Whole Horse dissection

MANUAL – Functional Horse Training by Thirza Hendriks

INTRODUCTION

When looking at the official definition, anatomy is defined as:

> *''The branch of science concerned with the bodily structure of humans, animals, and other living organisms, especially as revealed by dissection and the separation of parts.''*

In other words, anatomy is studying the architectural framework of the horse. This framework must be resilient to produce movement and to withstand internal and external forces. It is a beautiful and ingenious arrangement consisting of multiple parts or layers that makes up a holistic whole. The anatomical design of the horse also provides the foundation for studying movement (biomechanics).

This manual aims to give you a compact overview and understanding of basic equine anatomy and physiology. It is my wish that some of this content might give you a deeper understanding of your equine partner.

NOTE OF THANKS

I am forever grateful to the amazing Sharon-May Davis and Zefanja Vermeulen for influencing my learning processes through the horse inside-out principle.

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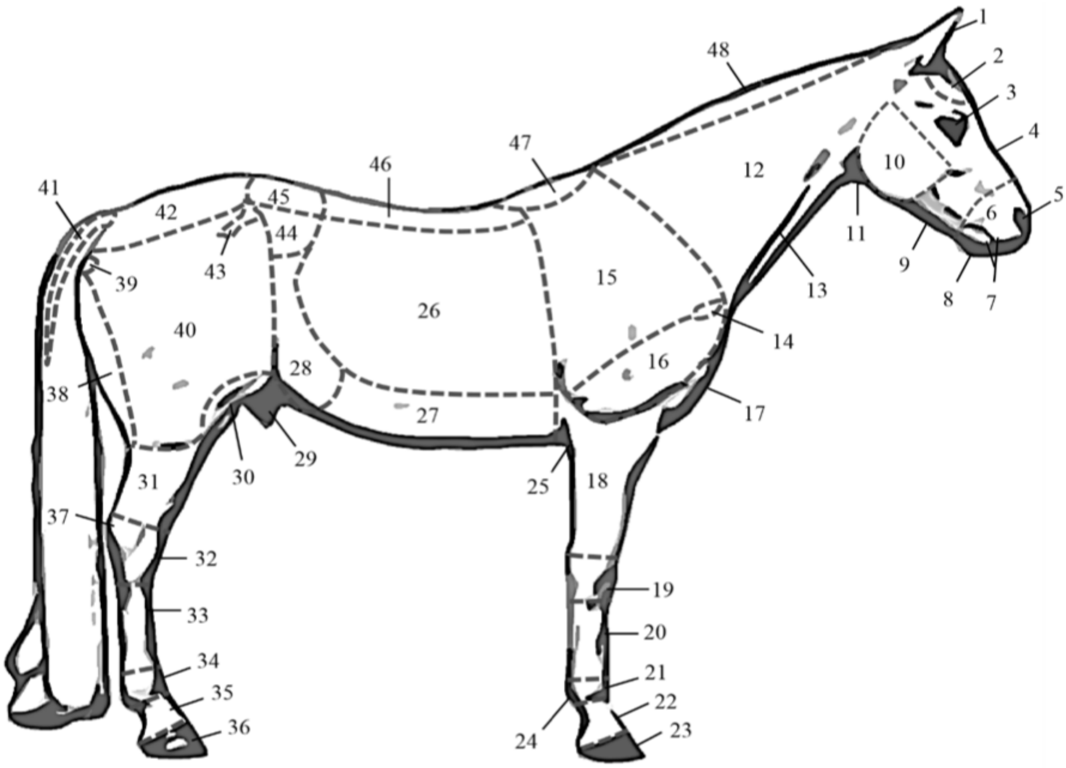

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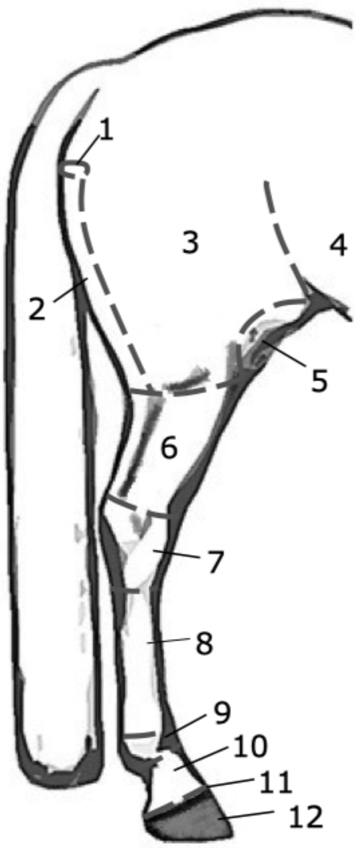

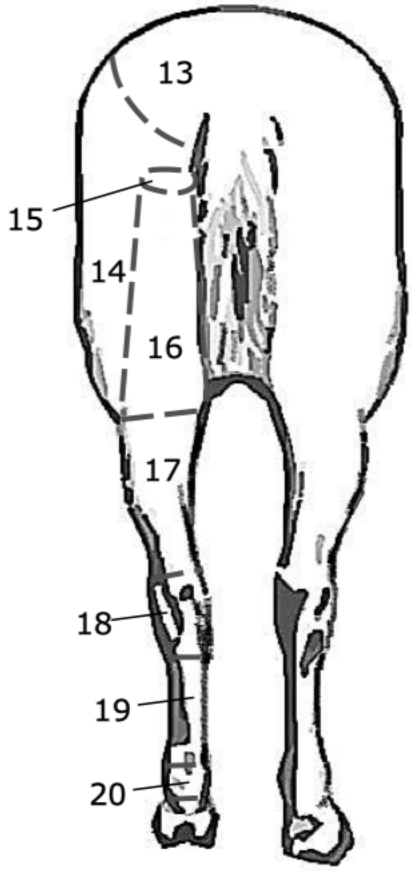

1. Medial Point of Buttock
2. Medial Quarter
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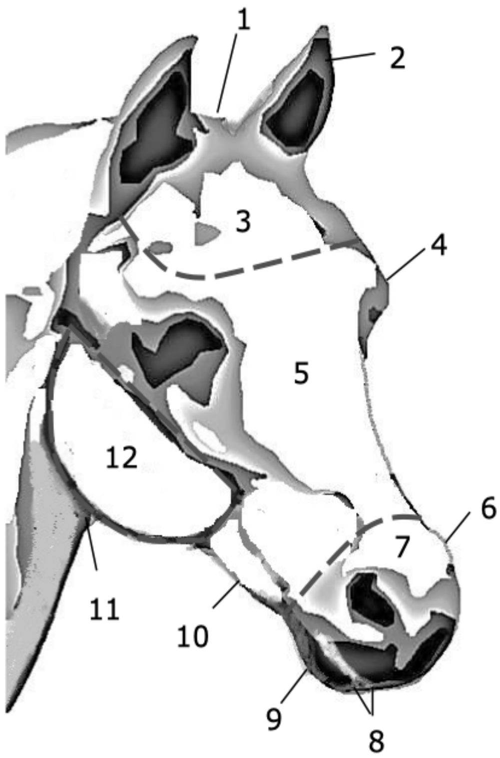
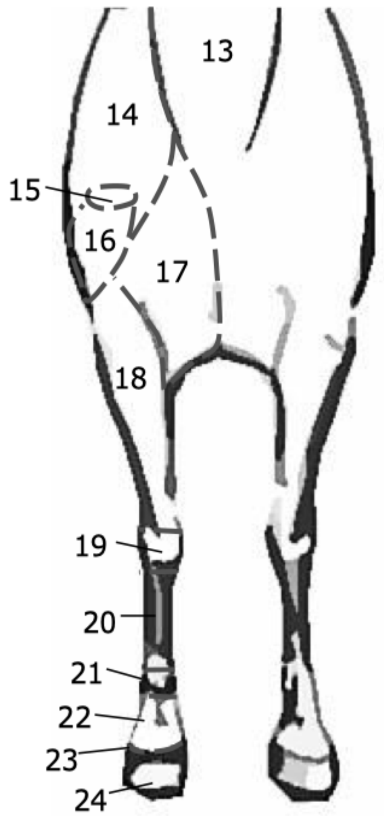


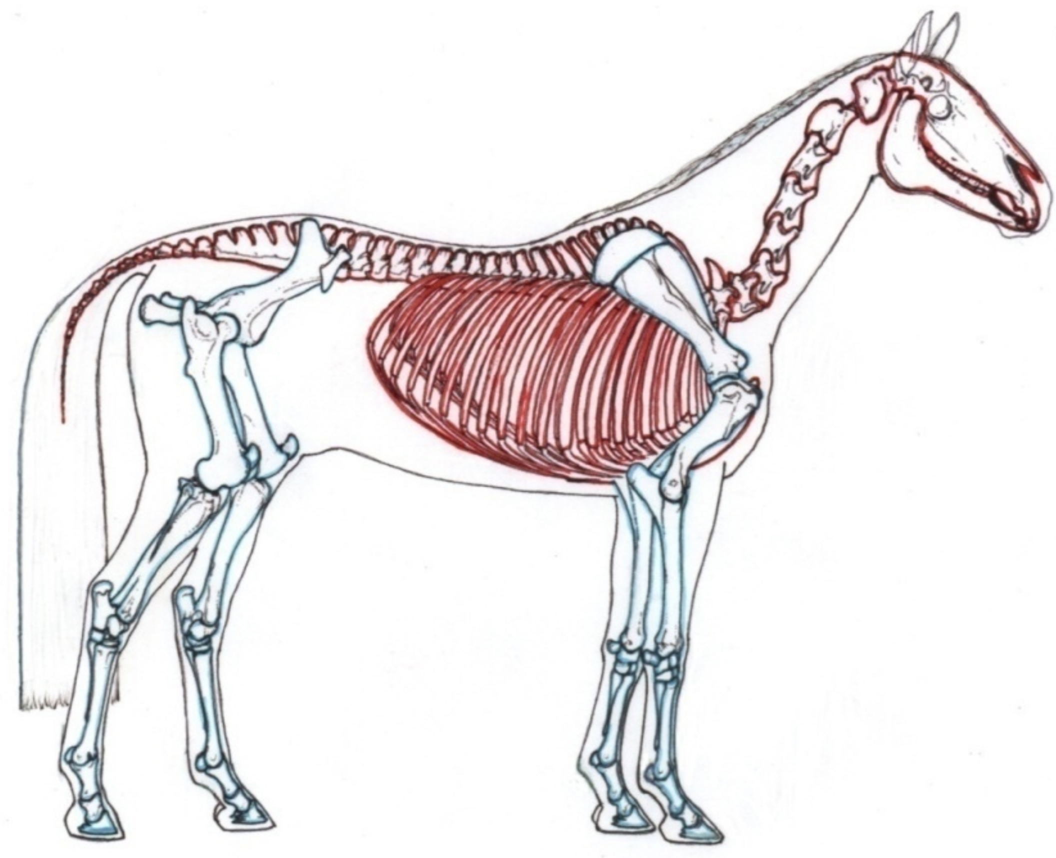


1. Poll	9. Chin	17. Chest
2. Ear	10. Mandibular Shaft	18. Forearm
3. Forehead	11. Throat	19. Knee
4. Eye	12. Cheek	20. Cannon
5. Face	13. Neck	21. Fetlock
6. Nostril	14. Shoulder	22. Pastern
7. Muzzle	15. Point of Shoulder	23. Coronet
8. Lips	16. Arm	24. Hoof

THE SKELETON

The skeleton forms the bony framework of the horse with an average of 205 bones
- with variations up to 18 bones.

The equine skeleton consists of an axial and appendicular part. The axial part includes the skull, vertebrae, ribs, sternum, and manubrium whereas the appendicular part consists of the thoracic (front) and pelvic (hind) limbs, including the pelvis. Unlike humans, horses don’t have a collarbone connecting the forelimbs to the trunk.



Picture illustrating the axial (red) and appendicular (blue) parts of the skeleton.

The total number of bones can be divided accordingly:

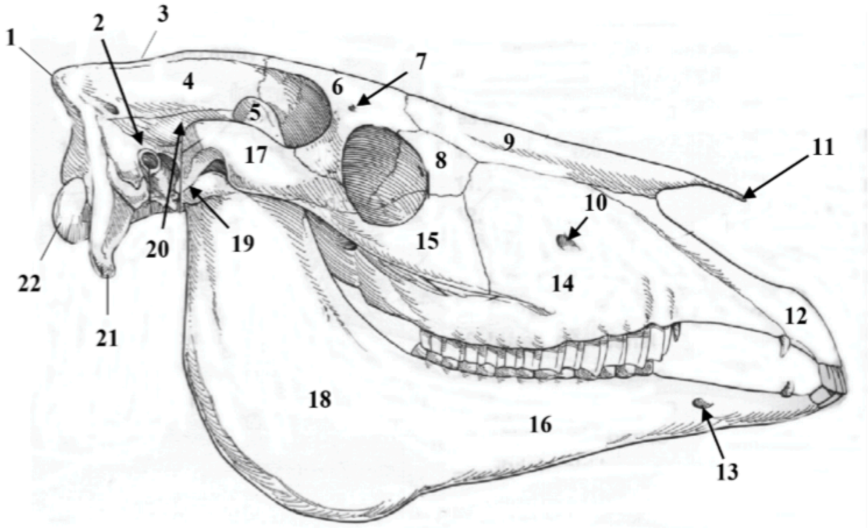
LOCATION	NUMBER OF BONES
Skull	34
Sternum / Manubrium	1
Vertebral column	49-54
Cervical	7
Thoracic	17-19
Lumbar	5-6
Sacral	5
Caudal	15-22
Ribs	34-38 both sides
Front limbs	38-40 both limbs
Hind limbs	38-40 both limbs

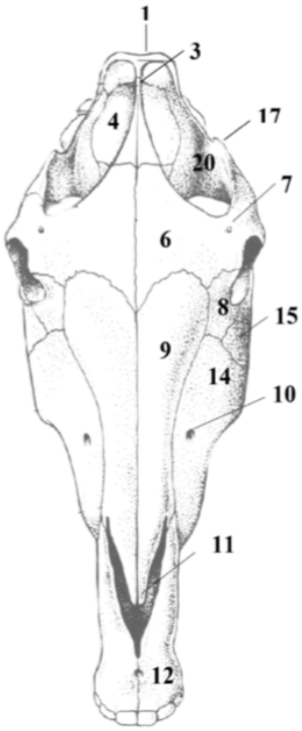
Some of the variations correspond with breed. For example, an Arabian horse usually has 17 thoracic and 5 lumbar vertebrae whereas a warm blood typically shows 18-19 thoracic and 6 lumbar vertebrae. Variations are of importance depending on the desired athletic purpose for a horse. For example, in selecting a racehorse or jumping horse, having at least 18 thoracic vertebrae is desired as this provides more room for a better heart/lung capacity.

Apart from breed, variations and abnormalities can also occur within the individual. For example, horses can have 17 ribs on one side and 18 to the other. Abnormalities include floating ribs and transitional vertebrae. A transitional vertebra either is a rib thinking it is a vertebral process, or a vertebral process thinking it is a rib.

Picture of a fused floating rib on the lumbar transverse process. The rib was first floating and then somehow started to attach. This is different to a transitional vertebra and shows the amount of variations possible within the individual.

AXIAL SKELETON – THE SKULL AND HYOID





1. Occipital / Nuchal Crest
2. Outer Acoustic Meatus
3. Interparietal
4. Parietal
5. Coronoid Process
6. Frontal
7. Supraorbital Foramen
8. Lacrimal
9. Nasal
10. Infraorbital Foramen
11. Nasal Peak
12. Incisive
13. Mental Foramen
14. Maxilla
15. Zygomatic
16. Mandibular Shaft
17. Zygomatic Arch
18. Mandible
19. Temp.Mand.Jt (TMJ)
20. Temporal
21. Jugular Process
22. Occipital Condyle
23. Stylohyoid
24. Thyrohyoid
25. Ceratohyoid
26. Basihyoid
27. Lingual process
28. Epihyoid
29. Tympanohyoid

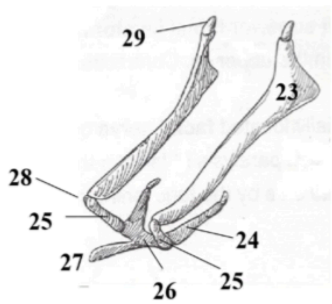


Fig. Adapted from Kainer and McCracken (1994) by SMD.

AXIAL SKELETON – SPINE AND RIBS

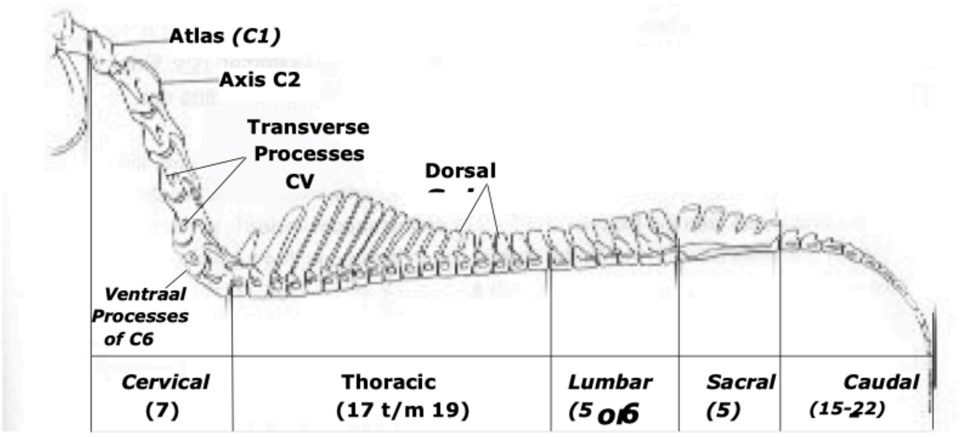


Fig. Adapted from Kainer and McCracken (1994) by SMD.

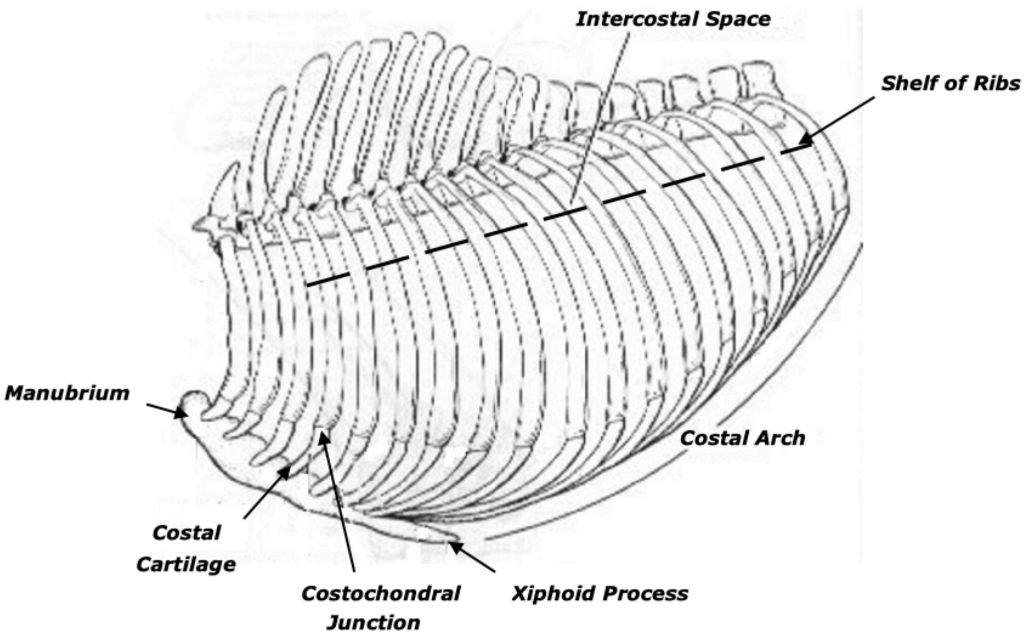
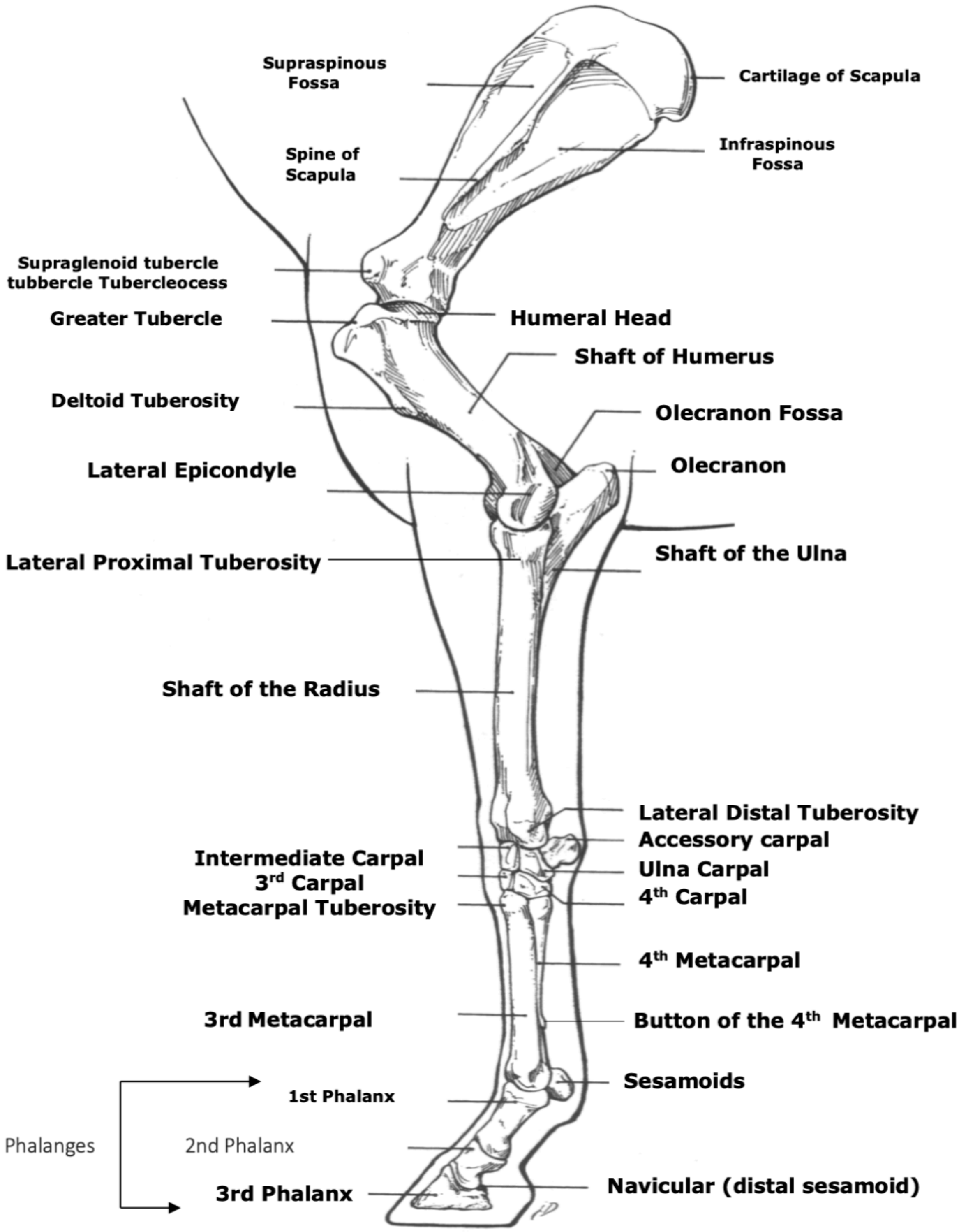
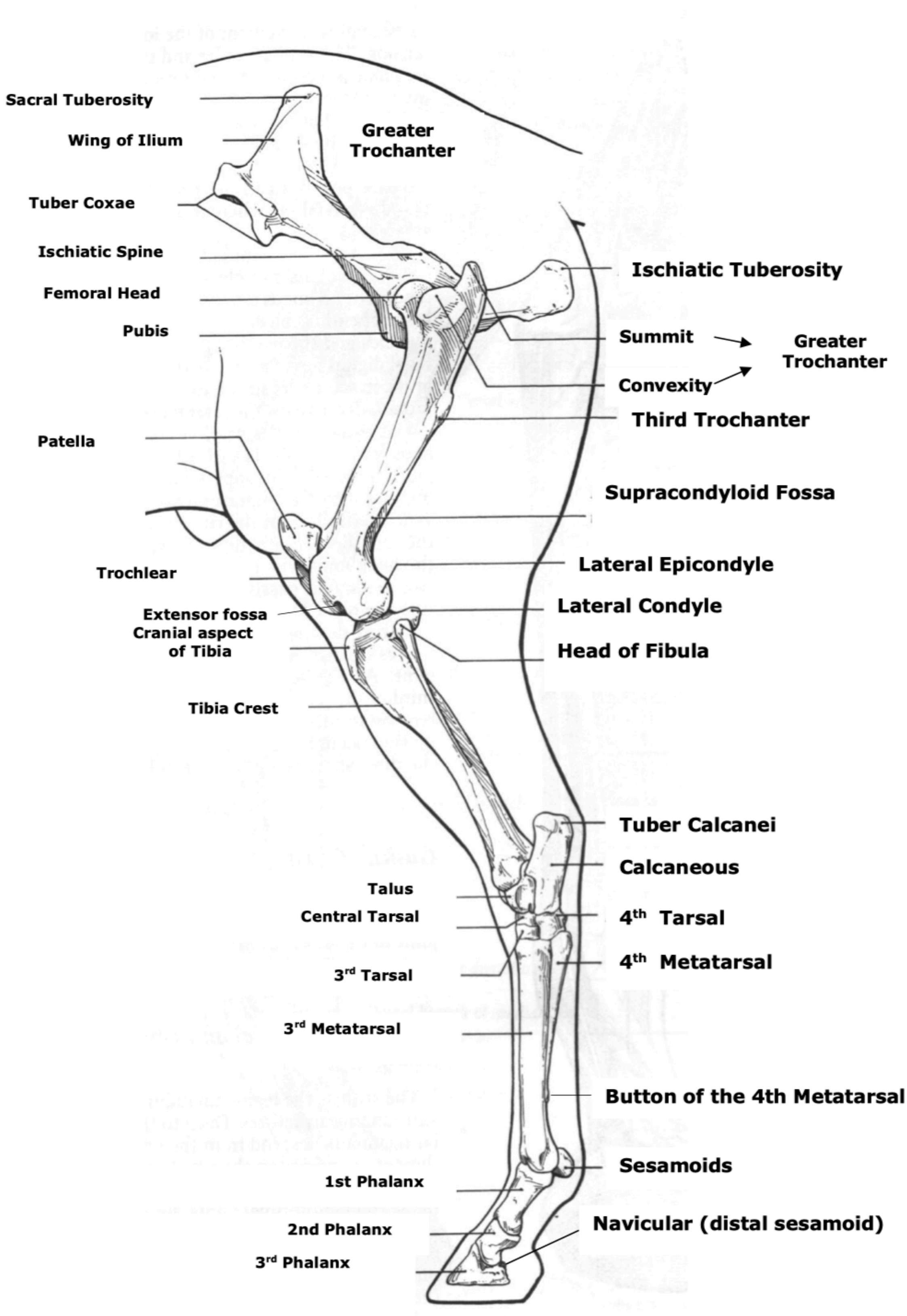


Fig. Adapted from Kainer and McCracken (1994) by SMD

APPENDICULAR SKELETON
– FRONT LIMB LATERAL ASPECT



APPENDICULAR SKELETON
– HIND LIMB LATERAL ASPECT



BONE FUNCTIONS

The main functions of the skeleton are:

- **Support** → Bones provide the framework for the body and is the hardest structure in the horse's body after the teeth.
- **Protection of vital organs** → For example: the skull protecting the brain; the entire structure is centred to protect the spinal cord.
- **Movement** → Through the action of skeletal muscles
- **Manufacturing of blood** → Red blood cell formation occurs in the bone marrow of the medullary cavity, mostly found in the centre of all 'long' bones. For example: femur, tibia, radius, and all cannons.
- **Storage of minerals** → Particularly calcium and phosphorus. They facilitate many reactions necessary for survival. Example: chemical aids in rapid muscle

BONE TYPES

Bones can be classified into five categories according to their shape:

- **Long bones** → These literally long bones contain marrow and have joint surfaces at either end. They support body weight, act as levers for muscle attachment and manufacture new blood cells. Examples are *Cannon bones, Radius, Tibia, Femur* and *Humerus*.
- **Short bones** → These strong and compact bones aid in absorbing concussion. Examples are the short *pasterns, carpal bones in the knees* and *tarsal bones in the hocks*.
- **Flat bones** → These bones have broad and flat surfaces and help enclosing cavities containing vital organs as well as providing large areas for muscles attachments. Examples are *ribs, skull, scapula,* and *sternum.*
- **Irregular bones** → These irregular shaped bones serve various purposes through the body. Examples are the *vertebrae* that protect the central nervous system.
- **Sesamoid bones** → These bones lie within tendons and ligaments behind the bones of the fetlock. They add strength and help protecting these tendons

and ligaments as they pass around over bony surfaces to ensure correct functioning. Examples are the *navicular* and *patella.*

Pictures Adapted from Gillian Higgins 2009. From left to right: long cannon bone, short carpal bone, flat scapula, irregular vertebrae, and sesamoid.

BONE COMPOSITION

Although bone is often considered inactive or static, it is a very active and dynamic tissue that is constantly undergoing change, responding to physical forces, metabolic, nutritional changes, and hormones.

In the mature horse, the basic structure of bone includes about 1/3 organic material such as cells and 2/3 inorganic materials such as osteoid and minerals. The organic material is composed by three types of cells:

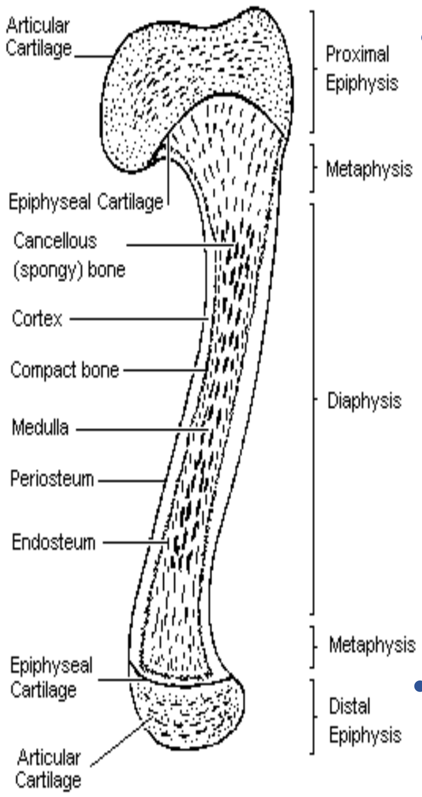
- **Osteoblasts** → These are bone-forming engines directing the formation and hardening of the bone.
- **Osteoclasts** → These are reabsorbing cells that break down the bone, opposing the osteoblasts.
- **Osteocytes** → These control the relative balance of both osteoblast and osteoclast activity. These cells can sense changes in bone loading and initiate an appropriate modelling or remodelling response.

The inorganic material is primarily composed of osteoid and minerals. Osteoid is an organic, uncalcified homogeneous substance that consists of the protein collagen (90%) which resists tension and furthermore some bone-specific proteins (10%) including osteonectin, osteopontin and osteocalcin. The mineral component primarily consists of calcium phosphate (80%), calcium carbon (20%) and magnesium phosphate. This is what gives bones its hardness and strength. In total, the mineral component accounts for 65%-70% of the bone.

Together, all the components of bone are arranged to give maximum strength for minimum weight.

BONE STRUCTURE

To study the structure of bone, it is easiest to look at a typical long bone such as the cannon bone in which we see the following characteristics:



- **Periosteum →** The periosteum is a specialized sheet of connective fibrous tissue covering the outer surface of bone, except at the articular surface, which is covered by articular cartilage. It consists of a rich supply of nerves and lymph vessels.

- **Cartilage →** This is the smooth, dense substance which covers the end of a bone where it meets other bones at a joint. It helps to absorb concussion and minimise friction.

- **Compact or cortical bone →** This is the hard outer layer, formed by a densely packed network of microscopic (haversian) canals containing blood vessels which supply nourishment for continuing growth and development. It is arranged to resist the stresses it must bear.

- **Cancellous or spongy bone →** This is located inside the compact bone. The name itself is misleading as spongy bone is spongy by appearance only but is actually hard and firm. In fact, it consists of the same materials as compact bone, with the difference lying in the arrangement thereof.

- **Medulla →** The central cavity inside the spongy bone.

- **Bone marrow →** This is contained within the medulla and forms red blood cells. As the horse ages it is partly replaced by fat, changing colour from bright red to yellow.

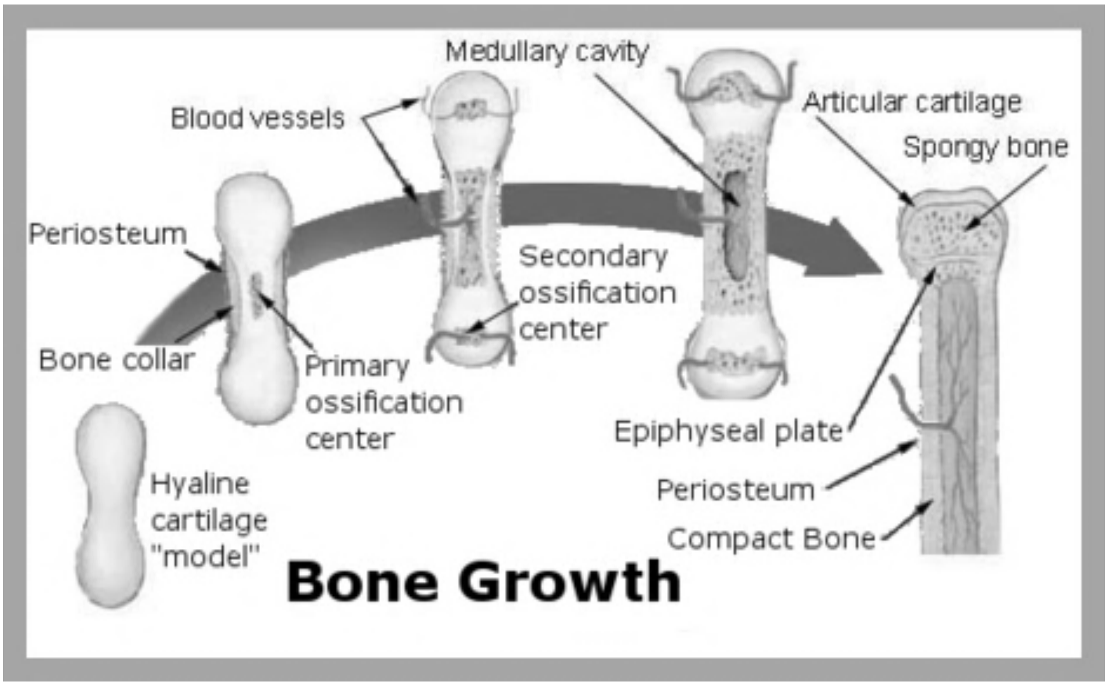
BONE MODELING

The skeleton is developed both pre- and post-birth. The formation of bone happens through two essential processes that create bone tissue, namely *intramembranous* and *endochondral ossification.*

Intramembranous ossification forms the flat bones of the skull and mandible without a cartilaginous predecessor. Bones are formed by direct ossification of collagen (fibrous type 1).

Endochondral ossification is the process responsible for the rudimentary formation of most bones in the horse's skeleton, especially the long bones of the appendicular skeleton and the irregular bones of the vertebral column. Furthermore, this process is also responsible for longitudinal growth as well as healing fractures. To study this process further in-depth, it is advised to look again at a typical long bone such as the cannon bone - *see picture on the previous page.*

The cannon bone has wide extremities at the ends of the bones called *epiphyses*, a hollow cylinder of compact bone called the *midshaft or diaphysis* and a developmental zone between them called the metaphysis and physis.



The long bone starts to develop in the embryo when the foetus has a pre-formed miniature bone template of *hyaline cartilage.* The material and structural properties of hyaline cartilage are adequate to support the low level of loading in the uterus. However, upon birth, the foal will experience a higher level of loading due to gravitational and muscular forces. Therefore, the hyaline cartilage needs to be gradually converted into a stronger material. This conversion is the process of endochondral ossification, accomplished by vascular invasion, calcification, removal of (calcified) cartilage and replacement with lamellar bone. There are two localised areas of bone formation:

- **Primary centre of ossification** → Diaphysis → The perichondrium initiates ossification of the fibrous tissue and forms a cuff of bone which develops to form the diaphysis.
- **Secondary centre of ossification** → Epiphysis → Primary ossification is followed by further vascular invasion at one or both ends of the developing bone. The bone grows in length at the junction of the epiphyses and diaphysis referred to as *metaphysis*. This is otherwise known as *epiphyseal or growth plate (May-Davis 2017).*

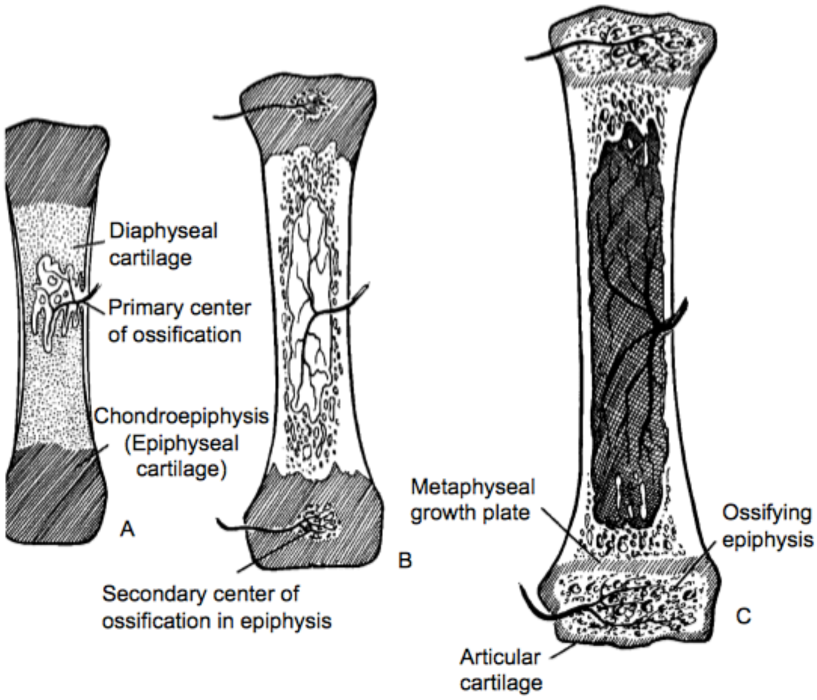


Figure 1. Diagram of ossification of a developing bone

Growth plates close when all the ossified areas have joined after which the bone can no longer grow in length. Different growth plates close at different times in the horse's young live and is influenced by multiple factors such as:

- **Genetics →** The taller the horse the slower the closure of growth plates
- **Nutrition →** The bony materials rely upon nutritional elements to support growth and form strong bones.
- **Gender →** In general, the vertebral column of a gelding closes approximately 6 months later than that of a mare.
- **Parasites →** They can interfere with nutritional uptake and place the body under stress and limiting the ability of the horse to grow.

In general, growth plates close approximately at:

3rd Phalanx	Later stages of gestation
2nd Phalanx	From birth to 6 months of age
1st Phalanx	From 6 months to 1 years of age
3rd Metacarpal	From 8 months to 1,5 years of age
Carpal bones	From 1,5 to 2,5 years of age
Radius, Ulna and Tibia	From 2-3 years of age
Humerus and Femur	From 3-3,5 years of age
Scapula and Pelvis	From 3,5-4 years of age
Tarsal bones	4 years of age
Vertebral column	Up till 6 years of age

Please consider that these are rough estimates. Anywhere up till six months could be added to large leg bones and the vertebral column. We speak of an abnormality only when growth plates aren't fused at the age of 9. If a growth plate is not closed, then movement is possible. As a result, friction or friction can occur. This can cause (chronic) inflammation of the growth plates. You can also see ossification of a ligament or fusion of growth plates.

BONE REMODELLING

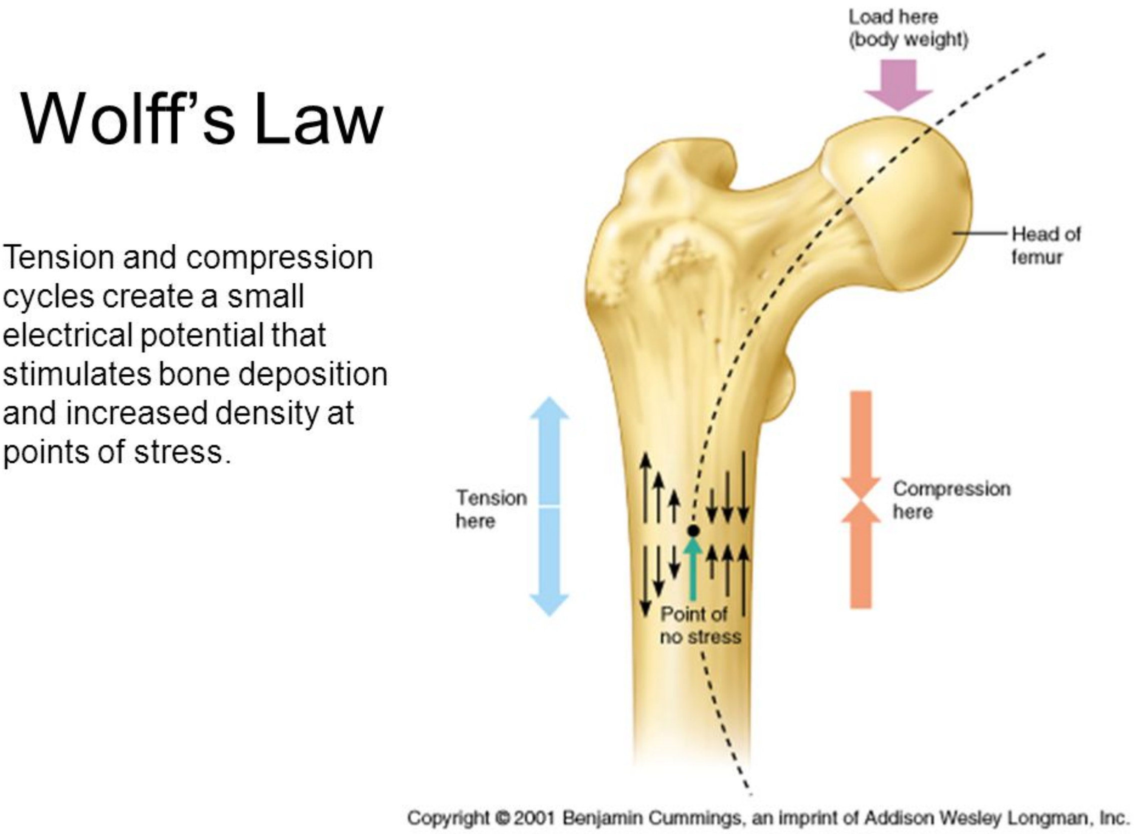
Once the growth plates have closed, bones remain dynamic due to the process of continuous remodelling. Remodelling is a repair process that occurs if a bone is fractured, its surface damaged, or if there is an increase in physical stress. It is argued that under normal circumstances about 5% of the total bone mass is 'turned over' each year by the process of remodelling (Geor 2012). Remodelling is possible due to the strong vascular invasion which holds special bone remodelling cells. The process first involves removal of bone, followed by a reaction of the periosteum to produce new bone. This new bone is eventually mineralized by the addition of calcium and phosphorus, showing that bone remodelling plays a part in ensuring a proper balance between calcium and phosphorus is maintained.

An over-reaction or trauma of the periosteum can lead to excess formations of bone that may interfere with function and cause pain. An example of this is "ringbone" and shin soreness or bucked shins. It is argued that about 70% of all thoroughbreds in training develop bucked shins to some extent (Westpoint Thoroughbreds 2015).

Pictures adapted from HorseVDM showing bucked shins.

Perhaps because of the magnitude, - ''as so many have it should be normal right?'' - it is often considered as non-serious issue that 'just happens''. However, this appears to be a cause-and-effect instance, with the remodelling is a response of the horse's body to excessive stresses it must bear during training: *''maintenance of bone content requires further exercise, however, below a critical threshold at which exercise can induce disease''.* (Kawcak 2010).

It has long been recognized that bone size is related to the amount of strain to which it is subjected. As far back as 1663, Galileo Galilei already described a positive relationship between body weight and bone size (In humans?). In the 19th century Dr. Julius Wolff built on these principles by stating that bone will adapt in response to the loads it is placed under. He developed mathematical laws describing the relationship between mechanical load, or strain on (an area of) bone and the changes in bone structure and strength.



Load (F) : The external force placed on the bone

Strain : The proportional change in the bone's dimensions

Stress : The internal forces resisting the change in dimension caused by the load

Therefore, increased load will result in an increase of bone mass whereas a decreased load will result in a reduction in bone mass. This enhances the understanding of bone as a dynamic organic that is ever changing and adapting to its local environment.

These are important concepts when considering the effects of training and performance on bone as appropriate training should stimulate bone modelling, improve skeletal strength, and, in theory, reduce the probability of exercise-associated skeletal injuries.

JOINTS

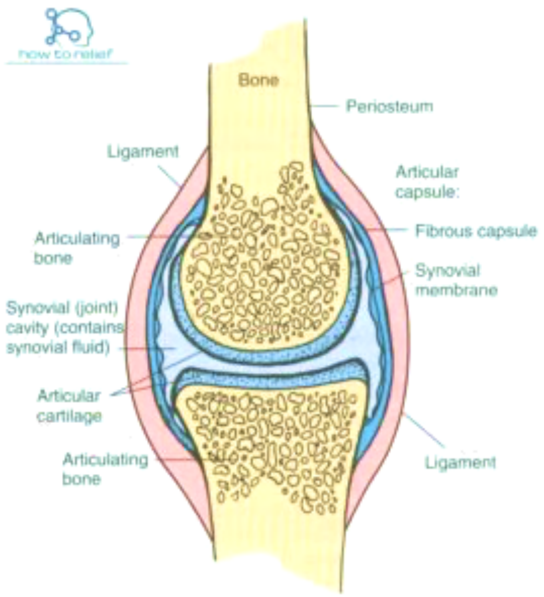
A joint or articulation is the connection made between bones in the body which link the skeletal system into a functional and holistic whole. They are designed to allow for different degrees and types of movement. Some joints, such as the carpus, elbow, and shoulder, are self-lubricating, almost frictionless, and can withstand compression and maintain heavy loads while still executing smooth and precise movements.

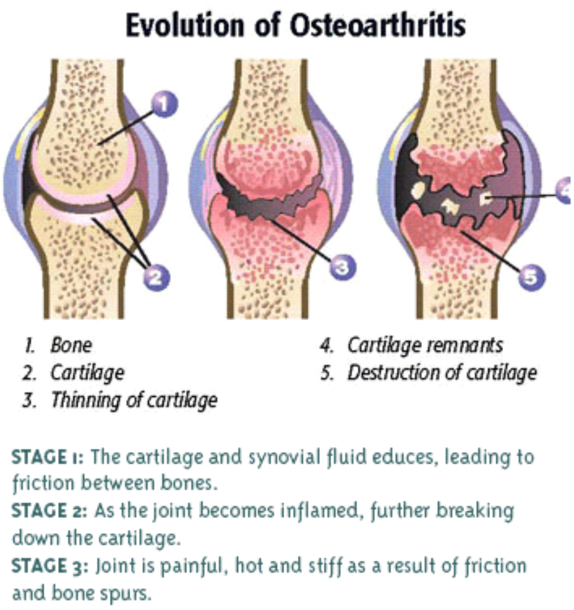
Other joints, such as sutures between the bones of the skull permit very little movement (only during birth) in order to protect the brain and the sense organs.

Joints are primarily classified according to their structure and the material that unites them:

- **Fibrous joint →** These are fixed joints where bones are connected by a dense fibrous material rich in collagen fibres. Range of motion is limited. E.g., splint bones and teeth.
- **Cartilaginous joint →** The joints have no cavity and bones are united by cartilage. Range of motion between bones is more than a fibrous joint but less than the highly mobile synovial joint. E.g., growth plates and vertebrae (intervertebral discs).
- **Synovial joint→** These join bones with a fibrous joint capsule that is continuous with the periosteum the joined bones, constitutes the outer

boundary of a synovial cavity and surrounds the bones' articulating surfaces. The synovial cavity/joint is filled with synovial fluid. The joint capsule is made up of an outer layer, the articular capsule, which keeps the bones together structurally and an inner layer, the synovial membrane, which seals in the synovial fluid. These joints are mostly found in the limbs or regions with a greater Range of motion. E.g., fetlock, knee, elbow and cervical vertebrae etc.





JOINT MOVEMENT

A healthy joint can exhibit the following movements:

- **Gliding →** One articular surface glides over the other articular surface. E.g., movement between the articular facet of vertebrae; carpals.
- **Flexion →** Closing the angle of the joint. E.g., carpus, elbow, intervertebral joints
- **Extension →** Opening the angle of the joint. E.g., carpus, elbow, intervertebral joints
- **Adduction →** Moving toward the midline of the body. E.g., shoulder joint; crossing over the legs; half pass.

- **Abduction →** Moving away from the midline of the body. E.g., shoulder joint; half pass; lifting the limb to the side.
- **Rotation →** Twisting movement around a longitudinal axis. E.g., shaking the head; twisting the vertebrae
- **Circumduction →** A circular movement that consists in part of all the previous actions except for rotation. E.g., a horse that plaits or paddles.

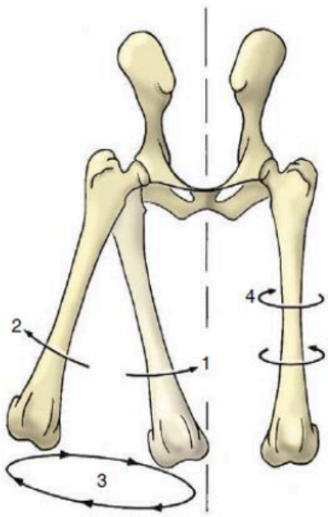


Figure 1–23 Limb movements illustrated by the femurs of the dog, cranial view. *1,* Adduction; *2,* abduction; *3,* circumduction; *4,* inward rotation; *5,* outward rotation.

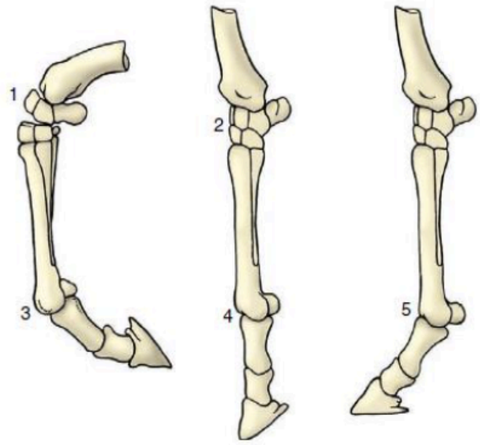


Figure 1–24 Flexion, extension, and overextension illustrated by the distal part of the horse's forelimb. *1,* Flexed carpal joint; *2,* extended carpal joint; *3,* flexed fetlock joint; *4,* extended fetlock joint; *5,* overextended fetlock joint.

MUSCLES

The horse is built for movement, ranging from the up and down motion of a trot to a flowing canter. Movement requires muscles of which three types can be found in a horse:

- **Striated muscles →** Skeletal muscles that move the bone. These muscles are controlled by the central nervous system, due to which muscle contractions occur involuntarily (Ettl 2017)
- **Cardiac muscles →** Muscles of the heart. These muscles occupy a special position due to its hollow structure. They have their own electrical stimulation system and cannot be voluntarily controlled.
- **Smooth muscles →** Muscles of organs, digestive system, and blood vessels.

These muscles are controlled by the automatic nervous system and therefore cannot be voluntarily controlled.

SKELETAL MUSCLES

The skeleton is the bony framework of the horse. Skeletal muscles attach to and move the bones. There are more than 700 skeletal muscles which makes up for half of the dynamic musculoskeletal system. They are mainly designed to:

- **Stabilize the joints**
- **Maintain posture**
- **Produce movement**
- **Generate heat via shivering**
- **Serve as a pathway for nerve and blood vessels**

Skeletal muscles are usually arranged in pairs and act in conjunction with other muscles. When muscles cause a limb to move through the joint's range of motion, they usually act in the following cooperating groups:

- **Antagonistic relationship →** Muscles opposing each other. Within an antagonistic pair, there is one muscle to flex a joint while the other extends it. This means while one muscle relaxes, the other will contract so that the joint operates correctly. The agonistic muscles are the ones activated and causing an action. Agonists are also referred to as *prime movers* since they are the muscles primarily responsible for generating the movement. The antagonistic muscles on the other hand act in opposition to the movement generated by the agonists and responsible for returning a limb to its initial position. A few examples include contracting biceps Brachii (agonist), opposing triceps (antagonist); contracting Quadriceps, opposing Hamstrings; contracting Flexors, opposing Extensors. The muscles or tendons attached are called a **flexor unit** if the joint is caused flexion and **extensor unit** if the joint is caused extension.

- **Synergetic relationship** → Muscles (assisting in) producing the same movement as the agonists. Synergists are also referred to as neutralizers because they help cancel out extra movement from the agonists to ensure that the output generated works within the desired plane of motion. Fixator muscles on the other hand stabilises the origin of the agonist and the joint that the origin spans - moves over - to help the agonist function most effectively. An example: Biceps Femoris (hamstrings) partners with Semitendinosus and Semimembranosus to flex and adduct the stifle. For the stifle to flex while not rotating in either direction, all three muscles contract to stabilize the stifle while it moves in the desired way.

In good quality movement, muscle groupings work in harmony and balance. Poor movement over stresses – hypertrophies - some muscle groups and underutilizes – atrophies - others resulting in poor posture and incorrect unbalanced muscle development, affecting the joints of the horse.

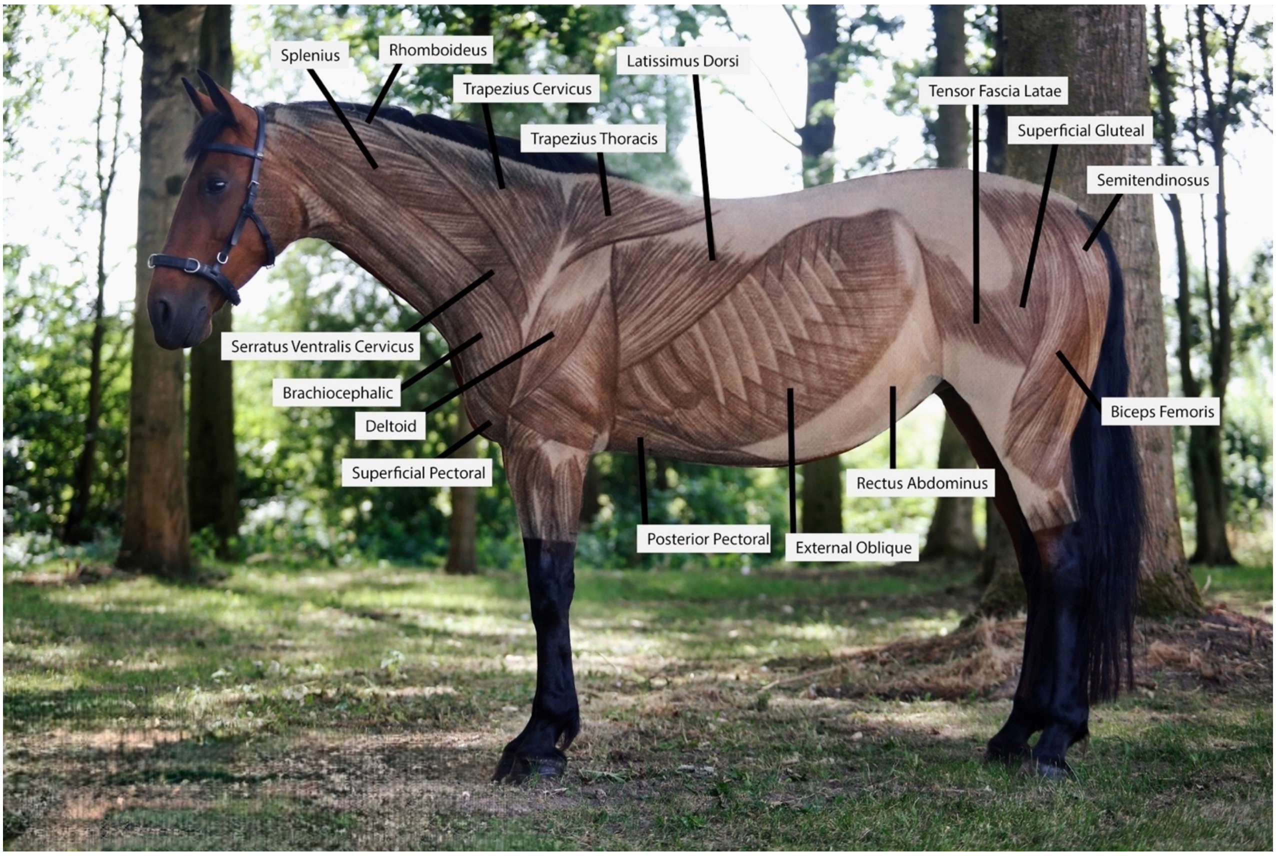
MUSCLE LAYERS

In regard to muscle layers, it becomes difficult to differentiate between the layers. However, *''one thing is for certain and that is the most external or superficial layer belong to the cutaneous group. These muscles are often activated when a fly or annoying insect lands on the horse.''*- May-Davis 2017

Note: Cutaneous muscles often appear as lines underneath the skin with a slightly raised edge and are sometimes mistakenly referred to as an unidentified inflammation. This is mostly due to an assessor's inability to explain what they are seeing or feeling. But this is not the case, every horse is different, and these lines are like identification markers creating their own personal signature. See the corresponding video for more explanation about cutaneous linings.

Below the cutaneous group we find the common superficial muscles.

The deep muscles are, as the name suggests, located below the superficial muscles.


Splenius
Rhomboideus
Trapezius Cervicus
Latissimus Dorsi
Trapezius Thoracis
Tensor Fascia Latae
Superficial Gluteal
Semitendinosus
Serratus Ventralis Cervicus
Brachiocephalic
Deltoid
Biceps Femoris
Superficial Pectoral
Rectus Abdominus
Posterior Pectoral
External Oblique

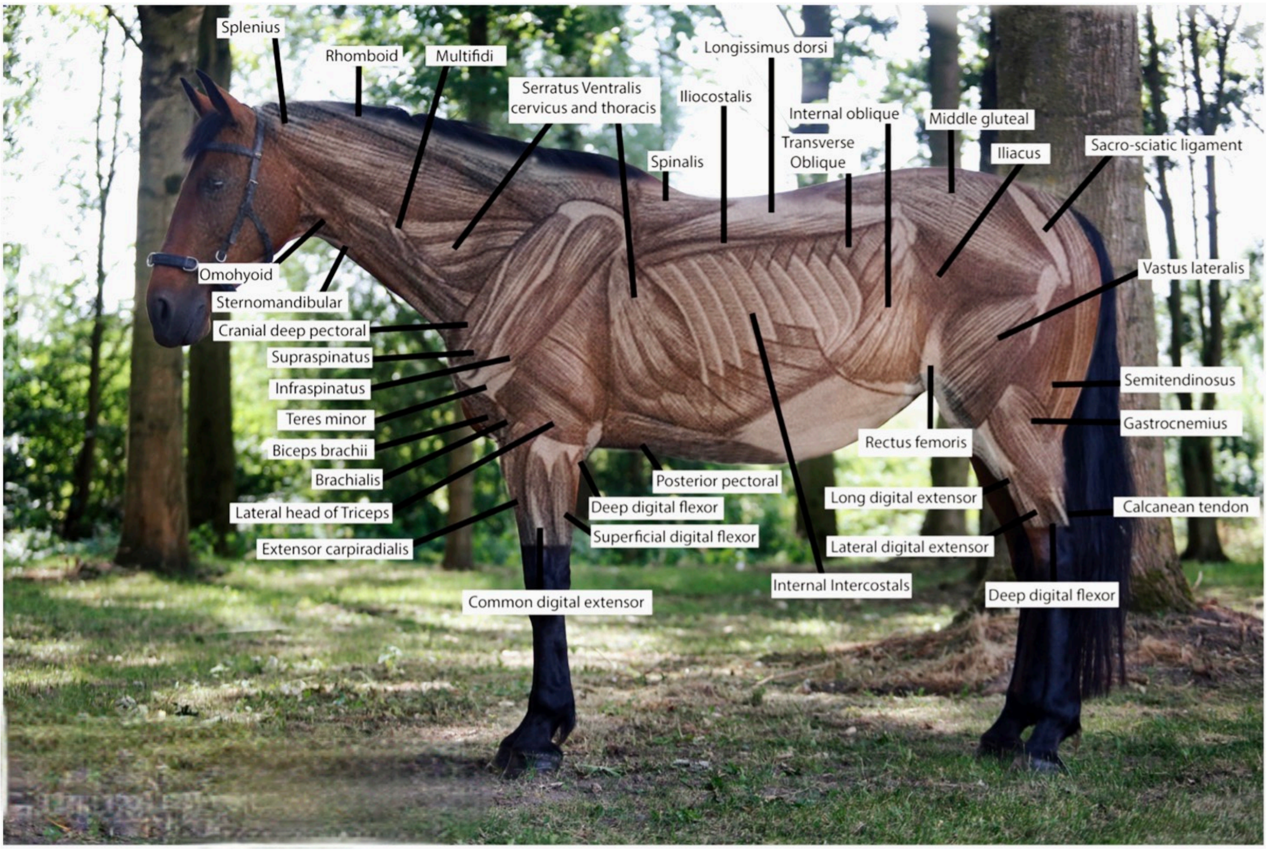
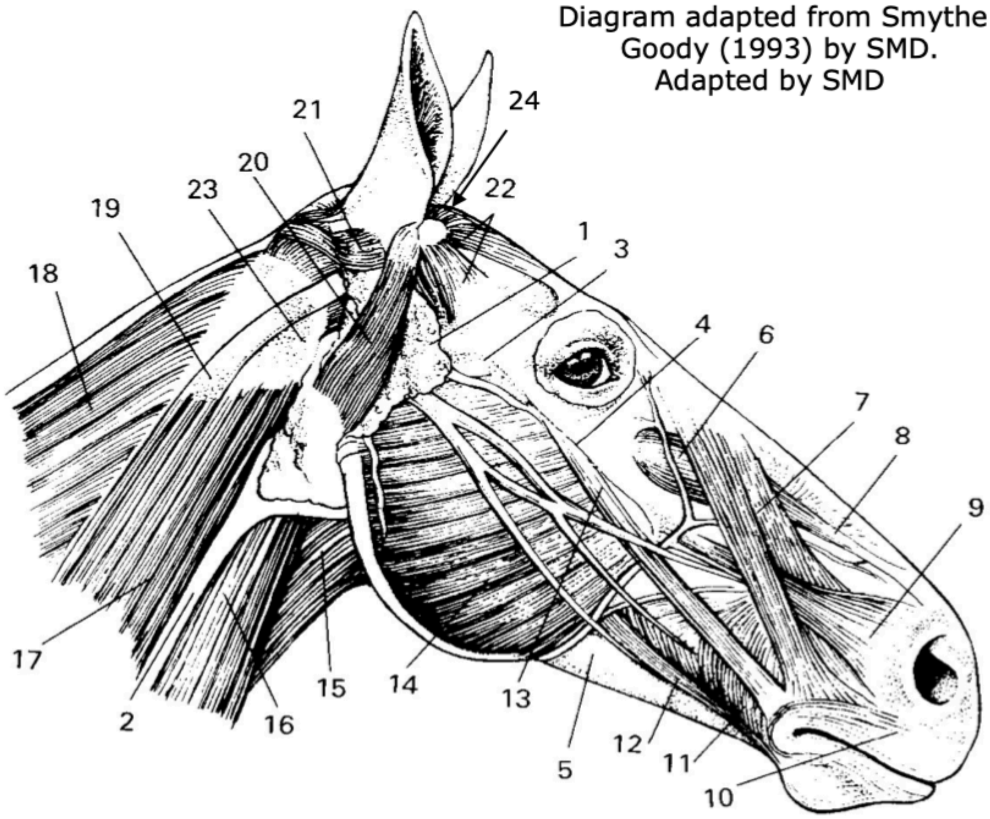

Splenius
Rhomboid
Multifidi
Longissimus dorsi
Serratus Ventralis cervicus and thoracis
Iliocostalis
Internal oblique
Middle gluteal
Transverse Oblique
Spinalis
Iliacus
Sacro-sciatic ligament
Omohyoid
Sternomandibular
Vastus lateralis
Cranial deep pectoral
Supraspinatus
Infraspinatus
Semitendinosus
Teres minor
Gastrocnemius
Biceps brachii
Rectus femoris
Brachialis
Posterior pectoral
Long digital extensor
Lateral head of Triceps
Deep digital flexor
Calcanean tendon
Superficial digital flexor
Extensor carpiradialis
Lateral digital extensor
Internal Intercostals
Common digital extensor
Deep digital flexor

Diagram adapted from Smythe and
Goody (1993) by SMD.
Adapted by SMD



1. Parotid Gland
2. Jugular Vein
3. Zygomatic Arch
4. Facial Crest
5. Ramus of Mandible
6. Levator labi
7. Levator nasolabialis
8. Rostral part of levator labii
9. Lateral nostril dilator (Canninus)
10. Orbicularis oris
11. Buccinator
12. Depressor
13. Zygomaticus
14. Masseter
15. Omohyoid
16. Sternomandibular
17. Brachiocephalic
18. Splenius
19. Mastoid tendon Brachiocephalic
20. Parotido-auricular
21. Cervico-auricular
22. Scutularis
23. Wing of Atlas
24. Temporalis (deep)

MUSCLE CONTRACTIONS

Skeletal muscles consist of several muscle bundles which consist of muscle fibres – or in scientific terms, fascicles. These fibres have bundles of myofibrils, which run parallel to each other. Contraction therefore involves motor function. The muscles are controlled by motor neurons that stimulate contraction of the muscle fibres. They are enabled to contract because of the protein's known as actin and myosin.

The neurons receive signals from the brain and stimulate contraction of all the muscle fibres in that particular motor unit. A motor unit is made up of a motor neuron and the skeletal muscle fibres innervated by that motor neuron to contract. This chemical synapse is referred to as a neuromuscular junction.

Apart from nerve impulses, outside stimuli can also act on muscles. These can include:

- **Mechanical stimuli** → Pulling, pushing or an impact.
- **Chemical effects** → Administration of drugs, acids, alcohol etc.
- **Thermal effects** → Extremely hot or cold temperatures can damage muscle fibres.

Although elastic, muscle fibres can tear if the muscle is suddenly over stretched. A warmed-up muscle that is well-supplied with blood is more elastic than a cold muscle. To prevent injuries by overstretching, a good warm-up routing is essential for any form of therapy as well as training.

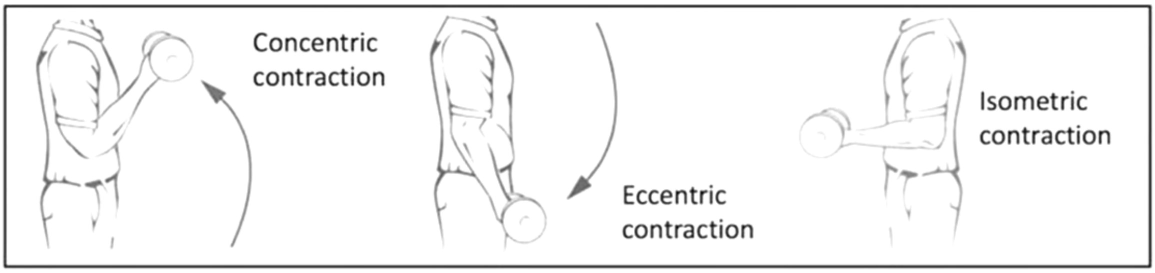
The contraction of a muscle does not necessarily imply that the muscle shortens; it only means that tension has been generated. The energy produced by muscle contraction consists of 25% kinetic energy and 75% heat energy (Ettl 2017).

Muscles can contract in the following ways:

- **Concentric** → Muscle shortens generating tension.
  Example: Piaffe with bending of the hind legs or going to lay down.
- **Eccentric** → Muscle lengthens as it generates tension. Eccentric contractions are believed to be the most powerful contractions and thus have no relation

with relaxation: *''Muscles working eccentrically can absorb up to 15 times more energy than during concentric contractions.''* - Payne et al. 2004

- **Isometric** → No change in muscle length as it generates tension. Often observed when the horse is trying to stabilize during transport.
- **Ballistic** → Ability to contract with momentum allowing fast movements to produce a larger range of motion. Example: Ballotade and croupade.



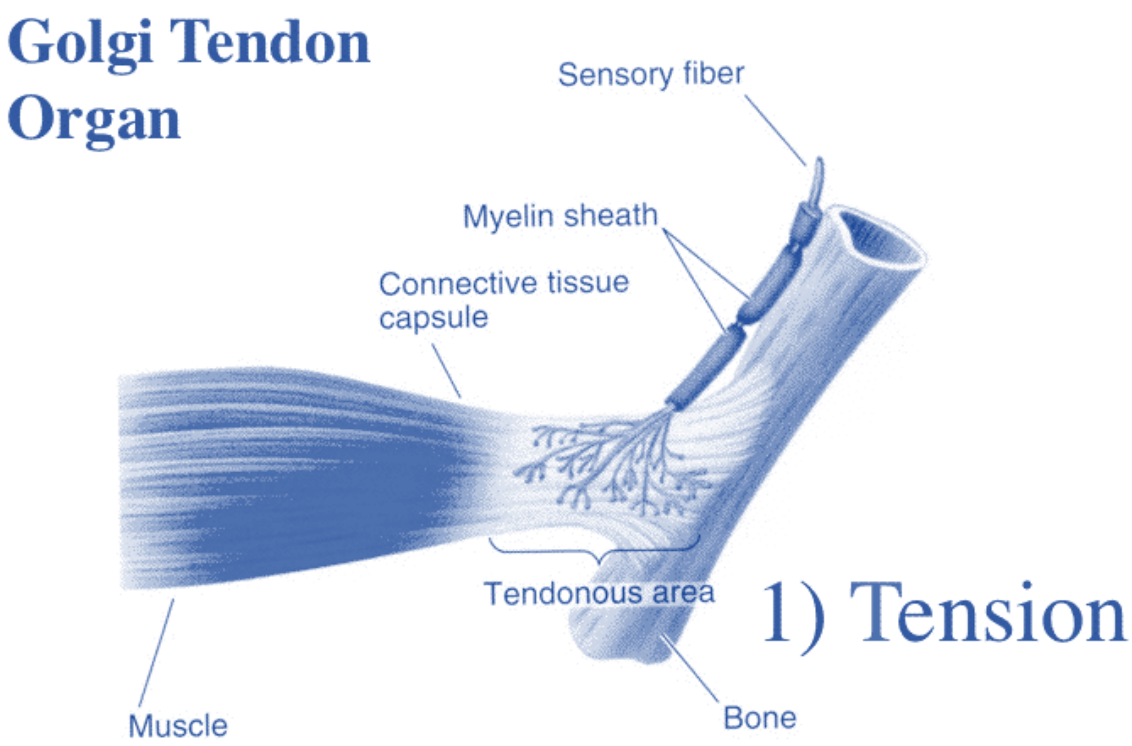
A Dutch Konik foal displaying both closed (right hind) and open (left hind) eccentric muscle contractions.

While muscle contractions describe tension producing movement, muscle toning describes tension in the muscles at rest. Even when a muscle is not contracting, a small number of its motor units are involuntarily activated to produce a sustained contraction of the muscle fibres.

This process gives rise to muscle tone. To sustain muscle tone, small groups of motor units are alternately activated and deactivated in a constantly shifting pattern. Muscle tone keeps skeletal muscles firm, but it does not result in a contraction strong enough to produce movement.

GOLGI TENDON ORGAN

The Golgi tendon organ is a proprioceptive sensory receptor organ that senses changes in muscle tension. It controls muscle contraction and therefore the timing of the swing and stance phases of the limbs in movement. It also provides feedback to the spinal cord and cerebellum from the musculo-tendinous junction.



The Golgi Tendon Organ is located at the origins and insertion of skeletal muscle fibres into the tendons providing the sensory component of the Golgi tendon reflex. It is comprised of strands of collagen that connects the muscle fibres to the tendon and is innervated by sensory nerves creating a spiral around the collagen strands. This unit is called the neuro - tendinous spindle which is enclosed by a fibrous capsule (Butler 2017).

MUSCLE ACTIONS

Muscle actions are movements caused by muscle contractions. Muscles actions can be:

- **Flexion** → Forward movement decreasing the angle between two bones. (bending). Examples: Coiling of the loins
- **Extension** → Backward movement increasing the angle between two bones. (Straightening a bend). Examples: Bring leg back; Hollowing the back
  Note: Skeletal muscles do not extend below the knee or hocks.
- **Abduction** → Lateral movement away from the body's midline / centre of mass. Example: Sideways movements; Lifting the leg to the side
- **Adduction** → Lateral movement towards the body's midline / centre of mass Example: Laterals (half pass); Crossing one leg in front of the other.
- **Rotation** → Twisting movement around longitudinal axis. Example: Shaking the head

Adduction in the half pass in walk

EQUINE MUSCLE NAMES

The purpose of naming each muscle in this section is to acquaint the reader with the array of muscles located throughout the horse's body. The names have primarily been acquired from Ashdown and Done (2000), Color of Veterinary Anatomy Vol.2 and other relevant anatomy text. Furthermore, some have a minor description of location, with an approximate layer depth; this will help any equine professional with their palpation skills. However, the pronunciation is up to you! Highlighted names indicate greater access to palpability.

1. Abductor pollicus longus digiti – Forelimb 2 nd layer: cranial forearm.

2. Accessory gluteal – Hind limb 2 nd layer: lateral to the pelvis.

3. Adductor – Hindlimb 2 nd layer: medial thigh.

4. Anconeus – Forelimb 2 nd layer: dorsal arm.

5. Biceps brachii - – Shoulder 2 nd layer: cranial arm.

6. Biceps femoris – Hindlimb first layer: lateral thigh

7. Brachialis - – Forelimb 2 nd layer: lateral to arm, cranial elbow joint.

8. Brachiocephalic – Neck 1 st layer: lateral cervical.

   i. Omotranservarius – Neck: part of the Brachiocephalic

   i. cleidocephalicus – cranial portion. ii.cleidobrachialis caudal portion.

   iii. cleidomastoideus – lateral caudal head.

9. Buccinator – Head 1 st layer: lateral. "A good name for a pirate."

10. Common digital extensor – Forelimb 1 st layer: lateral forearm, dorsal distal limb.

11. Cremaster – Penis: dorsal to the testicles.

12. Cutaneus coli – Neck superficial: ventral neck, cranial chest.

13. Cutaneus fascae – Head superficial: lateral mandible and throat.

14. Cutaneus omobrachialis – Forelimb superficial: lateral shoulder.

15. Cutaneus trunci - – Barrel superficial: lateral barrel.

16. Deep digital flexor - Forelimb and hind limb 2 nd layer: caudal forearm and gaskin and lower limb. Furthermore, Flexor digiti longus and Flexor digitorum longus form part of this muscle in the hind limb.

17. Deep gluteal – Hind limb 3 rd layer: dorsal to the pelvis.

18. Deltoid – Forelimb 1 st layer: lateral shoulder.

19. Depressor labii mandibularis – Head 1 st layer: lateral mandibular shaft.

20. Diaphragm – Thoracic cavity: separates the heart and lungs from the digestive and viscera.

21. Digastricus – Head: medial shaft of mandible.

22. Dilator naris apicalis – Head 1 st layer: on top of Alar cartilage between the nostrils.

23. Flexor carpi radialis – Forelimb 1 st layer: medial forearm.

24. Flexor carpi ulnaris – Forelimb 1 st layer: medial forearm.

25. Gastrocnemius – Hind limb 2 nd layer: caudal gaskin.

26. Gracilis – Hind limb 1 st layer: medial thigh.

27. Head obliques caudalis – Neck 4 th layer: lateral C2.

28. Head obliques cranialis – Neck 4 th layer: lateral C1.

29. Iliacus – Thigh 3 rd layer: medial thigh.

30. Iliocostalis – Back: dorsal and caudal ribs.

i. cervicis – Neck: latero ventral cervical to thoracic vertebrae.
ii. lumborum – Loins 2 nd layer: dorsal lumbar transverse process.

iii. thoracis – Back 2 nd layer: dorsal ribs.

31. Iliopsoas – Combination of the Psoas major and Iliacus muscles.

32. Infraspinatus – Shoulder: lateral caudal to the spine of scapula.

33. Intercostals externis – Barrel 2 nd layer: between the ribs.

34. Intertransversarii i. cervicis – Neck: lateral cervical vertebrae.
ii. dorsales ventralis caudae – Tail: lateral aspect.

iii. lumborum – Loin: between the transverse processes lumbar.

41. Levator nasolabialis – Head: lateral.

42. Linea alba – Belly: median plane.

lumborum – Loins 3 rd layer: dorsal ribs.

35. Lacertus fibrosus – Forelimb: medial forearm (a strong band passing from the chest to the forearm).

36. Lateral digital extensor – Forelimb 1 st layer: lateral forearm, dorsal lower limb.

37. Lateral digital extensor – Hind limb: oblique lateral gaskin.

38. Lateral nostril dilator (Canninus) – Head 1 st layer: nostril perimeter.

39. Latissimus dorsi – Shoulder barrel and back 1st layer: caudal shoulder, lateral barrel and dorsal back.

40. Levator labii – Head: dorsolateral aspect.

43. Long digital extensor – Hind limb 1 st layer: lateral gaskin, dorsal lower limb.

44. Longissimus atlantis - Neck 4 th layer: dorsal cervical vertebrae.

45. Longissimus capitis - Neck 4 th layer: dorsal cervical.

46. Longissimus dorsi i. cervicis – Neck 3 rd layer: dorsal cervical vertebrae.

ii. lumborum – loins 3rd layer: dorsal ribs

iii. thoracis – Wither and back 3 rd layer: dorsal ribs.

47. Longus capitis – Neck: cranial and ventral cervical vertebrae.

48. Longus coli – Neck: ventral cervical vertebrae and cranial thoracic vertebrae.

49. Masseter – Head 1 st layer: lateral mandibular ramus.

50. Middle gluteal – Hind limb 2 nd layer: dorsal to the pelvis.

54. Omohyoid – Throat to neck: ventral.

51. Multifidi - Neck 4 th layer: Neck, Back, loins and croup 3 rd layer: dorsal and close to the median plane.

52. Obliquus externus abdominis (External oblique) – Belly 1 st layer: ventral.

53. Obliquus internus abdominis (Internal oblique) – Belly 2 nd layer: ventral.

54. Omohyoid – Throat to neck: ventral

55. Orbicularis oris – Head: sphincter muscle of the mouth.

56. .Pectineus – Hindlimb 2 nd layer: forward in the medial thigh.

57. Pectoralis ascendens (Posterior / Deep pectoral) – Chest and belly.

belly: medial arm and ventral

58. Pectoralis superficialis (Superficial pectoral) – Chest: medial to lateral.

59. Pectoralis transverses **(Transverse pectoral)** Chest: medial to lateral.

60. Peroneus tertius: Hindlimb 2nd layer: cranial gaskin under Long digital ext.

61. Psoas major – Loin to coupling: sub lumbar, lateral to the median plane.

62. Psoas minor – Loin to thigh: sub lumbar to medial thigh.

63. Quadratus femoris – Thigh 3 rd layer: ventral to the pelvis and medial femur.

64. Quadratus lumbarum – Loin 3 rd layer: sub lumbar and ventral to the pelvis.

65. Rectus Addominus: Barrel and flank: ventral.

66. Rectus Capitus Dorsalis Major – Neck 4 th layer: lateral C1.

67. Rectus capitus dorsalis minor – Neck 4 th layer: dorsal C1.

68. Rectus capitis ventralis – Neck: ventral C1.

69. Rectus femoris – Hind limb: thigh, cranial femur.

70. Rhomboid. . cervicis: Neck 2 nd layer: cranial to the shoulder.

ii. thoracis: wither 2 nd layer: caudal to the shoulder.

71. Sartorius – Hindlimb 1st layer: medial thigh

72. Scalenus Ventralis – Neck: caudal lateral

73. Scutolaris – Forehead: forward ear muscle.

Inter: towards to Occipital crest.

Fronto: forehead above the eye.

74. Semimembranosus – Hind limb: caudal to medial thigh.

75. Semitendinosus – Hind limb: caudal thigh.

76. Serratus dorsalis caudalis – Back 2 nd layer: caudal back, dorsal ribs. S

77. Serratus dorsalis cranialis – Back 2 nd layer: cranial back, dorsal ribs.

78. Serratus ventralis cervicis – Neck: cranial and medial to the shoulder.

79. Serratus ventralis thoracis – Barrel: caudal and medial to the shoulder.

80. Soleus - Hind limb 2 nd layer: caudal gaskin.

81. Spinalis cervicis – Neck 4 th layer: caudal dorsal neck.

82. Spinalis thoracis – Back 4 th layer: wither to back.

83. Splenius - Neck 3 rd layer: lateral

84. Sternomandibular – Neck:ventral.

85. Subclavius (Cranial Deep Pectoral) cranial shoulder and lateral chest.

86. Subscapularis – Shoulder medial.

87. Superficial digital flexor – Forelimb and hind limb 2 nd layer: caudal forearm and gaskin and lower limb.

88. Superficial gluteal – Hind limb 1 st layer: dorsal and lateral to the pelvis

89. Supraspinatus – Shoulder: lateral.

90. Temporalis – Head: forehead.

91. Tensor fascae antebrachii – Shoulder: medial and caudal.

92. Tensor fasciae latae – Thigh 1 st layer: cranio lateral.

93. Teres minor – Shoulder: lateral.

94. Tibialis caudalis- Hind limb: caudal gaskin (Often blended in deep digital

95. Tibialis cranialis – Hind limb: cranial gaskin.

96. Transversus abdominis – Belly and flank: ventral.

97. Trapezius – Neck 1 st layer: wither and back (cervicus and thoracis)

98. Triceps – Shoulder 1 st layer: caudal.

99. Ulnaris lateralis – Forelimb 1 st layer: lateral forearm.

100.Vastus intermedius – Hind limb: thigh, cranial femur.

101.Vastus lateralis - Hind limb: thigh, lateral femur.

102.Vastus medialis - Hind limb: thigh, medial femur.

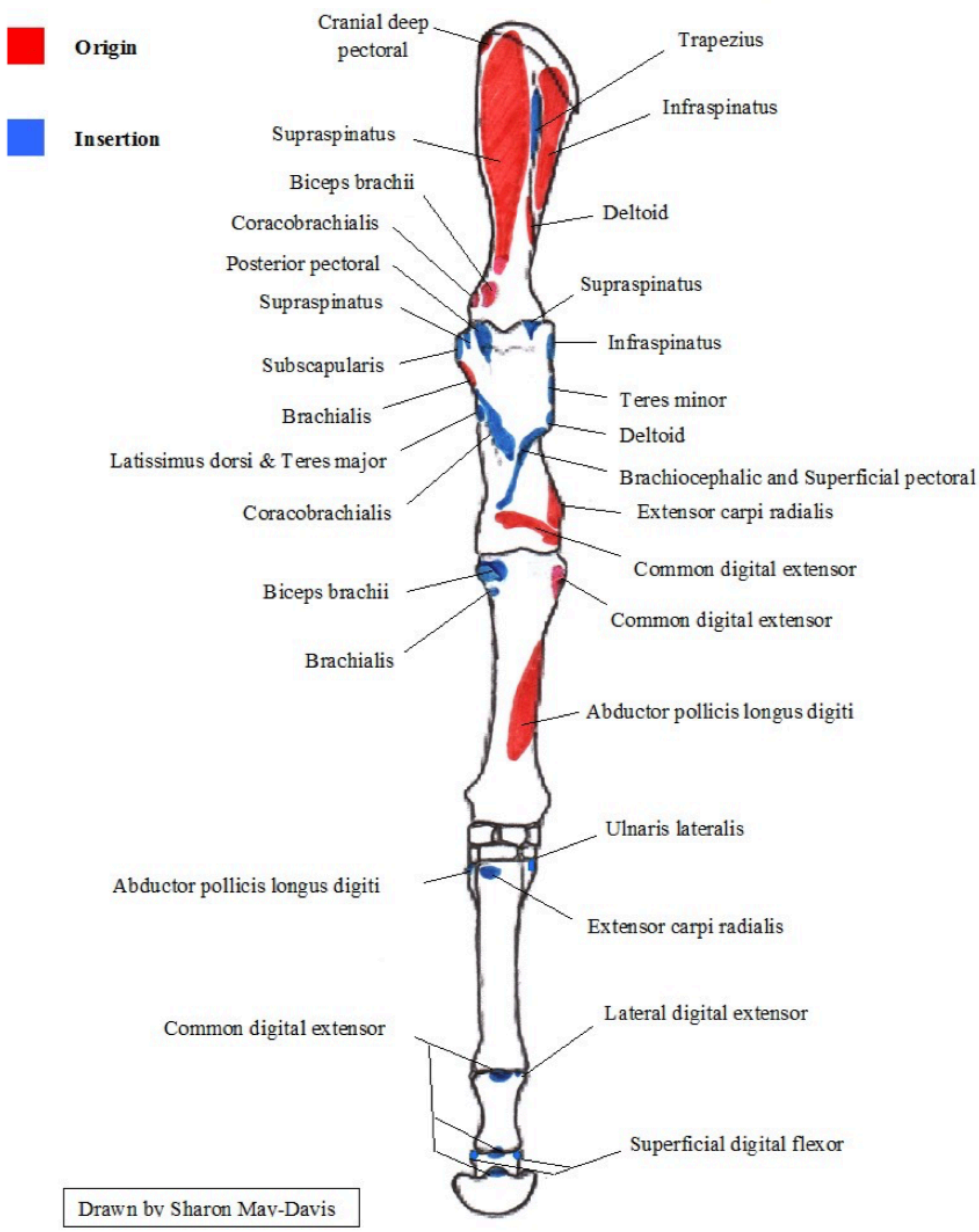
103.Zygomaticus – Head 2 nd layer: lateral.

ATTACHMENTS: ORIGINS AND INSERTIONS

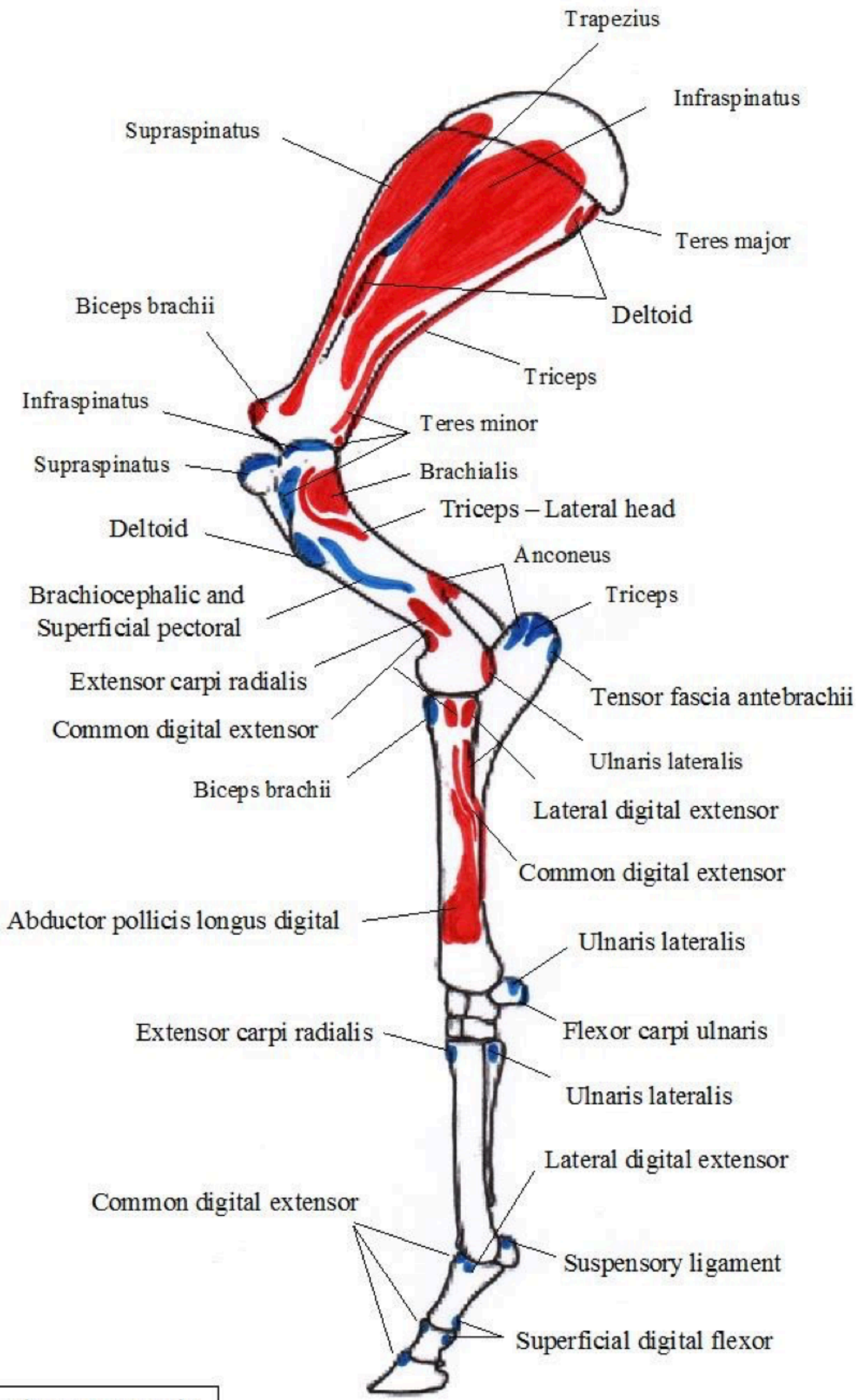
A muscle can have one or more origins and insertions. In general, origins are attached to the least movable (stationary) bone whilst insertions are attached to the more movable bone.
A muscle can have one or more origins and insertions.
As a muscle primarily contracts, it almost always brings the movable insertion closer to the least movable origin causing one or both bones to move, articulating the joints. Muscular contraction is therefore transmitted via the belly of the muscle to the point of attachment.

An example: *''The middle gluteal in the hindquarter originates from the ilium of the pelvis and inserts onto the summit of the greater trochanter. Upon contraction the hip joint is extended. However, in the case of the extensor carpi radialis, its origin attaches proximally to the Humerus and inserts distally into the dorsal proximal tubercle of third metacarpal. Upon contraction - the elbow is flexed, and the knee extended''* (May-Davis 2017).

Origins & insertions near side forelimb -cranial aspect

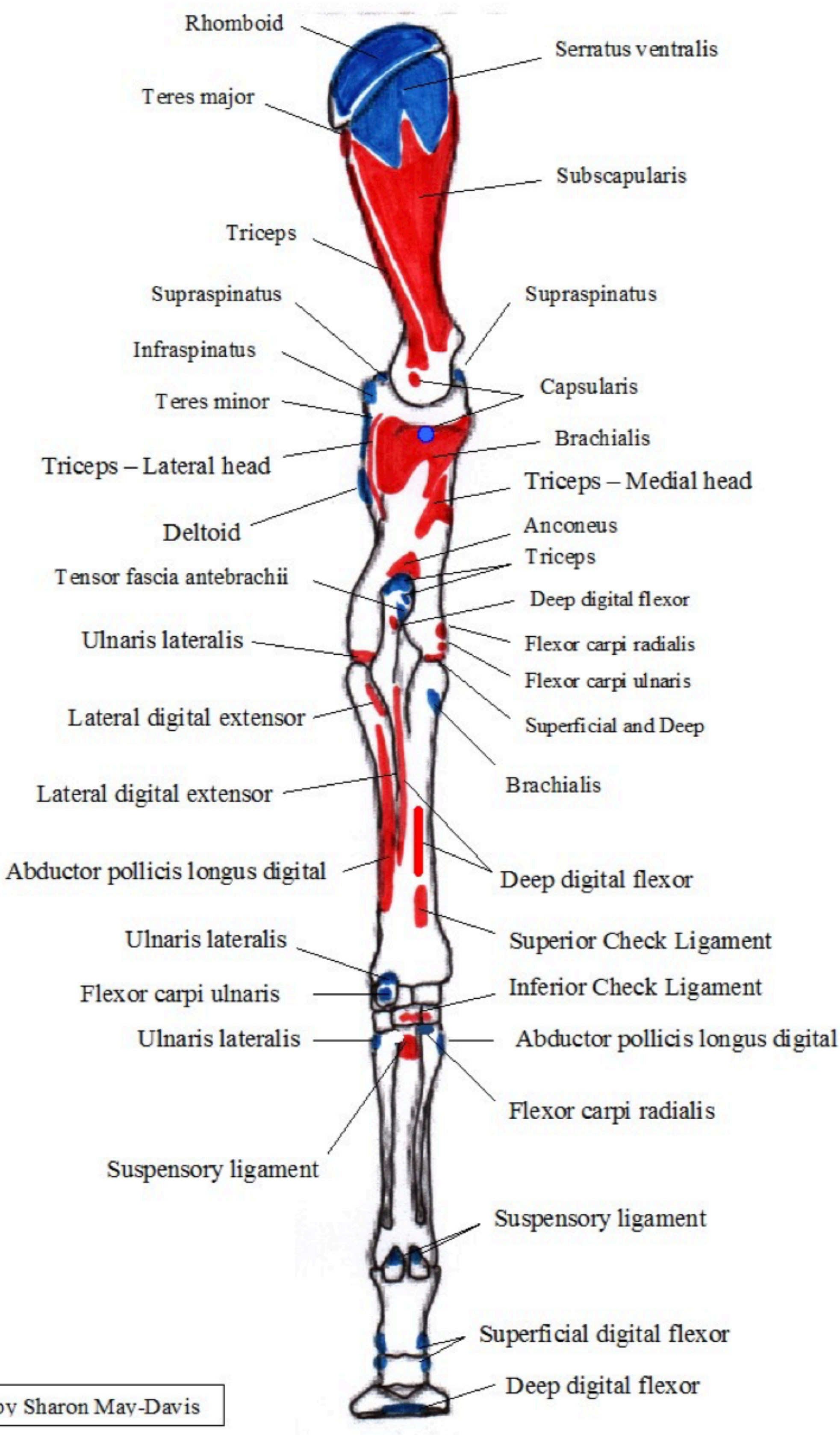


Near side forelimb – lateral aspect



Drawn by Sharon May-Davis

Near side forelimb – caudal aspect



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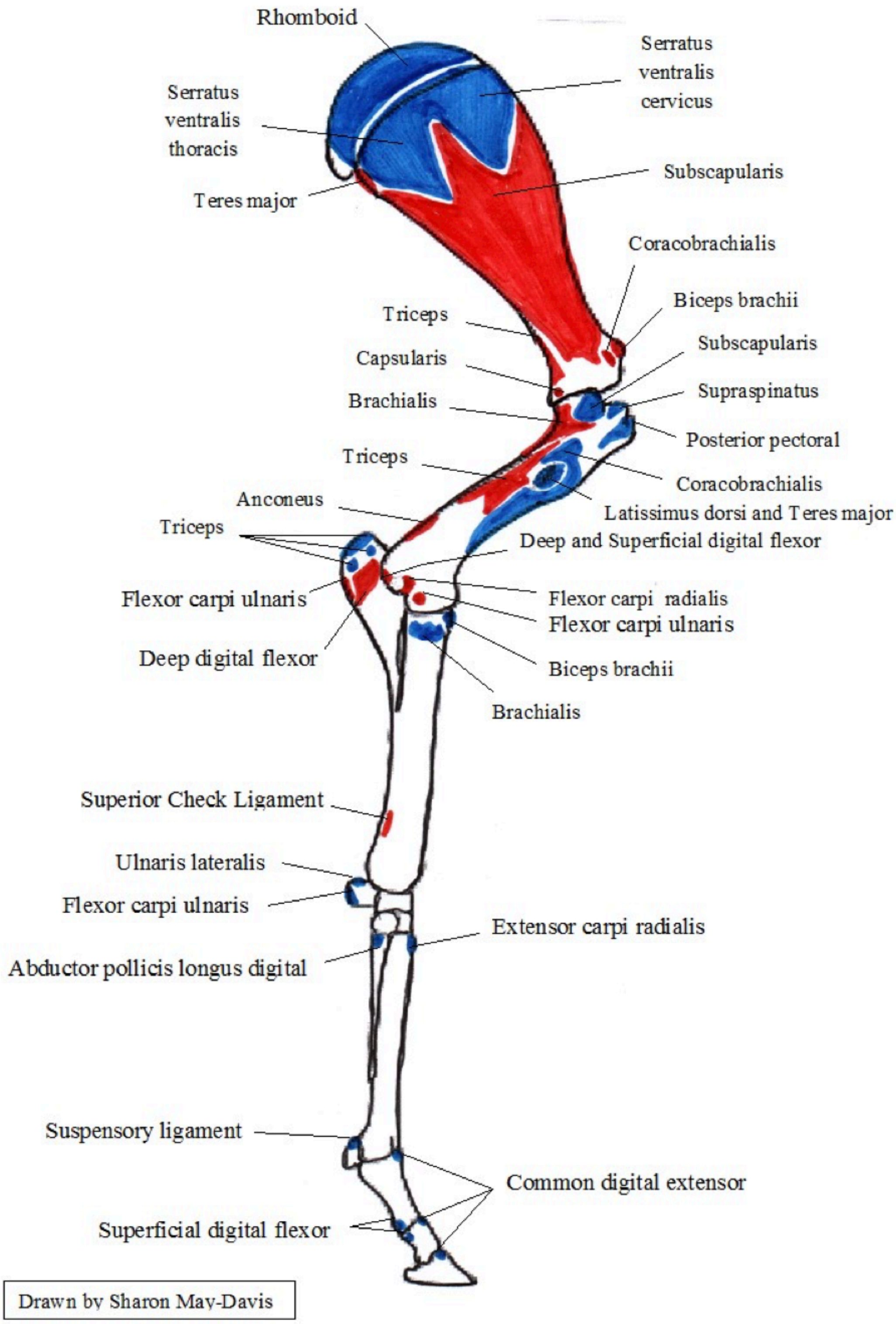
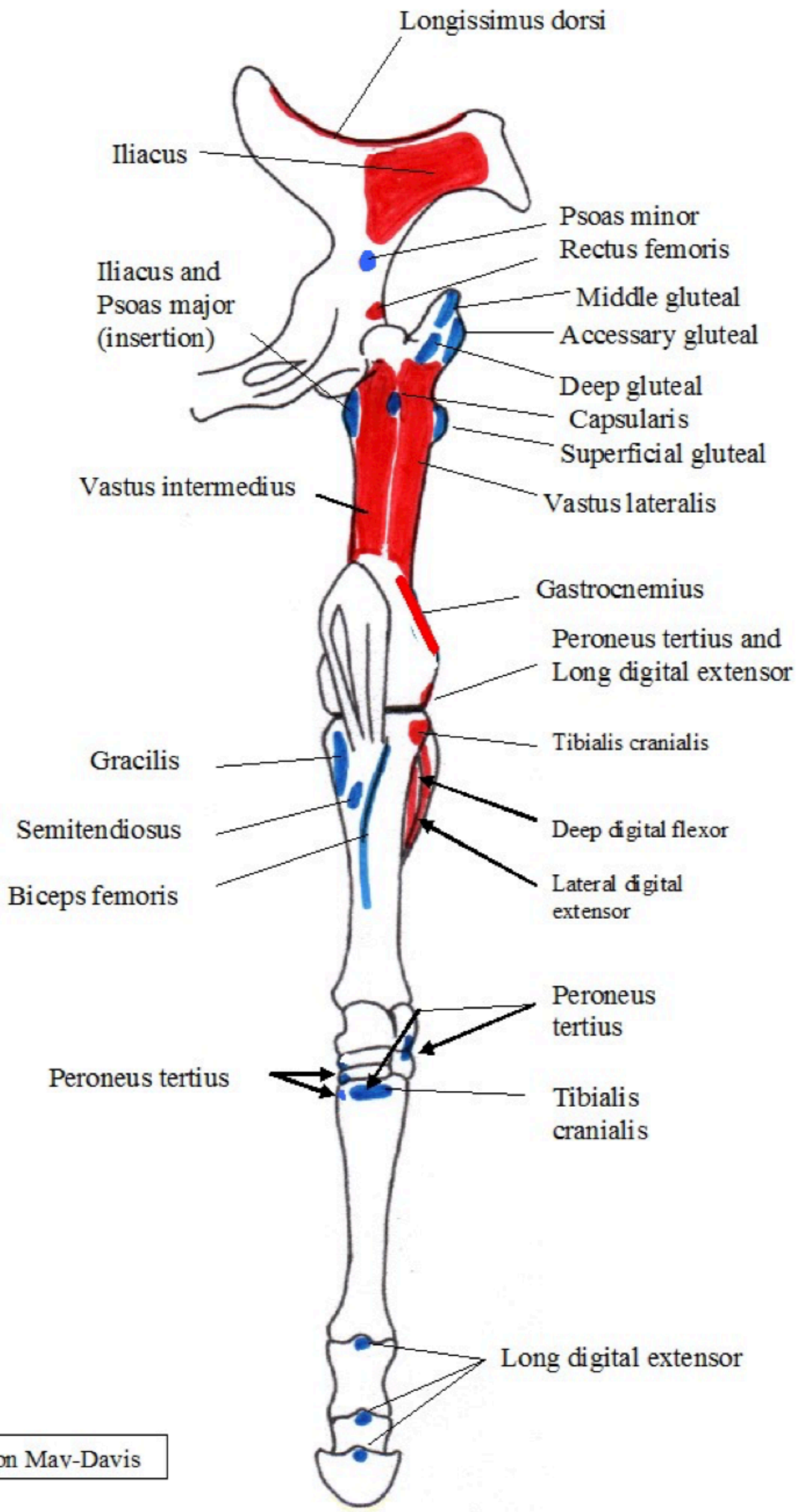
Near side forelimb – medial aspect



Near side hind limb cranial aspect



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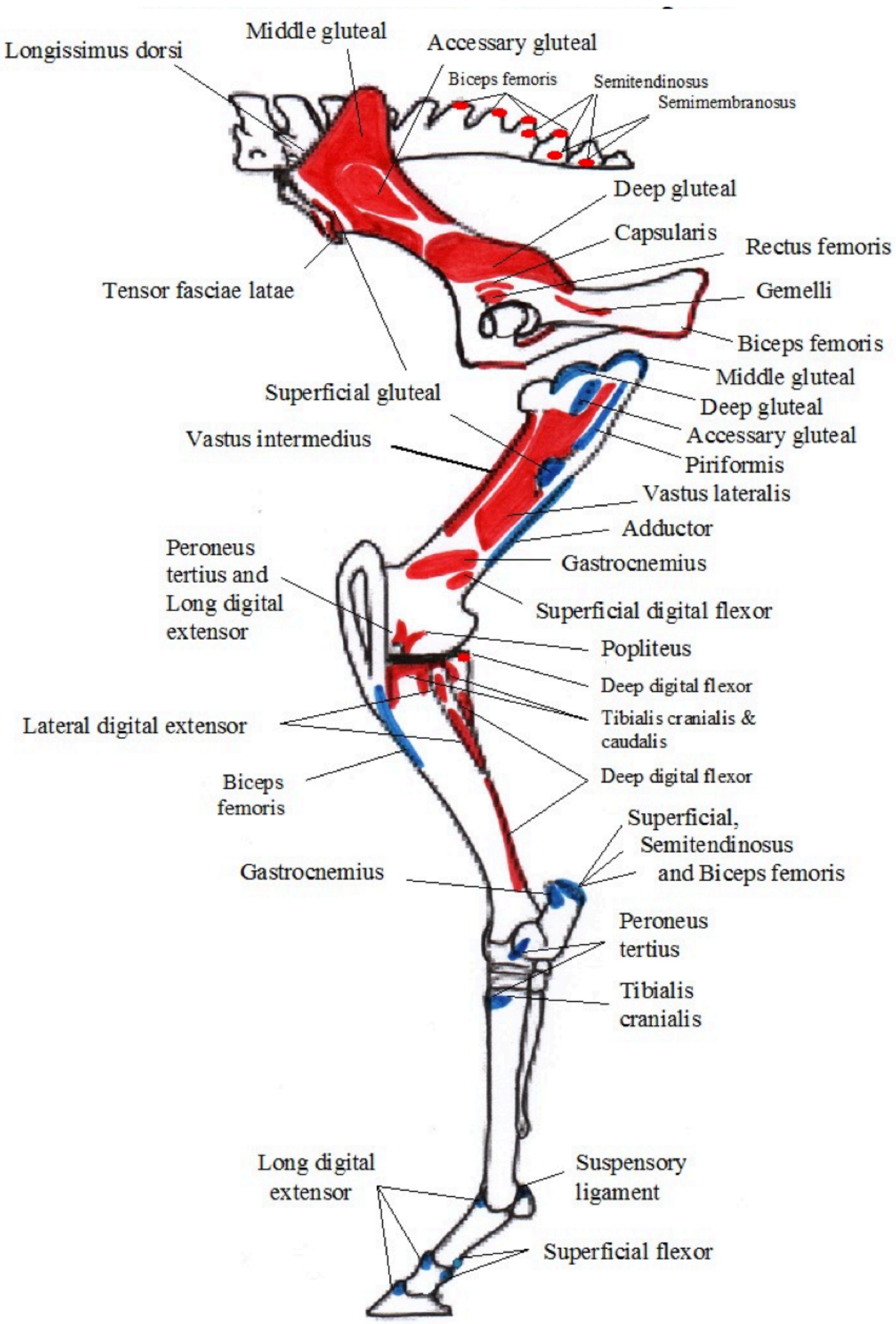
Near side hind limb – lateral aspect



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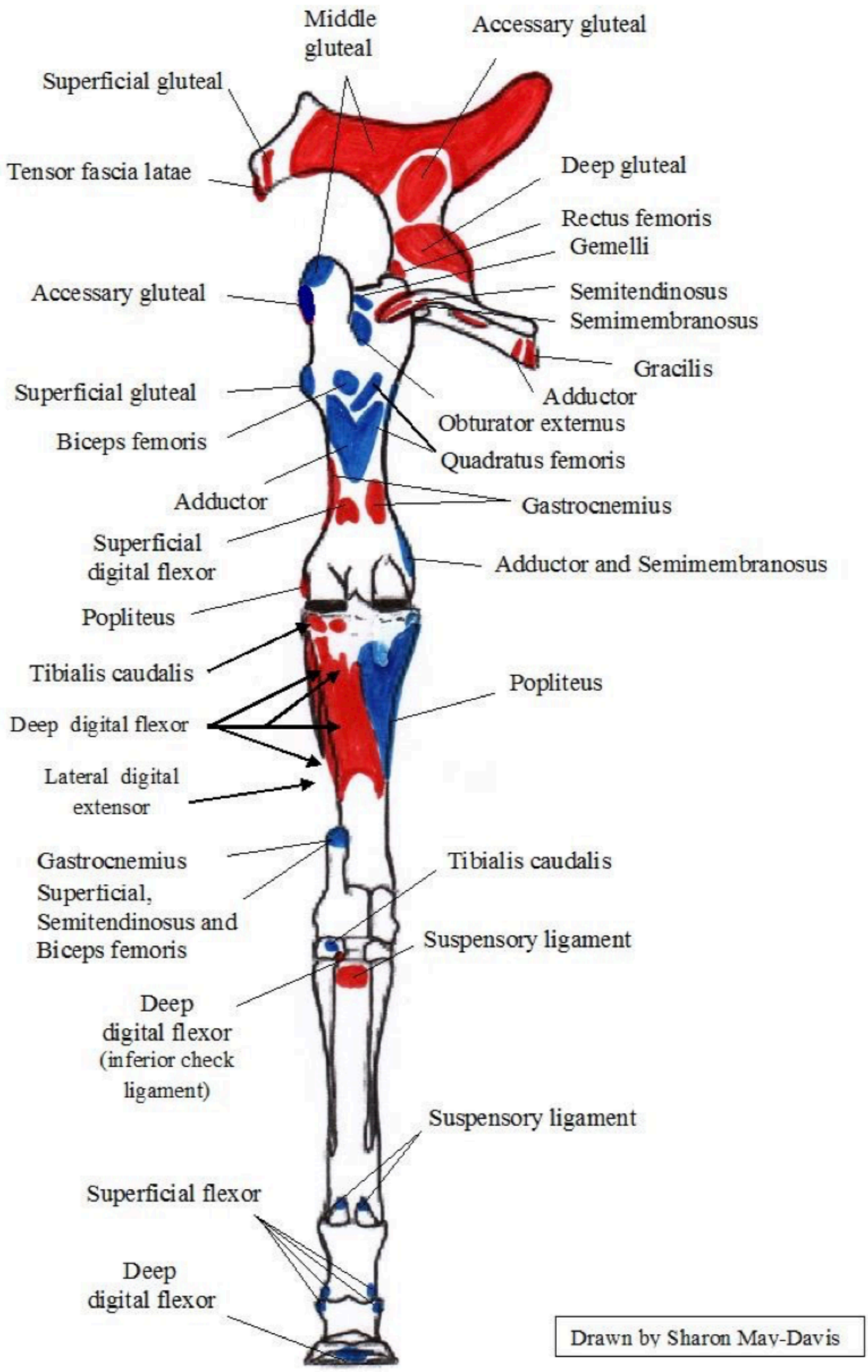
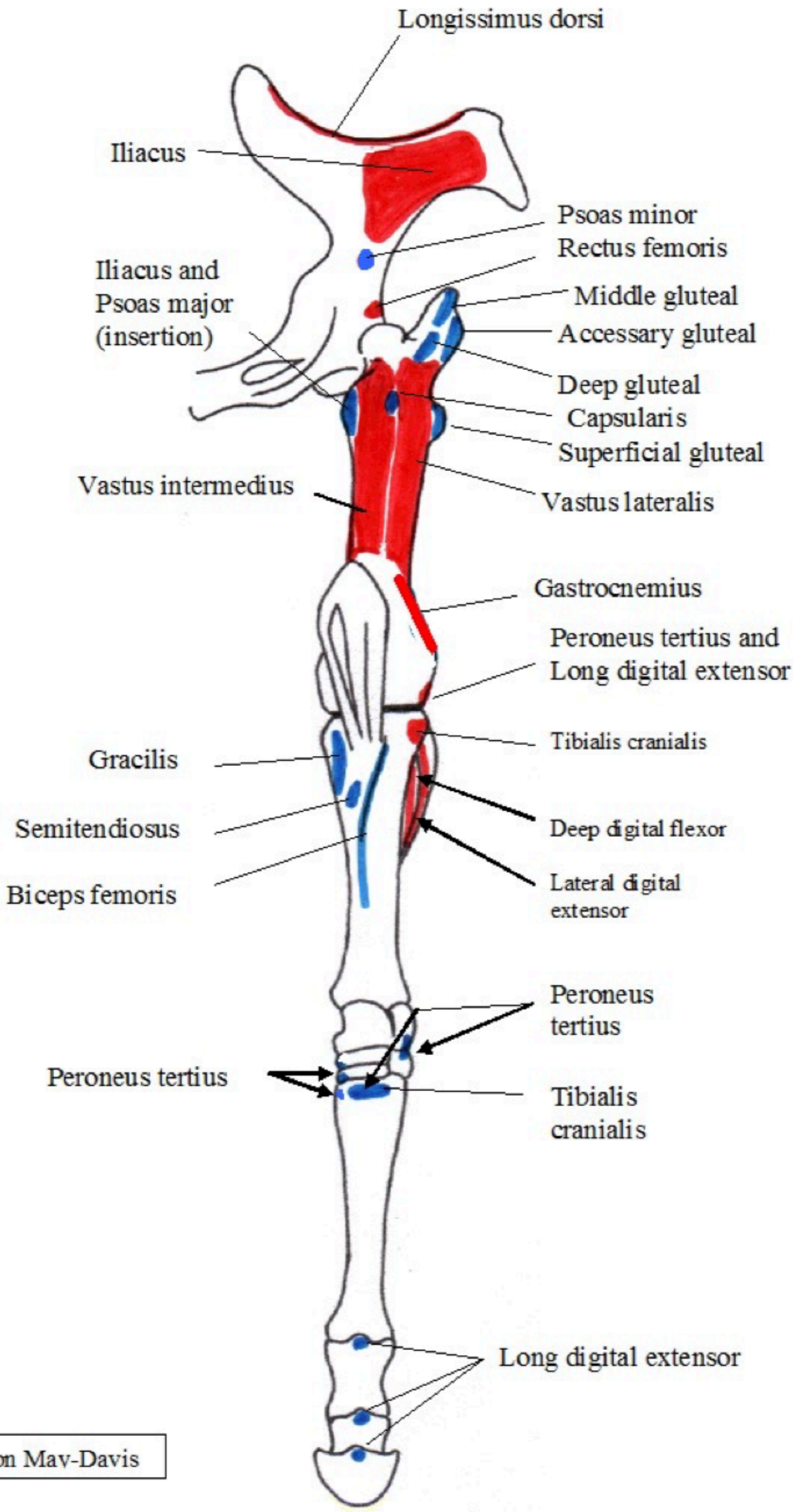
Near side hind limb caudal aspect



Near side hind limb – Medial aspect



SKELETAL MUSCLE GLOSSARY

Please note - this section does not outline every muscle, only those deemed relevant.

THE HEAD

Name: DIGASTRICUS

Origin: Ventral occipital bone Insertion: Medial mandibular shaft.

Nerve supply: Facial and mandibular

Function: Assists in depressing the mandible and opening the mouth.

Comments: A thick belly is connected by round tendinous fibers to its origin and insertion.

Name: PTERYGOIDES MEDIALIS

Origin: Basisphenoid and palatine bone Insertion: Mandibular ramus

Nerve supply: Mandibular

Function: Singularly, lateral movement of the jaw, together raise the mandible.

Comments: Highly tendinous in structure it has two parts. The first traverses medially and the second laterally.

Name: PTERYGOIDES LATERALIS

Origin: Basisphenoid bone Insertion: Mandibular condyle.

Nerve supply: Mandibular

Function: Singularly, moves the jaw towards the activated muscle. Simultaneously, moves the mandible rostral.

Comments: Highly fleshy in structure and longitudinal in length.

Name: STYLOGLOSSUS

Origin: Stylohyoid bone Insertion: Ventral tongue

Function: Retracts the tongue and or singularly draws the tongue to the side.

Comments: Lies along the lateral aspect of the tongue.

Name: HYOGLOSSUS

Origin: Hyoid bone (stylo and thryo) Insertion: Ventral tongue

Function: Retracts and depresses the tongue.

Comments: Lies along the lateral aspect of the tongue.

Name: GENIOGLOSSUS

Origin: Medial mandible Insertion: Tongue, basihyoid and ceratohyoid

Function: Depresses and retracts the tongue.

Comments: This fan shaped muscle lies parallel to the tongue.

Name: MYLOHYOID

Origin: Medial mandibular shaft.Insertion: Hyoid apparatus (basihyoid and thyrohyoid)

Nerve supply: Mylohyoid.

Function: Raises the hyoid, tongue, and floor of mouth. Comments: Helps to support the tongue in a sling formation.

Name: STYLOHYOID

Origin: Medial mandible. Insertion: Thyrohyoid

Nerve supply: Facial

Function: It draws the base of the tongue and larynx dorsally and caudally.

Comments: A slender fusiform muscle that runs nearly parallel to the thyrohyoid bone.

Name: STERNOHYOID and STERNOTHYROHYOID

Origin: Sternum – manubrium. Insertion: Sternothyrohyoid – lateral thyroid cartilage, sternohyoid – body of the hyoid.

Nerve supply: Derived from the 1 st and 2 nd cervical nerves.

Function: Sternothyroid – to depress the larynx when swallowing. Sternohyoid – depresses the tongue and hyoid.

Comments: These two muscles are very thin and difficult to dissect. They are blended at their origin until they separate at the intermediate tendon before inserting.

Name: MASSETER

Origin: Zygomatic arch, facial crest, and caudal temporal mandibular joint (TMJ). Insertion: Lateral mandible to the ramus.

Nerve supply: Mandibular

Function: To bring the jaw together and acts unilaterally to achieve a sideways action.

Comments: Regarded by some as the most powerful muscle in the equine body, it has layers of tendinous tissue permeating throughout, especially in the caudal region. Furthermore, it can have between 3-4 compartment type insertions due to these tendinous sheets. Trauma to the nerve may occur through pull backs on the head collar or an entrapment of the head, which may lead to head shaking, facial paralysis or muscle atrophy. Primarily involved in mastication, the masseter muscle in 60-70% of horses is unilaterally larger due to the mandible’s one-way sideways action in chewing.

Name: SCUTULARIS (fronto and inter)

Origin: Zygomatic arch, parietal ridge, sagittal crest/interparietal ridge and nuchal / occipital crest. Insertion: Anterior, lateral and medial borders of the scutularis/scutiform cartilage.

Function: Forward rotation of the ear.

Comments: These two very thin and flat muscles lie directly beneath the skin on the forehead over the Temporalis. They insert onto the scutularis/scutiform cartilage, which lies cranial to the ear and cover the supraorbital fat pad (a cushion for the action of the coronoid process behind the orbit) in the temporal fossa from the origin.

Name: TEMPORALIS
Origin: Parietal ridge, sagittal crest/interparietal ridge, nuchal/occipital crest, parietal, occipital, temporal and sphenoid bones.Insertion: Coronoid process.

Function: It assists the masseter in closing the jaw and to keep it clenched.

Comments: The insertion can overlap and blend into the masseter muscle which then terminates on the mandibular ramus close to the buccinator, linking it intimately to the masseter. The temporalis, like the masseter, is also unilateral in size due to 60-70% of horses masticating in one direction.

Name: BUCCINATOR (buccal and molaris)
Origin: Mandible, maxilla, and distal coronoid process. Insertion: Orbicularis oris muscle.
Nerve supply: Facial

Function: Retracts the angle of the mouth, aids in maintaining the position of the food in relation to the molars and is also used to suck up liquids.

Comments: This incomplete pennate muscle extends to the lateral and medial aspect of the mandible in its two forms (buccal and molaris). It sits obliquely on the lateral aspect of the head, half of which is covered by the masseter. It can be compressed by cavessons, nosebands and similar.

Name: ZYGOMATICUS
Origin: Facial crest. Insertion: Buccinator and can extend as far as the orbicularis oris muscle in most horses.Nerve supply: Facial

Function: It raises and retracts the angle of the mouth.

Comments: A thin narrow muscle appears quite pale in color upon dissection. It traverses the lateral aspect of the head and is superficial to the masseter and buccinator.

Name: LEVATOR NASOLABIALIS

Origin: Frontal and nasal bones (aponeurotica tissue). Insertion: Lateral wing of the nostril and lateral upper lip. Nerve supply: Facial

Function: To raise the upper lip and dilate the nostril.

Comments: From the origin this muscle divides in 2. The lip portion passes over the Lateral nostril dilator. The nostril portion passes underneath prior to inserting into the lateral aspect of the nostril.

Name: LATERAL NOSTRIL DILATOR also known as CANINUS

Origin: Maxilla just rostral to the facial crest. Insertion: Lateral wing of the nostril and upper lip. Nerve supply: Facial.

Function: It dilates the nostril.

Comments: This muscle divides the Levator nasolabialis and is triangular in shape after originating from a thin narrow tendon.

Name: ORBICULARIS ORIS

Origin: No bony attachments. Insertion: No bony attachments. Nerve supply: Facial

Function: To close the lips.

Comments: This muscle is referred to as the sphincter muscle of the mouth and attaches via soft tissue to surrounding skin and fibers from various muscles. Soft tissue trauma may occur via “twitching” the nose to control the horse.

Name: LEVATOR LABI

Origin: Lachrymal, zygomatic and maxilla.Insertion: Upper lip. Nerve supply: Facial

Function: A singular action will pull the upper lip to the side. Bilaterally, raises the upper lip.

Comments: It passes obliquely from beneath the eye and above the nostrils before uniting and inserting into the upper lip in a fibrous tendinous type of tissue that when activated can invoke the “Flehman”. As per Orbicularis oris regarding “twitching”.

Name: DEPRESSOR LABI

Origin: Mandible border and maxilla.Insertion: Tissue of the lower lip. Nerve supply: Facial

Function: To depress and retract the lower lip.

Comments: There is a considerable amount of fusion between the muscle belly of the Depressor labi and the Buccinator. In the lower lip the tendon divides and connects with similar bundles of tendon like tissue to its counterpart from the other side of the head. Its action on the chin can often reveal a horse’s mental state at that point in time.

Name: PINNA / EAR GROUPS

Auricular group, scutularis group and cervico group that further divide into levators and rotators depending on which anatomic text you read.Origin: Multiple bone and soft tissue attachments located in and around the ear. Insertion: Primarily the conchal cartilage.

Function: Multiple and complex actions of the ear.

Comments: These muscle groups consist of long thin types to the shortened strong versions. They activate a series of complex actions that elevate, rotate, and depress the ear and do this in a unilateral or bilateral state. Underneath the conchal cartilage of the ear is a fat pad that has muscles traversing dorsal and ventral around it. Its function is presumably the same as the supra orbital fat pad.

THE NECK

Name: LONGUS CAPITIS

Origin: Cervical vertebrae (transverse proc. 3-5) Insertion: Ventral occipital bone Nerve supply: Ventral branches of cervical.

Function: Singularly, inclines the head to the same side as the muscle contraction. Together, they flex the head.

Comments: The Longus capitus is the largest of the head flexors. Its muscle belly is largest at C2, where it is easily accessed underneath the Brachiocephalic. This muscle becomes quite stimulated at FEI level Dressage due to its ability to keep the poll flexed and fixed.

Name: RECTUS CAPITUS VENTRALIS

Origin: C1 (ventral arch) Insertion: Ventral occipital bone Nerve supply: Ventral branch of 1 st cervical.

Function: To flex the altanto-occipital joint.

Comments: This small muscle lies dorsal to the Longus capitus muscle underneath the wing of atlas. Its fleshy structure crosses the atlanto-occipital joint from a ventral aspect. As per the Longus capitis, this muscle can also be termed a cervical vertebrae fixater because of its influence at the poll, especially in dressage horses at FEI level.

Name: RECTUS CAPITUS LATERALIS

Origin: C1 (lateral to the Rectus capitus ventralis) Insertion: Skull (jugular process) Nerve supply: Ventral branch of the 1 st cervical.

Function: To flex the atlanto-ocipital joint.

Comments: The smallest of the head flexors the Rectus capitus lateralis is fleshy in structure and lies for the most part underneath the Cranial oblique muscle. Often referred to as a cervical fixater.

Name: CRANIAL HEAD OBLIQUE

Origin: C1 (cranial edge and ventral surface of the wing) Insertion: Skull (nuchal crest, jugular and mastoid process). Nerve supply: Dorsal branch of the 1 st cervical.

Function: Singularly, to flex the head laterally. Together, they extend the head.

Comments: This short muscle lies lateral to the atlanto-occipital joint and contains a good deal of tendinous tissue. A great deal of tension is placed on this muscle when a horse pulls back on the head collar or is trained in draw reins or when the head is placed in Rolkur.

Name: CAUDAL HEAD OBLIQUE

Origin: C2 (lateral dorsal spine and the caudal articular process) Insertion: C1 (dorsal aspect of the wing of atlas) Nerve supply: Dorsal branch of the 2 nd cervical.

Function: Rotate the head and atlas to the same side. Extend and fix the atlanto-axial joint.

Comments: The caudal head oblique covers the dorso lateral aspect of C1 and C2. It lies along the wing of atlas underneath 2 layers of muscles. A great deal of tension is placed on this muscle when a horse pulls back on the head collar or is trained in draw reins or when the head is placed in Rolkur.

Name: RECTUS CAPITUS DORSALIS MAJOR

Origin: C2 (spinous process) Insertion: Skull (occipital bone below the semispinalis capitis and Nuchal ligament funicular cord) Nerve supply: Dorsal branch of the 1 st cervical.

Function: To extend the head.

Comments: Often divided into two parallel parts (superficial and deep), this fleshy muscle travels dorsally alongside the Nuchal ligament. A great deal of tension is placed on this muscle when the poll is flexed in draw reins or when the head is placed in Rolkur.

Name: RECTUS CAPITUS DORSALIS MINOR

Origin: C1 (dorsal surface) Insertion: Skull (occipital bone underneath its major counterpart, lateral to the Nuchal ligament) Nerve supply: Dorsal branch of the 1 st cervical.

Function: To extend the head.

Comments: This fleshy muscle lies underneath the Rectus capitus dorsalis major and over the atlanto-occipital articulation. A great deal of tension is placed on it when the poll is hyperflexed and especially when the head is placed in Rolkur.

Name: SPLENIUS

Origin: Thoracic vertebrae (3rd , 4 th and 5 th dorsal spines) and Nuchal ligament (Funicular cord) Insertion: Nuchal crest, mastoid process, wing of atlas and the transverse processes of the 3rd , 4th and 5 th cervical vertebrae. Nerve supply: Dorsal branches of the last six cervical.

Function: Singularly, to turn the head and neck. Bilaterally, to elevate the head and neck.

Comments: Primarily a superficial muscle, it is however partly covered by 4 other muscles towards its ventral and caudal borders. Its shares aponeurotic attachments with the Bachiocephalic and Longissimus capitus at its insertion, whilst the origins are quite fleshy in comparison.

Name: SEMISPINALIS CAPITUS

Origin: Thoracic vertebrae (3rd , 4 th and 5 th dorsal spines, T1-T6 or T7 transverse processes) and the articular processes of the cervical vertebrae. Insertion: Skull (occipital - below to the Nuchal ligament) Nerve supply: Dorsal branches of the last six cervical.

Function: Singularly, inclines the head. Bilaterally, extends the head and neck.

Comments: This muscle is divided into 2 distinct portions; dorsally Biventer cervicus and ventrally Complexus. Four to five tendinous intersections cross obliquely in the Biventer cervicus which can be mistaken upon palpation for tension within the muscle. The

Complexus is a pennate muscle, and its bundles arise from the articular processes of the cervical vertebrae.

Name: LONGISSIMUS CAPITUS et ATLANTIS

Origin: Thoracic vertebrae (T1 and T2 transverse processes) L. capitus. Cervical vertebrae (C1–C7 articular processes) L. atlantis. Insertion: Skull (mastoid processes) L. capitus. C1 (wing of atlas) L. atlantis.Nerve supply: Dorsal branches of the last six cervical.

Function: Singularly, to flex the head and neck laterally or rotate C1. Bilaterally, extend the head and neck.

Comments: These two fusiform muscles run parallel to each other and lie ventral between the Splenius and Semispinalis capitus. L. atlantis shares a ribbon like insertion with the Brachiocephalic and Splenius, and its tendon runs caudal from the ventral aspect of the wing of atlas. They often feel like two leather straps when palpated in a horse with a stiff or tired neck. L. Capitis's insertion passes lateral to the wing of atlas and this strap like tendon can be easily palpated at this point.

Name: BRACHIOCEPHALIC

Origin: 1. Cleidomastoid - Skull (mastoid process and nuchal crest), 2. Omotransversarius - C1 (wing of atlas) and cervical vertebrae (2nd , 3rd , 4 th and sometimes the 5 th transverse processes) Insertion: Humerus (deltoid tuberosity and crest) Nerve supply: Accessory, cervical and axillary.

Function: Singularly, laterally inclines the head to the same side of contraction and draws the limb forward when the head and neck are fixed OR extends the head and neck when the limb is fixed.

Comments: Primarily a superficial muscle, it passes over the Biceps brachii and Brachialis before inserting with the Superficial pectoral onto the Humerus. This muscle is incompletely divisible into 2 parts; the Cleidocephalicus (extends dorsally from the clavicular intersection to the head) and the Cleidobrachialis (the distal segment from the clavicular intersection to the humerus). The incomplete division that exists traverses the length of the neck and disappears just before the shoulder joint. Cranial to the shoulder, a deep tendinous structure of variable development can be felt; this is believed to be the vestige of the clavicle and is known as the Clavicular intersection.

This muscle may exhibit a great deal of strain in the athletic horse and especially at the poll, for it acts as an anchor to extend the forelimb. Of note is the Cutaneus coli that adheres to the lateral and ventral surface of the Brachiocephalic muscle via the Superficial fascia midway along the neck and originates of the Manubrium. Aside from its relationship and action with the Brachiocephalic, it can show significant strain in those horses that jump or work down hills, as it seems to potentially act as part of the Thoracic sling upon landing. A horse may exhibit pain upon palpation where it adheres to the Brachiocephalic muscle.

Name: MULTIFIDUS CERVICIS

Origin: Cervical vertebrae (C3 - C7 articular processes). Thoracic vertebrae (T1 articular process). Insertion: Cervical vertebrae (spinous and articular processes) Nerve supply: Dorsal branches of the last six cervical.

Function: Singularly, to flex the head and rotate the neck. Bilaterally, to extend the neck.

Comments: M. cervicus is a cybernetic muscle that works in two layers, the superficial layer passes from the articular processes of the cervical vertebra to the next vertebra’s spinous process. While the deeper counterpart travels ventrally from the articular process to the next vertebra’s articular process. This muscle group can often feel like the side of a large braid upon palpation, and they are vital in fixating the caudal cervical vertebrae in high level dressage.

Name: INTERTRANSERVERSAII CERVICIS

A cybernetic muscle that starts from C2 with multiple bundles arranged dorsally and ventrally. The dorsal bundles pass from transverse process to articular process and the ventral bundles extend between the adjacent transverse processes. These bundles occupy the lateral spaces between the vertebrae and tend to blend with the Multifidus cervicus and Longus colli.

Nerve supply: Cervical.

Function: Singularly, to flex the neck.

Comments: Strong tendinous fibers that aid in stability intersect the bundles, hence the feeling of tension when you palpate between the cervical transverse processes.

Name: STERNOMANDIBULAR

Origin: Manubrium Insertion: Mandible (caudal ramus) Nerve supply: Ventral branch of accessary.

Function: Singularly, inclines the head and neck towards the contracting muscle. Bilaterally, it flexes the head and neck.

Comments: A totally superficial muscle, the Sternomandibular has an aponeurotic attachment to the Brachiocephalic at its origin that may be covered by the parotid gland. From the origin, it remains connected to its counterpart along the ventral aspect of the neck until about midway. At which point it then separates and passes under the Parotid gland to insert. This muscle becomes hypertrophic in a horse that windsucks.

Name: OMOHYOID

Origin: Subscapular fascia close to the neck of the scapular dorsal to the shoulder joint. Insertion: Hyoid apparatus (basihyoid and lingual process) Nerve supply: Ventral branch of the 1 st cervical.

Function: To retract the hyoid and the root of the tongue.

Comments: A ribbon like muscle that is almost entirely fleshy. It passes as a complete entity ventral to the trachea in the throat, after which it bifurcates and passes medial to the sternomandibular. It then forms an intimate attachment to the ventral medial aspect of the Brachiocephalic before diverting away towards the horse’s midline underneath the Cranial deep pectoral. This shows an anatomic connection from the bit - tongue - neck – subscapular region.

Name: SCALENUS

Origin: Sternum rib (cranial and lateral border) Insertion: The dorsal portion (transverse process of C7). The ventral portion (transverse processes of C6, C5 and C4) Nerve supply: Ventral branches of the cervical.

Function: Singularly, to incline the neck laterally. Bilaterally, it flexes the neck.

Comments: Located medial to the Brachiocephalic at the base of the neck, the Scalenus's dorsal portion is composed of several fleshy bundles whilst the larger ventral portion is very fleshy. This muscle becomes loaded in self-carriage and especially, in those horses that are absent in the caudal portion of the Nuchal ligament laminae on C6 and C7.

Name: ILIOCOSTALIS CERVICUS

The cervical portion is a continuation of the iliocostalis muscle from the thoracic and lumborum. It has 3 or 4 bundles attaching to the last 3 or 4 transverse processes of the cervical vertebrae. Nerve supply: Cervical.

Function: To laterally bend and extend the neck.

Comments: It sits dorsal to the scalenus muscle and lateral to the intertransversarii. Furthermore, the muscle fibers from the I. costalis blend with those of scalenus

Name: LONGUS COLLI

Origin: The thoracic vertebrae (vertebral bodies T1- T5 or T6). Cervical vertebrae (C2-C7 ventral transverse processes). Insertion: Cervical vertebrae (vertebral bodies, the ventral tubercle of the atlas and the transverse processes of the last two cervical vertebrae.Nerve supply: Ventral branches of the spinal nerves and 3 rd cervical.

Function: To flex the neck and fixate, rotate and stabilize the cervical vertebrae.

Comments: Known as a cybernetic muscle, the L. colli covers the entire ventral surface of the cervical column. The strongest portion being the tendinous bundles that insert into the last two cervical vertebrae from the thoracic vertebral bodies. It may miss an insertion on the caudal cervical vertebrae and especially in Thoroughbreds and their derivatives where a C6 and or C6 and C7 congenital malformation exists.

CHEST / SHOULDER

Name: SERRATUS VENTRALIS CERVICUS

Origin: Cervical vertebrae (C3-C7 transverse processes) Insertion: Scapula and cartilage (dorsal medial surface) Nerve supply: 5 th to 8 th cervical and long thoracic.

Function: Extends the neck and draws the dorsal aspect of the scapula cranial.

Comments: This muscle is thicker than its thoracic counterpart and almost entirely fleshy. Some aspects are accessed superficially, but for the most it lays underneath three other muscles, namely Trapezius cervicus, Brachiocephalic and the Cranial deep pectoral. It becomes quite pronounced and may even hypertrophy when there is a lower limb trauma and extension of the forelimb is diverted towards the trunk muscles.

Name: TRAPEZIUS

Origin: Two – Cervical: Nuchal ligament. Thoracic: Supraspinous ligament from T3-T10. Insertion: Spine of scapula. Nerve supply: Accessary and dorsal branches of the thoracic.

Function: The cervical part draws the scapula upward and cranial. The thoracic portion draws the scapula upward and caudal. Together they raise the shoulder.

Comments: The cervical portion of this muscle is decidedly thinner than its thoracic counterpart and is quite variable in shape, size and thickness. Furthermore, fibrous strands and stray muscle fibres exist on the superficial surface of the cervical portion that are difficult to define, and these can extend as far ventral as to the Brachiocephalic and in some horses, over it. The thoracic portion can become quite sensitive to ill-fitting saddles and especially in those horses fitted with a narrow gullet saddle.

Name: RHOMBOID

Origin: Two - Cervical portion: Nuchal ligament (funicular cord). Thoracic portion: Spinous processes of the 2nd -7 th Thoracic vertebrae. Insertion: The medial aspect of the cartilage of scapula dorsal to the Serratus ventralis muscles. Nerve supply: 6 th and 7 th cervical and the dorsal branches of the thoracic.

Function: Lifts the scapula and draws it forward. Assists in raising the neck when the limb is fixed.

Comments: There is no distinct separation between the cervical and thoracic portions dorsal to the spine of scapular. At its insertion, fibers intertwine with the Serratus Ventralis (cervical and thoracic). muscle. This muscle undergoes considerable strain when the horse is placed in an over flexed frame such as draw reins and especially when there are no regular intervals of release. It can also hypertrophy in the cervical portion when the horse has been lame in the hind end over a long period of time, this is due to the head acting as a counter lever when the horse moves.

Name: DELTOID
Origin: Cartilage and Spine of scapula, and the Infraspinatus via an aponeurosis attachment. Insertion: Humerus (deltoid tuberosity). Nerve supply: Axillary Function: To abduct the limb and flex the shoulder.

Comments: This muscle has two bellies, and the aponeurotic fibers connect to the Infraspinatus from the Deltoid. At this point, the two muscles are virtually one. These fibers extend as far dorsally as the cartilage of scapula. When a dressage horse advances up the levels, the Deltoid is highly activated for the purpose of lateral movement and shows significant change in tone and condition.

Name: SUPRASPINATUS
Origin: Scapula, cranial to the spine, the spine of scapular and cartilage. Insertion: Humerus (Greater & Lesser tubercles – cranial & medial respectively). Nerve supply: Suprascapular.

Function: To stabilize and extend the shoulder joint.

Comments: The muscle is covered by a strong aponeurosis and divides into two branches with tendinous cores before insertion. The medial branch acts as a medial collateral ligament of the shoulder joint. Frequently, a variable amount of atrophy occurs in this muscle in those horses that have received a cranial and or lateral trauma to the scapula and or compression or strain of the nerve.

Name: INFRASPINATUS

Origin: Infraspinous fossa, cartilage of scapula plus aponeurotic tendinous fibers into teres minor. Insertion: Two – humerus (convex area between the cranial and caudal tubercles of the greater tubercle and the caudal tubercle of the greater tubercle). This latter insertion also sends a tendinous extension distally to attach below the caudal tubercle. Nerve supply: Suprascapular

Function: To flex and stabilize the shoulder, assist in abduction, and to rotate laterally the forelimb.

Comments: A strong aponeurosis covers this muscle which assists those fibers arising from the Deltoid as part of its origin. As the spine of scapula distally regresses, the Infraspinatus and Supraspinatus muscles become intimately connected via a fascial septum. Atrophy of this muscle occurs under the same conditions that influence the Supraspinatus and accordingly the shoulder is destabilized in is action.

Name: TERES MINOR

Origin: Scapula – mid caudal region, infraspinous fossa and the caudal rim of the Glenoid Cavity. Insertion: Humerus - situated caudal to the greater tubercle of the humerus between the insertions of the Infraspinatus and Deltoid. Nerve supply: Axillary

Function: To flex the shoulder joint and abduct the arm whilst also assisting in lateral rotation.

Comments: A flat triangular muscle that has fibers extending into the Infraspinatus and Triceps. The fibers originating from the scapula are arranged in bundles. The short deep part of the muscle lies intimately caudal to the joint capsule of the shoulder. When a trauma has compromised the lower limb, this muscle (in most cases) activates and can become significantly strained and sore to palpate.

Name: TRICEPS

Origin: Three - Long head: Scapular (caudal border). Lateral head: Humerus (dorsal deltoid tuberosity). Medial Head: Humerus (mid, medial and dorsal). Insertion: Ulna (olecranon tubercle). Nerve supply: Radial.

Function: The long head flexes the shoulder joint, whilst in conjunction with its lateral and medial counterparts extends the elbow.

Comments: The largest and more powerful long head is the primary flexor of the shoulder. The smaller medial head assists its stronger lateral counterpart in extending the elbow joint. As the major flexor of the shoulder, this muscle dramatically changes in those horses that jump. The lateral head hypertrophy and becomes tender upon palpation when the elbow joint is compromised, which accounts for 100% of ridden and driven horses.

Name: ANCONEUS

Origin: Humerus (dorsal distal aspect). Insertion: Ulna (olecranon tubercle). Nerve supply: Radial.

Function: To extend the elbow joint and raising the joint capsule.

Comments: The deeper fibers of this muscle consort with the joint capsule of the elbow. This helps in preventing the before mentioned capsule from being pinched during extension.

Name: TENSOR FASCIA ANTEBRACHII

Origin: Scapula (caudal border) and Latissimus dorsi tendon. Insertion: Ulna (olecranon tubercle) and medial deep forelimb fascia. Nerve supply: Radial

Function: Extends the elbow joint and due to its attachments, must aid in shoulder flexion.

Comments: This muscle blends with the origin of the long head of the triceps and can be palpated along its caudal edge before insertion, where it often feels like a tight band of tissue behind the long head of the Triceps. Furthermore, the length of the caudal aspect varies per horse in height and thickness and ironically, the muscle shape itself mimics in appearance the Superficial gluteal in the hindquarter. This formula of similarity between muscle shapes and sizes appears in several of the major muscles that influence powerful actions.

Name: TERES MAJOR

Origin: Scapula (caudal border) Insertion: Humerus (tere major tuberosity - mid medial aspect). Nerve supply: Axillary

Function: It flexes the shoulder joint and adducts the humerus.

Comments: Its origin blends with the Tensor fascae antebrachii, whilst its insertion fuses with the Latisimus dorsi onto the humerus.

Name: SUBSCAPULARIS

Origin: Scapular (mid – distal medial surface). Insertion: Humerus (lesser tubercle caudal to the medial insertion of Supraspinatis). Nerve supply: Subscapular, cranial pectoral and axillary.

Function: To fix the shoulder joint medially and adduct the humerus.

Comments: This muscle contains a significant amount of tendinous tissue. As it passes the shoulder joint medially, fibres adhere to the joint capsule and act in conjunction with the Supraspinatus to act as a medial collateral ligament.

Name: CORACOBRACHIALIS

Origin: Scapula (coracoid process) Insertion: Humerus (above teres major tuberosity and the mid, medial cranial aspect). Nerve supply: Musculocutaneous

Function: It flexes the shoulder joint and adducts the humerus.

Comments: Although comparatively small, its fusiform belly arises from a long narrow ribbon like tendon that divides into two portions. Their extensive insertion into the humerus is near the common insertion of the Teres major and the Latissimus dorsi muscles.

Name: BRACHIALIS

Origin: Humerus (dorsal proximal aspect). Insertion: Radius (proximal medial aspect). Nerve supply: Musculocutaneous and frequently the radial.

Function: To flex the elbow joint.

Comments: It has an unusual path in that it passes dorso-lateral over the humerus, before crossing over the Biceps brachii at an oblique angle and then inserting below it on the radius.

Name: CRANIAL DEEP PECTORAL

Origin: Sternum and the cartilages of the first four ribs. Insertion: Supraspinatus aponeurosis and the fascia of the scapular. Nerve supply: Brachial

Function: To adduct the foreleg and draw it backwards. It also brings the trunk forward when the limb is fixed.

Comments: Travelling along the cranial edge of the scapula, it is mostly deemed fleshy. Its pointed insertion acts upon the scapula by drawing it downward towards the sternum. Very effective in jumpers and dressage horses for extension and is quite variable in size from one horse to the next. The CDP moves laterally over the scapula as the Therapist's hands pass underneath it.

Name: BICEPS BRACHII

Origin: Scapula (Supraglenoid tubercle) Insertion: Radius (Radial tuberosity). Medial collateral ligament of the elbow joint. Forearm fascia and tendon of the Extensor carpi radialis. Nerve supply: Musculocutaneous

Function: Flex the elbow joint and to fix the shoulder and elbow when standing.

Comments: Its thick tendinous and partially cartilaginous origin, incompletely divides in two as it passes cranially over the intertubercles of the humerus, after which it becomes primarily fleshy. This muscle becomes prominent with large movements involving extension of the forelimb. For example: racing and dressage. Important note: lacertus fibrosis travels longitudinally through the B. brachii before departing medially and entering the Extensor carpi radialis muscle thus becoming part of the stay apparatus. It palpates as a tense tendon like structure between the 2 muscles.

Name: SUPERFICIAL / ASCENDING PECTORAL

Origin: Manubrium Insertion: Humerus (deltoid tuberosity and the crest) Nerve supply: Musculocutaneous

Function: To adduct and advance the forelimb.

Comments: A short thick muscle that is easily seen when viewing the chest from a cranial perspective. Its insertion closely blends with that of the Brachiocephalic and the omobrachial fascia. This muscle often displays front-on trauma such as kicks and running into fence posts.

Name: TRANSVERSE PECTORAL

Origin: Sternum (from rib 1 – rib 6). Insertion: Humerus (medial aspect beside the S. pectoral and the fascia of the forearm). Nerve supply: Brachial and median.

Function: To adduct the foreleg.

Comments: A wide muscle at the sternum that inserts into the humerus with a 2.5cm wide attachment. The muscle has a high percentage of fibrous tissue that fuses at the sternum to its left or right counterpart and lies proximal to the S. pectoral in the cranial aspect. The girth can often influence the caudal aspect of this muscle and should always be checked for injury in girthy horses. Some stallions when dismounting a mare can tear this muscle if the forelimb gets hung up.

Name: POSTERIOR PECTORAL

Origin: Sternum, Xiphoid cartilage, Costal cartilages of ribs 4-9 and the abdominal tunic. Insertion: Humerus – lesser tubercle and the tendon of the Coracobrachialis. Nerve supply: Brachial, pectoral, and musculocutaneous

Function: Identical to the Cranial deep pectoral.

Comments: The largest pectoral in the group, the P. pectoral is mostly fleshy and finishes in a triangular shape along the abdominal tunic. Also known as either the; descending, ascending or deep pectoral in varying anatomic text. This muscle is influenced by girth pressure and should be checked in girthy horses. Can be traumatized in front from injuries such kicks and running into fence posts. Its insertion is significantly smaller than its origin.

THE FORELIMB

Name: EXTENSOR CARPI RADIALIS

Origin: 3 - Humerus (lateral epicondyloid crest). Coronoid fossa. Deep fascia of the arm in common with the Common digital extensor. Insertion: 3rd metacarpal (metacarpal tuberosity) Nerve supply: Radial

Function: To flex the elbow, fix the carpel joint and extend it.

Comments: Lying on the dorsal surface of the radius, this muscle is the largest extensor of its kind in the forelimb and is bipennate structure. Running through the ECR is the Lacertus fibrosus having originated from the Supraglenoid tubercle and traversing through the B. brachii it enters the ECR at the medial proximal aspect. The ECR is subject to frontal traumas e.g. kicks and jumps etc.

Name: COMMON DIGITAL EXTENSOR

Origin: 3 - Humerus (coronoid fossa). Radius (lateral proximal tuberosity). Ulna (lateral aspect). Insertion: 3 - 3 rd Phalanx (extensor process). 1 st and 2 nd Phalanges (dorsal proximal aspect). Nerve supply: Radial

Function: To flex the elbow and extend the forelimb.

Comments: Smaller than its cranial counterpart, the CDE is a bipennate muscle with a fusiform belly. However, the three origins appear to give rise to the 3 insertions although difficult to isolate. It also suffers from similar front on traumas as the ECR and when palpating the CDE tendon, it should move freely over the 3 rd metacarpal. Upon dissect it can have a secondary and much smaller tendon that can either originate from the CDE or Lateral digital extensor.

Name: LATERAL DIGITAL EXTENSOR

Origin: 3 – Radius (lateral proximal tuberosity). Ulna (lateral body) and the lateral collateral ligament of the elbow joint. Insertion: 1 st Phalanx (lateral to the CDE insertion). Nerve supply: Radial

Function: To extend the lower forelimb.

Comments: A unipennate muscle with a thin fusiform belly, it palpates lateral to the CDE, although on the distal 3rd metacarpal it runs parallel. It can appear to have a secondary tendon and this is due to either the addition of the accessory metacarpal ligament or a lateral addition from the CDE, hence it is larger in size along the 3rd metacarpal than when it traverses over the lateral knee.

Name: ABDUCTOR POLICUS LONGUS DIGITI

Origin: Radius (lateral mid shaft) Insertion: 2nd metacarpal (proximal tubercle) Nerve supply: Radial

Function: To extend the knee (carpal joint)

Comments: Ironically, a small bipennate muscle with a flat belly origin that lies underneath the CDE and LDE. Its distal tendon passes over the top of the ECR, dorsal to the carpus. I suspect this helps to lock down the tendon in flexion but can be severely traumatized through front end traumas.

Name: FLEXOR CARPI RADIALIS

Origin: Humerus (medial epicondyle) Insertion: 2nd metacarpal (proximal tubercle) Nerve supply: Median Function: To extend the elbow and flex the knee.

Comments: The FCR has a flattened fusiform belly with a short tendon at the origin. It may feel like a tight ribbon or band on the medial aspect behind the radius.

Name: FLEXOR CARPI ULNARIS

Origin: Humerus (medial epicondyle caudal to the FCR). Olecranon (medial and caudal border). Insertion: Accessory carpal (proximal) Nerve supply: Ulna

Function: Extend the elbow and flex the knee.

Comments: The humeral head is the larger, whilst the ulna head is small and thin. They join just proximal to the mid region of the medial forearm. It can feel like a tight band medial to the limb.

Name: ULNARIS LATERALIS

Origin: Humerus (lateral epicondyle – lateral to the lateral collateral ligament) Insertion: Accessary carpal (lateral proximal border) and the proximal tubercle 4th Metacarpal.
Nerve supply: Ulna

Function: Extend the elbow and flex the knee.

Comments: Substantial tendinous tissue intersects this muscle and as a result it may palpate firm but beware as it may tighten to the extent where it influences the posture of a horse which can lead to it being over at the knee, especially in foals.

Name: SUPERFICIAL DIGITAL FLEXOR

Origin: Humerus (medial epicondyle). Radius (mid medial border).

Insertion: 1st Phalanx (distal extremity medial and lateral.). 2nd Phalanx (proximal extremity medial and lateral). Both caudal / palmar to the collateral ligaments. Nerve supply: Ulna

Function: Extend the elbow and flex the lower limb.

Comments: The humeral head is fleshier whilst the radial head has a strong fibrous band known as the superior check or accessary ligament. The SDF lies medial to the U. lateralis. The belly of the muscle is multi-pennate and when it contracts, the fetlock of the horse straightens. This can be seen in young horses and can be referred to as a Developmental Orthopaedic Disease.

Name: DEEP DIGITAL FLEXOR

Origin: 4 - Humerus (medial epicondyle). Olecranon (lateral - mid surface). Radius (mid caudal surface). Ulna (small mid caudal surface). Insertion: 3rd Phalanx (semi lunar line and the adjacent surfaces). Nerve supply: Median and ulna.

Function: Extend the elbow and flex the lower limb.

Comments: The humeral head is the largest of all the DDF origins and is marked by tendinous insertions. A strong fibrous band joins the tendon distal to the mid region of the 3rd metacarpal (inferior check ligament). It originates from the entire width of the distal row of carpal bones. When the DDF contracts the heel of the hoof begins to rise and the hoof may contract as a result. This can be seen in young horses and can be referred to as a Developmental Orthopedic Disease.

SPECIAL NOTE: Palpation of the DDFT and SDFT can also be achieved by accessing the medial epicondyle of the distal humerus.

BACK, BARREL & BELLY

Important Structures Abdominal tunic – is an elastic sheet that assists the muscles in supporting the weight of the organs. Linea alba – is a median fibrous raphe extending from the xiphoid cartilage to the prepubic tendon. It is primarily the junction of the abdominal muscles.

Prepubic tendon – is located on the dorsal cranial aspect of the pubis and gives rise to multiple muscle attachments associated with the abdomen and hind limb.

Diaphragm – a broad unpaired muscle that attaches to the xiphoid cartilage, costal cartilages 8^{th} – 10^{th} rib and thereafter the ribs in an ascending formation to the second last rib.

Name: RECTUS ABDOMINIS
Origin: Outer surface of the sternum; 4^{th} or 5^{th} - 9^{th} costal cartilages of the ribs. Insertion: The pubis of the hip via the prepubic tendon. Nerve supply: Intercostal, costoabdominal and lumbar.

Function: To flex the spine from the thoracic to sacrum and assist the obliques of the abdomen.

Comments: This muscle covers the cartilages of ribs 9-14 being broadest at this point. It unites with its other side counterpart by a median fibrous band known as the linea alba. Bands of fibrous tissue known as tendinous intersections run transversely across the muscle giving it strength, but also helps to keep the fibers from separating.

Name: EXTERNAL OBLIQUE
Origin: Two - the lateral surfaces of the ribs from the 4th and the thoracolumbar fascia. Insertion: The linea alba, prebubic tendon and the pubis of the hip. Tuber coxae, ilium and the medial femoral fascia Nerve supply: Intercostal, costoabdominal and lumbar.

Function: Acting together both muscles compress the abdominal viscera, which aids in defecation, urination, parturition, and expiration, they also flex the spine. Separately, they flex the trunk to the same side as the muscle laterally.

Comments: It attaches to the linea alba and has an extensive aponeurosis sheet that blends its fibers with those of the Rectus abdominis and Internal oblique, whilst the muscle fibers in the dorsal aspect can blend with the Serratus Ventralis thoracis. Furthermore, these fibers can split longitudinally, possibly due to a trauma such as a kick or disruption from spurs.

Name: INTERNAL OBLIQUE

Origin: Tuber coxae and the inguinal ligament.Insertion: The cartilages of the last four or five ribs, the linea alba and the prepubic tendon. Nerve supply: Intercostal, costoabdominal and lumbar. Function: To assist the External oblique.

Comments: Like its external counterpart in structure, the aponeurosis of each side blend together to form the ventral part of the Rectus abdominis. This then becomes progressively thinner as the muscle extends from the xiphoid cartilage to the pubis. It can become hypertonic when aiding the pelvis through engagement or in a support posture for lameness.

Name: TRANSVERSE ABDOMINAL

Origin: 2 – The thoracolumbar fascia to the transverse processes of the lumbar vertebrae. The cartilage of the last twelve to thirteen ribs integrating with fibers from the diaphragm. Insertion: The xiphoid cartilage and the linea alba. Nerve supply: Intercostal, costoabdominal and lumbar.

Function: Like the External and Internal oblique muscles.

Comments: The muscle is thickest along its cartilage attachments and thins out greatly towards its aponeurosis and lumbar region. It lines the dorsal aspect of the Rectus abdominis.

Name: CREMASTER

Origin: Cranial to the origin of Sartorius on the iliacal fascia. Insertion: The vaginal tunic. Nerve supply: Genitofemoral nerve.

Function: To raise the vaginal tunic and testicle.

Comments: This muscle is cut to remove the testicles when the horse is gelded.

Name: RETRACTOR COSTAE

Origin: First three or four transverse processes of the lumbar vertebrae via the lumbar fascia. Insertion: The caudal border of the last rib. Nerve supply: Lumbar Function: To retract the last rib.

Comments: This muscle has been referred to in some text as a part of the Internal oblique. Its fibers are more tendinous in nature than muscular. It can also be larger or smaller according to the lumbar attachment or at times in two distinct sections giving rise to 2 muscles as opposed to one.

Name: LATISSIMUS DORSI Origin: The dorsal spines of the thoracic and lumbar vertebrae via the Thoracolumbar fascia. Insertion: Humerus (teres major tuberosity – mid medial aspect).

Nerve supply: Thoracodorsal Function: Flexes the shoulder. When acting together, if limbs are advanced draws the trunk forward. Comments: The muscle fibres start at the insertion and have virtually disappeared by the shelf of ribs, thereafter it is primarily an aponeurosis sheet. This aponeurosis attaches to the Serratus dorsalis caudalis muscle and the Thoracolumbar fascia. Influenced by saddle fit and girth, it can become quite reactive upon palpation. Its cranial aspect passes over the dorso caudal scapula and cartilage.

Name: SERRATUS VENTRALIS THORACIS

Origin: The lateral surfaces of the first 8 or 9 ribs. Insertion: The caudal triangular area on the costal (medial) surface of the scapula. Nerve supply: 5th - 8th cervical nerves and long thoracic nerve.

Function: The two muscles (SVT & SVC) form an elastic support that suspends the trunk to the scapula. Contracting together they raise the scapula, but singularly, the weight is shifted to the thoracic limb on the side that the muscle is acting. It may also act as a muscle of forced inspiration.

Comments: Highly tendinous in structure on its superficial surface, it aids in sustaining the weight of the horse when the muscle bulk relaxes. It can be intimately linked to the External oblique and be quite tender in some girthy horses.

Name: LONGISSIUMUS DORSI

Origin: Ilium of pelvis (ventral: sacral tuberosity, ilium and crest), first 3 sacral spines, lumbar and thoracic dorsal spines and supraspinous ligament. Insertion: Transverse processes of the lumbar, thoracic, and last four cervical vertebrae. The articular processes of the lumbar, spinous processes of the last four cervical vertebrae and the lateral surfaces of the ribs (except the first rib). Nerve supply: Thoracic and lumbar.

Function: Extends the back, lumbar and neck. Singularly, it flexes the spine laterally. May also assist in expiration due to its costal attachment.

Comments: The longest muscle in the body with an extensive and complex system of muscle fibers. Divided into 3 major components (cervicus, thoracis and lumborum) it consorts closely with the Spinalis dorsi muscle. Pain in the L. dorsi has often been associated with saddle fit issues and rider asymmetry / bad riding, furthermore, inflammation has been seen where the Middle gluteal tongue attaches to the L. dorsi. This attachment usually corresponds somewhere between T15 to L1. Each horse is different in the length of the tongue, but it is always crucial to ascertain its attachment point into the L. dorsi and especially when the sacroiliac joint is strained. This is due to the origin of the L. dorsi the ilia and its position altering due to the torn ventral interosseous ligaments releasing the tension on the ilum and thus subluxing the SI joint as a direct result.

Name: SPINALIS DORSI

Origin: Spinous processes T1-T6 and lumbar, T13-T18 thoracic vertebrae. Insertion: Spinous processes of the last 4 or 5 cervical vertebrae. Nerve supply: Thoracic and lumbar.

Function: Assists the Longissimus dorsi to extend the lumbar, thoracic and neck.

Comments: Frequently regarded as part of the Longissimus dorsi or its extension, the S. dorsi muscle extends into the wither region of the horse and can be influence by saddles with high gullets.

Name: SERRATUS DORSALIS CAUDALIS

Origin: Thoracolumbar fascia Insertion: The caudal aspect of the last eight to nine ribs. Nerve supply: Thoracic

Function: To assist in expiration.

Comments: Thin triangular muscles running in a cranial direction drawing the ribs caudal.

Name: SERRATUS DORSALIS CRANIALIS

Origin: Thoracolumbar fascia and the dorsoscapular ligament. Insertion: The lateral surfaces of the 5th / 6th to the 11th / 12th ribs. Nerve supply: Thoracic

Function: To assist in inspiration by drawing the ribs in a lateral cranial direction.

Comments: A deeper muscle than its caudal version, but still located laterally along the ribs.

Name: ILIOCOSTALIS

Origin: 2 - Thoracolumbar fascia and from the cranial borders from rib 4-18. Insertion: Caudal borders of the ribs close to the shelf of ribs, the transverse process of the 7th cervical vertebra and lumbar vertebrae.Nerve supply: Thoracic

Function: Assists in expiration and bilaterally, extends the spine. Singularly, it inclines the spine in a lateral direction.

Comments: In the lumbar region the muscle may vary and insert onto the ilium and or the lumbar transverse processes. Often referred to as Iliocostalis thoracis or lumborum this segmented muscle extends across the ribs on the latero ventral aspect of the Longissimus dorsi.

Name: LEVATORES COSTARUM

Origin: The transverse processes of the thoracic vertebrae. Insertion: The cranial border of the ribs. Nerve supply: Intercostal

Function: Move the ribs cranial to assist in inspiration. Flex the spine laterally.

Comments: The first rib is excluded from attachment, after which, it forms a series of small muscles thereafter. Furthermore, not all behave as indicated, instead, some choose to pass over a rib and insert into the next.

Name: MULTIFIDI

Origin: Three - Lateral aspect of the sacrum. Articular processes of the lumbar vertebrae. Transverse processes of the thoracic vertebrae. Insertion: Spinous processes from C7 to S2. Nerve supply: Thoracic and lumbar.

Function: Singularly, flexes the spine laterally and when acting together it, extends the spine.

Comments: The muscle bundles lie close to the vertebral column and pass over several vertebrae before insertion. As the series of bundles progress towards the wither region of the thoracic vertebrae, their insertion is less dorsal on the spinous process and venture more towards the mid region at a horizontal angle.

Name: EXTERNAL INTERCOSTALS

Origin: Caudal borders of the ribs. Insertion: Cranial borders of the ribs. Nerve supply: Intercostal

Function: To rotate the ribs outward and cranial, thus aiding in inspiration.

Comments: Mixed with tendinous fibers this muscle consorts closely with the Levatores costarum, before running transversely and reaching the costal cartilages, where it ceases.

Name: INTERNAL INTERCOSTALS

Origin: Cranial borders of the ribs. Insertion: Caudal borders of the ribs. Nerve supply: Intercostal

Function: To draw the ribs caudal and assist in expiration.

Comments: A smaller number of tendinous fibers exist in this muscle as opposed to its external counterpart. It also extends into the intercostal cartilage spaces unlike the EI.

SUBLUMBAR

Name: PSOAS MAJOR

Origin: The last two ribs, lumbar transverse processes and the lumbar vertebral bodies. Insertion: Lesser trochanter of the femur in common with the tendon of the Iliacus. Nerve supply: Lumbar and femoral.

Function: To flex the hip joint and rotate the femur laterally, it also consorts with the Iliacus.

Comments: In the sub lumbar, Psoas major extends beyond the lumbar transverse processes in some horses before entering the grove of the Iliacus where it becomes known as the Iliopsoas.

Name: PSOAS MINOR

Origin: Vertebral body of the last three thoracic and ribs, and L1 – L5. Insertion: Psoas tubercle of the Ilium. Nerve supply: Lumbar

Function: Singularly to incline the pelvis laterally and jointly to flex the pelvis. Comments: It lies along the median plane of the horse, fusiform in appearance and pennate.

Name: QUADRATUS LUMBARUM

Origin: Last two ribs and the lumbar transverse processes. Insertion: Wing of sacrum and the ventral sacro-iliac ligament. Nerve supply: Lumbar

Function: When acting singularly, it flexes the lumbar region laterally. In action together, it fixes the last two ribs and the lumbar vertebrae, which assists in the action of the diaphragm.

Comments: It is considerably underdeveloped in comparison to other vertebrates. It is pennate, thin, partly fleshy, and tendinous, it lies latero ventral to the transverse processes of the lumbar vertebrae.

HINDQUARTER

Muscles of the tail: Coccygeus, Sacrocaudalis medialis / lateralis / ventralis (medialis and lateralis).

Muscles of the anus: In a male horse: Levator ani, Sphincter ani, Retrococcygeus, Retractor penis, Bulbospongiosis, Ischiocavernosis and Internal pudendal.

Name: SUPERFICIAL GLUTEAL

Origin: Two - Tuber coxae in partial partnership with the tensor fasciae latae and the gluteal fascia in vicinity of the sacral tuberosity. Insertion: 3 rd trochanter. Nerve supply: Caudal and cranial gluteal

Function: Adducts the limb, flexes the hip joint whilst placing tension on the gluteal fascia. Comments: As the name suggests, this is the most superficial of the four gluteal muscles. It consists of two fleshy parts with its dorsal aspect consorting with the Biceps Femoris.

Name: MIDDLE GLUTEAL

Origin: Ilium, aponeurotic covering of the Longissimus dorsi, gluteal fascia and the long and short dorsal sacro-iliac ligaments. Insertion: The great trochanter of the femur (summit).

Nerve supply: Cranial gluteal

Function: To extend and abduct the hip, but when the femur is fixed it raises the trunk.

Comments: The thickest and strongest of the 4 gluteals it has a deeper section that will be dealt with as a separate muscle called "Accessary gluteal". There are several tendinous sheets passing through the M. gluteal, which adds to its strength. This muscle forms the bulk and contour of the rump to the lumbar as it tapers dorsally towards and over the last 1-4 ribs. This is referred to as the "gluteal tongue" and often atrophies when the sacroiliac subluxes. The tongue tapers to <1mm in its attachment into the L. dorsi.

Name: ACCESSARY GLUTEAL

Origin: Ilium (dorsal mid to lateral). Insertion: Lateral aspect of the Great Trochanter (Femur)
Nerve supply: Gluteal

Function: Emphasis is placed on assisting the Middle gluteal, however the Greater trochanter rotates dorso cranial upon contraction and this aids abduction of the femur.

Comments: Regarded as a deeper portion of the Middle gluteal, this muscle may or may not be found in other text or even named as "Deep" and this is primarily due to the indecision between anatomists. However, research performed by this author concurs with the Accessary gluteal being an individual entity separate to the Middle gluteal in function, but certainly assisting it in function. For example, the leading hind limb at the gallop alters the bony insertion of the A. gluteal in racehorses and this is emphasized by turning at speed.

Name: DEEP GLUTEAL

Origin: Ilium and the sacro-sciatic ligament. Insertion: Convexity of the greater trochanter (femur). Nerve supply: Cranial gluteal

Function: To abduct the limb while rotating medially.

Comments: A short, strong thick muscle with multiple tendinous fibers running transversely along its length. Some of these fibers connect to the cranial aspect of the capsule that covers the hip joint. The D. gluteal also alters at its insertion in a similar fashion to the A. gluteal in racehorses.

Name: PIRIFORMIS

Origin: Caudal Sacrum Insertion: Inter- trochanteric fossa of the Femur.

Function: To assist the Middle gluteal and rotate the femur laterally.

Comments: A little known muscle that blends with the M. gluteal at its origin. It lies along the posterior border and is often overlooked in text as relevant, but its size indicates otherwise.

Name: TENSOR FASCIAE LATAE

Origin: Tuber coxae in partial partnership with the Superficial gluteal. Insertion: Fascia lata, Crural fascia of the leg, patella, lateral patellar ligament, and the tibia crest. Nerve supply: Cranial gluteal Function: Flex the hip joint and extend the stifle while tensing the fascia latae.

Comments: The insertions into the patella, lateral patellar ligament and the tibia crest are regarded as indirect due to respective fascial tissue connections. The TFL has 2 muscle bellies close the Tubercoxae with the longer belly closer to the flank. The fascia under dissection wraps around to the medial aspect and is quite hard to separate.

Name: BICEPS FEMORIS

Origin: 3rd , 4 th and 5 th sacral dorsal spines. 1 st caudal vertebra, gluteal fascia, sacro-iliac ligament and sacro tuberous ligament. The 2 nd and primary origin arises from the Ischiatic tuberosity. Insertion: Patella, lateral patellar ligament, femur, tibia crest, fascia latae and calcaneus. Nerve supply: Caudal gluteal, ischiatic and fibular.

Function: Multi-functional! It extends and abducts the hind limb. Extends the hip, stifle, and hock, and FLEXES the stifle joint, making this muscle very complex in its action due to the numerous points of attachment.

Comments: This muscle is one of a group of three known as "the Hamstrings". Rightfully regarded as the most powerful, its other two well-known partners are the Semitendinosus and Semimembranosus. Beginning with two heads, it quickly forms a single mass that soon divides into three parts. These quickly become visible in their division as it descends the leg. However, its dorsal origin being so intimately connected to the Superficial gluteal has caused some confusion with other text. My research confers with its dorsal spinous origins and as such, remains clearly as a muscle separate to its superficial counterpart. The insertion into the femur has also created some controversy in that some texts don't refer to this insertion. The divisions as they descend towards their insertions can separate and upon palpation feel like holes within the structure. This is often seen in Grand Prix dressage horses and appears quite manageable without too much ado.

Name: SEMITENDINOSUS

Origin: 2 - Dorsal Spine of the SV5, transverse processes of the 1 st and 2 nd Ca V, tail fascia and the sacro sciatic ligament. The 2nd head springs from the Ischiatic tuberosity and is the primary origin. Insertion: Tibia crest, crural fascia (lateral hind limb) and the calcaneus. Nerve supply: Caudal gluteal and ischiatic.

Function: Extends the hip and hock joints while flexing the stifle.

Comments: Regarded as the 2nd strongest hamstring it lays between B. femoris and Semimembranosus. Its appearance from behind is that of a long strap and as such, is susceptible to distal "fibrotic myopathy" in performance horses. In addition, blunt traumas to the Ischiatic tuberosity, such as bumps during floating, can dislodge the Semitendinosus from its origin.

Name: SEMIMEMBRANOSUS

Origin: 2 - Sacro sciatic ligament, 1st and or 2nd Ca V, and the ventral to medial Ischiatic tuberosity as its primary origin. Insertion: Medial epicondyle of the femur, medial collateral ligament of the stifle, medial tibia with the adductor and the medial fascia. Nerve supply: Ischiatic

Function: Adducts the hind limb and extends the hip.

Comments: Like the Semitendinosus the main origin arises from the Ischiatic tuberosity and being the most medial of the hamstring group it is susceptible to sliding stops or skidding and therefore, “fibrotic myopathy”.

Name: RECTUS FEMORIS

Origin: Ilium of the pelvis cranial to the Deep gluteal. Insertion: Patella. Nerve supply: Femoral

Function: To flex the hip joint whilst extending the stifle joint.

Comments: The Rectus femoris is regarded as the third and middle member of the quadriceps. The other three members of this group are beginning with Vastus: lateralis, intermedius and medialis. It is the largest of the four quadriceps muscles, but I have seen it incorrectly referred to as the Vastus lateralis in several books.

Name: VASTUS LATERALIS

Origin: Lateral and cranial surface of the shaft of femur. Insertion: Patella in common with the Rectus femoris. Nerve supply: Femoral

Function: To extend the stifle joint.

Comments: Referred to as the second head of the quadriceps group, the Vastus lateralis is also the most lateral of the four. Notably wider through the belly and narrower at its origin and insertion, this muscle works in unison on the patella with the Rectus femoris.

Name: VASTUS INTERMEDIUS

Origin: Cranial surface of the shaft of femur. Insertion: Patella and femora-patella joint capsule. Nerve supply: Femoral

Function: To extend the stifle joint.

Comments: VI is extensively blended with the Vastus medialis (VM) and is regarded as the fourth in the quadriceps group. However, in many texts this muscle is frequently referred to as the VM and thought of as one with this same muscle rather than as an individual.

Name: VASTUS MEDIALIS

Origin: Medial surface of the shaft of femur. Insertion: Patella, patella cartilage, medial patellar ligament, and the Rectus femoris tendon.

Function: To extend the stifle joint.

Nerve supply: Femoral Comments: Regarded as the first in the quadriceps group, Vastus medialis closely blends its origin with the cranial border of the Vastus lateralis. Being the most medial of the four it lies in a similar position to its lateral counterpart and has a similar fiber direction.

Name: GRACILIS

Origin: Pelvic symphysis, Pubis and accessory ligament of the hip joint. Insertion: Medial patellar ligament, tibia and crural fascia. Nerve supply: Obturator

Function: To adduct the limb.

Comments: The most medial muscle in the horse's thigh. When viewed from the most posterior aspect of the horse this muscle appears to be large and fleshy.

Name: SARTORIUS

Origin: Iliac fascia and tendon of the psoas minor muscle Insertion: Tibia and medial patella ligament in common with the Gracilis. Nerve supply: Saphenous

Function: To adduct the limb and flex the hip joint.

Comments: A long narrow and comparatively thin muscle that extends from the sub lumbar region that follows the cranial border of the Gracilis. Stifle issues can influence Psaos minor and it has been seen that the horse’s lumbar will roach in direct correlation. I believe the connection may be between the insertions of the Sartorius acting on its Psaos minor origin creating a banded tension and it is this that leads to the roaching in affected horses.

Name: ADDUCTOR

Origin: Pubis, Ischium and the tendinous origin of the Gracilis.Insertion: Caudal aspect of the femur, medial epicondyle & medial collateral ligament of the stifle. Nerve supply: Obturator

Function: It adducts the hind limb and extends the hip joint. Rotates the femur medially.

Comments: Totally covered by the Gracilis, the Adductor has a fleshy body that can be divided into two muscles; the Adductor brevis and Adductor magnus. Now if that isn't confusing enough, sometimes a third short muscle appears in the Adductor and is known as the Adductor longus.

Name: PECTINEUS

Origin: Cranial border of the Pubis, prepubic tendon and the accessary femoral ligament. Insertion: Femur medial mid shaft. Nerve supply: Obturator

Function: To adduct the limb and flex the hip joint.

Comments: The accessary femoral ligament splits the origin of this muscle and virtually divides it into two unequal parts. A difficult muscle to palpate, especially in techy horses.

Name: GEMELLI

Origin: Lateral border of the Ischium near the Ishiatic caudal to the hip joint. Insertion: Femur (trochanteric fossa and crest) Nerve supply: Ischiatic

Function: It rotates the femur laterally.

Comments: The Gemelli has 2 divisions regarded as 1 st and 2 nd strata. Both insertions into the femur are near the two Obturator muscles - internus and externus.

Name: QUADRATUS FEMORIS

Origin: Ventral surface of the ischium. Insertion: Posterior surface of the femur near the Adductor. Nerve supply: Ischiatic

Function: Adducts the limb while extending the hip joint.

Comments: A narrow slender muscle, the Quadratus femoris appears triangular along its body. The parallel bundles of fibers are directed ventrally, cranially, and laterally as they pass obliquely beside the hip joint.

Name: CAPSULARIS (hindlimb)

Origin: Ilium close to the hip joint. Insertion: Cranial aspect of the Femur.

Function: Aids in hip flexion.

Comments: A reasonably short and innocuous muscle, the little known Capsularis has a round fleshy belly with flat tendons to both the origin and insertion.

Name: POPLITEUS

Origin: Lateral epicondyle of the femur. Insertion: Medial and caudal aspect of the tibia. Nerve supply: Tibial

Function: To flex the stifle joint and rotate the hind limb medially.

Comments: The origin of this muscle lies beneath the lateral collateral ligament of the stifle joint and therefore, must pass through the joint capsule before travelling obliquely to its insertion. Its thick triangular belly is made up of fibers that initially travel medially from the origin before changing direction and inclining towards its insertion.

Name: ILIACUS

Origin: Ventral surface of the ilium, ventral aspect of the sacro-iliac ligament, wing of sacrum and the tendon of the psoas minor.

Insertion: Lesser trochanter of the femur in common with the tendon of the Psoas major. Nerve supply: Lumbar and femoral.

Function: To flex the hip joint and rotate due to their individuality and origins.

Comments: On the ventral aspect of the ilium, the Iliacus combines with Psoas major to form the Iliopsoas muscles. In fact, this intensifies the function of the Psoas muscles on the femur. It is a deep muscle being sub ilium and palpation is therefore indirect.

Name: OBTURATOR EXTERNUS

Origin: Pubis and Ischium. Insertion: Trochanteric fossa of the femur. Nerve supply: Obturator

Function: To adduct the thigh and rotate it laterally.

Comments: Circulatory vessels and nerves perforate the origin, while the muscle belly displays coarse and loosely connected fibers.

Name: OBTURATOR INTERNUS

Origin: Two - Pubis and ischium as the first, the second, ilium and wing of sacrum. Insertion: The trochanteric fossa of the femur. Nerve supply: Ischiatic

Function: It rotates the femur laterally.

Comments: The iliac origin has been termed as a separate muscle known as the Piriformis. It contains a central tendon and has a pennate belly.

HINDLIMB

Name: TIBIALIS CRANIALIS

Origin: Lateral surface of the tibia and adjoining fibula. Insertion: 2nd - 3rd metatarsal and 1st and 2nd tarsal. Nerve supply: Peroneal

Function: It flexes the hock joint.

Comments: The second tendon passing over the cranial aspect of the hock to the 1st and 2nd tarsal and 2nd metacarpal is known as the Cunean tendon. You see this term mostly referred to in surgical text, but it has found its way out and can now be seen elsewhere. The fibers of TC are intimately connected to Peroneus tertius close to mid shaft of the tibia and stay this way until they divide into 2 tendons just dorsal to the tarsals.

Name: TIBIALIS CAUDALIS

Origin: Lateral condyle of the tibia and the fibula head. Insertion: Ties into the Deep digital flexor close to the distal tibia. Nerve supply: Tibial

Function: To flex the lower leg while extending the hock.

Comments: Regarded as part of the Deep digital flexor it lays at the back of the gaskin with a fleshy belly that gives rise to a flattened tendon that joins the DDF shortly before the end of the tibia.

Name: GASTROCNEMIUS

Origin: 2 - medial and lateral aspect of the distal femur either side of the supracondyloid fossa. Insertion: Calcaneus (point of hock). Nerve supply: Tibial

Function: To flex the stifle and extend the hock.

Comments: The heads from the origin quickly unite to form a common fleshy belly before tapering into the Calcanean tendon. This is a common tendon for 4 major muscles: Biceps femoris, Semitendinosus, Superficial digital flexor and the Gastrocnemius. Originating between the 2 heads is the Superficial digital flexor (also known as Plantaris).

Name: SOLEUS

Origin: Proximal Fibula Insertion: Gastrocnemius tendon. Nerve supply: Tibial

Function: To assist the Gastrocnemius

Comments: A narrow thin muscle, the Soleus lies on the lateral border of the Gastrocnemius as it descends the Gaskin region of the horse. Its action is virtually non-existent in the horse and can be easily missed when dissecting the horse, even to the extent where one must raise the question about its function, when in many cases it appears absent because visibility.

Name: PERONEUS TERTIUS

Origin: Lateral distal femur in common with the Long digital extensor. Insertion: 5 – Calcaneus, 3rd and 4th tarsal, 2nd and 3rd Metatarsal. Nerve supply: Peroneal

Function: It allows hock flexion when the stifle is fixed and prevents over extension of the hock joint.

Comments: This is an unusual muscle in that it is entirely tendinous in structure and as such, provides substantial support in protecting the hock from over extension.

Name: LONG DIGITAL EXTENSOR

Origin: Lateral distal femur in common with the Peroneus tertius. Insertion: 1-3 Phalanx.

Nerve supply: Peroneal

Function: Extend the limb, flex the hock, assist in fixing the stifle.

Comments: The long distal tendon of this muscle flattens along the 3rd metatarsal before meeting with fibers from the Lateral digital extensor tendon. It also resembles its thoracic limb counterpart the Common digital extensor tendon as it travels along the dorsal aspect of the 3rd metatarsal. This tendon should also be checked for similar issues as those found in its thoracic counterpart.

Name: LATERAL DIGITAL EXTENSOR

Origin: Fibula and its ligamentous attachments to the tibia. Insertion: The distal tendon of the Long extensor muscle. Nerve supply: Peroneal

Function: To assist the Long digital extensor muscle.

Comments: The muscle is pennate and fusiform with its tendon running the entire length of the muscle before passing laterally over the hock. Sometimes its insertion into the Long digital extensor does not occur and its inserts instead into the 1st phalanx like its corresponding forelimb counterpart.

Name: DEEP DIGITAL FLEXOR (HIND)

Origin: Multiple origins with three heads. 1. Tibialis posterior (also Tibialis caudalis) arises from the lateral aspect of the tibia and the fibula. 2. Flexor hallucis longus arises from the lateral aspect of the tibia, caudal to the fibula.3. Flexor digitorum longus arises from the lateral and caudal aspect of the tibia. Insertion: Collectively the 3rd Phalanx on its plantar surface. Nerve supply: Tibial

Function: To flex the lower leg while extending the hock.

Comments: Regarded as the deep flexor of the lower leg, its 3 muscles unit close to the hock to form a powerful common tendon. This tendon then passes medial to the calcaneus. The characteristics of each of the 3 muscles range from fleshy to tendinous, which provides for strength and stability. It is a much larger muscle to its thoracic counterpart.

Name: SUPERFICIAL DIGITAL FLEXOR

Origin: Caudal distal aspect of the femur in the Supracondyloid fossa.Insertion: 1st medial & lateral) distal phalanx; 2nd (medial & lateral) proximal phalanx after it unites with the Calcanean tendon proximal to the calcaneus and inserts via medial & lateral slippers. Nerve supply: Tibial

Function: To extend the hock and flex the lower leg. It also keeps the hock in a state of extension whilst the hip and stifle are also in an extended state.

Comments: The muscle is extremely tendinous in structure and chiefly relies upon other muscle groups to act upon the limb. This gives it incredible tensile strength as its distal tendon spirals around the Gastrocnemius tendon from a medial to dorsal aspect creating more of a mechanical effect in its action. As it passes over the Calcaneus, a medial and lateral attachment known as "slippers" insert before the tendon progresses distally. It is a much smaller muscle to its thoracic counterpart.

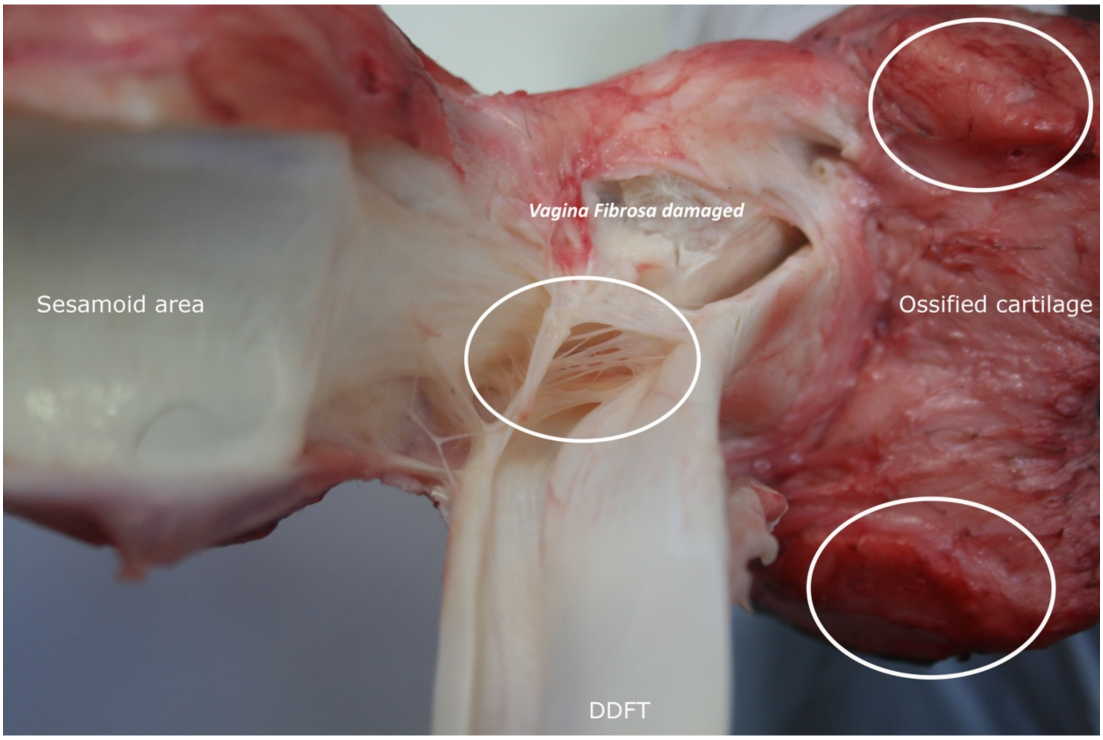
TENDONS & LIGAMENTS

Skeletal muscles are covered by fascia and rely on associated connective tissue to assist in function.

Tendons attach muscle to bone and sometimes to another muscle or cartilage. When a skeletal muscle contracts, it pulls on a tendon. Tendons assist in acting on the bone to bring it closer to the point of contraction and can articulate two or more bones depending on their site of attachment (May-Davis 2017). Tendons come in various shapes and have little elasticity. Notable exceptions are the Middle Gluteal Tongue, Cranial portion of Biceps Femoris and Lacertus fibrosis.

Furthermore, tendons are poorly supplied with blood and thus take a long time to heal or train.

Ligaments attach 'bone to bone' and in some cases 'tendon to bone'. Unlike tendons, they're usually flat. They're highly inelastic and are designed to stabilize the joints and prevent abnormal joint movement. For example: collateral ligaments. Exceptions are however, the Nuchal, Suspensory and Inferior/ Superior check ligaments.



Below: The Vagina Fibrosa is a 'check' ligament that rarely appears in any anatomy textbooks. It protects the Deep Digital Flexor Tendon from excessive movement. When it is torn or inflamed, the horse often gets problems in the fetlock area such as hypermobility or suspensory ligament desmites.

Both ligaments and tendons are accredited to have a certain recoil system upon movement that creates 'spring' in the horse's movement:

> *''Elastic structures, like tendons and ligaments, store energy when elongated. This energy is released when they return to their normal length''*
> - Meershoek en van den Bogert (1996)

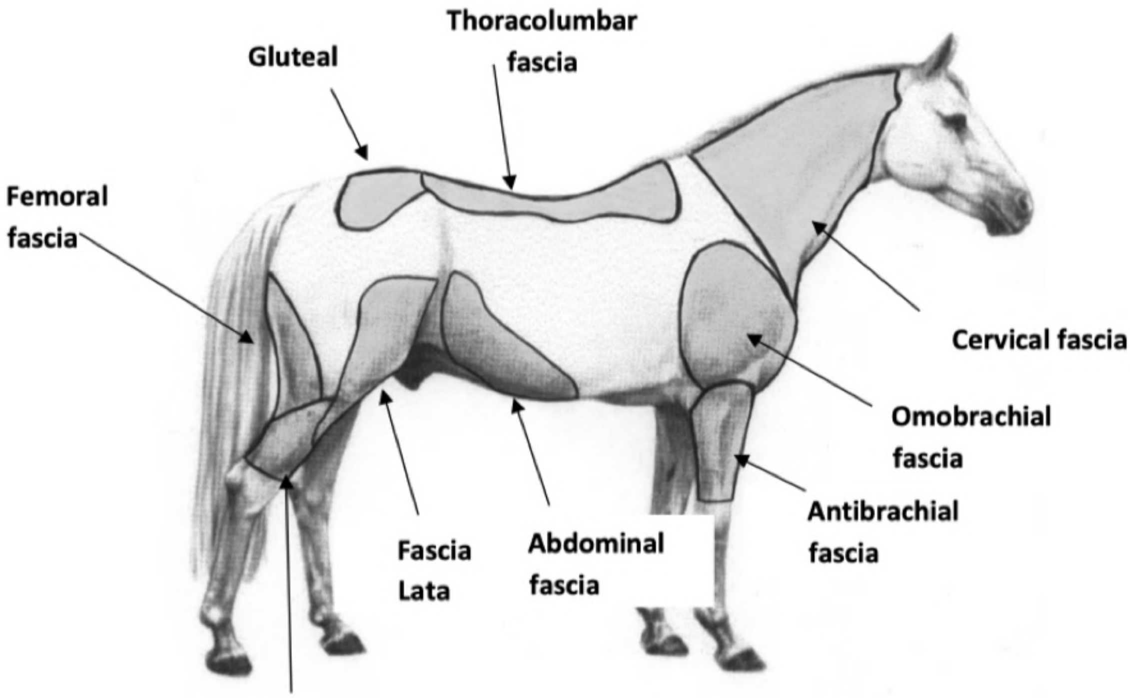
Although recoil is a phenomenon used widely in horse anatomy, it is actually very limited and discreet as most tendons and ligaments are not overly elastic and in fact quite rigid.

FASCIA

The definition of fascia, while many, sounds simpler than its function. In general, it is considered as a multidimensional dynamic and static web of collagenous based connective soft tissue that wraps around 'everything' in the body.

You may have also heard about the term 'myofascia'. All this means is muscle (myo-) and its surrounding web of connecting tissue (-fascia). Myofascia thus links muscular and non-muscular tissue. Through this relationship it influences muscle mechanics and is involved in energy distribution recoil and shock absorption as well as posture and biomechanics. When a practitioner is working on fascia, they most commonly try to loosen the connections between the muscles so that the horse can move (more) freely.

Located beneath the skin, fascia is primary composed of collagen and attaches, stabilizes, encloses, and separates muscles and other internal organs. By doing so it defines and influences the entire body.



Similarly, to ligaments, aponeuroses and tendons, fascia also contains closely packed bundles of collagen fibres oriented in a wavy pattern which is parallel to the direction of pull. Consequently, it is elastic in structure with enormous tensile strength and contractile properties. Since it can contract on its own, it can store and release elastic potential energy. However, in some cases it can also lead to muscles becoming stuck to other muscles and structures, therefore decreasing the ability of the muscles to contract and lengthen correctly.

In a normal state, fascia can appear as a gelatinous substance, but when damaged it can become rigid and form fibrotic bands. Fascial restrictions can have far reaching effects as nerves and blood vessels get compromised. Furthermore, it can also impede joint function.

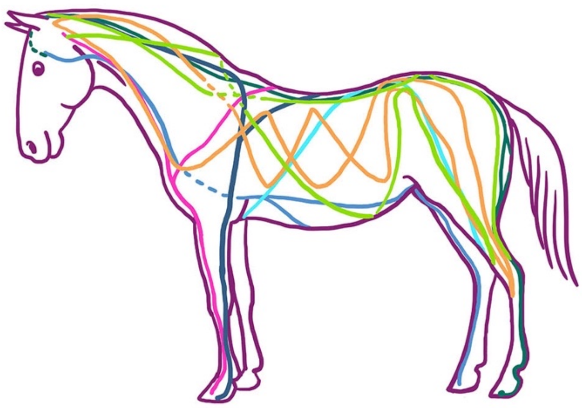
Fascia is also frequently innervated by sensory nerve endings and therefore plays a pivotal role in proprioception and posture. When pressured or stretched, it emits an electromagnetic signal and with its richly endowed nerve endings, it can produce a painful burning sensation when damaged resulting in neuropathic pain.

Although fascia can often not be discerned, there are roughly 3 common layers of fascia:

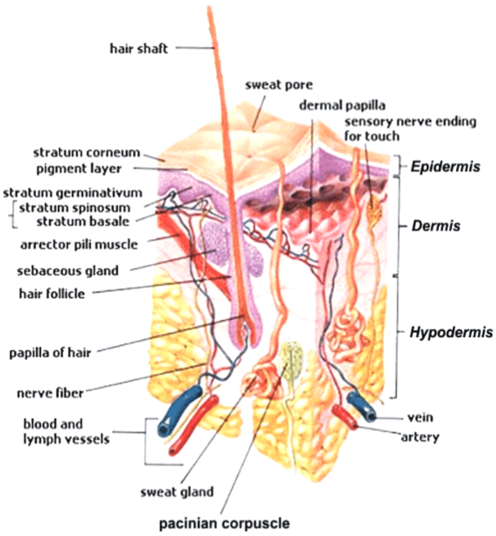
- **Superficial fascia →** A loose collagenous connective tissue directly under the skin. Example: Cutaneous fascia, Thoracolumbar fascia, and Gluteal fascia. Superficial fascia can interface with deep fascia, at which point it becomes tighter and more tensile in structure. Due to this connection, any trauma or restriction to the superficial fascia can influence the deeper musculature it encompasses.
- **Deep fascia →** A dense collagenous connective tissue below the superficial layer. It separates certain muscles or their structures and may provide (in part), an origin or insertion for that muscle. Example: The Superficial gluteal and the Tensor Fascia Latae originate from the Tubercoxae, however, they also originate in part from an intermuscular septum formed between these two muscles, which is deep fascia. Also, the duramater can be considered as a deep fascia as it is a dense fibrous tube surrounding the brain and spinal cord.
- **Subserous fascia →** Suspends the organs within their cavities and wraps them in connective tissue layers. Subserous fascia is less extensible than

superficial fascia. Due to its suspensory role of the organs, it needs to maintain its tone rather consistently. If it is too lax, it contributes to organ prolapse, yet if it is hypertonic, it restricts proper organ motility (Paoletti 2006).

In 2015, Danish researchers Vibeke, Sødring, Elbrønd and Rikke Mark Schultz published a paper on myofascial kinetic lines in horses. The outcomes of this research were accepted, and many diagrams of these lines have been published. However, in practice these lines are somewhat of a creative oversimplification of a complex reality.



SKIN



Hill, M.A. (2020, August 31) Embryology Skin structure cartoon.jpg. Retrieved from https://embryology.med.unsw.edu.au/embryology/index.php/File:Skin_structure_cartoon.jpg

Skin is the largest dynamic organ in the horse's body. It has the ability of multidirectional stretch and compression and a low friction gliding movement. The skin has multiple functions:

- **Regulating temperature** → Through shivering
- **Providing a protective barrier** → Against the environment
- **Providing sense of touch and physiology** → Live sensory feedback via somatosensory and autonomic neurons.

The skin contains a complex microvascular system and neurovascular network. There is a close integrated relationship with the underlying fascial endoskeleton which is formed via retinacular ligaments, blood vessels, nerves, and lymphatic vessels.

Skin is made up of an amorphous matrix, fibrillar collagen, sulphated proteoglycans, glycoprotein, glycosaminoglycans (GAGS) and Hyaluronic acid (HA). They carry a negative charge allowing them to bind up to 3000 x their own volume of water influencing dermal and hypodermal volume and compressibility. Skin is affected by race, sex, age, site, scars and obesity.

Skin can be roughly divided into 3 layers:

- **Epidermis** → Outer layer
- **Dermis** → Middle layer
- **Hypodermis** → Deepest layer

The epidermis provides a protection barrier from foreign substances. It includes multiple types of cells such as keratinocytes, melanocytes, Langerhans- and Merkel cells.

Keratinocytes provide a protective layer that is constantly being regenerated in a process called keratinization. In this process, new skin cells are created near the base of the epidermis and migrate upwards. This produces a compact layer of dead cells on the skin surface. This layer traps in fluids, electrolytes, and nutrients, while keeping out infectious or noxious agents. The top layer of dead skin cells is continuously shed and replaced by cells from lower layers. The rate of cell replacement is affected by nutrition, hormones, tissue factors, immune cells in the skin and genetics. Disease and inflammation can also change normal cell growth and keratinization.

Melanocytes produces the skin and hair colouring – pigment – called melanin at the base of the epidermis, the outer root sheath of hairs, and the ducts of the sebaceous and sweat glands. Production of melanin is controlled by both hormones and the genes received from parents. Melanin helps protect the cells from the damaging rays of the sun.

Langerhans cells are part of the immune system. These cells are damaged when exposed to excessive ultraviolet light and glucocorticoids (anti-inflammatory drugs). Langerhans cells play an important role in the skin's response to foreign substances and contribute to such things as the development of rashes when an animal is exposed to irritating materials.

Merkel cells are specialized cells associated with the sensory organs in the skin. Merkel cells help provide animals with sensory information from whiskers and the deep skin areas called *tylotrich* pads (Moriello et. All 2015).

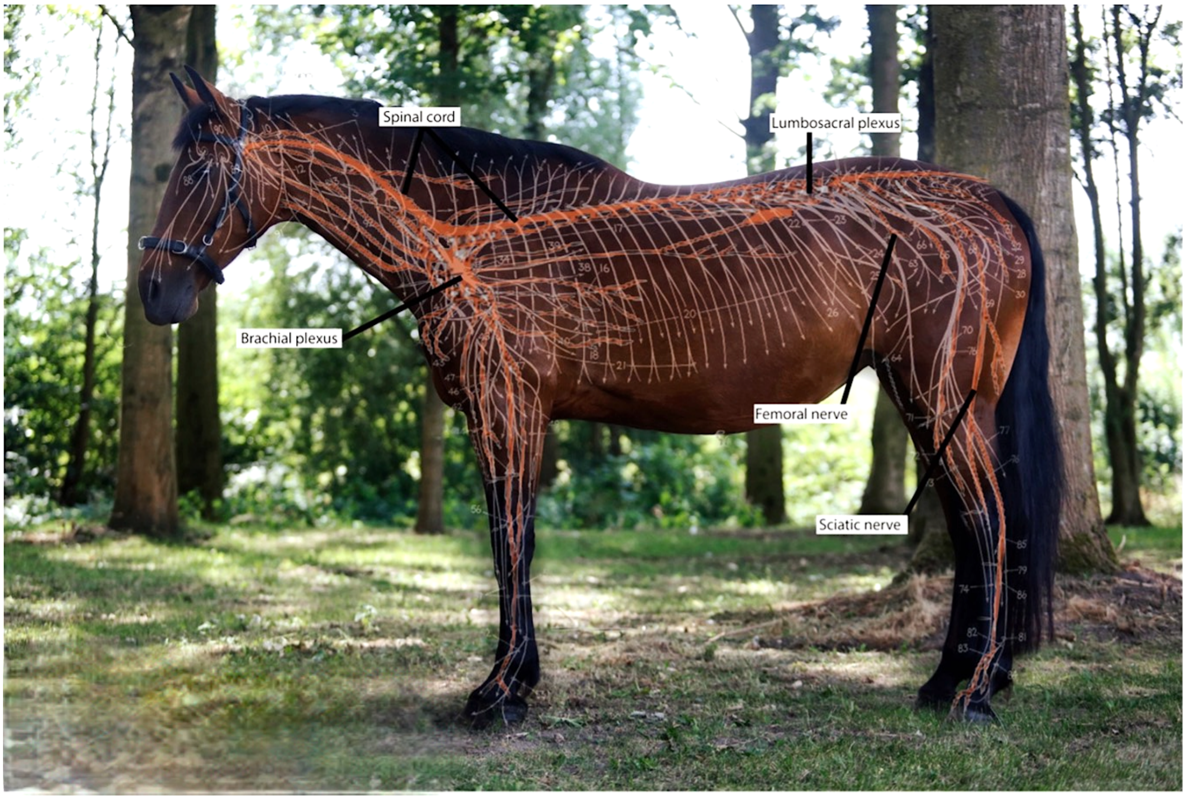
The hypodermis serves as a protective barrier between the epidermis and the dermis.
The dermis is the thick layer containing nerve ends, hair follicles, sebaceous (oil) and sweat glands, blood, and lymphatic vessels. It supports and nourishes the epidermis and skin appendages. It secrets collagen fibres that give the skin elasticity. These layers are divided by loose connective tissue regions allowing gliding.

Therefore, there is a close interaction with the underlying fascial endoskeleton:

''The skin acts as an envelope to the body and is closely integrated to the underlying fascial endoskeleton through retinacular ligaments, blood vessels nerves and lymphatics. Only when skin is diseased, scarred or aged do we appreciate how important this feature is to daily activity. '' - Schierling 2015

The fascial endoskeleton is important limiting the range of skin movement – the gliding of skin over muscle. The connections between fascia through to skin act as a continuum for finite movement. When the fascial system degenerates due to aging, obesity, and disease we can see a change in skin movement – for example wrinkles.

NERVOUS SYSTEMS



The neurology of the horse is a highly complex single unit that regulates all bodily functions and should therefore, although difficult, be the centre of any training method: *''Guiding the horse's brain towards the most efficient body coordination demands understanding and respect for reality.''*

The regulation of body functions and movement is organized by the Central Nervous System (CNS) and the Peripheral Nervous System (PNS). Below you can find a schematic outline of all divisions:

Central Nervous System CNS

Peripheral Nervous System PNS

→ Somatic Nervous System SNS

Automatic Nervous System ANS

→ Sympathetic Nervous System SNS

Parasympathetic Nervous System PNS

The Central Nervous System can be considered the information highway or the 'computer' of the horse and consists of the brain and spinal cord. The Peripheral Nervous System governs the neurons located outside the CNS and consists of two type of nerves that communicate with the CNS:

- **Sensory Nerves →** Carry information from the body parts to the CNS.
- **Motor Nerves →** Carry information from the CNS to the body parts.

The PNS can further be divided into two divisions which are designated into specific regions:

- **Somatic Nervous System (SNS) →** Regulates organs and tissue (except the gut) and administers control of sense organs and most skeletal muscles.
- **Automatic Nervous System (ANS) →** Regulates the involuntary systems such as the heart, respiratory and digestive systems as well as the functioning of

glands. The ANS can further be divided into the sympathetic and parasympathetic nervous systems which usually supply the same organ but trigger different responses.

The **sympathetic nervous system** governs the 'fight or flight' reaction in a horse. It alerts the horse to danger, stress, or any other unwanted circumstances, sending messages to the CNS to increase heart rate, blood pressure etc. to get the horse ready for fight or flight.

The **parasympathetic nervous system** on the other hand governs the 'rest, relaxed and digest' reaction in a horse, which increases blood flow, strengthens the immune system, and promotes healing.

Many horses suffer from ANS imbalance to some extent. They are often considered nervous, inconsistent, or even naughty. The lesser aware trainers fault the horse, attributing it to an attitude problem, instead of realizing there may be a fundamental physical problem. The best of trainers will recognize this underlying issue and wait until the balance is restored and the horse starts to settle before attempting to work with a horse exhibiting these symptoms. Horses with a sympathetic nervous system dominance often display an overly acidic gut and may not be able to gain or hold condition and/or may lack interest in feed. However, signs can be subtler as some horse internalise their anxiety. See a short overview below:

	Parasympathetic Nervous System	**Sympathetic Nervous System**
Increases	Digestions	Heart rate
	Intestinal mobility	Blood pressure
	Fuel storage	Body temperature
	Insulin activity	Blood to skeletal muscle
	Resistance to infection	Stimulation sweat glands
	Rest and recuperation	Bronchodilation

The nervous system reacts to a certain set of stimuli via electrical impulses or 'messages. These messages can be initiated from internal organs or in response to an environmental influence. They are sent to the brain (CNS) for analysis and the return message initiates the response. An example: A fly lands on a horse and it becomes irritated by its presence. The brain receives the message and sends out an instruction to respond with one or several actions to remove the fly such as flicking the tail, twitching the skin, or scratching (May-Davis 2017).

THE BRAIN

The central nervous system includes the brain and the spinal cord.

The brain is divided into 3 main sections:

- The brain stem, which controls many basic life functions.
- The cerebrum, which is the centre of conscious decision-making.
- Cerebellum, which is involved in movement and motor control.

Both the central and peripheral nervous systems contain billions of cells known as neurons. Neurons connect with each other to form neurological circuits. Information travels along these circuits via electrical signals.

Cerebral Cortex: Receives information from the body, it analyses it and interpretates it. The cortex translates this information in thoughts and the next step in the body, handle/react.

White matter= Neurons, all neurons have a centre portion called a cell body and 2 types of extensions called dendrites and axons. Dendrites receive signals from other neurons and transmit electrical charges to the cell body. Axons transmit the electrical charges away from the cell body. When the electrical current reaches the end of the axon, the axon releases chemicals.

Grey matter: information storage.

Cerebellum: Monitors and regulates motor behaviour, particularly automatic movements.

Recent studies associated the cerebellum with cognitive functions. 10% off the total brain weight, it contains more neurons than the rest of the brain combined. Coordination, balance, reflex memory, posture, timing.

Spinal cord: Nerves tissue, Controlling autonomic function:

- Breathing
- Heart rate
- Blood pressure

Corpus Colossum: a large bundle of fibres connecting the right and the left hemisphere, allows information to pass between them.

Thalamus: Relaying information between the cortex and the brainstem.

- Memory
- Alertness
- Consciousness
- Contributes to perception and cognition

Hypothalamus: Regulates a wide range of behavioural and physiological activities. Controls many autonomic functions such as :

- Hunger
- Thirst
- Body temperature
- Sexual activity.

Also, blood pressure heart rate shivering, pupil dilatation, sleep.

Midbrain: Portion of the central nervous system. Associated with:

- Hearing
- Motor control
- Sleep/awake

- Alertness
- Thermoregulation.

Pons: Most closely associated with breathing and with circuits that generate respiratory rhythms its forms a bridge between the cerebrum and cerebellum and is involved in motor control: posture and balance

The basal Ganglia: Group of structures that regulate the initiation of movement and posture. Also involved in cognitive and emotional behaviours and play an important role in reward and reinforcement, addictive behaviours, and habits formation.

- Movement regulation
- Skill learning
- Habit formation
- Reward systems

Limbic system: Group of brain structures

- Amygdala, involved with emotions and fear learning, fight or flight response
- Hippocampus, memory
- Hypothalamus, Memory formation, regulates emotions, processing smells, sexual arousal

Breathing:	Spinal cord & Pons
Motor control posture & balance	Cerebellum & Pons (Basal Ganglia)
Learning	Basal Ganglia
Heart rate	Spinal cord & Hypothalamus

Types of Neurons

Sensory neurons carry information from the body to the spinal cord or brain stem, and then on to the cerebellum and cerebrum for interpretation. Sensory information includes sensations of pain, position, touch, temperature, taste, hearing, balance, vision, and smell.

Motor neurons carry responses to the sensory information from the spinal cord and brain to the rest of the body. Inside the spinal cord, the axons of motor neurons form bundles known as tracts, which transmit this information to peripheral motor neurons going to muscles in the limbs. Motor neurons are important for voluntary movements and muscle control.

A specialized set of neurons controls and regulates basic, unconscious bodily functions that support life, such as the pumping of the heart and digestion. These neurons make up what is called the autonomic nervous system, which sends axons from the brain stem and spinal cord to various areas of the body such as the heart muscle, the digestive system, and the pupils of the eyes.

A dissection picture of an equine brain

Thus, in summary it can be said that the equine brain can be somewhat classified into three progressive 'layers' with various functions that interact considerably, but differ from the human brain quite extensively:

- **The reptilian brain →** Consists of the brain stem and cerebellum. This part of the brain is concerned with survival and body maintenance. Digestion, reproduction, circulation, breathing, and the 'flight or fight' response are all reptilian brain functions. Since a horse is a motor/sensory animal, the horse is all but ruled by the cerebellum. The cerebellum plays a role in controlling balance, head, and eye movements. For the rest of the horse's life, the cerebellum will act as a library for storing all learning regarding physical movement.

- **The limbic system →** It includes the amygdala and hippocampus and interacts with the basal ganglia. This part of the brain is concerned with emotions, motivation, pleasure, and memory. Activities related to food, sex, bonding, and memories are all functions of the limbic system.
- **Cerebral cortex →** Language speech and writing are functions within the cerebral cortex and makes up most of the human's brain. This large cerebral cortex versus the smaller version of the equine is one of the most notable differences between the way humans and horses operate.

PROPRIOCEPTION

The concept dates as far back as 1557 by Julius Caesar Scaliger as a 'sense of locomotion'. Proprioception is often referred to as a sixth sense. Proprioception is derived from the Latin word *proprius*, meaning "one's own", "individual", and *capio, capere*, meaning "to take" or "grasp". Thus, proprioception is the subconscious awareness of the relative position of the body and its limbs in space, their relationship to each other and the surrounding environment. It enables the maintenance of balance and control regardless of gait or type of work being performed and the need to consciously look at it or process the information.

Proprioception is facilitated by mechanically sensitive proprioceptor and sensory neurons distributed throughout the horse's body. A horse possesses three basic types of proprioceptors:

- **Muscle spindles →** These are embedded in skeletal muscle fibres.
- **Golgi Tendon organs →** These lie at the interface of muscles and tendons.
- **Joint receptors →** These are embedded in joint capsules.

The sensory systems of the horse include:

- **Visual perception →** The ability to interpret the surrounding environment using light in the visible spectrum reflected by the objects in the environment. The resulting perception is also known as (eye)sight or vision.
- **Vestibular system →** Provides the leading contribution to the sense of balance and spatial orientation for the purpose of coordinating movement with balance. It consists of the *semi-circular canals* which indicate rotational movements and the *otoliths* which indicate linear accelerations.

The central nervous system integrates the information received from those proprioceptive and sensory neurons to create proper spatial awareness.

Proprioceptive deficit in the horse shows in the loss of spatial awareness of the body, limbs and/or head. It alters gaits and movement in a way that cannot be explained by changes in the limb. For example: ataxia, a change in the rate and force of movement, but also ECVM.

NEUROSCIENCE AND INTELLIGENCE

Neuroscience and intelligence refer to the various neurological factors that are partly responsible for the variation of intelligence within a species or between different species. A large amount of research in this area has been focused on the neural basis of human intelligence.

The definition of intelligence is controversial. The word derives from the Latin nouns *intelligentia* or *intellectus,* which in turn stem from the verb *intelligere* - meaning to comprehend or to perceive. Intelligence has been defined in many ways including: the capacity for logic, understanding, self-awareness, learning, emotional knowledge, reasoning, planning, creativity, critical thinking and problem solving. More generally, it can be described as the ability to perceive or infer information, and to retain it as knowledge to be applied towards adapted behaviours within an environment or context.

Human intelligence is thus the intellectual power of humans, which is marked by complex cognitive feats and high levels of motivation and self-awareness. It gives us the cognitive abilities to learn, form concepts, understand and reason, including the capacities to recognize patterns, comprehend ideas, plan, solve problems and use language to communicate. Intelligence enables us to experience and think.

DOES SIZE MATTER?

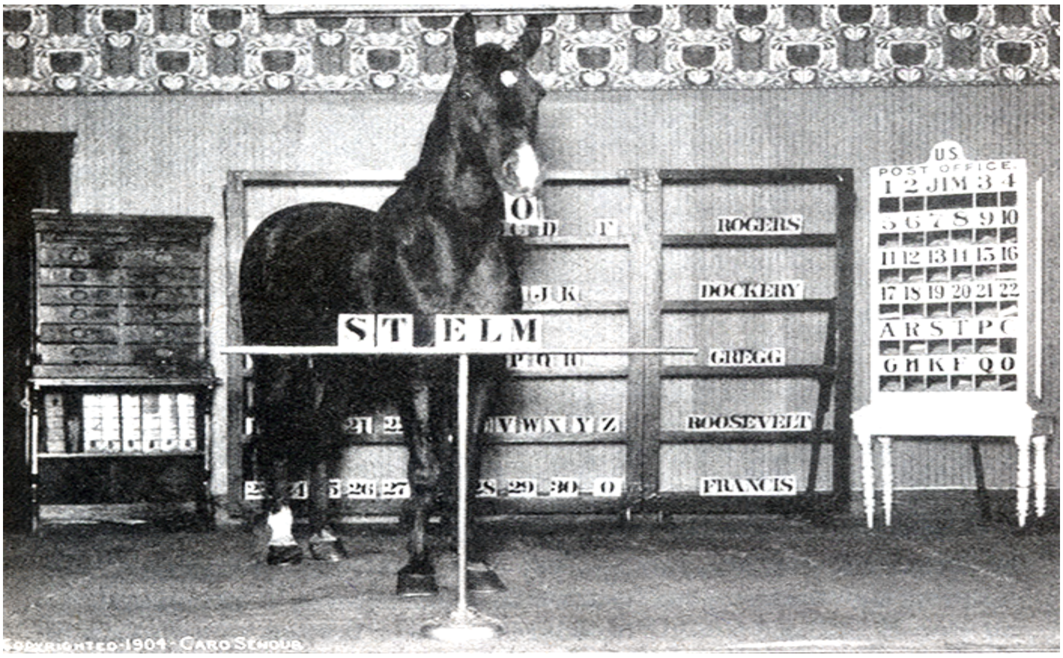
Brain size and weight is often equated with intelligence. The brain size usually increases with body size in animals, but the relationship is not linear. A human's brain weights about 3 pounds; a horse's brain weights about 2.5 pounds. Furthermore, the horse's brain is proportionately about 1/650th of its body weight, whereas the human brain is about 1/50th of our body weight (Stephen Peters). Current research still supports that the brain to body mass ratio reflects a certain level of cognitive skills. However, it must be pointed out that some birds outclass the human brain ratio to body mass. For example, the brain of a shrew takes about 10% of its total body mass.

Yet, it is not quite clear what all this means in terms of the cellular contents of brains. Several researchers argued that factors other than size are more highly correlated with intelligence, such as the number of cortical neurons and the speed of their connections (Roth and Dicke). Moreover, they point out that intelligence depends not only on the amount of brain tissue, but on the details of how it is structured. Neuroscientists previously assumed that humans have more cortical neurons than any other species on the planet, no matter the size of their brain. However, a study (2014) of 10 long-finned pilot whales implied that these whales have roughly 37.2 billion neurons – about twice as much as humans do.

ARE WE SMART ENOUGH TO KNOW HOW SMART HORSES ARE?

For centuries, other animals have been considered inferior to humans when it comes to intelligence or in a broader sense, cognition. Well-known French philosopher Descartes (17th century) believed animals were mindless and could neither reason nor feel pain. The work of Ivan Pavlov (19th century) and B.F. Skinner (20th century) portrayed animals in merely reacting *''reflexively to their environment or behaving only in response to positive or negative reinforcement''.* Dr. N.H. Hodman, a veterinary behaviourist stated *''The extreme behaviourists' view that other animals' behaviour is to be observed and measured but not interpreted prevailed through much of the last century''.*

However, where scientists have been divided over the subject, most horse owners - and owners of other animals for that matter – would argue that horses are intelligent and have emotions. Daily we observe that horses are capable of sophisticated behaviours, including sensory discrimination, learning, decision-making, planning and highly adaptive social behaviours.



Jim Key on stage spelling the name of celebrity Greyhound, St. Elmo. In the background are names of politicians, which Jim would retrieve at the request of audience members. Picture adapted from Beautiful Jim Key by Mim Eichler Rivas (2005).

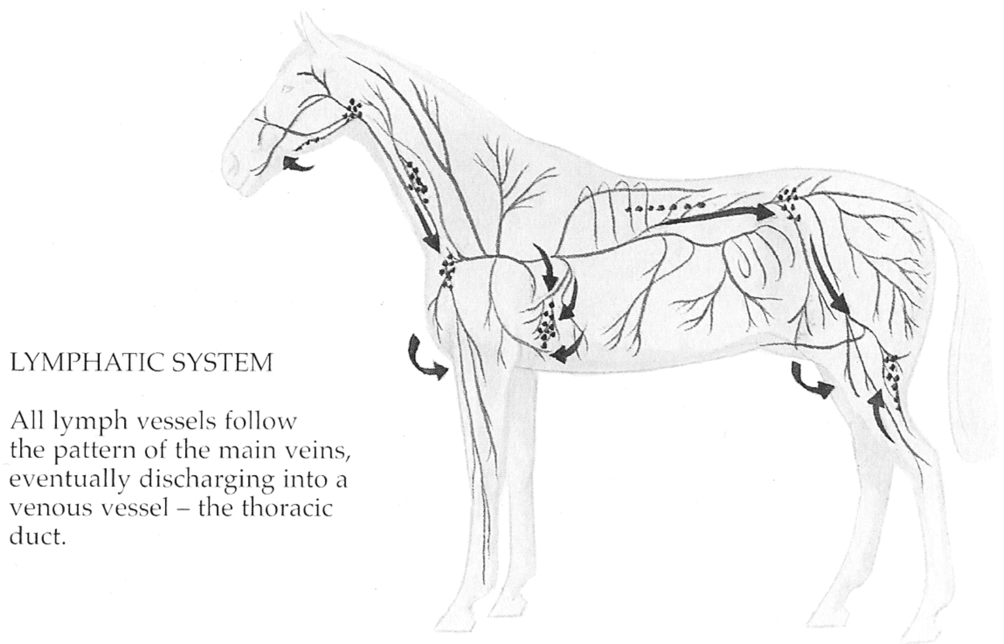
So, the question should not be whether horses are less or more intelligent, but whether we are capable to comprehend. Research recently indicates that it may well be that the differences between humans and horses (and other mammals) are more quantitative than qualitive. In other words, the difference is more in degree than basic functioning, indicating that horses in fact have (some of the) cognitive abilities as we do, but maybe on a different level. So, do horses understand us? Of course. Do they communicate with us? Yes. Do we know for sure what's going on in their minds? Nope.

As such, it is not (relative) brain size or absolute number of neurons that distinguishes humans from horses. *''People forever ask for the single thing that distinguishes humans from* *all other animals, on the supposition that this one magical property would explain our evolutionary success—the reason we can build vast cities, ride horses, put people on the moon, write Anna Karenina and compose Eroica'' (Koch 2016)*. But the simple answer reveals our ignorance of how intelligent behaviour comes about – we don't know.

LYMPHATIC SYSTEM

Just as in humans, horses have two closely cooperating circulatory systems: the cardiovascular system and the lymphatic system. Until recently, limited research surrounding the lymphatic system has been performed. This has led to it not only being overlooked, but also to the development of inaccurate information on its function within the body.

The lymphatic system is a low-pressure system, like the venous system. It is a system of ducts, collector vessels and nodes which drain excess lymph fluid from body tissues back into the blood stream and onwards to the kidneys.

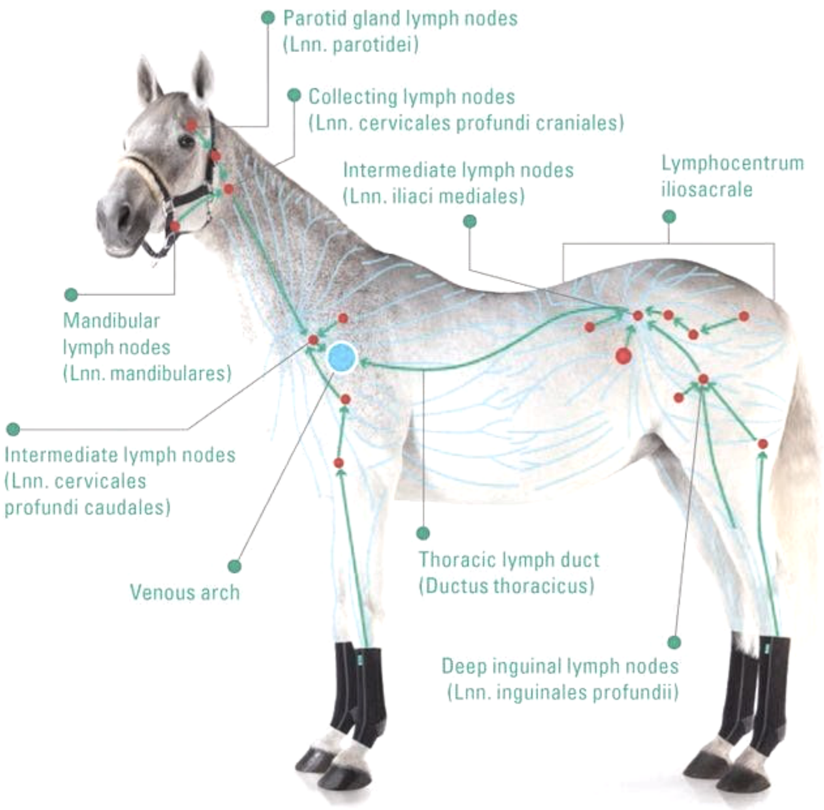


Unlike the venous system, the lymph system does not function as a closed circulatory system. The lymph vessels begin as open-ended capillaries in the intercellular space and ultimately flow into veins located near the heart. The cardio-vascular and lymph systems work closely together and therefore are mutually dependent. Any disease in one system automatically affects the parallel system. Furthermore, it works closely together with the nervous system.

The lymphatic system not only includes the lymph vessels and lymph nodes, but also the spleen, thymus gland, pharyngeal lymphatic ring – tonsils and lymphoreticular tissue – as well as the lymphatic tissue of the intestines.

Lymph forms an intercellular fluid and thus its composition largely corresponds to that of blood plasma – with difference in the amount and type of blood cells. But lymph nodes also encapsulate harmful components of the lymph fluid. The nodes mainly consist of water, plasma proteins, hormones, enzymes, cellular debris and foreign substances (i.e. bacteria and viruses during infections).

Lymph drains towards the heart. The main lymph vessel is the thoracic duct, which collects the lymph from the afferent lymph channels of the hind limbs, abdominal cavity and the unpaired abdominal organs – intestine, stomach, liver and spleen – and feeds it into the venous blood.



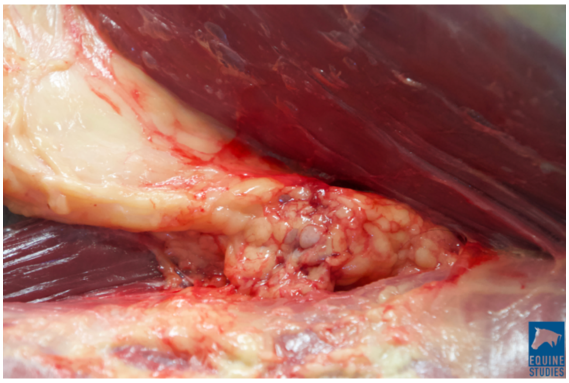
The lymph nodes are embedded in the drainage system and serve as filter points for the lymph. The horse has about 8000 lymph nodes irregularly distributed throughout its body. However, the lymph nodes are quite densely concentrated in the lymph node centres. In case of infections, these become noticeably swollen. Depending on their position, the lymph node centres are not always visible and palpable, but the mandibular ones are very easy to palpate.

The lymphatic system is a very active, sensitive, and highly complex structures with several important functions:

- **Immune surveillance →** Fighting of pathogens.
- **Drainage and transportation of waste -->** Proteins, fluids, fats and cells back into the bloodstream.

The lymphatic system ensures the removal of tissue fluid. This tissue fluid originates from the bloodstream and supplies the cells with nutrients. Cells, in turn, release waste into this tissue fluid. A properly functioning lymph system ensures that tissue fluid and waste do not remain

behind in the tissue but are quickly removed. The function of the lymphatic system is to clean the body from, among other things, germ, and waste products.
As the lymph system removes germs, it has a clear effect on the immune system. Furthermore, lymph contains white blood cells - called lymphocytes – that help fight infection and form antibodies.



Left: healthy lymph nodes in tissue. Right: unhealthy lymph node. A blackened lymph node could be inflammation or melanoma.

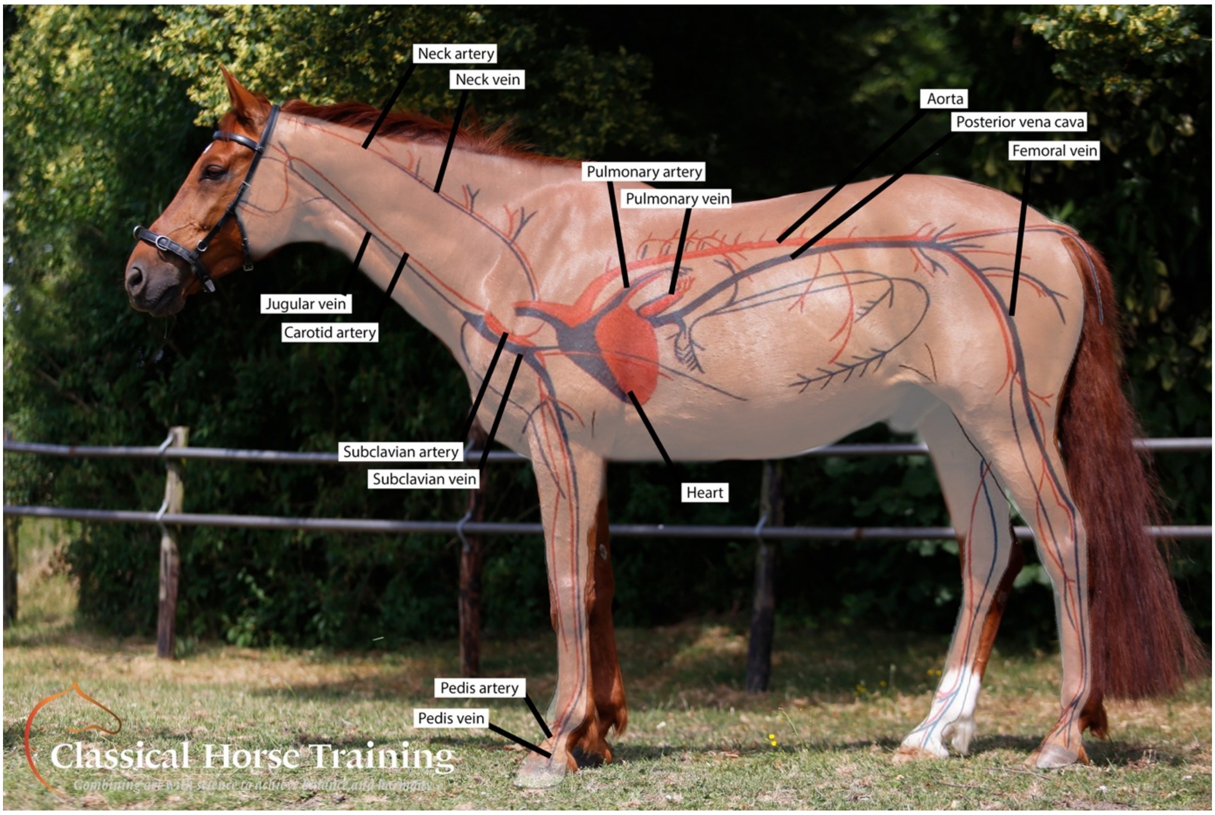
When the lymph system in an area is at maximum carrying capacity it leads to leakage of lymph fluid, which is called oedema – for example a thickened leg.

CARDIOVASCULAR SYSTEM

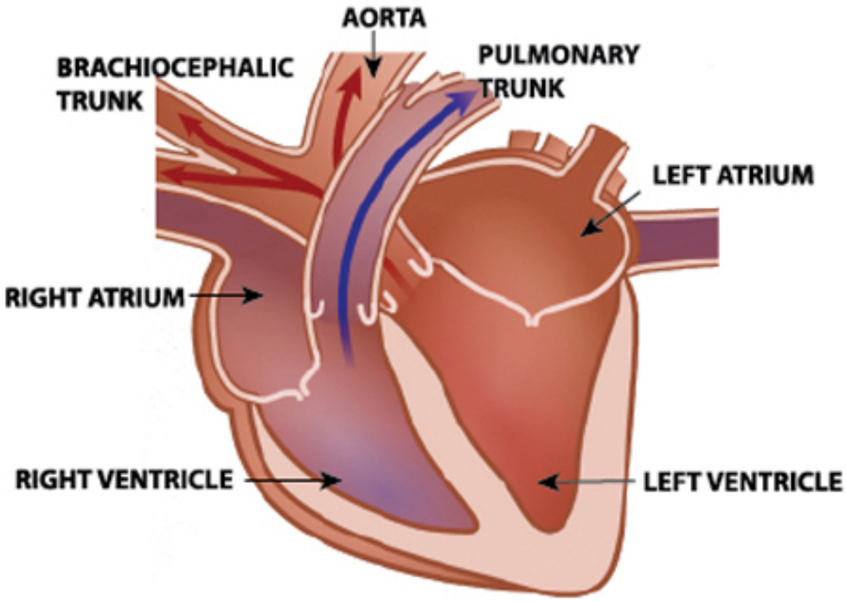
The horse's innate athletic ability is largely due to a specialized circulatory system that, along with the respiratory system, can accommodate the large oxygen demands of the muscles in an exercising horse.

This circulatory system transports blood throughout the horse's body via a network of vessels. The number of litres of blood represents about 10% of the horse's total body weight.

The equine circulatory system consists of two major organs, the heart and spleen, which are connected by a vast array of vessels that serve to deliver oxygen and nutrients to the cells of the body and remove wastes and toxins those cells produce.



As in humans, the equine heart is central to the circulatory system. Simply put, the heart can be described as a large muscular pump which is made up of cardiac muscle fibres (see chapter about muscles). The heart can weigh up to 5.5kg in a large horse and increase in size as the horse becomes fitter, for example the great racehorses Phar Lap (6.35kg). Its primary function is to send blood via a network of vessels throughout the body to supply bodily tissues with nutrients such as O2 and absorbed carbohydrates.



THE EQUINE HEART

The heart is split into four chambers:

- **Left and right atrium**
- **Left and right ventricle**

The chambers on the right control the venous – deoxygenated – blood and transports it to the lungs for oxygenation. The left side chambers control the arterial – oxygenated – blood from the lungs and transports this throughout the body.

This vitally active system between the heart and lungs is known as the pulmonary system. The venous blood flow is conducted through veins whereas the heart pumps the oxygenated blood through arteries. This is a common functional rule except in the case of the pulmonary system, whereby the pulmonary artery leaves the right ventricle with deoxygenated blood and returns to the heart via the pulmonary vein with oxygenated blood (May-Davis 2017).

The heart rate of a horse provides information of how body and mind are coping with a certain set of circumstances at a given point in time. There are two main methods to measure heart rate:

- **Listening via a stethoscope →** Above the point of elbow on the left side.
- **Slightly pressing an artery close to the surface →** Pulse can be felt with a forefinger.

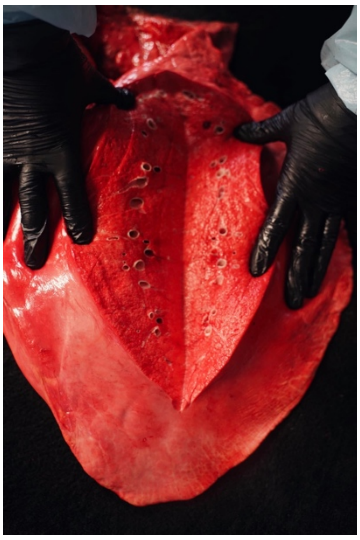
The heart rate should be measured for a least one minute to ensure accuracy. If that is not possible, then a multiplier can be used to determine the beats per minute.

Heart rate is affected by:

- **Gender →** Mares have slightly faster rate than stallions or geldings.
- **Excitement →** Increases heart rate.
- **General condition →** Conditioned horses generally have a slower rate at rest than normal horses (this is a questionable statement as it is deemed that a heart rate is genetically influenced. However, experience is proving to be somewhat different.
- **Exercise →** Increases heart rate according to intensity. It can reach 260 bpm at the gallop.
- **Digestion →** Good digestion decreases heart rate whereas issues in the digestive system increases heart rate.
- **Weather →** Cold weather decreases heart rate, warm weather increases heart rate.
- **Fever and pain →** Increases heart rate.
- **Age →** Higher in the first five years of the horse. From there, adult horses have an average of 28-40 beats per minutes.

RESPIRATORY SYSTEM

The respiratory system encompasses the upper and lower airways. The nose, sinus cavities and pharynx constitute the upper airways, whereas the lower airways comprise the larynx,



trachea, alveoli, pleurae, and the lungs. The respiratory system has multiple functions:

- **Gas exchange** → CO_2 and O_2.
- **pH control** → Regulation in acidity.
- **Temperature control**
- **Water elimination**
- **Production of voice** → E.g., Neighing.
- **Production of sense of smell** → E.g., Nasal cavity

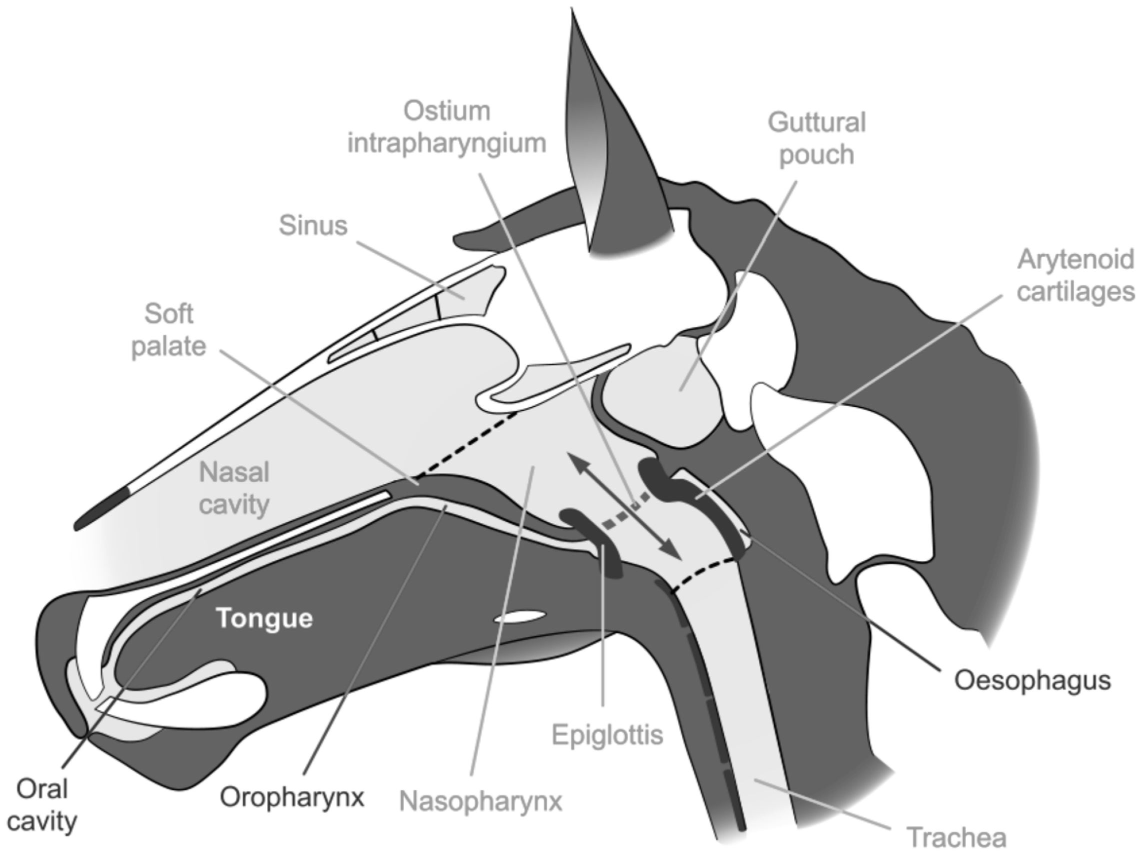
As a flight animal, horses require a considerable amount of oxygen to enable the horse to store sufficient kinetic energy within its muscles. Furthermore, the horse is often asked to engage in athletic performances. The harder a horse works, the greater the oxygen required to maintain performance which is obtained via an increased volume of air transported through the lungs. Over the course of a race or a grand prix jumping course, a horse would have processed around 1800 litres of air through the respiratory system, the equivalent of six bathtubs. Evidently, the lungs of the horse are relatively large and occupy a large amount of space behind the ribs and are separated from the abdominal wall by the diaphragm – which is notably the only impaired membranous muscle in the horse’s body. When fully expanded, the lungs can reach the 16th rib of the horse.

The respiratory system provides an open passageway for air to enter the lungs. The lungs expand with help of the diaphragm which contracts away from the thoracic cavity, thereby decreasing the pressure and pulling air into the lungs. Once in the lungs, the oxygen diffuses into the blood, so the lungs get fully oxygenated. At the same time, carbon dioxide is released by the blood, exchanged for oxygen, and then exhaled again.

Respiration involves:

- **Inspiration (breathing in)** → Inflow of air into the lungs. Contraction of the diaphragm forces the abdominal contents caudal and aids the increase in size of the thoracic cavity along with the intercostal muscles. This results in the lungs following the expansion of the diaphragm and thorax, resulting in the inflow of air into the lungs.

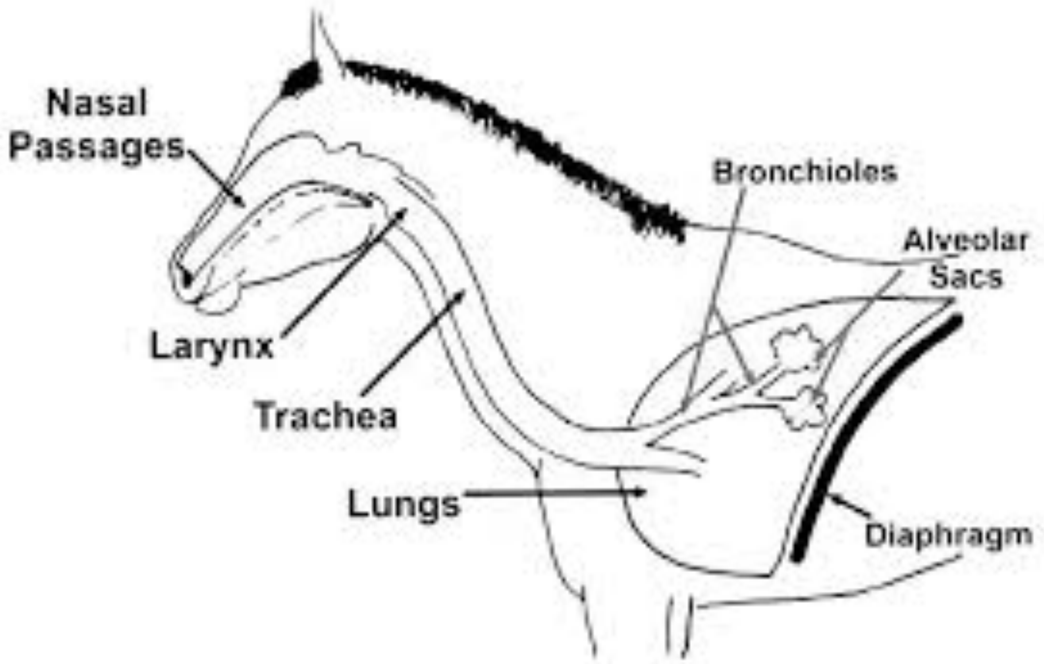
- **Respiration (breathing out)** →Flow of air out of the lungs. This happens whenever the volume of the thorax is decreased. This process is largely passive because of the tendency of elastic structures of the costal cartilages, lungs, and abdominal wall to return to their normal shape and location – without muscular effort.



The respiratory tract starts at the nostrils and nasal passages. This is also the area where the horse's olfactory receptors – those responsible for the sense of smell – are located. Due to the excessive length of the nasal cavity, there are a large area of receptors and therefore the horse has a better ability to smell compared to a human. Additionally, the horse also has a vomeronasal organ – or Jacobson's Organ – which is in the hard palate and able to pick up pheromones and other scents when a horse exhibits what is known as the 'flehmen response'. The flehmen response forces air through slits in the nasal cavity and into the Jacobson's organ.

When air is inspired through the nostrils, the air is warmed and humidified, and large particles are trapped so they cannot continue down the respiratory tract. The air then travels to the pharynx which delivers air from the nasal passages to the larynx as well as delivers food from oral cavity to the oesophagus (see digestive system). Interestingly, horses are different to humans in the sense that they can't breathe through the mouth as the oral cavity and pharynx are always separated by the soft palate, with the only exception being when swallowing. The horse is thus the epitome of the proverb "The nose is for breathing; the mouth is for eating''.

In summary, the pharynx brings the air to the larynx which prevents food from getting inhaled into the lower airway. From there, the air is passed into the trachea which delivers the air to the bronchi. The bronchi branch into bronchioles which then finally branch to the alveoli where the oxygen exchange occurs. Oxygen diffuses from the alveoli of the lung into the pulmonary capillary circulation where it is picked up by haemoglobin and transported by the bloodstream to the muscles. The muscles use oxygen to burn fuels from the horse's diet (carbohydrates and fats) to produce the energy necessary for muscle contraction. Carbon dioxide is the by-product that is exhaled. When inhaled, the air contains about 20% of oxygen. When exhaled, it contains about 16% of oxygen. About 4% of oxygen that streams into the lungs is replaced by the same quantity of carbon dioxide.



There are two forms of respiration:

- **Internal respiration →** Occurs in metabolizing tissues, where oxygen diffuses out of the blood and carbon dioxide diffuses out of the cells.
- **External respiration →** Exchange that occurs in the lungs where oxygen diffuses in the blood and carbon dioxide diffuses into the alveolar air.

Classifications of breathing:

- **Eupnoea →** Normal quiet breathing.
- **Dyspnoea →** Difficult breathing.
- **Apnoea →** Absence of breathing.
- **Hyperpnoea →** Increased depth and/or rate of breathing.
- **Polypnea →** Rapid, shallow breathing.

Types of breathing:

- **Diaphragmatic breathing →** This occurs during ordinary quiet breathing - eupnoea.
  It requires minimal abdominal movement due to the diaphragm contracting and forcing the abdominal contents caudally.
- **Costal/ Thoracic breathing →** This occurs if more air is needed than the normal diaphragmatic breathing is provided.

A normal respiration rate of a mature horse at rest lies between 8-16 breaths per minute. New-born foals have respiration rates between 60-80 breaths per minute whereas older foals usually have between 20-40 breaths per minute. You can measure respiration by watching the horse's ribcage expanding and contracting – an inhale and exhale is one breath – or feeling the air coming out of the nostrils. Remember, if your horse or foal becomes excited or agitated, the respiratory rate can become temporarily elevated. Heat and humidity can raise the respiration rate considerably, especially if the horse has a dark coat and is in the sun.

Regular breathing is a reflex action but can also be consciously controlled by the brain. The respiratory centre of the brain contains the following structures:

- **Medulla oblongata →** Made up of the **dorsal and ventral respiratory neuron groups.** The dorsal group initiates inspirations whereas the ventral groups control the exhalation area. Together, they control the basic rhythm of respiration.
- **The pons →** Made up of the pontine respiratory neurons group which includes two areas knows as the **pneumotaxic centre** – associated with deep inspiration e.g., sighing – and the **apneustic centre** which prevents over distension of the lungs and inspiration occurring before expiration is finished.

The way this mechanism operates is straightforward. When the horse is asked to engage in athletic activity, its body requires a greater intake of oxygen to be delivered to the muscles. Both the respiratory and circulatory system need to ensure that the oxygen is getting to the muscles at a rate which is required to maintain the required performance. Furthermore, they need to make sure that the CO2 produced is removed efficiently. The medulla oblongata detects carbon dioxide (CO_2) and oxygen (O_2) levels in the bloodstream and determines what changes need to happen in the body. It can then send nerve impulses to muscles in the heart and the diaphragm letting them know that they need to increase their rate of function to meet the requirements for optimal function. The horse's respiration rate increases. The amount of air moved in and out of the lungs increases in direct proportion to how fast the horse is running. If a horse runs twice as fast, it must move twice as much air in and out. The horse's heart also starts beating faster as not only does the oxygen need to get into the body, but it needs to be delivered to the muscles as well.

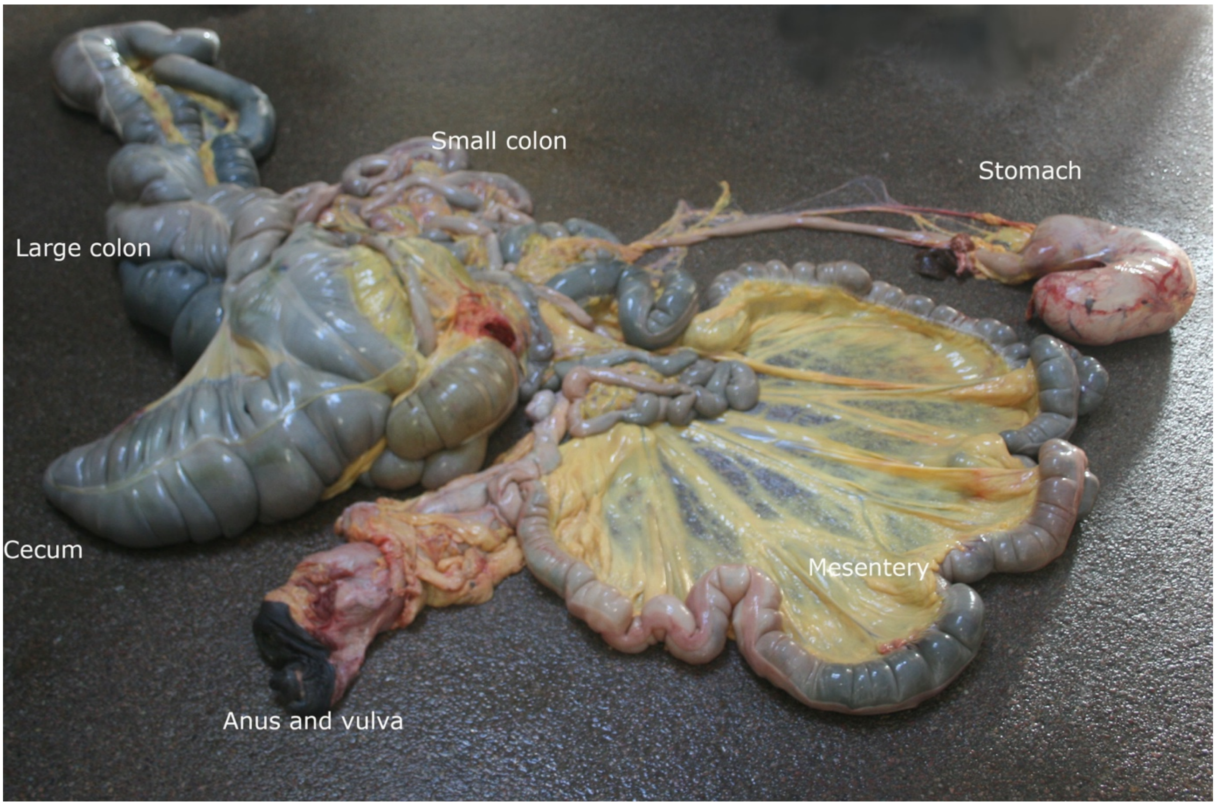
When horses inhale during exercise, around 90% of the resistance to air movement is in the airways that are in the head, namely, the nostrils, the nasal passages, and the larynx. But when horses are exhaling most of the resistance to air movement (55%) is in the airways within the lung.

The "locomotive-respiratory coupling system" is a term used when the respiratory rate is linked to the horse's gait. This synchronisation of stride to breathing occurs primarily at the gallop. As the head is raised during the stride, the gut moves back, and the horse breathes in. As the head is lowered during the stride, the gut moves forward, and the horse breathes out.

From a rider's perspective, it is important to realize that we sit on the lungs. When fully expanded, the lungs can reach to the 16th rib of the horse. Therefore, any 'kicking of the legs' or 'squeezing' of the thighs affects your horses breathing process in a negative way and should always be avoided. If you tighten a horse's girth too much, it will affect the horse's performance–not because of constricting the chest and preventing the lungs from expanding, but because it decreases the effectiveness of the muscles around the front of the chest and shoulder that move the front limbs.

Finally, there is quite some discussion whether you can train the respiratory system of the horse. Plenty of books will tell you that you can. However, several scientific studies show the reverse demonstrating that the amount of air moved in and out by an unfit horse at a fixed speed will be the same six months later when that horse is fully fit (Marlin 2007).

DIGESTIVE SYSTEM

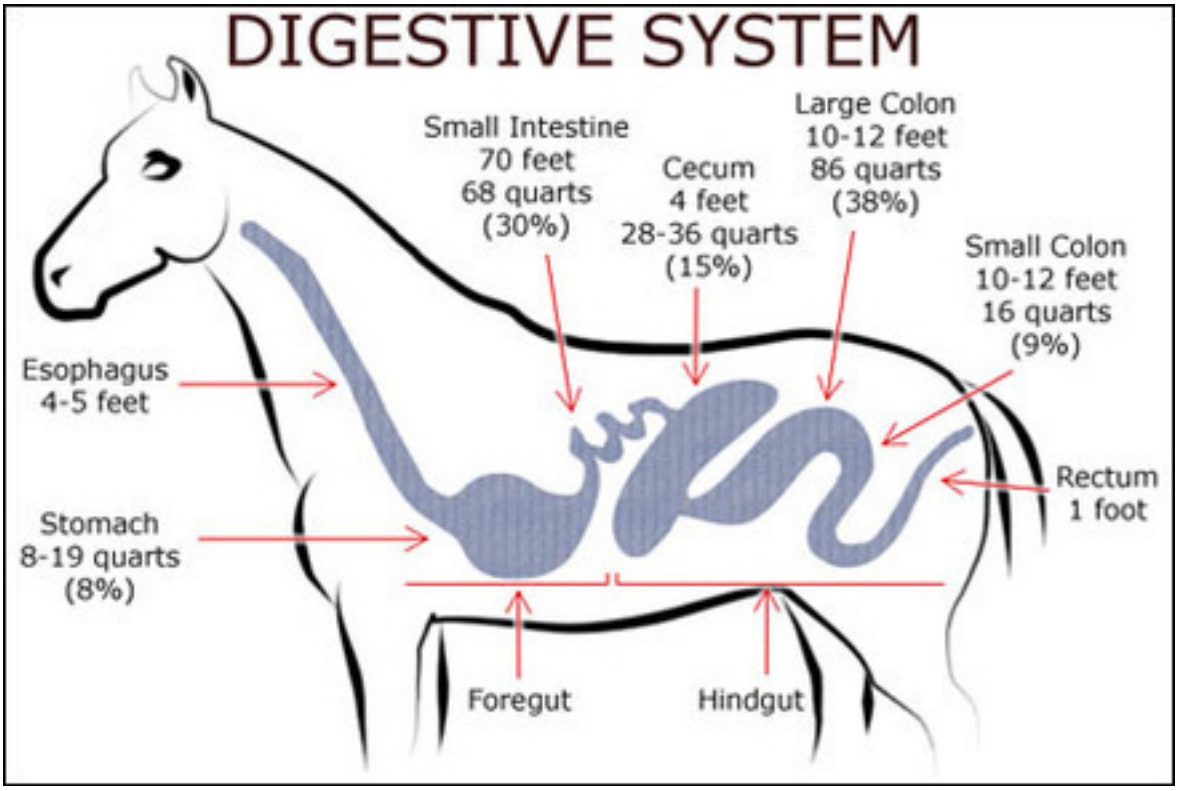


The horse is a non-ruminant herbivore. Non-ruminant means that horses do not have multi-compartmented stomachs as cattle do. Instead, the horse has a simple stomach that works much like a human. Herbivore means that horses live on a diet of plant material. The equine digestive tract is unique in that it digests portions of its feeds enzymatically first in the foregut and ferments in the hindgut.

The gastrointestinal tract is a muscular-membranous tube that extends from the mouth to the anus. In a 16hh horse, it can approximate up to 30m in length.

The digestive system can be divided into two parts:

- **The foregut →** Consists of the mouth, pharynx, oesophagus, stomach, and small intestine.
- **The hindgut →** Consists of the large intestine, rectum, and anus.



Furthermore, the liver, pancreas and salivary glands are accessary digestive organs and provide enzymatic secretions necessary for digestions. It is important to note that, unlike humans, a horse has no gall bladder and hence, no gall stones.

Since the functions carried out in the front- and hind gut are very different, it makes sense to focus on each part separately.

FOREGUT

The processes of the foregut start with the ingestion of food through the horse's mouth. The tongue moves the food to the molars where it is grinded through a series of chewing movements. The salivary glands – which can produce up to 12 litres of saliva a day – aid to moisten the food and form it into a ''ball like mixture'' which is called a (food) bolus. Furthermore, saliva contains an alkaline – bicarbonate – that helps to neutralize stomach acids and an enzyme – amylase – which aids in the process of digestions.

Once the chewed and moistened food has been formed into a bolus, the pharynx will guide it into the oesophagus by the process of swallowing:

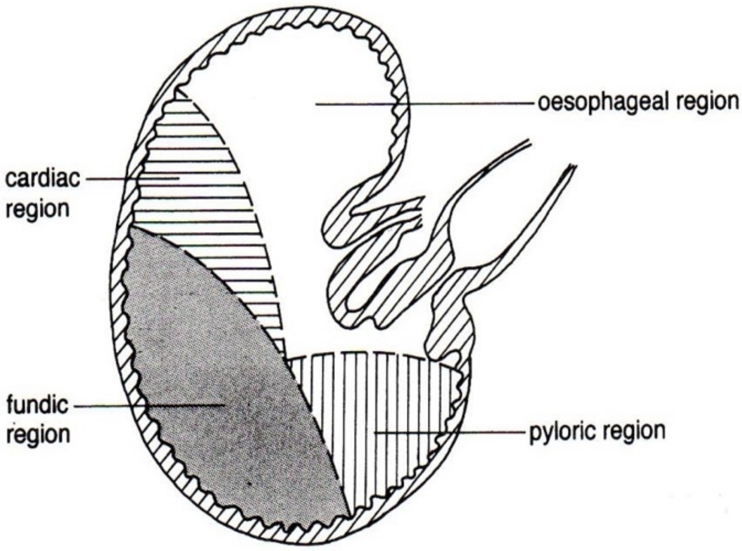
''The tongue pushes the bolus into the pharynx, which elevates the soft palate, closes the epiglottis over the larynx and guides the bolus into the oesophagus. This mechanism prevents foodstuffs entering the trachea.''
- May-Davis 2017

Once the bolus of food has been swallowed, the oesophagus moves it into the stomach along the digestive tract by waves of muscular contractions known as peristalses. The oesophagus is a muscular tube which is roughly 1.2-1.5 meters long. If the food bolus gets obstructed here, the horse will choke resulting in the well-known phenomenon oesophagus congestion. The passage of food from the oesophagus to the stomach is controlled by a muscular valve called the 'cardiac sphincter'. This valve is very powerful and only functions one-way, explaining why horses can't vomit. Therefore, in cases of severe stomach issues, it often ruptures before a horse can vomit.

After the food has been chewed and swallowed the stomach kicks into gear. The main functions of the stomach are to store the incoming food boluses, add gastric acid to help with the breakdown of the boluses, to secrete the enzyme pepsinogen to begin protein digestion, and to regulate the passage of food into the small intestine. Basically, the stomach is a holding and mixing tank, not unlike a cement truck that is constantly churning and mixing ingredients. Lying under the diaphragm, the stomach is divided into four regions:

- **Oesophageal region →** Otherwise referred to as *saccus ceacus.* This region is responsible for storage of the food boluses.
- **Cardiac region →** This area contains mucous secreting glands - called cardiac glands.
- **Fundic region →** This area contains enzymes, mucus, and hydrochloric acid.
- **Pyloric region →** This area contains enzymes and mucus.

Picture adapted from Pilliner and Davies (1996).



Mucus is used as a lubricant for materials that must pass over membranes, e.g., food passing down the oesophagus. Mucus is extremely important in the intestinal tract. It forms an essential layer in the colon and in the small intestine that helps reduce intestinal inflammation by decreasing bacterial interaction with intestinal epithelial cells. A layer of mucus along the inner walls of the stomach is vital to protect. the cell linings of that organ from the highly acidic environment within it. Mucus is also secreted from glands within the rectum due to stimulation of the mucous membrane within.

The stomach holds between 8-10% of the total gut volume. Due to its shape and size, food remains in layers in the stomach for approximately 45 minutes and the pyloric sphincter controls the passage of food exiting the stomach into the small intestine.

True digestion only begins in the small intestine that receives the liquefied feed material from the stomach. With assistance from enzymes secreted by pancreas into the small intestine, it is the main site for digestion and the absorption of protein, carbohydrates - sugar and starch - and fat. The small intestine is a tube-like structure that is approximately between 20-27 metres in length. It holds between 55-70 litres and can be divided into three parts:

- **Duodenum →** Roughly 1 meter in length. This is the area where pancreatic and liver secretions are delivered.
- **Jejunum →** Roughly 20 meter in length and thus makes up for the main region of the intestine. This is the area where most of the absorption occurs. It is important to note that this structure lies to the left in the abdomen.
- **Ileum →** Roughly 1-1.5 meters in length and together with the jejunum is also part of the area where absorption occurs. It is important to note that this structure lies to the left in the abdomen.

The small intestine is also the main site of nutrient. Amino acids, glucose, fat soluble vitamins (such as A, D, E and K), minerals (such as calcium and phosphorus) and fatty acids are taken into the body as they move along the small intestine, so progress shouldn't be too fast or too slow.

HINDGUT

The next segment in the digestion process, the hindgut, starts with the large intestine and ends in the anus.

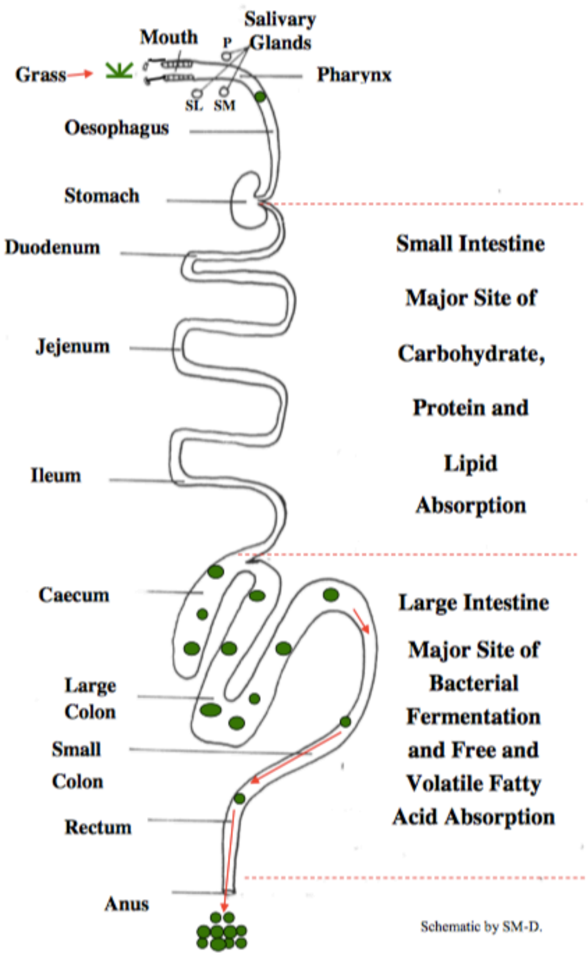
The processes that occur in the hind gut are focused on fermenting complex carbohydrates into useful end products with the assistance of the "good bugs" (Gray 2016).

The large intestine is about 8 meters in length and the ingested food remains here for 36-38 hours. It houses bacteria and ferments the fibrous material in the food that the horse is unable to break down by its own enzymes. In addition to generating fatty acids, which supply energy or calories, the helpful ''good bugs'' also produce vitamin B and K, and some amino acids. The colon then not only absorbs these nutrients but also a large amount of the water that accompanies food as it moves along the digestive tract. This function occurs very efficiently such that by the final step in the small colon, the waste material unused by the horse is formed into faecal balls. These are subsequently passed into the rectum before exiting through the anus.

The large intestine can be divided into three parts:

- **Caecum →** A large 'sac' holding between 25 – 35 litres of ingesta which can reach here in three hours after the food has been chewed. The entrance of the caecum – the *ileo caecal* valve – lies close to the right coupling with caecum lying in a forward -downward position before ending on the bottom of the abdominal floor.

- **Large colon →** Holds about 90-110 litres of ingesta and is about 3-4 meters in length. It 'folds' into four regions throughout the abdomen with turning points – flexures – that are most likely points of blockage.
- **Small colon →** Holds about 9-70 litres and is about 3-4 meters in length as well. It lies intermingled with the jejunum and moves quite freely. However, it can cause a crisis through what is called a 'twisted gut'.



The small colon is followed by the final segments of rectum and anus. The rectum is about 30 centimetres in length, connecting the small colon to the anus, and functions as a storage for faeces that gets eliminated out of the body through the anus. The anus has a sphincter muscle dividing the digestive tract from the outside environment.

The cycle of mastication and digestion is now complete. In summary, please see the diagram below that illustrates a schematic view of the full processes of the digestive system.

INNER ORGANS

It is easy not to think too much about your horse's inner organs. If there's some indication that they're working – such as normal neurological responses, good appetite, good faeces, and proper urinating – you probably don't invest a lot of time wondering just how well they function. It is easy to not take notice and hence, once we start seeing problems, the organ might already be failing. Therefore, it is worth to spend some time to getting to know your horse's inner organs to assess what normal functioning is.

SPLEEN

The spleen is a lymphatic organ located between the kidney and the small colon on the left side of the abdomen, lying against the ribcage. A so-called nephrosplenic ligament connects the spleen to the left kidney. It has two main functions:

- **Storage of red blood cells**
- **Production of lymphocytes**

There are two types of spleen. The defensive type, found in humans, primarily functions to filtrate blood, remove foreign materials and bacteria, and produce lymphocytes. The storage type of spleen is larger and, in addition to these defensive functions, serves as a reservoir for red blood cells. The spleen of horses, dogs and cats is classified as the storage type and therefore differs from human spleens mostly due to this storage function. However, the horse is thus not unique in this regard because the spleen of the dog and cat serve a similar storage function.

The storage ability of the equine spleen plays an important role in the horse's athletic ability. When the horse required an uptick in performance – for example during exercise – the spleen contracts and releases the stored red blood cells into general circulation. The spleen has the capacity to pump twelve extra litres of bloods within seconds, supplying the body with enough oxygen to enable the horse to perform quickly and enduring.

Apart from its major contribution to athletic performance, the spleen also plays an important role within the immune system through the production of lymphocytes which is a type of white blood cell that filtrates the blood by removing all useless or dangerous elements – including bacteria – and old blood cells. Blood cells, especially the red ones, have a short lifespan and it is the job of the spleen to recognize and remove old and degenerating cells from the circulation. In addition, important substances in the blood are stored as well as possible.

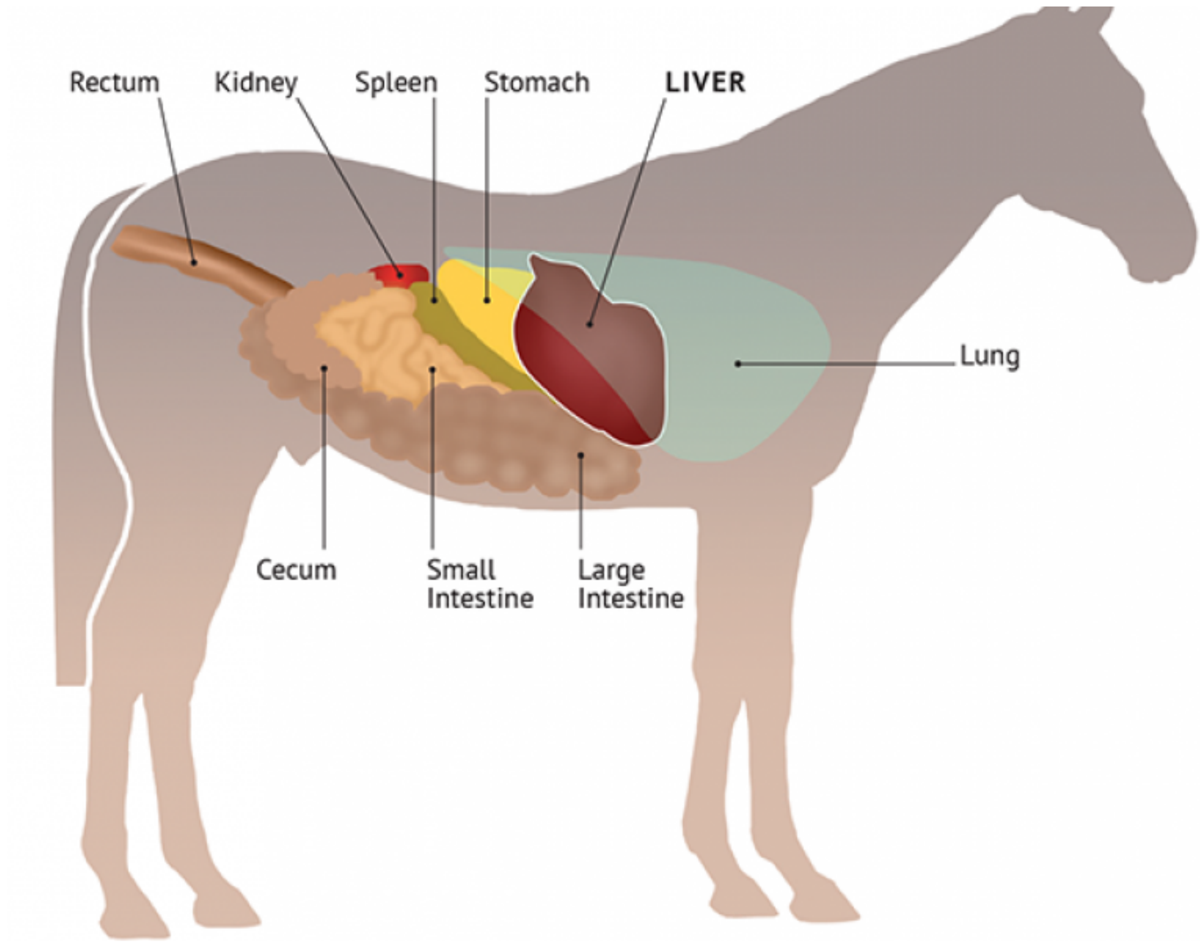
Although it searves an important function, it is not essential to life. However, knowing the important role it plays during exercise, horses whose spleen has been removed suffer a sharp decline in athletic ability (Geor 2001).

A spleen with scar tissue

LIVER

The liver is an organ that is usually described as part of the digestive system, but its functions extend far beyond that. It is estimated that the equine liver performs about 500 distinct functions (Kellon 2015). The liver is the largest internal organ and can be classified as both an organ and a gland. It is also the only tissue that has any significant ability to regenerate itself.

On the digestive function, the liver produces bile. Bile is an alkaline fluid which is essential for the processing and absorption of fats and fat-soluble vitamins as well as altering the pH value of food that enters the gastrointestinal tract. In most mammals, bile is secreted from the liver and stored in the gall bladder, only to be released when needed. However, a horse doesn't have a gall bladder. Therefore, bile cannot be stored and must be deposited directly into the intestine in response to feeding. This is one of the reasons why horses must be slowly adapted to high-fat diets, as bile volume and composition must be altered over time to allow proper digestion of a high-fat diet. Sudden increases in fat content of a horse's diet can lead to poor digestibility of fats and gastric upset (Pearson 2015).

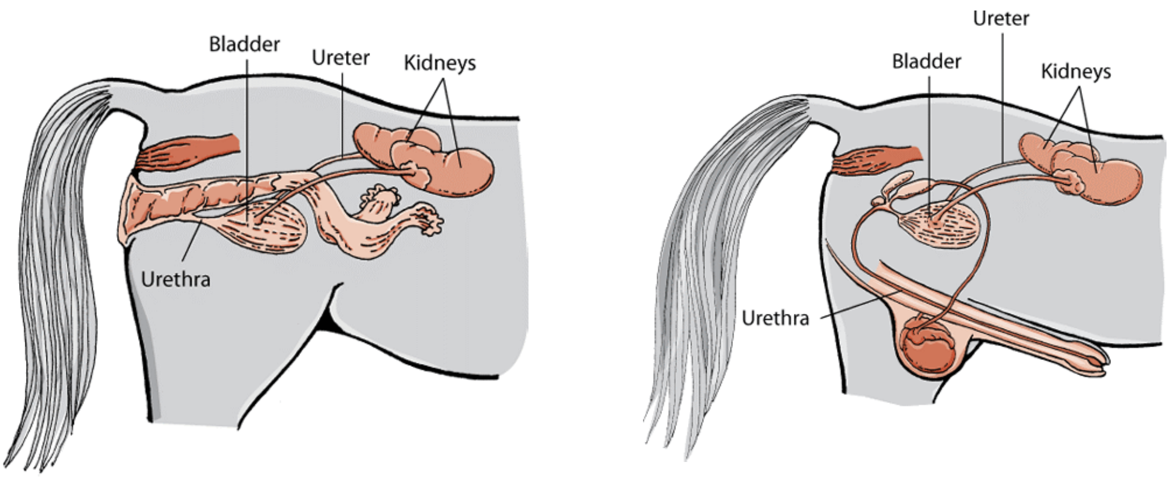


In addition to facilitating digestion, the liver also is the primary site for the process of gluconeogenesis in which glucose is generated from certain non-carbohydrate carbon. It also provides a storage for fat-soluble vitamins such a A, D and E. The liver is a major storage site for glycogen which is key in providing energy for the exercising horse.

KIDNEYS

The kidneys are part of the urinary system of the horse.

Situated on either side of the spine, just beneath the last few ribs[1], the equine kidneys function very much like a waste-water treatment plant. The right kidney lies to the sacrum whereas the left one lies to the psoas and diaphragm. Protected from impact and injury by a cushioning layer of fat, fascia, muscles and bone, the kidneys sort through the various substances carried in the blood, conserving those that the horse needs and disposing of those that could do harm. The kidneys are extremely efficient in their job, processing every drop of blood at least twice per hour. The entire blood volume (on average about 9 gallons) passes through the kidneys more than 60 times in 24 hours. Therefore, the kidneys prove to be amongst the most reliable of all the regulatory systems.



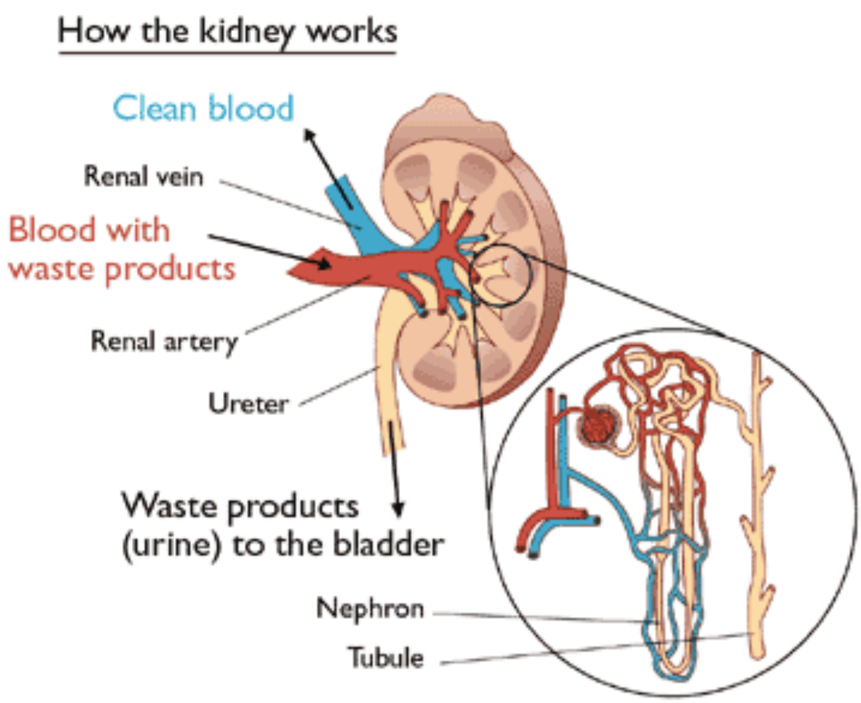
Pictures adapted from Merck Veterinary Manual 2019 illustrating the urinary systems of a mare and a stallion/gelding.

[1] *Because of this location a floating rib can interfere with kidney function.*

As the kidneys carry out their basic filtration duties, they also monitor and regulate fluid volume and composition. Furthermore, they promote red blood cell production, modulate blood pressure, and control the blood's pH (acidity) and the body's electrolyte balances. Specifically, the kidneys closely regulate the body's salt balance. Any extra salt is excreted while necessary salts and fluids are returned to the bloodstream along with valuable materials such as mineral electrolytes and sugars.

Blood arrives in the kidneys via the renal artery—a branch of the aorta—and is processed in two layers of kidney tissue that lie beneath the organs' covering. Within the tissue, more than a million microscopic filtering units called nephrons handle the purification duties. These nephrons are the structural and functional units of the kidneys and are composed of:

- **A renal corpuscle →** Consist of a tuft of capillaries called a glomerulus and an encompassing Bowman's capsule. The glomerulus filters the blood.
- **Renal tubule →** Extends from the Bowman's capsule. The tubule returns needed substances to the blood and pulls out additional wastes. These wastes and extra water become urine.



Only about 25 to 30 percent of the nephrons actively process fluid full-time. The remainder stand by in case of an increase in blood flow, which may be triggered by illness, excitement or cold temperatures. Additional nephrons also may be called into service when a horse consumes more water than usual.

The nephrons work though a four-step process:
Filtration → Reabsorption → Secretion → Excretion

The process starts with the mass movement of water and solutes from blood to the renal tubule that occurs in the renal corpuscle. The filtration process is primarily driven by hydraulic pressure (blood pressure) in the capillaries of the glomerulus. About 20% of the blood plasma volume passing through the glomerulus at any given time is filtered. Those molecules of protein, fats and blood cells that are too large to fit through the filters of the Bowman's capsule are rejected and remain in the circulation for other destinations.

The filtered fluid then flows from the Bowman's capsule into the kidney's tubules through a long winding tube called the 'Loop of Henle'. Important materials passing through these filters – such as salt, potassium, sulphate, phosphate, sugars, amino acids, and nitrogenous wastes – are sorted. What is needed by the body gets extracted and returned by the blood to replenish deficits. What is harmful or excessive is removed.

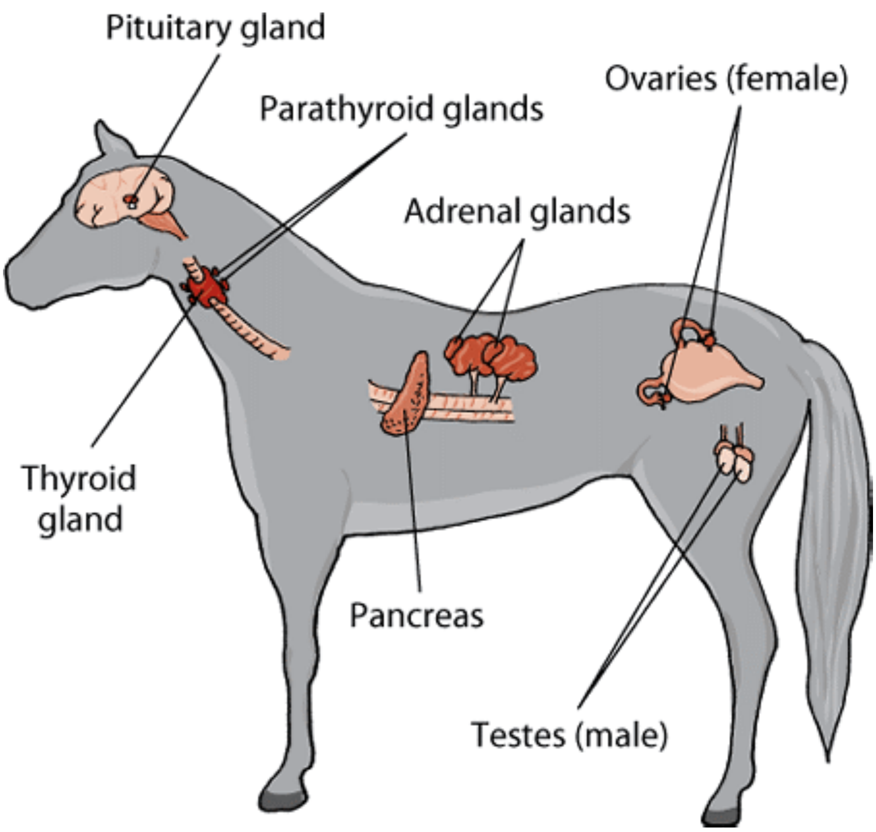
Even after the filtration and reabsorption processes, the tubules continue to secrete additional substances into the tubular fluid. This enhances the kidney's ability to eliminate certain wastes and toxins. It is also essential to regulation of potassium concentrations and pH balance.

Finally, the remaining waste will be concentrated into urine. Excretion is what goes into the urine and therefore the result of the above three processes. The kidneys filter much more fluid than the amount of urine that is excreted as the original volume of the tubule fluid is dramatically altered by the processes of reabsorption and/or secretion.

Any potential waste that proves too large to fit through the kidneys' tubes is rerouted to the liver or the gut wall, where it is processed for excretion with solid faeces.

ADRENAL GLANDS

The adrenal glands are small organs situated on top of both kidneys and is part of the horse's hormone management – the endocrine system.



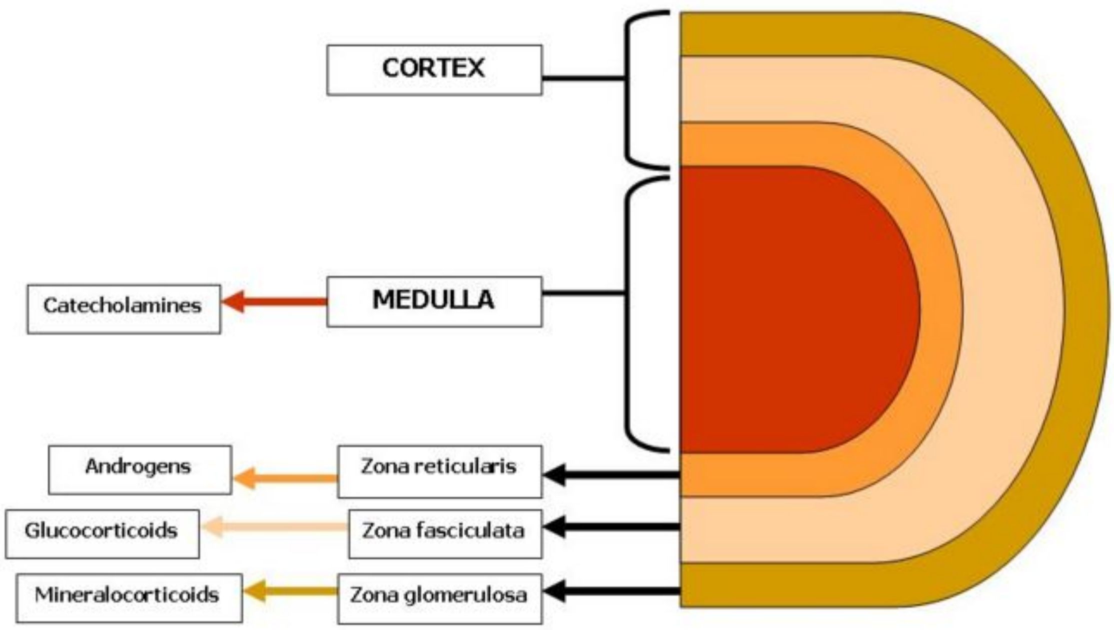
Picture adapted from Merck Veterinary Manuals (2019) illustrating the major endocrine glands in the horse.

The adrenals play an important role in the production of various hormones. The adrenal glands can be divided between the cortex and the medulla. The adrenal cortex consists of three layers, each of which produces a different set of steroid hormones:

- **Zona Golmerulosa →** The outer layer produces the mineralocorticoids which help to control the body's balance of sodium and potassium salts.
- **Zona Fasciculata →** The middle layer produces the glucocorticoids which are involved in metabolizing nutrients as well as reducing inflammation.
- **Zona Reticularis →** The inner layer produces the androgens – otherwise referred to as sex hormones – such as oestrogen and progesterone which play an important part in the procreation process.

The adrenal medulla plays an important role in response to stress –hence it's nickname as the 'shock organ' - of low blood sugar (glucose). It releases epinephrine – adrenaline – and norepinephrine, both of which increase heart output, blood pressure, blood glucose and slow digestion.

The lymphatic network within the adrenal glands drains into the lumbar aortic lymph nodes.



PANCREAS

The pancreas lies in the abdominal cavity, near the start of the small intestine and below the kidney. It plays a role in the horse's metabolism by producing digestive enzymes, but the organ is mostly known for its involvement in the production of the hormone insulin and thus the disease such as Equine Metabolic Syndrome (Insulin resistance). Hence – the ancient Greeks referred to it as the ‘stomach sweetbreads.

The pancreas consists of hormone producing cell clusters called Islets of Langerhans which contain three different kind of cells each which produces a different hormone:

- **Insulin** → Most of the beta cell. Insulin affects, either directly or indirectly, the function of every organ in the horse’s body, particular the liver, fat cells and muscle. It is the primary modulator of blood-sugar (glucose) concentration, acts swiftly after food intake to limit the liver's production of glucose and increase stored energy (glycogen) in that organ, to facilitate increased protein synthesis, to convert un-needed energy to fat for storage in body tissues and possibly to control appetite.
- **Glucagon** → Insulin and glucagon work together to keep the concentration of glucose in the blood and other body fluids within a relatively narrow. range. Glucagon raises blood sugar level by controlling glucose release from the liver.
- **Somatostatin** → Found in the delta cells. Inhibits insulin and glucagon secretion. It affects neurotransmission and cell proliferation. In the stomach, somatostatin acts directly on the production of acid.

CONCLUSION

Woohoooo! By now you’ve made it through ☺ Fascinating, isn’t it? Although a bit complicated and maybe dry matter, I hope you have gained a bit more insight into the fascinating being of your horse. Give yourself time to consolidate the information and I hope to see you again for a next course!

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