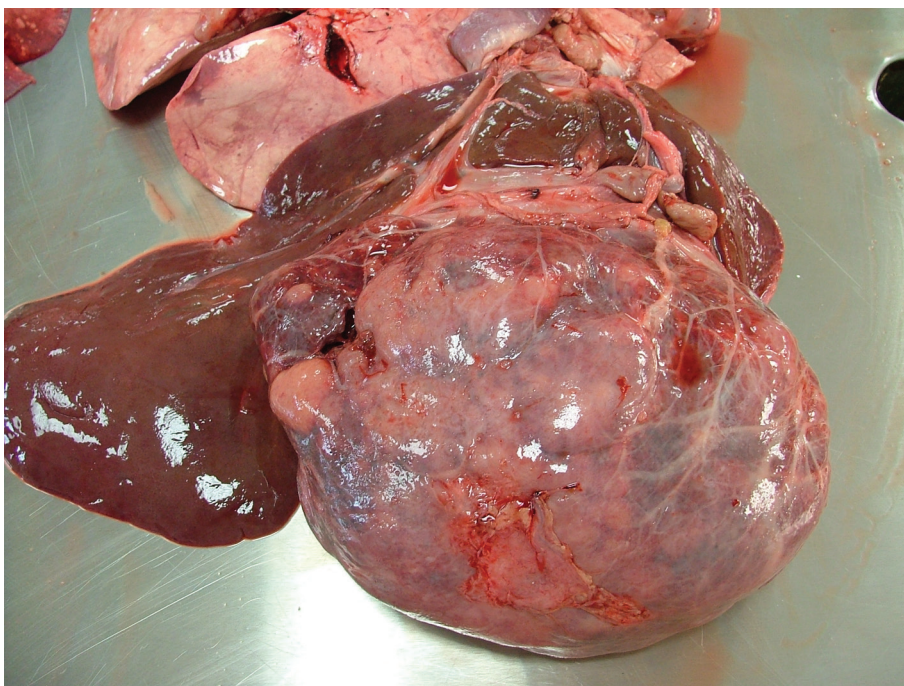
The term tumour literally applies to any abnormal swelling, but nowadays it tends to refer exclusively to neoplasms, which are abnormal new growth of tissue, in which cell multiplication is uncontrolled and progressive in addition to serving no purpose and growing faster than normal tissue. These neoplastic formations are classified as being either benign or malignant, the gross appearance of neoplasia is variable being dependant on their origin and type. Both malignant and benign tumours are served by increased blood vascularisation, any tumour requiring nutrients to continue growth. In the case of the rapidly growing malignant tumours the blood vessels tend to be thin, poorly formed and prone to rupture creating the appearance of haemorrhagic areas within the tumour. Masses require histological examination for a definitive diagnosis, however there are characteristics of benign and malignant tumours.

BENIGN TUMOURS

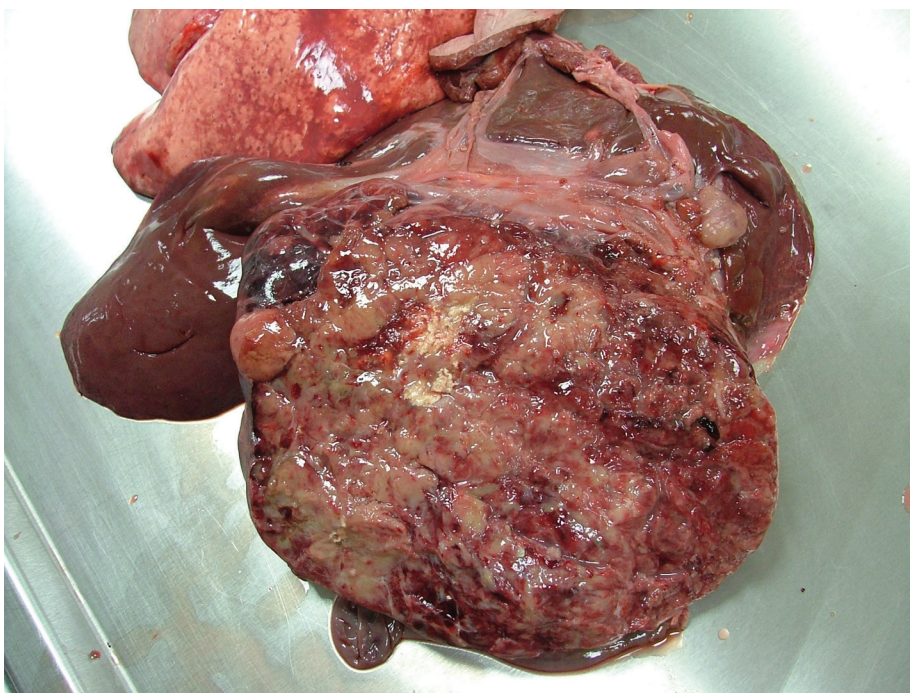
These grow slowly, pushing aside normal tissue without invading it. They are usually encapsulated and do not produce secondary tumours within the body. Although some benign tumours are caused by viruses, on the whole they do not appear to be infectious. The effect of their presence tends to be physical, blockage of systems in the body and pressure applied to organs being obvious examples.



A large tumour (hepatic tumour) attached to a liver



Large hepatic malignant tumour



Variegated cut surface with areas of necrosis

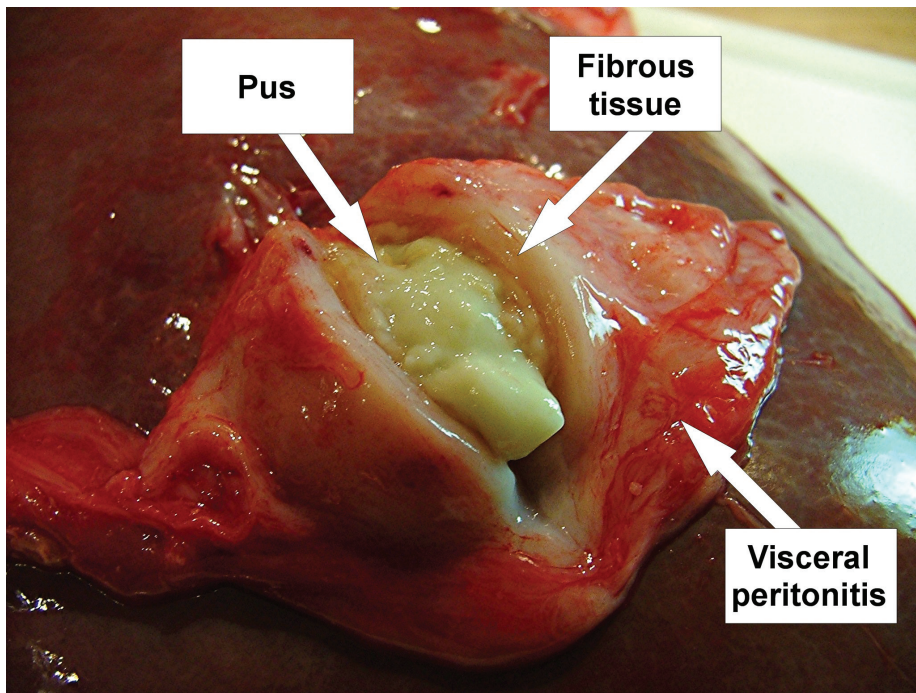
5

CONDITIONS ENCOUNTERED AT OVINE POST MORTEM INSPECTION



ABSCESSSES

An abscess is a collection of pus surrounded by fibrous tissue; it is part of the bodies' defence mechanism normally triggered by the presence of pus forming bacteria. This fibrous tissue is a normal healthy reaction and consists of newly formed connective tissue and blood vessels. Pus may consist of dead or dying bacteria, dead tissue cells that formerly occupied the area, dead or dying white blood cells, debris and a certain amount of fluid exuded from the blood vessels in the vicinity.



Anatomy of a hepatic abscess

If the organisms multiply, the abscess will continue to increase in size until the pus escapes. If the abscess is near the surface of the tissue part of the wall becomes necrotic and is removed allowing the pus to discharge.

When the abscess is deeper within tissue and the pus is under tension it can burrow through less resistant tissue and reach the surface through a canal known as a sinus. If the bodies' immune response is sufficient to destroy the organisms contained in the pus the abscess may remain localised and be eventually absorbed, caseated or calcified.

The synovial joints, for example knees, knuckles and shoulders, provide a nutrient rich fluid surrounded by a good blood supply that offers ideal conditions for bacterial growth. Microorganisms can enter the joint through a penetrative wound, via the blood stream or from a nearby area of infection, foot rot for example. The most common method of acquired infection is through the umbilicus, however studies have also demonstrated that *Streptococcus dysgalactiae* infection of joints can be achieved via the digestive route from the mother during feeding.

When infected the joint swells as fluid increases, the synovial membrane becomes hyperaemic and thicker (fibrinous). If the infection entered via, or gains access to, the blood stream it can lead to polyarthritis, where most joints are infected, especially the large joints of the limbs.



Arthritic joint (arrowed)

One of the most commonly isolated pathogens in cases of lamb arthritis is *Streptococcus dysgalactiae*; other implicated bacteria include *E.coli*, *Erysipelothrix rhusiopathiae*, *Actinomyces pyogenes*, *Pasteurella haemolytica* and *Streptococcus spp.*

6

AIDE MEMOIRE - ANATOMY



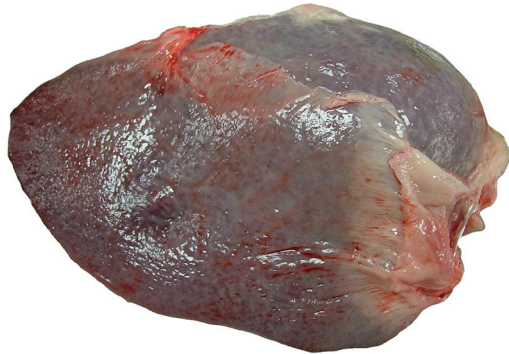
Heart

- Fat is crispy due to stearin
- 2 bones present at aortic origin in older animals
- 3 ventricular furrows
- 4 chambers, left atrium and ventricle, right atrium and ventricle.
- Average heartbeat 70-120 bpm at rest.
- Weight 100-150g



Spleen

- Flat and oval in outline
- Bluish/red in colour
- White Malphigian corpuscles visible in red pulp when incised
- Attached to rumen
- Weight 50-100g



7

CONDITION AND CAUSE



<i>Disease</i>	<i>Aetiology</i>	<i>Type</i>
Actinobacillosis (Leather lips, 'Cruels')	<i>Actinobacillus ligniersi</i>	Bacterial
Actinomycosis (Lumpy Jaw, Ray Fungus)	<i>Actinomyces bovis</i>	Bacterial
Anthrax (Wool sorters disease, Splenic fever, Charbon, Malignant pustule)	<i>Bacillus anthracis</i>	Bacterial
Babesiosis (Haemosporidiosis, Piroplasmosis, Red Water Fever)	<i>Babesia motasi</i> <i>Babesia ovis</i>	Parasitic
Bacillary Haemoglobulinuria (Red Water Disease)	<i>Clostridium haemolyticum</i>	Bacterial
Black Disease (Infectious necrotic hepatitis)	<i>Clostridium novyi</i>	Bacterial
Blackleg (Black quarter)	<i>Clostridium chauvoei</i>	Bacterial
Bloat	Miscellaneous	
Bluetongue (Ovine catarrhal fever, 'sore muzzle' disease)	Orbivirus	Viral
Braxy	<i>Clostridium septicum</i>	Bacterial
Brucellosis (Ovine brucellosis, OB)	<i>Brucella melitensis</i>	Bacterial
Campylobacteriosis (Ovine Genital Campylobacteriosis)	<i>Campylobacter fetus</i> <i>Campylobacter jejuni</i>	Bacterial
Caseous Lymphadenitis (CLA. CL. Cheesy Gland. Pseudotuberculosis)	<i>Corynebacterium pseudotuberculosis</i>	Bacterial
Contagious Epididymitis (Ram Epididymitis)	<i>Brucella ovis</i>	Bacterial
Coccidiosis	<i>Eimeria arloingi</i> <i>Eimeria crandallis</i> <i>Eimeria ovinoidalis</i>	Parasitic

8

AFFECTIONS OF SPECIFIC PARTS



ANTE MORTEM INSPECTION OF SHEEP

Many things can hamper ante mortem inspection of sheep but one factor predominates: sheep are almost the ultimate prey species and as such will attempt to appear fit and healthy in the presence of a predator (humans), disguising clinical signs of disease or weakness due to injury.

Given the time constraints of ante mortem inspection, the reaction of the animals to the preceding transportation, strange lairage environment, and the factors above, the clinical signs of disease, trauma or other animal health and welfare issues can be barely noticeable; a fact that leads to sheep being the forgotten species in terms of welfare. The greatest tool available to those conducting ante mortem inspection of sheep is experience, especially of normality in the species and as such this section gives a guide to ante mortem conditions based on deviation from the norm for sheep in the setting of the lairage environment under the following headings: Abnormality of behaviour, Abnormality of breathing, Abnormal discharges, Abnormality of movement/posture, Abnormality of shape / condition and Abnormality of skin/eyes/mucous membranes.

The process of ante mortem inspection should ideally be performed with the animals in movement and at rest, and preferably with the opportunity to view the animal from both sides in cases of conditions that may be unilateral. Movement obviously allows for checking gait, locomotion and central nervous system lesions; monitoring resting behaviour can demonstrate signs of conditions such as pruritus and laboured breathing.

PHYSIOLOGICAL DATA

Rectal temperature	39.5°C ± 0.5°C
Heart rate	60-120 beats per minute, average 75 bpm
Respiratory rate	19 breaths per minute

DEAD ON ARRIVAL/IN LAIRAGE

Anthrax, Black Disease, Bluetongue, Braxy, Enterotoxaemia, Haemorrhagic enteritis, Salmonellosis, Tetanus

ELEVATED TEMPERATURE

Bacillary Haemoglobinuria, Black Disease, Blackleg, Bluetongue, Braxy, Foot and mouth disease, Leptospirosis, Louping Ill, Malignant oedema, Pasteurellosis, Peste Des Petits Ruminants, Salmonellosis, Tetanus, Tick borne fever, Sarcocysts, Toxoplasmosis

INDEX



INDEX

A

A-band 13
Abomasum 25, 28
Abscess 193
Acquired Immune Response 73
Actin 13
Actinobacillosis 82
Actinobacillus lignieresii. *See* Actinobacillosis
Actinomyces bovis. *See* Actinomycosis
Actinomycosis 82
Adenosine triphosphate 12, 13
Adenovirus 79
Adrenals 65
Affecter cells 74
Alveoli 20
Anaemia 202
Ankylosed joint 206
Anthrax 84
Antibodies 73
Apthous fever. *See* Foot and Mouth Disease
Arachnoid mater 64
Arthritis 202
Arytenoid cartilage 19
ATP. *See* Adenosine triphosphate
Atrium 38
Autotrophs 75
Axillary L.N. 46
Axon 63

B

Babesia motasi. *See* Babesiosis
Babesia ovis. *See* Babesiosis
Babesiosis 151
Bacillary Haemoglobinuria 84
Bacillus anthracis. *See* Anthrax
Bacterial necrosis 207
Barber's Pole Worm. *See* *Haemonchus contortus*
B-cells 73
Benign tumours 177
Bible. *See* Omasum
Bicuspid 38
Big head. *See* Malignant Oedema

Bile 35
Bilirubin 35
Biliverdin 35
Binary fission 76
Birnavirus 79
Blackbottles 163
Black Disease 85, 288
Blackleg 85
Black quarter. *See* Blackleg
Bladder 54
Bladder worm 122
Bloat 86
Bloodsplash 209
Blood vessels 37
Bloody scours. *See* Haemorrhagic Enteritis
Blowfly myiasis 163
Blue bag. *See* Mastitis
Bluebottles 163
Blue Tongue 86
Body strike 164
Bone types 4
Bowman's capsule 53
Bradshot. *See* Braxy
Bradyzoite 154
Brain 63
Braxy 88, 223
Breech strike 164
Bronchi 272
Bronchi 20
Bronchial L.N. 44
Brucella melitensis 88
Brucella ovis. *See* Contagious edipididymitis
Brucellosis 88
BSE 81
Buccal cavity 22
Buccal papillae 22
Bulbourethral gland 59

C

Caecum 32
Calculosis. *See* Urethral calculi
Calliphora vomitoria 163
Cardiac muscle 39
Cardiovascular system 37

Carpus 8
 Cartilaginous joints 4
 Caseous lymphadenitis 89, 210
 Caudate lobe 35
 Central Nervous System 62
 Cerebellum 63
 Cerebrum 63
 Cervix 57
 Charbon. *See* Anthrax
 Cheesy Gland. *See* Caseous Lymphadenitis
 Chemotaxis 73
 Chemotrophy 75
Chlamydia psittaci. *See* Enzootic Abortion
 Chlamydiosis. *See* Enzootic Abortion
 Cholecystitis 214
 Chordae tendineae 39
Chorioptes bovis 167
 Chorioptic mange. *See* *Chorioptes bovis*
 Chronic endometritis 229
 Chyle' 34
 Circling disease. *See* Listeriosis
 Cirrhosis 215
 CLA. *See* Caseous Lymphadenitis
Clostridium chauvoei. *See* Blackleg
Clostridium haemolyticum. *See* Bacillary
 Haemoglobinuria
Clostridium novyi. *See* Black Disease
Clostridium perfringens Type D. *See* Enterotoxaemia
Clostridium septicum. *See* Braxy, Malignant
 Oedema
Clostridium tetani. *See* Tetanus
 Clotting 41
 Club lamb fungus. *See* Ringworm
 Cobalt deficiency. *See* White Liver Disease
 Coccidiosis 150
 Coenuriasis 137
 COID. *See* Foot Rot
 Colon 32
 Congestive Haemorrhagic Hepatitis 216
 Contagious Agalactia 90, 280
 Contagious ecthyma. *See* Orf
 Contagious Epididymitis 91
 Contagious ophthalmia. *See* Ovine Infectious
 Keratoconjunctivitis
 Contagious ovine interdigital dermatitis. *See*
 Foot Rot
 Contagious pustular dermatitis. *See* Orf

Contagious pustular stomatitis. *See* Peste de
 Petits Ruminants
 Coronavirus 79
 Corpus albicans 56
 Corpus cavernosum 59
 Corpus luteum 56
 Corpus spongiosum 60
Corynebacterium pseudotuberculosis 210. *See*
 Caseous Lymphadenitis
 Cotyledons 57
 Cricoid cartilage 19
 Cruels. *See* Actinobacillosis
 Cystic duct 34
Cysticercus ovis 122
Cysticercus tenuicollis 126
 Cystitis 217
 Cytotoxic T-cells 74

D

Deciduous incisors 23
 Deep cervical L.N. 45
 Demodectic mange. *See* *Demodex bovis*
Demodex bovis 167
 Dental pad 23
Dermatophilus congolensis. *See* Strawberry
 Foot Rot
Dichelobacter nodosus. *See* Foot Rot
Dictyocaulus filaria 138
 Dimorphic fungi 80
 Dog bites 263
 Driving sickness. *See* Jaagsiekte
 Ductless glands 65
 Ductus deferens 58, 276
 Duodenum 30
 Dura mater 64

E

Echinococcus granulosus 131
 Ectoparasites 118
 Efferent nerves 62
Ehrlichia phagocytophilia. *See* Tick Borne
 Fever
Eimeria arloingi. *See* Coccidiosis
Eimeria crandallis. *See* Coccidiosis
Eimeria ovinoidalis. *See* Coccidiosis
 Emaciation 240
 Embryophore 131
 Endocrine system 65

Endometrium 57
Endomysium 12
Endoparasites 118
Endotoxins 77
Enteritis 217
Enteroliths 265
Enterotoxaemia 92, 287
Enzootic Abortion 92
Enzootic ataxia. *See* Swayback
Enzootic Pneumonia. *See* Pasteurellosis
Enzootic staphylococcosis. *See* Tick Pyaemia
Epicardium 39
Epididymis 59
Epiglottis 19
Epimysium 12
Erysipelothrix rhusiopathiae. *See* Post
Dipping Lameness
Erythrocytes 37
Exhalation 21
Exotoxins 77

F

Facial bones 6
Fasciola hepatica 155
Fat Necrosis 219
Femur 9
Fever 220
Fibre types 14
Fibrin 41
Fibrinogen 41
Fibrinous pneumonia 253
Fibrous joints 4
Fibula 9
Filiform papillae 24
Flat bones 4
Fleece rot. *See* Green Wool Disease
Fly blown' 163
Fly struck 164
FMD. *See* Foot and Mouth Disease
Follicle Stimulating Hormone (FSH) 56
Foot and Mouth Disease 92
Foot foul. *See* Foot Rot
Foot lure. *See* Foot Rot
Foot Rot 94
Foot Scald. *See* Scald
Foreleg 8
Forestomachs 25
Foul of the foot. *See* Foot Rot
Fungi 80

Fungiform papillae 24
Fusobacterium necrophorum. *See* Scald, Foot
Rot

G

Gall bladder 34, 274
Gametogony 150
Gangrenous pneumonia 253
Gastric stomach. *See* Abomasum
Genetic Cysts. *See* Renal retention cysts
Gid. *See* Coenurirosis
Glomerulonephritis 231
Glomerulonephropathy. *See* Glomerulone-
phritis
Glomerus 53
Gonads 65
Graafian follicle 56
Gram's staining 77
Grass tetany. *See* Grass Staggers
Greenbottles 163
Green Wool Disease 94, 280
Gut associated lymphoid tissue 50

H

Haemorrhagic Enteritis 95
Haemosporidiosis. *See* Babesiosis
Hairballs 265
Hard bag. *See* Mastitis
Heart 38, 44, 46
Helper/inducer T-cells 74
Hepatic portal L.N. 44
Hepatic portal vein 35
Hepatocytes 35
Herpesvirus 79
Heterotrophs 75
Hindleg 9
Honeycomb. *See* Reticulum
Hooves 10
Host / parasite Relationship 119
Humerus 8
Hydatidosis 131
Hydronephrosis 231
Hyperketonaemia. *See* Pregnancy Toxaemia
Hyphae 80
Hypoglycaemia. *See* Pregnancy Toxaemia
Hypophysis 65
H-zone 13

I

I-band 13
 Icterus. *See* Jaundice
 Ileo-caecal valve 32
 Ileum 31
 Iliac L.N. 48
 Immunity 72
 Infarction 237
 Infectious necrotic hepatitis. *See* Black Disease
 Inflammation 74
 Ingrowing Horn 263
 Inspiration 21
 Intercostal L.N. 46
 Intermediate nerves 62
 Intramuscular abscesses 195
 Ischiatic L.N. 48
Ixodes ricinus 151, 166

J

Jaagsiekte 95, 253
 Jaundice 224
 Jejunum 31
 Jöhne's Disease 96

K

Kidney 44, 52, 274
 Kupfer cells 35

L

Large intestine 31
 Larynx 19, 43
 Leather lips. *See* Actinobacillosis
 Lenticular papillae 24
Leptospira hardjo. *See* Leptospirosis
 Leptospirosis 98
 Leucocytes 37
Linguatula serrata 172
 Lip and leg ulceration. *See* Ulcerative Dermatitis
 Lipomatosis. *See* Fat necrosis
Listeria monocytogenes. *See* Listeriosis
 Listeriosis 98
 Liver 34, 44, 48, 67, 71, 81
 Lock-jaw. *See* Tetanus
 Long bones 4
 Loop of Henlé 53
 Louping Ill 99

Lucilia sericata 163
 Lumpy Jaw. *See* Actinomycosis
 Lumpy wool. *See* Ringworm
 Lung disease. *See* Maedi-Visna
 Lutenizing Hormone (LH) 56
Lymnaea truncatula. *See* Fascioliasis
 Lymph 42
 Lymphadenitis 225
 Lymphatic circulation 41
 Lymph nodes 42
 Lymphoid tissue 50
 Lymph vessels 41
 Lytic infection 80

M

Macrogametocyte 151
 Mad Cow Disease. *See* Bovine Spongiform Encephalopathy
 Maedi-Visna 99
 Malignant foot rot. *See* Foot Rot
 Malignant Oedema 100
 Malignant pustule. *See* Anthrax
 Malignant tumours 178
 Malpighian bodies 53
 Malpighian corpuscles 51
 Mammary glands 46, 60
 Mandible 4, 6, 22, 43, 82, 83, 289
 Manyplies. *See* Omasum
 Masseter muscles 23
 Mastitis 226
 Mediastinal L.N. 44
 Medulla oblongata 63
 Melanosis 227
 Melioidosis 100
Melophagus ovinus. *See* Sheep Ked
 Melt. *See* Spleen
 Memory cells 74
 Merozoites 151
 Mesenteric L.N. 44
 Mesenteric lymph nodes 31
 Mesophiles 77
 Metacarpus 8
 Metastasis 178
 Metritis 229
 Microgametes 151
 Mites 167
Moniezia expansa 146
 Mouth. *See* Buccal cavity
 Mucin 23

Muellerius capillaris 142
Muscle 12, 40
Mycobacterium bovis. *See* Tuberculosis
Mycobacterium johnei. *See* Johne's Disease
Mycoplasma agalactiae. *See* Contagious Agalactia
Mycoplasma conjunctivae 102
Myoblasts 13
Myometrium 57
Myosin 13

N

Necrobacillosis of the foot. *See* Scald
Neoplasia 177, 178
Nephritis 229
Nephrons 53
Nephropylitis 233
Nephrosis 229
Nerves 62
Nostrils 18
Nutritional muscular dystrophy. *See* White Muscle Disease

O

OB. *See* Brucellosis
Obstructive Uropathy 231
Oesophagus 25
Oestrus ovis 170
Omasum 25, 27
Onchosphere 131
Oocyst 151
OPP. *See* Maedi-Visna
Orf 100
Orthomyxovirus 79
Os calcis 9
Osteoblast 3
Osteoclast 3
Ostertagia ostertagi. *See* Ostertagiosis
Ostertagiosis 148
Ovaries 55
Overeating disease. *See* Enterotoxaemia
Ovine brucellosis. *See* Brucellosis
Ovine catarrhal fever. *See* Bluetongue
Ovine dermatophytosis. *See* Ringworm
Ovine encephalomyelitis. *See* Louping Ill
Ovine Infectious Keratoconjunctivitis 102
Ovine Progressive Interstitial Pneumonia. *See* Maedi-Visna

Ovine pulmonary adenomatosis. *See* Jaagsiekte
Ovine pulmonary carcinoma. *See* Jaagsiekte
Ovine Ringworm 104. *See* Ringworm
Ovulation 56

P

Pampiniform plexus 58
Pancreas 34, 44, 65, 66
Pancreatic duct 30
Paramphistomum cervi 162
Paramyxovirus 79
Parasitic Gastroenteritis 148
Parasitic granulomatous peritonitis 248
Parasitism 118
Parathyroid 3, 65, 67
Parathyroid hormone 3
Paratrophy 75
Paratuberculosis. *See* Johne's Disease
Parotid L.N 43
Parvovirus 79
Pasteurella haemolytica. *See* Pasteurellosis
Pasteurellosis 103
Patella 9
Pelvic symphysis 7
Pelvis 7
Penis 59
Pericarditis 245
Pericardium 39
Perimetrium 57
Perimysium 12
Periosteum 3
Peripheral nerves 64
Peripheral Nervous System 62
Peritonitis 247
Permanent dentition 23
Peste Des Petits Ruminants 103
Peyer's patches 29, 50, 81
Phagocytosis 73
Phalanges 8
Pharynx 19, 22, 23, 43
Phormia terrae-novae 163
Phototrophy 75
Pia mater 64
Picornavirus 79
Pinkeye. *See* Ovine Infectious Keratoconjunctivitis
Pipey liver 157
Piroplasmosis. *See* Babesiosis

Pituitary 56, 65, 67
 Pizzle strike 164
 Plasma 37
 Platelets 37
 Pleurisy 250
 Pleuritis. *See* Pleurisy
 Pneumonia 253
 Poll strike 164
 Polycystic kidney. *See* Renal retention cysts
 Popliteal L.N. 49
 Portal circulation 40
 Post Dipping Lameness 104
 Pox virus 79
 PPR. *See* Peste des Petits Ruminants
 Precrural L.N. 49
 Predilection site 120
 Pregnancy Toxaemia 104
 Prescapular L.N. 46
 Presternal L.N. 48
 Prion proteins 81
 Prokaryotic organisms 74
 Proliferative dermatitis. *See* Strawberry Foot
 Rot
 Prothrombin 41
 Protoscolex 118
Protostrongylus rufescens 138, 142
Pseudomonas aeruginosa. *See* Green Wool
 Disease
Pseudomonas pseudomallei 100
 Pseudotuberculosis. *See* Caseous Lymphadenitis
Psoroptes ovis 167, 168
 Psoroptic mange. *See* *Psoroptes ovis*
 Psychrophiles 77
 Psychrotrophs 77
 Pterygoid muscles 23
 PTH. *See* Parathyroid hormone
 Pulmonary System 40
 Pulpy kidney. *See* Enterotoxaemia
 Pyaemia 260
 Pyelonephritis. *See* Nephropylitis
 Pyloric sphincter 29
 Pyometra 229

R

Radius 8
 Ragwort 216
 Ray Fungus. *See* Actinomycosis
 Rectum 33

Red marrow 3
 Red Water Disease 84
 Red Water Fever. *See* Babesiosis
 Renal cortex 53
 Renal L.N. 44
 Renal pelvis 52
 Renal Retention Cysts 236
 Reticulum 25, 26, 80
 Retropharyngeal L.N. 43
 Ribs 7
 Rida. *See* Scrapie
 Rigor mortis 15
 Ringworm 104
 Romney Marsh Disease. *See* Haemorrhagic
 Enteritis
 Routes of infection 71
 Rumen 25, 26, 52, 86, 273, 275
 Rumination 28

S

Saliva 23
 Salivary glands 23
Salmonella typhimurium 105
 Salmonellosis 105
Sarcocystis gigantea. *See* Sarcocysts
 Sarcocysts 152
 Sarcolemma 13
Sarcoptes scabiei 167
 Sarcoptic mange. *See* *Sarcoptes scabiei*
 Scald 106
 Scapula 8
 Schizonts 151
 Schwann cells 63
 Scrapie 106
 Scrotum 58
Senecio jacoboea 216
 Sensory nerves 62
 Septicaemia 221
 Septic metritis 229
 Serpentine tracts 127
 Serum 41
 Sheep ked 169
 Sheep measles 122
 Sheep nasal bot 170
 Sheep Pox 107
 Sheep scab 168
 Shizogony 150
 Skeleton - Appendicular 8
 Skeleton - Axial 6
 Skull 6

Small intestine 29
 Smooth muscle 15
 Sore Mouth. *See* Orf
 Soremuzzle disease. *See* Bluetongue
 Spinal Cord 63
 Spleen 50
 Splenic abscesses 200
 Splenic fever. *See* Anthrax
 Sporoblasts 150
 Sporozoites 150
 Sporulation 150
Staphylococcal pyaemia. *See* Tick Pyaemia
Staphylococcus aureus. *See* Tick Pyaemia
 Stiff lamb disease. *See* White Muscle Disease
 Stomatitis-pneumoenteritis complex. *See* Peste
 des Petits Ruminants
 Strawberry Foot Rot 107
 Struck. *See* Haemorrhagic Enteritis
 Sturdy. *See* Coenuriasis
 Sublumbar L.N. 48
 Submaxillary L.N. 43
 Superficial inguinal L.N. 48
 Suppressor T-cells 74
 Suprasternal L.N. 48
 Sutures 4
 Swayback 108
 Synovial joints 5
 Systemic Circulation 41
 Systole 37

T

Tachyzoite 154
Taenia hydatigena 126
Taenia multiceps. *See* Coenuriasis
Taenia ovis 122
 Taste buds 24
 TB. *See* Tuberculosis
 T-cells 73
 Teat cistern 60
 Testicle 58
 Tetanus 109
 Thermophiles 77
 Thoracic L.N. 46
 Thrombokinas 41
 Thymus 65, 66, 73, 81
 Thyroid 65
 Thyroid cartilage 19
 Tibia 9

Tick Borne Fever 109
 Tick Pyaemia 110
 Ticks 166
 Tongue 24
 Toxaemia 221
 Toxic Shock 239
Toxoplasma gondii 154
 Trachea 17, 19, 44, 45, 272
 Trauma 260
 Traumatic peritonitis 248
 Tremblante du mouton. *See* Scrapie
 Trichobezoars 265
 Trichophagia 265
Trichophyton verrucosum. *See* Ringworm
 Tricuspid 39
 Trophozoites 151
 Tuberculosis 71, 110
 Tubulonephrosis. *See* Renal infarction
 Tunica adventitia 37
 Tunica interna 37
 Tunica media 37
 Turbinate bones 18
 Twin Lamb Disease. *See* Pregnancy Toxaemia

U

Udder clap. *See* Mastitis
 Ulcerative Dermatitis 112
 Ulna 8
 Uraemia 266
 Ureter 52
 Urethra 276
 Urethra 54
 Urethral Calculi 267
 Urinary calculi. *See* Urethral calculi
 Urolithiasis. *See* Urethral calculi
 Uterine horns 57
 Uterine ligament 57

V

Vagina 58
 Vallate papillae 24
 Vas deferens. *See* Ductus deferens
 Venereal balanoposthitis. *See* Ulcerative
 Dermatitis
 Ventricle 38
 Virion 78
 Viruses 78



W

Waterbelly. *See* Urethral calculi
White Liver Disease 113
White Muscle Disease 113
White spotted kidney. *See* Renal infarction
Wireworm. *See* *Haemonchus contortus*
WMD. *See* White Muscle Disease
Wool pull 260
Wool rot. *See* Ringworm
Wool sorters disease. *See* Anthrax
Wound strike 164

Y

Yersinia enterocolitica 113
Yersinia pseudotuberculosis 113
Yersiniosis 113

Z

Z-disc 13