Examine the anatomy of a horse from an entirely different perspective with this intriguing and original explanation of the 11 internal body systems painted on the outside to explain everything on the inside.

Gillian Higgins turns her trademark technique of painting internal diagrams directly onto live horses to show how all the systems work together to affect performance and reduce the risk of injury.

Divided into 12 chapters, it clearly explains the importance, relevance and interaction between each of the anatomical systems.

Visually appealing, original and easily understandable, Horse Anatomy for Performance explains how anatomy influences the way we manage, ride and train our horses.

“Finally a book where you can learn how your horse ticks inside out and it is easy to understand and fun to read. A must for every serious equestrian.”

Dr. W. Bechtolsheimer
HORSE ANATOMY
for Performance

Gillian Higgins
with Stephanie Martin

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with Stephanie Martin
FOREWORD

by Dr. Andrew Hemmings
Neuroanatomist and principal lecturer in Animal Science and Production at the Royal Agricultural College

Fifty million years of evolution shaped the equine form to perfectly fulfil its biological function within a challenging ecological niche. On that basis the domestic horse is well equipped as a herd dwelling herbivore, able to survive on poor quality forage, with sufficient athleticism to outwit its prey. If we are to harness these attributes for leisure or competition purposes, horse keepers should gain a full appreciation of the various equine biological systems, and how they work in concert to maintain optimal health status. Previous books by Gillian have focussed primarily on anatomical characteristics of the musculoskeletal system. This most recent offering extends that information and also does considerably more. The 12 body systems of the horse and their interactions are presented in such a manner that always considers practical management and welfare applications. Furthermore, the beauty of the equine form, is once more illuminated and celebrated by Gillian’s excellent painted horse illustrations. Indeed, it is a rare occurrence to find pleasing aesthetics and sound biological information in a single text. As such this most recent offering most certainly constitutes a logical progression for the Horses Inside Out concept.

INTRODUCTION

The horse is a highly sophisticated living organism made up of atoms, molecules, cells, tissues, organs and systems. To enable him to reach his full athletic potential and give him a happy, healthy quality of life, it is up to us as carers, riders, trainers and therapists to ride him sensitively, manage him effectively, predict his emotions and behaviour, ensure that all his needs are met and give him the best possible chance to succeed.

To do this, it is important to understand both his capabilities and limitations within the context of his structure and function. The horse’s body is a marvellous machine. Each anatomical system has individual tasks to perform but is also interdependent on each other. This book, a sequel to How Your Horse Moves, delves more deeply into how the horse functions and looks at some practicalities of anatomical training. Like How Your Horse Moves, it can be read as a whole or dipped into as required. Although there are suggestions for achieving desirable outcomes, it is not intended either as a training manual or a definitive anatomical text. It is designed to encourage the reader to study further, look at the horse in a new light, care for him with empathy and ride him with perception and consideration.
The skin, together with the hair, hoof and various glands, make up the integumentary system, which is involved in protection and temperature regulation, vital to health and survival.
THE SKIN

The skin is a highly organised, complex system of nerves, tissue and cells designed to harmonise the horse’s metabolism with his internal and external environment. Structurally, the skin consists of the epidermis and the dermis. It is the largest, heaviest organ in the horse’s body. Its healthy condition is of vital importance to health and survival.

The epidermis is made up of several stratified layers of tough, non-vascular cells that vary in thickness. The layers can be likened to roof tiles overlapping. As the layers move up from the lower underlying living layer, they gradually die off and become toughened by a structural protein called keratin. The oil and sweat glands pass through the epidermis and reach the surface as pores. Vitamin D, synthesised in the epidermis following exposure to the ultra violet rays from the sun, is important for the absorption of calcium and for strong bones and teeth. Melanin, the pigment responsible for colour, also protects the skin from sunlight and is found deep within this layer.

The dermis is the deeper thick, live layer of the skin which is rich in blood vessels, nerve endings, lymphatic vessels, hair follicles and sweat glands. It is anchored to the hypodermis by an intricate network of collagen fibres, another structural protein, which give the skin its elasticity, suppleness and healthy appearance. Nerves in the dermis, together with hair follicles, act as receptors for touch, pressure, pain, vibration, tickling, warmth and coolness. Pain, when the skin is manipulated or exposed to temperature extremes can be an indication of impending or actual tissue damage.

Within the dermis there are two main types of gland:

- **The Sebaceous glands** which are located in the dermis and attach to each hair follicle. They produce sebum, a mixture of fats, cholesterol, proteins, salts and pheromones. Sebum coats the hairs to prevent them from becoming dry and brittle. It also prevents excessive evaporation of water from the skin keeping it soft and pliable and inhibiting the growth of certain bacteria.

- **The sweat glands** which release their secretions onto the surface of the skin through millions of pores.

The hypodermis is a layer of loose connective tissue which allows the skin to move freely. Subcutaneous fat is stored here. This provides insulation, is an energy store and acts as a cushion between the dermis and the muscle which, in turn, attaches to underlying tissues and organs. The hypodermis also contains large blood vessels that supply the skin. This region together with the dermis contains nerve endings that are sensitive to pressure.

**SKIN MOVEMENT**

The panniculus carnosus is a thin sheet of subcutaneous muscle that attaches to and interweaves with the skin around the trunk of the horse. It is responsible for moving, wrinkling and dimpling the skin. When the sensory nerves in the skin or hairs are stimulated by the tickle of a fly, for example, nervous messages pass directly to the panniculus carnosus causing it to contract and twitch the skin. This is well worth remembering when a horse does not respond to the leg!

This muscle only extends as far as the knee or hock and is not present in the neck. This means that when a fly irritates the skin on the lower legs, the horse will stamp his hoof or, if it lands on the neck, he will shake his head. This has been cited as a contributory factor in head shaking.

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**Cross-Section of the skin**

![Cross-Section of the skin](image-url)
THE HAIR

Hair originates in the dermis and is set at an angle. Each hair is a cuticle made of dead cells bonded together with protein. It has a shaft that grows from the root, which is surrounded by a hair follicle. Sebaceous glands secrete oils into the hair follicle, nourishing the hairs and creating a healthy shine to the coat. This is particularly evident in darker coloured horses. The oils also provide extra insulation and grease the coat to make it more waterproof.

There are three types of hair:

- **Permanent hair** – the mane, tail, eyelashes and feathers.
- **Tactile hair** – used to estimate the distance between the muzzle and an object. Especially relevant when the horse needs to locate an object.
- **Temporary hair** – consists of an undercoat of fine, densely packed hair, covered by a layer of longer, coarser hairs. This hair undergoes three phases in its life cycle, the growth phase, the transition phase and the quiescent or inactive phase, which ends with the twice-yearly moult triggered by hormonal changes, day length and temperature. During the growth stage, new cells are continuously being added to the hair follicle. When they die, they are pushed upwards, causing the hair to grow longer. In time growth stops and the resting stage begins. After inactivity, a new growth cycle begins to push the old hair root out of the hair follicle growing a new one in its place.

THE FUNCTION OF THE SKIN

Protection

The skin serves as the primary physical, chemical and biological barrier against weather, injury, dehydration and infection. It is also involved in controlling fluid balance, stabilising blood pressure and giving flexible support to the horse’s body. The skin varies in thickness over the body depending on breed, age and sex. This makes some areas more sensitive than others. On the back, for example, it is denser and tougher than on the inner surfaces of the limbs where it is not as exposed. Around a joint, extra sebaceous glands make it more pliable. The skin is water resistant and cannot become waterlogged or completely dry out. The naturally acidic pH value of the skin inhibits the growth of micro-organisms and bacterial chemicals and can kill surface bacteria, fungi and viruses. It is also responsible for excreting some waste products.

The pigment melanin within the skin provides protection from the sun’s rays. Horses with a white nose or snip are prone to sunburn.

Communication

The hair offers protection against grazes, bacteria, foreign bodies and the sun’s rays. Touch receptors in the follicles are activated whenever a hair is moved even slightly. This means that horses are extremely sensitive to touch. Sebaceous glands secrete oils into the hair follicle helping to nourish the hairs. These secretions develop grease within the coat adding extra insulation and shine and helping to make the coat more waterproof.

The skin is also responsible for producing chemicals that influence behaviour and attract the opposite sex.
PAINTING HORSES

The paint that is used on the horses is water based, non toxic and completely harmless.

All of the paintings are designed and painted on the horse by the author. It takes between 4 and 6 hours to paint a horse depending on the complexity of the anatomical system.

All diagrams in the book are hand drawn by the author.

Most of the paint rubs off with a rubber curry comb, and the remainder washes off with warm water.

UNDERSTANDING TERMINOLOGY

Adipose – fatty tissue
Amygdala – the part of the brain involved in processing emotions, especially anger and fear
Antigens – foreign substances such as bacteria, viruses and other toxins
Axon – the long part of a neuron or nerve fibre that conducts impulses away from the body of a cell
Caudal – towards the tail
Cell body – this contains the nucleus and mitochondria, really important for energy production
Cilia – tiny hair like projections that move in a Mexican wave like motion
Collagen – the fibrous protein constituent of bone, cartilage, tendon and other connective tissue
Cranial – towards the head
Cryotherapy – the use of cold to remove heat from a body part
Dendrites – fibres of brain and nerve cells that receive signals from other brain and nerve cells
Distal – furthest from the centre
Dorsal – towards the back
Electrolytes – minerals, mainly salts, that are dissolved in fluid
Fight or flight – an early evolutionary behaviour strategy to deal with dangerous and unexpected situations
Glycogen – a type of carbohydrate stored in the liver and muscle cells that is easily converted to glucose to meet metabolic energy needs
Hives – a skin condition characterised by itching welts caused by an allergic reaction
Homeostasis – internal stability or equilibrium
Hypothalamus – control centre for the autonomic nervous system regulating functions such as sleep, body temperature and appetite. Also acts as an endocrine gland controlling hormonal secretions of the pituitary gland.
Keratin – the chief structural constituent of hair, nails, horns and hooves
Lymphocyte – a white blood cell that plays an important role in defending the body against disease
Medulla oblongata – the part of the hindbrain that controls autonomic functions such as breathing, digestion and heart rate
Meninges – the three membranes that cover and surround the brain and spinal cord
Mitochondria – parts of cells responsible for energy production
Neuron – nerve cells responsible for controlling reactions from the senses, mood, thoughts and emotions
Neurotransmitter – a chemical substance that transmits nerve impulses across the spaces between nerve cells or neurons
olfactory – relating to the sense of smell
Peristalsis – movement of contents along a tubular structure by wave like muscular contractions
pH scale – measure of the degree of the acidity or the alkalinity of a solution on a scale of 0 to 14. Water is 7
Phagocyte – a white blood cell that engulfs and absorbs harmful micro organisms and waste material from the blood and other tissues
Pheromone – a chemical substance secreted to influence the behaviour of another member of the same species
Plexus – a network of nerves
Protein – a fundamental component, including substances such as enzymes, hormones and antibodies, essential for the proper functioning of all living cells
Protraction – reaching forward, the forward swing of the stride
Receptor – an organ or cell, which can transmit a signal to a sensory nerve in response to light, heat or other external stimuli
Retraction – the backward push of the stride
Subcutaneous – the third and deepest layer of skin
Swann cells – these fatty cells increase the speed at which signals can travel along axons
Synthesis – the combining of separate parts to produce a more complex product
Vascular – relating to vessels that circulate fluids
Vasconstriction – the constriction of blood vessels, which reduces blood flow
Vasodilation – the dilation of blood vessels, which increases blood flow
Ventral – towards the underside
ABOUT THE AUTHOR

GILLIAN HIGGINS is an equine and human sports and remedial therapist, event rider and coach with a passion for equine anatomy and anatomical art. As a leading expert in her field she founded Horses Inside Out. This unique organisation gives riders, trainers, students and therapists a fascinating insight into the training, management, comfort and welfare of their horses through understanding anatomy, physiology and biomechanics. With an enthusiastic style of presentation and the ability to bring her subject to life, Gillian is in demand worldwide. Gillian runs courses in anatomy and biomechanics, dissections for therapists, massage and stretching for horse owners as well as day courses for colleges and universities and evening lecture demonstrations for all. She has written several books including:

- *Pilates and Stretching for Horses*
- *The Horses Inside Out Anatomy Poster Book*
- *How Your Horse Moves*
- DVDs:
  - Movement from the Anatomical Perspective
  - Pilates for Horses

STEPHANIE MARTIN has been involved with horses from a very early age and has a particular interest in their welfare. With a keen interest in literature, and a ‘way with words’, she has written various articles for many magazines and has played a valuable part in putting together the text for this book.

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I would like to thank my father

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