GLANDS AT A GLANCE: A HORSE'S ENDOCRINE SYSTEM

By Emily Kilby

Your horse's life-sustaining endocrine system works in wondrous, if little-noticed, ways.

Think of the equine body as an enlightened corporal corporation. Under the direction of president hypothalamus, CEO pituitary gland processes messages to and from department managers, known collectively as endocrine glands, and circulates them bodywide.

These interoffice memos are the hormones. Every single cell has at least one "in" basket--a receptor--and maybe several, to receive hormonal memos specifically related to its duties. Those messages of no significance to the individual cell's function just float on by unread.

This corporation really cares about its workers' well-being, along with their output. Feedback from the cells is as important as the hypothalamus directives telling them what to do. Individual cells grow old and wear out or are lost to disease or trauma, and these are replaced in an orderly process. But the constant goal is survival of the organism, which is assured only when all of life's basic needs are maintained within certain parameters, a state called homeostasis.

Of course, the brain is ultimately in charge of this hypothetical corporation. As head of the nervous system, it sends out electronic commands that are far quicker than the endocrine system's chemical memos. But the brain couldn't do the job alone. Without the endocrine system's attention to well-being of the rank and file, the brain would quickly die, along with its insufficiently nourished, hydrated or defended underlings.

The brain and the endocrine system are in constant communication with each other and with individual cells. The two communications systems integrate through the hypothalamus, which translates electronic information supplied by the senses into the chemical orders that lead to cellular responses. For example, when your horse's skin registers extremely cold temperatures, the nervous system responds immediately in two ways: It causes the horse's hair to stand up for better heat retention, and it makes the horse shiver as an emergency means of producing heat. Meanwhile, the hypothalamus monitors this sensory input; if the cold persists over many days, it acts via the pituitary gland to produce more lasting warmth. The pituitary notifies the thyroid gland to increase the body's rate of fuel consumption--to turn up the thermostat, so to speak--which it does by releasing more of its energy-enabling hormone.

At any given time, 30 to 40 different hormones are in distribution in your horse's blood stream, orchestrating energy usage, water and mineral balance, heart rate and blood pressure, growth and sexual development, reproduction and stress reactions. Endocrine memos arrive in two formats--as hormones derived from proteins, which bind to receptor cells' outer membranes, and as hormones derived from solid steroid alcohols, which enter into the cells and bind to internal receptors.

These messages usually instruct the cell to "do" or "do more," as in do produce your protein, do excrete your substance, do contract or dilate--whatever its function may be. Reduction or absence of the hormone means "slow down" or "don't." So long as the hormone is present on the receptor, the switch stays on. When feedback informs the boss that the level of production is adequate or excessive, the order is scaled back or withdrawn, and the output remains stable or dwindles.

Some functions, however, require such fine-tuning that pairs of hormones may act on the same cells in antagonistic fashion. For instance, a hormone from the thyroid gland enables calcium to leave the blood
stream and go into storage in bones, while a hormone from the parathyroid glands orders the same mineral out of storage and into circulation. These opposing hormonal actions permit a more rapid response to a circulatory excess of deficiency of this critical mineral than a simple on/off mechanism controlled by a single gland.

Read on to discover how the astonishing endocrine glands—the smallest of all the organs, squirting out minute quantities of specialized chemicals—manage your horse's life-sustaining processes second by second, day by day, season by season, over a lifetime. It’s a marvel of corporate communication.

**The Pituitary Gland**

*Aliases:* the "hypophysis" (from the Greek for "to grow underneath"); the "master gland."
*Location:* within the skull, in its own niche in the floor of the braincase, next to the brain stem and underlyng the hypothalamus.
*Appearance:* a flattened, oblong structure embedded in connective tissue; in horses, about the size of a prune (pea size in people).
*Structure:* a two-part gland attached by special blood vessels and nerves to the hypothalamus.

- The neurohypophysis derives from the nervous system and serves as storage for two direct-acting hormones manufactured by cells in the hypothalamus.
- The adenohypophysis develops from cells in the roof of the mouth and is itself divided into three sections. Some hormones produced here act directly on target cells, but most pituitary hormones serve to stimulate other glands to release their hormones.

*Hormones and actions:* control most of the vital bodily functions.

- circulation and kidney function—Vasopressin, also called antidiuretic hormone (ADH), increases blood pressure by signaling the kidneys to retain water and by constricting the small arteries when blood pressure drops. The hypothalamus produces ADH.
- metabolism and growth—Thyroid-stimulating hormone (TSH) triggers hormone synthesis and secretion in the thyroid gland; adrenocorticotropic hormone (ACTH) regulates steroid production in the adrenal glands; growth hormone (GH) orchestrates protein synthesis, carbohydrate metabolism and related processes throughout the body as a foal grows to maturity.
- reproduction—Follicle-stimulating hormone (FSH), luteinizing hormone (LH) and others stimulate the ovaries and testes for their roles in conception and pregnancy; prolactin supports milk production in the udder. Oxytocin, produced by the hypothalamus, triggers the smooth-muscle contractions of the uterus and mammary glands involved in birth, expulsion of the placenta and milk "let down."

*Diseases:* Equine Cushing's syndrome (also known as pituitary pars intermedia dysfunction) occurs when feedback signals from other glands begin to fail, causing the pituitary gland to stimulate overproduction of the steroid hormone cortisol by the adrenal glands. This, in turn, triggers over-activity of various other endocrine metabolic disturbances produce obesity, muscle weakness, behavioral changes and, most visibly, abnormally long or curly haircoat and failure to shed.

**The Adrenal Gland**

*Alias:* "the shock organ." *Appearance:* like lumpy knit caps sitting on the ends of the kidneys.

*Structures:* a two-part organ that's virtually two endocrine glands in one.
• The adrenal cortex, the outer layer derived from urinary/genital-tract cells, is divided into three zones which produce numerous steroid hormones.
• The adrenal medulla, the gland's interior portion derived from neurological cells, produces catecholamines, organic compounds that act both as hormones in the bloodstream and as neurotransmitters in the nervous system.

**Hormones and actions:** affect a broad range of essential life functions.

- circulation--The mineralocorticoids, including aldosterone, regulate body salt (sodium levels) and help maintain blood volume and blood pressure.
- metabolism--The glucocorticoids, including cortisol, cortisone and coricosterone, regulate energy, protein, fat and mineral use as well as help to reduce inflammation.
- reproduction--The gonadocorticoids have a role in sperm production in stallions but have the greatest influence on secondary sex characteristics, including gender-specific behavior.
- stress response--The catecholamines (epinephrine, with some help from norepinephrine and dopamine) orchestrate the immediate "fight or flight" response to perceived threats. The glucocorticoids alter metabolism and body functions when stress persists.

**Diseases:**

- As the "shock organ," the adrenals can be damaged and permanently scarred by bouts of severe systemic disease, such as endotoxemia and anaphylactic shock.
- Adrenocortical insufficiency occurs when corticosteroid medications are administered for extended periods at high doses. With plenty of supplemented steroid hormones in circulation, the feedback mechanism keeps adrenal production turned off, and the gland eventually shrivels from disuse.
- Hyperadrenocorticism, overproduction of corticosteroid hormones, typically occurs because of pituitary hypertrophy.
- Anhidrosis, the inability to sweat when needed, may have an adrenal-hormone component, as affected horses have more epinephrine in circulation than normal horses.

**The Thyroid Gland**

*Alias:* none
*Location:* on each side of the windpipe, just behind the larynx.
*Appearance:* rather lake a split golf ball, with the two hemispheric lobes joined by an "isthmus" extending across the underside of the windpipe; isthmus is larger in foals and asses than in adult horses.

*Structures:* made up entirely of follicles, hollows lined by cells that produce and secrete hormones. **Hormones and actions:** affect all organ systems, adjusting body metabolism, growth, sexual maturation and vital functions to meet environmental conditions.

- Thyroxine (T4) level determines the body's metabolic rate. The more there is, the more calories will be burned, the faster and more forcefully the heart will beat, the greater will be the appetite, the more active will be the digestive tract and the more alert, even hyperactive, will be the horse.
- Triiodothyronine (T3) and related hormones have actions similar to thyroxine but are faster acting and one tenth as prevalent.
- Calcitonin reduces the amount of circulating calcium by moving it out of the blood and into storage in the bones. This hormone plays a modulating role behind the primary calcium regulator, parathyroid hormone.
Diseases: Thyroid malfunctions in horses are considered to be rare, possibly because they're not well documented, and blood hormone levels are difficult to test.

- Goiter is an enlargement of the gland due to either excess or deficiency of dietary iodine, the essential ingredient of thyroxine. Foals may be born with goiter when their dams get too little or too much iodine in their diets. Often the cause is an iodine excess from kelp-containing feed supplements.
- Hypothyroidism, thyroid insufficiency, causes broad ranging signs, including failure to grow, decreased appetite, dull haircoat, increased sensitivity to cold, delayed shedding, lethargy and failure to produce milk in broodmares.
- Thyroid tumors occur often in older horses, but they are usually benign adenomas and have no effect on the gland's function. Cancerous tumors do sometimes develop, and they can be surgically removed, leaving the remaining part of the gland to carry on.

The Parathyroid Gland
Alias: none

Location: accounts differ; horse is believed to have four, at least two of which are in connective tissue on or near the thyroid gland; remaining two may be in the chest, close to the first pair of ribs or elsewhere on the thyroid.

Appearance: obviously hard to identify, but irregularly shaped and quite small, the size of a shirt button.

Structure: a single-function gland of paler, less dense tissue than the thyroid.

Hormone and actions: act independently of other endocrine glands, sensing plasma calcium levels and making minute-to-minute adjustments. Calcium plays a role in clotting, neuromuscular controls, cell-membrane permeability, and muscle contraction, as well as providing the building block of bones and teeth. Parathyroid hormone (PTH) increases plasma calcium by stimulating bones to release the mineral the kidneys to retain calcium in circulation rather than eliminate it in urine, and the gastrointestinal tract to take up more from food. Vitamin D is the essential partner of PTH in calcium retention and absorption. Calcitonin is the antagonist.

Diseases: Horses' parathyroid glands rarely malfunction and cause disease, but dietary imbalances can wreak havoc with calcium chemistry.

- Tumors affect hormone production, increasing the amount of calcium brought into circulation from bone, gut and kidneys.
- Hyperparathyroidism occurs when PTH release is no longer responsive to blood calcium levels.
- Vitamin D deficiency or excess disrupts calcium utilization. With only a little exposure to sunlight, horses synthesize adequate amounts of the vitamin, which is also present in sun-cured roughages; oversupplementation of vitamin D causes the gut to absorb more calcium than the body needs, leading to mineralization of soft tissues.
- Nutritional secondary hyperparathyroidism results from a dietary imbalance in which phosphorus substantially exceeds calcium, causing shifting lameness and "big head" disease.
- Hypocalcemia, also called lactation tetany, transit tetany eclampsia and "thumps," depending on the triggering event, occurs when plasma calcium drops precipitously from stress, feedback error or lactation. A low-level disturbance causes excitability in the horse; midlevel deficiency produces incoordination and muscle tremors and spasms; severe deficiency quickly brings the horse down, leading to stupor and death. Calcium given intravenously saves the day.

The Pancreas
Alias: "stomach sweetbreads," so called by the ancient Greeks.

Location: in the abdominal cavity, near the start of the small intestine and below the kidneys.

Appearance: roughly triangular in shape and lumpy, with small lobes.
Structure: hormone-producing cell clusters called islets of Langerhans, which contain three different kinds of cells. The rest of the organ—the vast majority of it—serves digestive enzymes directly into the gastrointestinal tract.

Hormones and actions: the primary players in the body's complex energy management scheme; micromanage mobilization, storage and cellular use of carbohydrates, proteins and fats.

- Insulin, 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 raises blood sugar levels by pulling reserves out of storage when circulating energy supplies begin to dwindle.

Diseases: Upsets of pancreatic endocrine function usually are secondary to other diseases or dietary problems.

- Diabetes mellitus, insulin deficiency, occurs when the pancreas does not produce enough of the hormone, excessive antagonistic hormones are present or target tissues have become sensitive to insulin. Cushing's syndrome, adrenal malfunctions, and tumors or inflammation of the pancreas itself may cause diabetes to develop in a horse.
- Obesity in ponies and late-term pregnancy may cause temporary abnormalities in insulin function.

The Gonads
Aliases: the testes/testicles (males); ovaries (females).
Location: scrotum/rear of the abdominal cavity not far below the spine.
Appearance: egg-shaped/bean-shaped.
Structures: seminiferous tubules for producing semen in each testicle, with attached duct (epididymis) to further concentrate and transport semen; follicles mature, erupt to produce one egg (ovum) per heat cycle, then regress; egg passes through the fallopian tubes to the uterus.

Hormones and actions: control reproduction, determine puberty, influence secondary sexual characteristics. Pituitary hormones give permission for reproduction, while local hormones look after the day-to-day details. Both sexes produce male and female hormones, but at different levels, depending on gender.

- Testosterone, the primary androgen, or male hormone, maintains sperm production, contributes to secondary sex characteristics and fires libido.
- Estrogen, produced by an active follicle, causes estrous behavior in mares in conjunction with ovulation and supports conception.
- Progestins (progesterone), produced by the erupted follicle, prepare the reproductive tract for pregnancy, suppress ovulation and estrous behavior for the first three months of pregnancy, and, if no conception occurs, diminish over the course of several weeks to allow a new estrous cycle to occur.

Diseases: Most reproductive problems in horses result from the breeding practices imposed by domestication. Overuse of anabolic steroids can disrupt normal reproductive cycles in mares. Malfunction of other endocrine glands can affect sexual maturation and normal cycling. Ovarian tumors may masculinize mares.

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