The College of Animal Physiotherapy

Diploma in Animal Physiotherapy

Module 1

Anatomy and Physiology

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AIMS
The aims of this module are to provide the student with the information needed to build on prior knowledge and develop a broad, in depth understanding of the musculoskeletal system and the functions of the canine and equine body.

OBJECTIVES
At the end of this module you should be able to:
- Describe the structure of cells and tissues
- Identify structures and landmarks of the canine and equine body – from diagrams and by palpation
- Demonstrate a knowledge and understanding of the major muscles and their origin, insertion and function.
- Demonstrate a knowledge and understanding of tendons, ligaments and joints.
- Demonstrate an overview of the main physiological systems of the body.
- Draw comparisons between equine and canine anatomy.

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INTRODUCTION

It is essential for the Animal Physiotherapist to have a good knowledge and understanding of anatomy and physiology. A physiotherapists job is to aid the healing of the body and this means working with all matter such as bone, muscle, tendons, ligaments, lymph and blood.

Anatomy and physiology is also the foundation of all learning based on animals and their performance and wellbeing. A trainer will be more successful if they understand the anatomy and muscle development of their subject and their physical ability to do what is being asked of them.

This module aims to provide an overview of the Anatomy and Physiology of the Equine and Canine body. It is important that as well as being able to identify structures on diagrams; you can translate this knowledge to real life. Ensure that you spend some time with your animals palpating their muscles bones and joints in order to consolidate your knowledge. Some of the areas in this module will be covered in more depth in a later module.
SECTION 1
DIRECTIONAL TERMINOLOGY

The following terms are commonly used when discussing anatomy or describing different areas of the animal. It is essential that you are familiar with this terminology before you study Anatomy and Physiology:

*With regard to the body:*

**Dorsal** – Toward the animals’ topline

**Ventral** – Toward the animals’ abdomen

**Cranial (or anterior)** – Toward the head

**Caudal (or posterior)** – Toward the tail

*With regard to the head:*

**Caudal** – Toward the ears

**Rostal** – Toward the muzzle

*With regard to the limbs:*

**Proximal** – Toward the body

**Distal** – Away from the body, or ‘free end’

**Lateral** – furthest from the median plane - the outside of the limb

**Medial** – nearest to the median plane – the inside of the limb

Abaxial – away from midline
Axial – towards the midline

The cranial and caudal aspects of the proximal limb – above the carpus and hock - are referred to as just that – cranial and caudal. However these areas are termed differently when referring to the distal limb.

With regard to the distal region of the forelimb (carpus downward):

Dorsal – The cranial aspect of the limb

Palmar – The caudal aspect of the limb

Think about your palm – this is the palmar surface of your hand

With regard to the distal region of the hind limb (from the hock downwards):

Dorsal - The cranial aspect of the limb

Plantar – The caudal aspect of the limb

Body planes:

Median plane – Divides the body into two halves – left and right

Sagittal plane – Runs parallel to the median plane and is any distance either side of the midline
Frontal views:

**Lateral** – Furthest from the median plane

**Medial** – Nearest to the median plane

**Transverse or segmental plane** – At right angles to the median plane.
   Divides the body into two halves – cranial and caudal.

**Frontal or Dorsal plane** – At right angles to both the median and transverse planes. Divides the body into two halves – dorsal and ventral.

Deep – refers to structures further away from the body surface
Superficial – towards the body surface

It is important to become familiar and comfortable with directional terminology, because this is the language used by veterinarians when describing a problem. For example, when describing a swelling, you may see the term ‘swelling over the dorsomedial fetlock’, meaning the swelling is located on the medial aspect of the limb, towards the front (dorsal). Understanding these terms means you will know what a veterinary history means!
SECTION 2
MICROANATOMY OF CELLS AND TISSUES

In order to understand injury and healing of the body it is essential to understand the make up of the tissues that you will be working with.

BASIC CELL STRUCTURE

Key components of the cell

- **Nucleus** – The control centre or ‘brain’ of the cell. Contains chromatin which is made up of DNA (deoxyribonucleic acid), RNA (ribonucleic acid) and nuclear proteins. DNA and RNA are the nucleic acids inside the cell and carry genetic information. When the cell is going to divide, the chromatin becomes very compact, and condenses into distinct chromosomes made up entirely of DNA. Chromosomes carry the information required to help a cell grow, thrive and reproduce. Chromosomes also work with other nucleic acids in the cell to build proteins and help in cell division.

- **Cell membrane** – All living cells are surrounded by cell membranes. This is a semi-permeable membrane which allows for selective transport of materials in and out of the cell. A cell membrane is different from a cell wall. A cell wall is an extracellular structure found in plant cells but never found in animal cells.

- **Cytoplasm** - The ‘background liquid’. Cytoplasm is mostly water and contains a variety of molecules, many of which are proteins, and the organelles.

- **Organelles** – These have specific functions within the cells. Key organelles are:
  - **Mitochondria** – Provide the energy required for cellular function. More active cells, such as muscle cells, will have more mitochondria than those requiring less energy.
Endoplasmic reticulum – Endoplasmic meaning ‘inside the cytoplasm’ and reticulum meaning ‘network’. The endoplasmic reticulum is a network of membranes which forms an interconnecting channel throughout the cytoplasm. There are two types of endoplasmic reticulum (ER): rough and smooth. The smooth ER acts as a storage organelle, whereas the rough ER works as a ‘packaging system’ for proteins that are synthesised by the ribosomes found on its surface.

Ribosomes – Found free in the cytoplasm or attached to the outer surfaces of the membranes of the endoplasmic reticulum. Ribosomes are responsible for protein synthesis.

Golgi apparatus – The golgi apparatus takes simple molecules and combines them to make more complex molecules. It then packages the molecules in vesicles and either stores them for later use or sends them out of the cell. It is also the organelle that builds lysosomes.

Lysosomes – Cell digestion machines. Lysosomes contain a variety of enzymes which digest vesicles, such as bacterium or depleted mitrochondrion, to produce soluble substances which absorb into the cytoplasm. They also digest energy substrates such as protein and glucose.

CELL DIFFERENTIATION

Cells are specialised in different areas to carry out specific functions:

- **Muscle cells** – cells that make up skeletal muscles are called **muscle fibres**. These cells look very different from other cells in the body. They are large cells. They are elongated and have many nuclei that lie close to the cell surface.

- **Nerve cells** – There are two main types of nerve cell:
  - **Neurons** – These cells consist of a cell body, which contains the nucleus. Extending from this are fibres, known as dendrites, and a single long fibre known as the axon. These may be sensory neurons (detect changes such as pain, temperature) and
motor neurons (provide signals that lead to movement via muscle contraction).

  - **Glial cells** – These surround neurons, maintaining homeostasis, form myelin, and provide support, nutrition and protection for neurons in the brain and peripheral nervous system. They also destroy pathogens and remove dead neurons.

- **Bone Cells** – Three types:
  - **Osteoblasts** – These are bone forming cells.
  - **Osteocytes** – These are bone maintaining cells.
  - **Osteoclasts** – These are bone matrix dissolving cells.

- **Blood cells** – Three main groups:
  - **Red blood cells** – Responsible for carrying oxygen to all the cells in the body.
  - **White cells** – Responsible for defence against disease.
  - **Platelets** – Involved in the blood clotting process.

- **Secretory cells**

- **Fat cells**

**TISSUE STRUCTURE**

The specialised cells outlined above are grouped together to form different types of tissue:

**Epithelial tissue**

Epithelial tissue lines all the internal and external surfaces of the body. Epithelial cells vary depending on their site in the body and can be cuboidal or columnar. These cells are tightly packed together with only very little extracellular matrix between them. Epithelial tissue is more commonly termed the epithelium.

Epithelium is avascular (has no blood supply) but is supplied with nerve fibres. This tissue is nourished from substances diffused from underlying structures. There are many different types of epithelium which are classified according to the shape of their cells and the number of cell layers that make up the tissue. These can be classified into eight main types:

- **Simple squamous** – Single layer.
- **Simple cuboidal** – Single layer.
- **Simple columnar** - Single layer.
- **Pseudostratified** – highly modified simple columnar.
- **Stratified squamous** – five layers.
- **Stratified cuboidal** – two layers
- **Stratified columnar** – two layers
- **Transitional** – modified stratified squamous. Six layers but can expand, reducing cell layers down to one.

**Bone**
Bone has calcium salts in its matrix, which makes it the hardest, strongest tissue in the body. It can withstand compression, torque and tension. Two main types of bone usually occur. These are:

- **Dense (compact)** - The presence of Haversian canals allow for the movement of waste in and out of bone and also carry nerve fibres.
- **Spongy (cancellous)** – trabeculae, which are thin irregular bars, make up the network of spongy bone. Red marrow surrounds this in some spongy bone.

**Nerve tissue**
This tissue is able to conduct electrical signals through the body. Each nerve is made up of a bundle of nerve fibres. Each nerve fibre has many neurons within it. A neuron is a cell that forms the core of the nervous system; they have the ability to receive and transmit signals. Neurons have a unique, elongated shape and consist of three main parts:

Nerve cell body – the rounded part of the neuron that contains the nucleus, organelles, and ER

Dendrites – these are tiny projections that branch off the nerve cell body at the neuron’s receiving end. These act like tiny antennae to pick up signals from other cells

Axon – a long, thin fibre that extends from the nerve cell body. At the tip of the axon are branches that end in a synaptic terminal, marked by swellings called synaptic knobs.
Similar to the insulation on most electrical wires, many neurons are insulated by special cells called Schwann cells that form a fatty myelin sheath. This sheath makes nerve conduction much more rapid.

**Connective Tissue**

Connective tissue is the most widely distributed tissue and, in its variable forms, is found everywhere in the body. This can be solid (in bone), soft (in loose connective tissue) or liquid (blood). Some of its major functions are:

- Support
- Binding
- Insulation
- Protection
- Transportation of substances

The specific characteristics of connective tissue are:

- **Matrix** - a non-living extra-cellular matrix is the ‘filling’ between the cells and carries the important fibres that add the characteristic strength to connective tissue. This may be solid (bone), soft (loose) or liquid (blood).

- **Fibres** – There are three fibre types:
  - **Collagen fibres** – very strong fibres made up of the fibrous protein collagen.
  - **Elastic fibres** – coiled structure – able to stretch and return to shape. Made up of the fibrous protein elastin.
  - **Reticular** – fine collagenous fibres. Provide support networks (e.g., around small blood vessels). These are found at junctions between connective tissue and other tissue types.

- **Cells** – The cells of connective tissue are separated from each other by the matrix. The immature (blast) cells such as chondroblasts develop into mature cells (cytes) such as chondrocytes.

**Types of connective tissue**

**Connective tissue proper**
Connective tissue proper has two major divisions:

- **Fibrous tissue** – consists mostly of protein fibres with little matrix.
  - **Loose or areola** – This is the soft gel-like packing of the body. Found in areas such as under the skin and surrounding blood vessels. All three fibre types are found in this tissue.
  - **Dense regular** – primarily collagen fibres and a few elastin fibres. The fibres are parallel and tightly packed which make them very strong. This tissue can withstand high tensile forces. This connective tissue is what makes up the tendons and most of the ligaments found in the body.
  - **Dense irregular** – primarily collagen fibres. The fibres are randomly arranged. This strong yet flexible tissue is found in joint capsules, surrounding some organs and in the dermis of the skin.
  - **Elastic tissue** – Primarily elastin fibres. These fibres are kinked or coiled and can be stretched and return to shape (rather like an elastic band). This tissue can be found in regular and irregular varieties. An important material in the nuchal ligament, this tissue is also found in other ligaments, in the abdomen, in the walls of some arteries and in some parts of the respiratory tract.

**Special connective tissue**

Some examples are:

- **Adipose tissue** – Fat
- **Reticular connective tissue**
- **Bone marrow tissue**

**Cartilage**

Most connective tissue is vascular. Cartilage, however, is avascular (has no blood supply). Cartilage is composed of firmly bound collagen fibres and some reticular or elastin fibres which make it a strong, flexible tissue. There are three major divisions:

- **Hyaline cartilage** – this is the most widely distributed cartilage within the body. This is found at the articulation between long bones (articular
cartilage). It’s extremely smooth finish helps reduce friction and its cushioning effect helps to reduce concussion and compression.

- **Fibrocartilage** – found in the intervertebral discs to provide support and to help resist pressure. Collagen fibres are arranged in parallel bundles – similar to that found in dense connective tissue. This tissue is not as firm as hyaline cartilage.

- **Elastic cartilage** – this is similar to hyaline cartilage but contains more elastin and is therefore more elastic. The outer ear is made up of elastic cartilage.
MUSCLE TISSUE
There are three types of muscle tissue. These are:

- **Smooth (involuntary)** – found in systems of the body such as the digestive system.
- **Cardiac (involuntary/striated)** – Only found in the heart.
- **Skeletal (voluntary/striated)**

Skeletal muscle cells
The cells which make up skeletal muscle are striated – meaning striped – as they appear striped when looked at under a microscope. These specialised, elongated multi-nucleated cells are called muscle fibres. It is in fact the myofibrils within the muscle fibres that make it look striped. These myofibrils are the contractile element of the muscle. Protein filaments – namely actin and myosin - line up with the same in neighbouring cells and produce alternating light and dark bands across the muscle fibre.

A muscle fibre has similar elements to other cells in the body:

- **Nucleus** - muscle fibres are multi-nucleated. The nuclei lie close to the cell surface.
- **Cytoplasm**
- **Mitochondria** – Large numbers of mitochondria lie alongside the myofibrils.
- **Cell surface membrane** – In muscle fibres this is called the sarcolemma. The sarcolemma folds deeply into the cell in some areas forming transverse tubules or t-tubules.
- **Endoplasmic reticulum** – in muscle fibres this is known as the sarcoplasmic reticulum. This is very extensive and forms cisternae throughout the cell. The membranes of some of these cisternae are very closely associated with the t-tubules. The cisternae contain large
amounts of calcium ions which are essential in triggering muscle contraction.

- **Myofibrils** – A myofibril contains thick and thin filaments. The thick filaments are myosin and the thin filaments are made mostly of actin. Actin and myosin are proteins. One end of each actin filament is anchored at the ‘Z’ disc (or ‘Z’ line). This line runs right across the myofibril. The part of a myofibril that lies between two ‘Z’ discs is called a sarcomere. The myosin lies in the centre of each ‘Z’ disc, parallel to the actin. These are anchored to a ‘M’ disc (or ‘M’ line) which is parallel to the ‘Z’ disc.

In a resting muscle, for half of their length the filaments lie along side each other. The pattern dictates different coloured bands. These are:

- **I band** – Actin filaments only nearest the ‘Z’ disc. Light in colour.
- **A band** – Actin and myosin filaments lie between each other. Dark in colour.
- **H band** – Myosin filaments only. Intermediate in colour.

**Muscle structure**

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Muscle fibres lie parallel to each other bound together by connective tissue – perimysium – forming a muscle bundle

↓

Muscle bundles are bound together by connective tissue – epimysium – to form a muscle

↓

The epimysium extends into a strong tendon – known as endotendon – that weaves with the fibres of the periosteum of bone for attachment. A bursa will be present over boney prominences to protect the tendon. This can be between the tendon and the bone or can encapsulate the tendon in a tendon sheath.
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Origin and insertion
Areas of attachment to bone are known as the origin and insertion. The insertion is pulled towards the origin when the muscle contracts.

Muscle contraction
Explained above is the structure of myofibrils in a relaxed muscle. When an electrical impulse is received, the actin and myosin filaments slide between each other causing the sarcomere in each muscle fibre to shorten – thus shortening the muscle. This is known as the ‘sliding filament mechanism’. The energy required for this mechanism is converted by myosin in the form of ATP – converting chemical energy into the mechanical energy of motion.

Regulatory proteins troponin and tropmyosin are involved in switching the contraction process on and off. These are found on the thin filaments.
SECTION 4
SKELETAL ANATOMY

The functions of the skeleton are to support and provide a framework for the body, provide points of attachment for muscles and tendons, articulate between joints to facilitate movement, protect the internal organs, produce red blood cells, and provide a reservoir for certain minerals (calcium and phosphorus). The skeleton of most quadrupeds is very similar but there are differences. Perhaps the two most obvious differences between that of canine and equine are the distal limb and the vertebral formula.

There are four main shapes of bone:

- **Long bones** – in the limbs. Act as levers and provide strength and support.
- **Short bones** – are found in complex joints where they absorb concussion.
- **Flat bones** – (as in the skull) provide protection for vital organs.
- **Irregular bones** – vary in size and shape.

The skeleton can be looked at in two halves - the axial skeleton and the appendicular skeleton.

THE AXIAL SKELETON

The axial skeleton consists of the skull and mandible, the vertebral column, ribs and sternum. This forms the central line of the body.

The vertebral column

The vertebral column is made up of a string of articulated, incompressible bony vertebrae. Between the vertebrae are inter-vertebral discs made of dense fibrous tissue. These discs are slightly compressible shock absorbers that allow for a certain amount of movement along the spine. The spine of a horse is more rigid than that of a dog or cat. It is worth remembering that a horse pivots on its hind legs and it is this, coupled with the abduction and adduction of the limbs and the swing of the thoracic girdle, that enables the horse to turn as quickly as it does. The lateral flexion of the spine is very
limited and the horse could not rely on this as its only way of turning.

The key functions of the vertebral column are:

- Protection of the spinal cord
- Provide strength for the propulsion and suspension of the body weight
- To provide and attachment for the ribs

It has 5 regions. These are:

- **Cervical vertebrae** – found in the neck. The first two cervical vertebrae have unique shapes and are known as the *atlas* and the *axis*. These vertebrae have reduced spinous processes to allow for the range of motion required in the neck.

- **Thoracic** – The spinous processes of these vertebrae are very tall, some of which make up the horses withers. The ribs extend from the thoracic vertebrae joining to the sternum and creating the protection for the organs within the chest. This area of the vertebral column is where the saddle on a horse sits.

- **Lumbar** – characterised by the length and width of the transverse processes and the length of the dorsal spines. This is a very vulnerable area of the back. The horse has three extra articular facets in this region.

- **Sacrum** – This is a composite bone made up of fused vertebrae. The first coccygeal vertebrae can sometimes be fused to the sacrum giving the impression of an extra bone. The first vertebrae has enlarged transverse processes which are known as the sacral wing. These articulate with the transverse processes of the last lumbar vertebrae at the lumbosacral joint. The underside of the sacral wing is attached to the ilium of the pelvis via the sacroiliac joint.

- **Caudal or coccygeal** – Tail bones. These decrease in size caudally.
The spinal cord
The spinal cord runs through the vertebrae via individual foramina that make up the vertebral canal. In the mid–sacral area the spinal cord comes to an end and from here coccygeal nerves extend in the vertebral canal to supply the tail. The vertebral canal diminishes in size after the lumbar vertebrae until it disappears completely at about the fourth coccygeal vertebrae.

Ligaments of the vertebral column
*Note: ligaments join bone to bone and tendons join muscle to bone.*
The vertebrae of the vertebral column are supported by a network of ligaments, tendons and muscles. The two major ligaments that support the vertebral column are:

- **The nuchal ligament** – This ligament supports the weight and position of the head and neck and has two parts:
  - **Funicular portion** – extends along the top of the neck and can be seen as a continuation of the supraspinaous ligament.
  - **Laminar portion** – fan like extensions from the funicular portion down each side of the neck attaching to the cervical vertebrae.

- **The supraspinous ligament** – runs along the top of the spinous processes of the back from the sacrum joining and supporting the lumbar and thoracic vertebrae.

Vertebral formula
There are a certain amount of bones in each region of the vertebral column. This is species specific. The formulae for the equine and canine are as follows:

**Equine**
- **Cervical (7)** – Seven bones. C1 is the *Atlas* and C2 is the *Axis*.
- **Thoracic (18)** – Eighteen bones. A pair of ribs extending from each vertebrae.
- **Lumbar (6)** – Six bones. The horse has 3 extra articular facets.
- **Sacral (5)** – Five bones. Usually fully fused at age 4 to 5 to make one composite bone – the sacrum.
- **Coccygeal (15 – 24)** - These vary from 15 to 24 although there are
usually 18.

*Note:* In some eastern breeds, commonly the Arab, there are only five lumbar vertebrae. Where this is found there is usually a 19 thoracic rib and an extra pair of false ribs.

**The equine vertebral formula:** C7, T18, L6, S5, Cy15-24

**Canine**

- **Cervical (7)** – Seven bones. C1 is the *atlas* and C2 is the *Axis*.
- **Thoracic (13)** – Thirteen bones. A pair of ribs extending from each vertebrae.
- **Lumbar (7)** – Seven bones.
- **Sacral (3)** – Three bones. Usually fully formed at the age of 1 to 1 ½ to make one composite bone – the sacrum.
- **Coccygeal (18-23)** – These vary from 18 to 23 although there are usually 20.

**The canine vertebral formula:** C7, T13, L7, S3, Cy 18-23

**The ribs and sternum**

The rib cage is made up of the ribs and the sternum. These elastic bones form a strong protective cage around the chest that is able to increase and decrease in size in order to allow for breathing movements.

The dorsal end of each rib articulates with the transverse process and the vertebral body of the adjacent thoracic vertebrae. At the ventral end the rib carries a rod of cartilage - the costal cartilage. The costal cartilages of the first (true ribs) attach directly to the sternum (breastbone). The remainder of the ribs (false ribs) do not attach directly to the sternum but connect to each other forming the costal arch and therefore are connected to the sternum via the costal cartilage of the last true rib. The last rib (floating rib) projects freely into the abdominal wall. The floating rib has a fibrous connection with the costal arch.
**True and false ribs:**

*Equine:* True 8, False 10  
*Canine:* True 9, False 4

The sternum forms the floor of the chest and supports the true ribs. The sternebrae never completely ossify. At the anterior of the sternum is the presternal or cariniform cartilage. This cartilage provides attachment to some of the neck muscles eg: the sternomandibularis. At the posterior of the sternum is the heart shaped xiphoid cartilage. This forms the floor at the front end of the abdomen and provides attachment to the muscle fibres of the diaphragm.

**APPENDICULAR SKELETON**

The appendicular skeleton consists of the freely moveable bones of the limbs including the pelvis and scapula.

**The forelimb**

The forelimb of quadrupeds such as dogs and horses is attached to the chest wall by a network of very strong muscles and ligaments. There is no boney
attachment to the skeleton of the trunk as neither a horse or dog has a functional clavicle (collarbone). The proximal limb of the equine and canine is similar but the distal limb is very different.

Canine forelimb and digit

- **Scapular** – The shoulder blade. Roughly triangular in shape. Note the spine of the scapula, as this is an important site for attachment of the shoulder muscles. Occasionally in dogs a very small, vestigial (non-functional) collar bone is found. When present, it lies embedded in the brachiocephalicus muscle, is poorly ossified, and is not attached to the skeleton. The scapular articulates distally with the humerus at the shoulder joint.

- **Humerus** - The humerus is a long bone which articulates with the radius and ulna at the elbow joint. The humerus has a slight spiral twist.

- **Radius and ulna** – The radius and ulna move together as one bone. The radius is the main weight bearer. The ulna forms most of the elbow joint. The ulna terminates distally at the olecranon process (point of elbow). This lever is an attachment for the extensor muscles of the limb. Distally the radius and the ulna articulate with the proximal row of carpal bones

- **Carpus** – (in a human this joint is the wrist). This joint contains seven bones. The proximal row of bones articulates with the radius and ulna via the radiocarpal joint. The distal row of bones articulates with the proximal row of bones via the middle carpal joint and distally with the metacarpal bones via the carpometacarpal joint. The joints between individual carpal bones are intercarpal joints. The accessory carpal bone (pisiform bone) protrudes from the palmar aspect of the joint. The carpal joint as a whole is stabilised by collateral ligaments, and the individual joints are stabilised by intercarpal ligaments. There is a large carpal pad at the back of the carpus made up of cornified epidermis. This carpal pad is an important shock absorber during
locomotion; if you study videos of a dog running and jumping you will see this pad come into contact with the ground

- **Metacarpal bones** – There are five metacarpal bones. The first metacarpal is a shortened vestigial bone that forms part of the dewclaw. The metacarpal bones articulate distally with the proximal phalanges via the metacarpophalangeal joints.

- **Proximal phalanges** – These articulate with the middle phalanges via the proximal interphalangeal joints.

- **Middle phalanges** – these articulate with the distal phalanges via the distal interphalangeal joints.

- **Ungual process (claw)** – each toe terminates with a claw. These are composed of layers of dead horn-like epidermal tissue. This is attached by dermis and can easily bleed if cut too short.

- **Metacarpal pads** – these cushioned pads made up of cornified epidermis provide contact with the ground.

- **There are several sesmoid bones in the canine distal limb**; study your anatomy texts to be familiar with their locations and functions.

*Note: The dewclaw only has two phalanges*

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**Equine forelimb and digit**

- **Scapular** – The shoulder blade. Roughly triangular in shape. Note the spine of the scapula, as this is an important site for attachment of the shoulder muscles. The scapular articulates distally with the humerus at the shoulder joint.

- **Humerus** - The humerus is a long bone which articulates with the radius and ulna at the elbow joint. The humerus has a slight spiral twist.
• **Radius and ulna** – The radius and ulna are fused together. The radius is the main weight bearer, as in the horse the ulna is a shortened bone. Together these bones articulate proximally with the humerus at the elbow joint. The ulna terminates proximally at the olecranon process (point of elbow). This lever is an attachment for the extensor muscles of the limb. Distally the radius articulates with the proximal row of carpal bones. The ulna does not extend to the carpus.

• **Carpus** – (in a human this joint is the wrist). Commonly known as ‘the knee’ in the horse. This joint contains seven bones. The proximal row of bones articulates with the radius via the radiocarpal joint. The distal row of bones articulates with the proximal row of bones via the middle carpal joint and distally with the metacarpal bones via the carpometacarpal joint. The joints between individual carpal bones are intercarpal joints. The accessory carpal bone (pisiform bone) protrudes from the palmar aspect of the joint. The overall joint is stabilised by collateral ligaments, and the individual joints by intercarpal ligaments.

• **Metacarpal bones** – The third metacarpal bone in the horse is commonly referred to as the cannon bone. This bone is the weight bearer and articulates distally with the first or proximal phalanx (long pastern bone) via the metacarpophalangeal joint (fetlock joint) and proximally, along with the second and fourth metacarpal bones (splint bones), with the distal row of carpal bones via the carpometacarpal joint. The second and fourth metacarpal bones are more commonly known as the splint bones. These are shortened bones which are not weight bearing. They terminate with the ‘button’ of the splint bones, which are clearly palpable in the horse.

• **Proximal phalanx** – more commonly known as the long pastern bone. This bone articulates distally with the middle phalanx or short pastern bone via the proximal interphalangeal joint - more commonly known as the pastern joint.

• **Middle phalanx** – more commonly known as the short pastern bone. This bone articulates distally with the distal phalanx – more commonly known as the pedal bone – via the distal interphalangeal joint – more
commonly known as the coffin joint. This joint lies entirely within the hoof.

- **Proximal phalanx** – more commonly known as the pedal bone (sometimes the coffin bone).
- At the back of the fetlock joint are the two sesamoid bones; these are an important part of the suspensory apparatus.

**The equine hoof**

The equine hoof is a specialised structure. It is encapsulated by the insensitive corium or laminae – the horn.

Refer to ‘The BHS Veterinary manual’ and study pages 44 – 47. Refer to ‘The horse in motion’ and study pages 37 - 39. Ensure that you can locate the following structures and that you understand the functions, anatomy and workings of the equine hoof:

- The bones and joints within the hoof – including the distal sesamoid (navicular bone) its bursa and joint (coffin joint)
- The ligaments and tendons within the hoof
- The laminae – sensitive and insensitive
- The wall
- The white line or zone
- The periople
- The coronary band
- The plantar or digital cushion

**The sole**

- The sole
- The frog
- The bars
• The bulbs of heel
• The angle of heel (seat of corn)
• The white line or zone (as above)
• The wall (as above)

The canine hindlimb and digit
Distally from the hock or tarsus the hind limb is essentially the same as the fore limb. The differences are as follows:
• There are usually only four metatarsal bones and subsequent sets of phalanges. The first metatarsal is sometimes present – it is small and only attached by fibrous tissue.
• The metacarpal pads are named metatarsal pads on the hind limbs.

Note: inclusion of the word carpal indicates the structure lies within the forelimb and inclusion of the word tarsal indicates the structure lies within the hind limb.

The pelvic girdle
The pelvic girdle has two sections, fused caudally at the pubic symphysis. The pelvis comprises of three bones:
• The illium – the anterior portion of the pelvic bone. This bone forms a wing like projection. Attaches to the sacrum via the sacroiliac joint.
• The ischium – The posterior portion of the pelvic bone.
• The pubis – forming the pelvic floor

The coxofemoral joint (hip joint) lies between the pelvic wing and the ischial tuberosity – the rear section of the pelvis. This joint is twice as far from the wing as it is from the ischial tuberosity. The pelvis articulates here with the femur.

• Femur – A substantial long bone. Articulates distally with the tibia at the stifle (knee) joint. This is also the location of the patella (knee cap). This is an ovoid sesamoid bone which sides up and down in a groove at the distal end on the femur.

The stifle joint is a complex joint and must be studied carefully.
Refer to a canine anatomy book to study the anatomy of the stifle joint.
Ensure you can identify:

- The patella
- The patella ligament
- The meniscus
- The collateral ligaments
- The cranial and caudal cruciate ligament
- The meniscofemoral ligament

- **Tibia and fibula** – The tibia is the larger bone of the two and articulates proximally with the stifle joint. The tibia is the primary weight bearer. The slender fibula remains for attachment of muscles and ligaments. The tibia articulates distally with the tarsus at the tibiotalarsal joint.

- **Tarsus (hock)** - There are seven bones in the hock. This joint represents the ankle in the human. The tibia articulates with the talus and the calcaneus, a bony prominence that forms the point of the hock.
The major joint in the hock is the tarsocrural joint. There is little movement between the other joints in the hock. The hock articulates distally with the metatarsal bones.

**Equine hind limb and digit**
Distally from the hock or tarsus the hind limb is essentially the same as the fore limb the only difference being the angle of the hoof.

The pelvic girdle has two sections, fused caudally at the pubic symphysis. The pelvis comprises of three bones:

- **The ilium** – the anterior portion of the pelvic bone. This bone forms a wing like projection. Attaches to the sacrum via the sacroiliac joint.  
- **The ischium** – The posterior portion of the pelvic bone. 
- **The pubis** – forming the pelvic floor 

The coxofemoral joint (hip joint) lies between the pelvic wing and the ischial tuberosity – the rear section of the pelvis. This joint is twice as far from the wing as it is from the ischial tuberosity. The pelvis articulates here with the femur.

- **Femur** – A substantial long bone. Articulates distally with the tibia at the stifle (knee) joint. This is also the location of the patella (knee cap). This is an ovoid sesamoid bone which sides up and down in a groove at the distal end on the femur. The stifle joint is a strong joint and suffers much less trouble in the horse than in the dog.

The stifle joint is a complex joint and must be studied carefully.

Refer to an equine anatomy book for the anatomy of stifle joint. Ensure you can identify:

- The patella
- The patella ligament
The meniscus
The collateral ligaments
The cranial and caudal cruciate ligament
The meniscofemoral ligament

Tibia and fibula – The tibia is the main leg bone of the second thigh. The tibia is the weight bearer. Similarly to the ulna the fibula is reduced in size.

Tarsus (hock) - Seven bones in the hock. This joint represents the ankle in the human. The tibia articulates with the talus and the calcaneus (or os calcis). The calcaneus is a boney prominence which forms the point of hock and is the attachment site for the achillies tendon. The true joint in the hock is the tarsocural joint. There is little or no movement between the other joints in the hock. The hock articulates distally with the metatarsal bones.

Refer to an equine anatomy book to study the anatomy of the hock and the tarsal joints.

The stay apparatus
This specialised system of muscles and ligaments, in the horse, is able to ‘lock’ the main joints of the forelimbs and one hind limb in position so that the horse can stand in one position for a long time without becoming fatigued, particularly while sleeping. The stay apparatus is made up of three major components: the ability of the horse to lock its patella, the reciprocal mechanism, and the check apparatus. The reciprocal mechanism is made up of the perineus tertius, the superficial digital flexor and the gastrocnemius. These muscles ensure that when the patella is locked the hock is also immobilised. The final part of the stay apparatus is the accessory ligament of the deep digital flexor tendon.
Ligaments and tendons of the limbs

Using your texts and other resources research the major tendons, muscles and ligaments in the limbs of the canine and equine. Compose a list for your own records of the major tendons, muscles and ligaments – their whereabouts, points of attachments and functions. Keep this list with your module for revision.

Arthrology
Bones are held together by articulations (joints). There are a variety of joints found within the animal.

Types of joints
- **Fibrous joints** – bones are joined by fibrous connective tissue.
- **Synovial joints** – have a joint cavity containing synovial fluid.
- **Cartilaginous** – have no joint cavity. Bones are united by cartilage and have limited movement.

Using your texts and other resources research joints. Ensure you understand the following joints and identify their locations in the body:

- Suture
- Symphysis
- Synovial joint
  - Hinge joint (ginglymus)
  - Sliding joint (plane joint)
- Ball-and-socket joint (spheroidal joint)
- Pivot joint (trochoid)
- Ellipsoid joint
SECTION 5
MUSCULATURE

Your set texts cover - in detail - the location of the muscles in the animal body. As a physiotherapist the understanding of the workings of the musculoskeletal system is of major importance. It is therefore suggested that you take time to study this subject fully and use your own methods and learning resources to help you become familiar with the muscles and how they work on the skeleton to produce movement. There are also practical days covering these topics.

There are many muscles and these muscles often are referred to with slight variations in their names and even their origins and insertions. Only someone with a photographic memory, or perhaps a lecturer using all of the names on a daily basis, could remember all of these names and the origin, insertion and functions of all the muscles. What is important is that the main muscle groups are remembered and that the depth and complexity of the musculature is appreciated and understood.

Terminology

- **Abductors** – muscle groups move part away from the medial line of the body. Think of a child being abducted from the family. *Note: there is a muscle named ‘abductor’. Although this muscle is involved in abduction other muscles are also classed as abductors due to their function.*
- **Adductors** - muscle groups move part towards the medial line of the body. Think of a child being added into the family.
- **Extension** – pulls a joint to straighten a limb moving it away from the body.
- **Flexion** – bends a joint to bring a limb closer to the body.
- **Protraction** – Forward motion of a limb.
- **Retraction** – backward motion of a limb
- **Agonist** – prime movers assisted by synergists.
- **Antagonist** – control action of prime movers by relaxing.
In the following table are the major muscles and their origins, insertions and functions. Further reading on musculature is expected. You may find that some exercises, such as colouring an anatomy atlas or drawing your own diagrams or charts, help you to absorb this information.

Many of the muscles give a clue in their name as to their origin, insertion or function. The inclusion of the word brachii – meaning arm – indicates a muscle of the forelimb and similarly the inclusion of the word femoris or femoral indicates a muscle in the region of the hindlimb. Extensor and flexor muscles, such as extensor carpi radialis, often give away their function in their title.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sternocephalicus</td>
<td>Sternum (manubrium cartilage)</td>
<td>Caudal edge of jaw.</td>
<td>Flexes head and neck downwards and forwards.</td>
</tr>
<tr>
<td>Splenius</td>
<td>Thoracic spinous processes.</td>
<td>Nuchal crest, wing of atlas and transverse processes of C3 to C5</td>
<td>Elevates and turns head and neck.</td>
</tr>
<tr>
<td>Trapezius</td>
<td>Thoracic portion</td>
<td>Thoracic portion</td>
<td>Lifts shoulder</td>
</tr>
<tr>
<td>Muscle</td>
<td>Origin</td>
<td>Insertion</td>
<td>Action</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>---------------------------------------------</td>
<td>----------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Serratus ventralis – cervical portion</td>
<td>Transverse processes of the last 4-5 cervical vertebrae</td>
<td>Scapula</td>
<td>Raises or laterally inclines the neck. Pulls scapular towards the neck.</td>
</tr>
<tr>
<td>Subscapularis</td>
<td>Scapula – subscapula fossa</td>
<td>Humerus</td>
<td>Adducts the humerus</td>
</tr>
<tr>
<td>Deltoideus</td>
<td>Spine and caudal border of scapula</td>
<td>Humerus</td>
<td>Flexes shoulder joint. Lateral abduction and rotation of the forearm.</td>
</tr>
<tr>
<td>Brachialis</td>
<td>Posterior surface of the humerus. Medial surface of the elbow.</td>
<td>Radius</td>
<td>Flexes the elbow joint.</td>
</tr>
<tr>
<td>Biceps brachii</td>
<td>Scapula</td>
<td>Radius and</td>
<td>Extends</td>
</tr>
<tr>
<td>Muscle</td>
<td>Origin</td>
<td>Termination</td>
<td>Action</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------------------------------</td>
<td>------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Triceps brachii</td>
<td>Caudal border of scapula.</td>
<td>Olecranon process.</td>
<td>Flexes shoulder and extends elbow joint.</td>
</tr>
<tr>
<td>Deep pectorals</td>
<td>Sternum</td>
<td>Humerus</td>
<td>Draws forelimb backwards. Helps raise thorax.</td>
</tr>
<tr>
<td>Superficial pectorals</td>
<td>Sternum</td>
<td>Humerus</td>
<td>Adduction of the forelimb.</td>
</tr>
<tr>
<td>Serratus ventralis -</td>
<td>Lateral surface of the first 8-9 ribs (horse) or 6-7 ribs (dog)</td>
<td>Scapula</td>
<td>Lifts trunk in relation to the scapula. Draws scapula backward. Aids in respiration.</td>
</tr>
<tr>
<td>thoracic portion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latissimus dorsi</td>
<td>Supraspinous ligament</td>
<td>Humerus</td>
<td>Flexes the shoulder joint. Lateral flexion of the back.</td>
</tr>
<tr>
<td>Longissimus dorsi</td>
<td>Illium and sacrum.</td>
<td>Thoracic and lumbar transverse processes and the last four cervical</td>
<td>Extends and supports the back. Lateral flexion.</td>
</tr>
<tr>
<td>Muscle Name</td>
<td>Origin</td>
<td>Insertion</td>
<td>Function</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------</td>
<td>-------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Tensor facia latae</td>
<td>Ventral tuber coxae</td>
<td>Facia latae which is attached to the lateral patella ligament</td>
<td>Flexes hip and extends stifle.</td>
</tr>
<tr>
<td>Gluteus superficialis</td>
<td>Tuber coxae</td>
<td>Femur</td>
<td>Extension of the hip joint and medial rotation of the hind limb.</td>
</tr>
<tr>
<td>Gluteus medialis</td>
<td>Thoracic/lumbar fascia</td>
<td>Femur</td>
<td>Extension and abduction of the pelvis. Hind and action (kicking, rearing)</td>
</tr>
<tr>
<td>Semimembranosus (part of the hamstring group)</td>
<td>Pelvis – ischiatic tuberosity</td>
<td>Femur</td>
<td>Extends hock and hip. Adducts hindlimb.</td>
</tr>
<tr>
<td>Semitendinousus (part of the hamstring group)</td>
<td>Pelvis – tuber ischii and coccygeal vertebrae.</td>
<td>Tibia and gastrocnemius.</td>
<td>Extends hip and hock and flexes stifle.</td>
</tr>
<tr>
<td>Biceps femoris (part of the hamstring group)</td>
<td>Pelvis – tuber ischii and sacroiliac ligament.</td>
<td>Femur, patella ligament and os calcis.</td>
<td>Extends and abducts the hindlimb. Propulsion, rearing and kicking.</td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td>Femur</td>
<td>Os calcis</td>
<td>Extends the hock and flexes the stifle.</td>
</tr>
<tr>
<td>Gracilis</td>
<td>Pubis ventral</td>
<td>Patella ligament</td>
<td>Pulls limb</td>
</tr>
<tr>
<td>Muscles</td>
<td>Surface</td>
<td>Ligament/Location</td>
<td>Function</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------</td>
<td>---------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sartorius</td>
<td>Surface and tibia</td>
<td>Patella ligament and tibia.</td>
<td>Backward and adducts the hip joint.</td>
</tr>
<tr>
<td>Quadriceps femoris</td>
<td>Pelvis and femur</td>
<td>Tibia and medial patella ligament</td>
<td>Extends stifle joint.</td>
</tr>
</tbody>
</table>

Research The Longissimus muscle, using your texts and other resources. Ensure that you understand:

- The anatomy of the muscle in all its parts.
- The function and the role of the muscle in the quadruped.

Consider how you think this muscle will be relevant to you in your work as an animal physiotherapist.
THE CIRCULATORY SYSTEM
There are two types of circulation;

- **Pulmonary** – transports deoxygenated blood to the lungs via the pulmonary artery. At the lungs the blood is oxygenated and then is transported, via the pulmonary vein, back to the heart where it is used in systemic circulation.

- **Systemic** - oxygenated blood is transported from the left ventricle via the aorta around the body giving oxygen and nutrients to tissues. Once this blood is used it then travels back to the heart via the bilateral vena cava.

Exercise increases the demands for oxygen elevating the heart rate.

- **Arteries** – carry blood away from the heart to the rest of the body. They are made up of elastic, collagen and nerve fibres and smooth muscle.

- **Veins** – carry blood to the heart. They contain valves, to prevent the back flow of blood, and have thinner walls than arteries with less muscle tissue.

THE LYMPHATIC SYSTEM
The lymphatic system is closely integrated with circulatory system and complements it by:

- **Aiding the return of tissue fluid and proteins to the blood**

- **Absorbing and transporting fats**

- **Filtering out bacteria and toxins via the lymph nodes**

Lymphatic capillaries run parallel, throughout the body, to blood carrying capillaries. Lymphatic tissue collects to form ‘lymph nodes’ located in places such as in the throat area, base of bronchi and larger blood vessels in the
abdominal cavity. These ‘lymph nodes’ become enlarged and tender when infection is present.

The ‘lymph fluid’ is propelled through the body by muscular activity. The action of movement and muscle contractions also help to keep the blood flowing toward the heart. Filled legs, due to inactivity, are a common problem in horses that are stabled for long periods of time or following surgical procedures in dogs.

**Lymph flow**

Tissue fluid – blood plasma carrying oxygen, nutrients and white blood cells – leaks into tissue from surrounding blood capillaries

↓

Tissue fluid gives up oxygen and nutrients

↓

This fluid, now known as lymph, drains into lymphatic capillaries

↓

Small vessels link to form larger ones which carry lymph to the subclavian veins – lymphatic capillaries contain valves to control the direction of flow

↓

Lymph passes through lymphatic tissue and rejoins the blood flow
THE RESPIRATORY SYSTEM

There are two aspects of the respiratory system:

- **The external respiratory system** – breathing and transportation of gasses

  The upper respiratory tract consists of the airways such as:
  - **The nostrils**
  - **Nasal cavities** – with turbinate bones covered with mucous and cilia.
  - **Pharynx** – used for respiratory and digestive systems
  - **Larynx** – at the top of the trachea to prevent food penetrating the lungs. The larynx also holds the voice box.
  - **Trachea** – this is held open permanently by incomplete cartilaginous rings and extends to the lungs. Cilia assist in removing trapped foreign material and excess mucus.

The lower tract consists of:

- **Bronchi** – tubes held open by complete cartilaginous rings.
- **Bronchioles** – there are no cartilaginous rings in the second bronchioles. Contains a continuous ciliated mucous membrane.
- **Alveoli ducts** – which end in the alveoli – an air sac.

The thorax is separated from the abdomen by the diaphragm. Pleural sacs surround the lungs.

Refer to your set texts for an overview of the respiratory system. It is not essential that you learn this subject and the terminology thoroughly, you just need knowledge and understanding of how the respiratory system works.
THE ENDOCRINE SYSTEM
The endocrine system works in conjunction with the nervous system and other body function controls and its main function is to produce essential hormones which regulate growth, metabolism and the sexual reproductive system.

Refer to your set texts for an overview of the endocrine system. It is not essential that you learn this subject and the terminology thoroughly just that you have a knowledge and understanding of how the endocrine system works.

THE NERVOUS SYSTEM
The nervous system has two main divisions:

- The central nervous system (CNS) – This consists of the brain and spinal cord, which are protected by the skull and vertebral column.
- The peripheral nervous system (PNS) – This is connected to the brain and runs throughout the body. The PNS consists of the sensory organs and the peripheral nerves. The PNS can be subdivided into two parts:
  - The somatic or voluntary nervous system – Receptors such as the eyes, ears, skin, nostrils and taste buds provide information for the voluntary system. This information is transported to the muscles, via motor neurons, to initiate a response.
  - The autonomic or involuntary nervous system – is subdivided into:
    - The sympathetic nervous system – involved in the flight/fight response.
    - The parasympathetic nervous system – Involved in the involuntary control of the organs and bodily functions such as heart rate and digestive movements.
The nervous system is covered in a much greater depth in a subsequent module.

SUGGESTED FURTHER READING
The BHS Veterinary Manual
Goody – Dog Anatomy
Goody – Horse Anatomy
Colour Atlas of Veterinary Anatomy (Dog and/or Horse)