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Regulation/ Control of Hormone Secretion

Hormones may be regulated by other hormones, by glands and organs, and by feedback mechanism.

Hormones that regulate the release of other hormones are called **tropic hormones**. The majority of tropic hormones are secreted by the anterior pituitary in the brain. The hypothalamus also secretes tropic hormones. The hypothalamus produces the tropic hormone thyrotropin-releasing hormone (TRH), which stimulates the pituitary to release thyroid stimulating hormone (TSH). TSH is a tropic hormone that stimulates the thyroid gland to produce and secrete more thyroid hormones.

Organs and glands also aid in hormonal regulation by **monitoring blood content**. For example the pancreas monitors glucose concentrations in the blood. If glucose levels are too low, the pancreas will secrete the hormone glucagon to raise glucose levels. If glucose levels are too high, the pancreas secretes insulin to lower glucose levels.

Feedback Systems:

Hormone secretion is commonly controlled by what are called feedback systems. This means that the level of hormone in the blood directly or indirectly "feeds back" to the gland that produced it and affects the activity of the gland. If the activity is decreased by rising levels of the hormone, the feedback is said to be negative feedback. If the activity is increased by falling levels of the hormone, the feedback is said to be positive feedback.

Types of Hormonal feedback system:

1. **Positive feedback systems**
2. **Negative feedback systems**
3. **Non feedback systems**

Positive feedback systems: Much less common. In this situation a hormone is secreted to achieve a certain end point. Once the hormone is first secreted, it promotes further secretion of hormone until some physiologic end point is achieved. **Positive feedback systems** do play specific, limited roles, for example in the complicated interplay of hormones involved in the **female estrous cycle**.

Act of ovulation of an oocyte from the ovary Or Mechanism of ovulation:

- This process begins with the hypothalamus secreting gonadotropin-releasing hormone (GnRH) into the hypothalamohypophyseal portal system, perhaps in response to the pineal gland sensing a change in day length.
- This causes luteinizing hormone (LH) to be secreted by the adenohypophysis.
- This hormone causes estradiol to be released from a developing ovarian follicle.
- The estradiol reaches the hypothalamus and causes increased secretion of GnRH, resulting in more LH secretion, and more estradiol secretion.
- This increased estradiol again feeds back on the hypothalamus to stimulate GnRH and LH secretion, causing more estradiol production to stimulate even more GnRH secretion.
- Finally, the surge in LH secretion is great enough to induce ovulation, the end point of this physiologic sequence.

Negative hormonal feedback systems:

Most common type in the animal body. In **negative feedback** regulation, the initial stimulus is reduced by the response it provokes. The response eliminates the initial stimulus and the pathway is halted. In this case, some perturbation of the physiology of the animal is sensed by regulatory centers in the endocrine or nervous system. This causes a hormone to be secreted. That hormone acts on target tissues to alter the physiology of the animal to correct the abnormal situation. The regulatory centers sense that the target cells have accomplished their mission and the regulatory centers cause hormone production to cease.

They function in a similar fashion to a thermostatically controlled room heater on a cold day. When the heater's thermostat is set to a temperature higher than the current ambient temperature, the heater is turned on to heat the air. When the room's rising temperature reaches the thermostat setting, the heater is turned down or off. Without a source of heat, the air in the room cools. When the temperature falls below the thermostat setting, the heater is turned back on

again, and so forth. The rising temperature of the room air feeds back to the thermostat and has a negative effect on the heater; that is, the heater is turned down or off. This is an example of a negative feedback system.

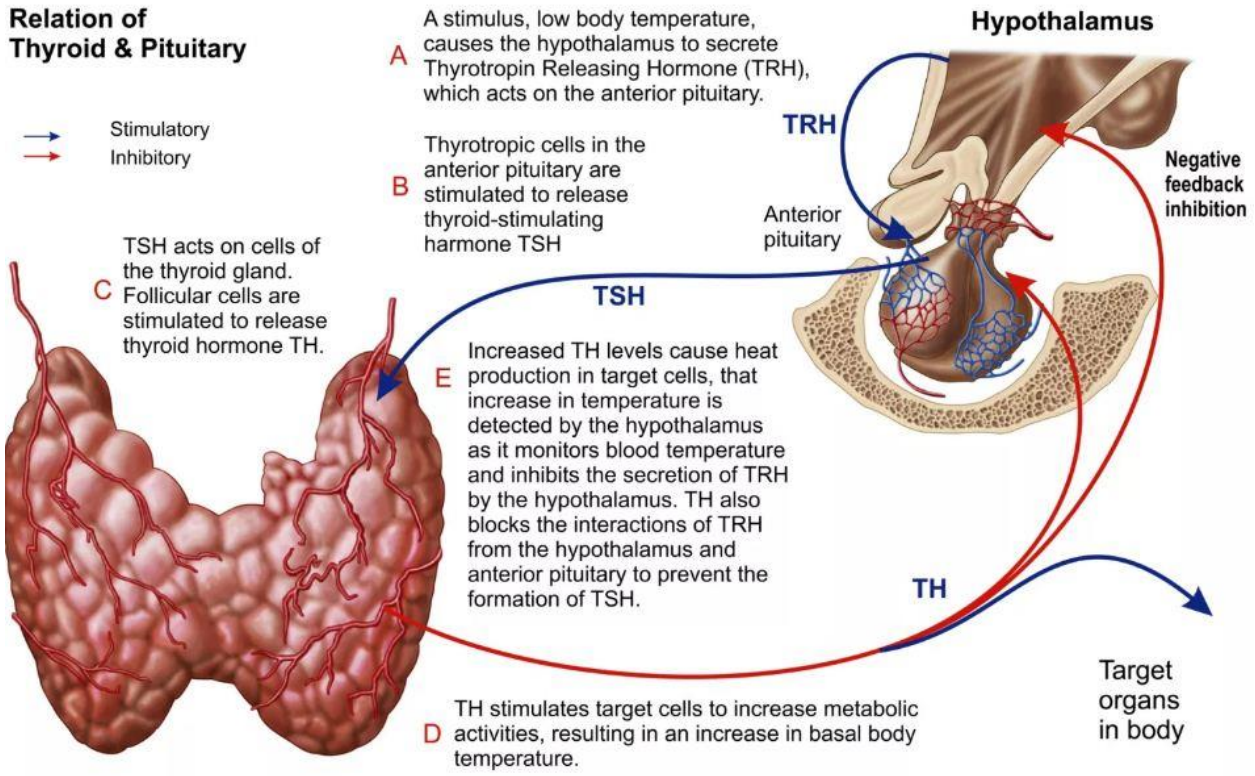
The secretion of many hormones is controlled in a similar fashion. For example, let's assume the "heater" is the thyroid gland, which produces its hormone as a result of stimulation by another hormone, called thyroid-stimulating hormone (TSH), from the anterior pituitary gland. When the level of thyroid hormone drops below needed levels the "thermostat setting" the anterior pituitary produces more TSH, which stimulates the thyroid gland to produce more of its hormone. This "turns on" the heater (thyroid gland) and tells it to produce more heat (thyroid hormone). The rising level of thyroid hormone in the bloodstream eventually reaches the level required in the body. Once that level is reached, the production of TSH by the anterior pituitary is turned down. This reduces the stimulation of the thyroid gland, causing it to produce less thyroid hormone (the heater has been turned down). When the level of thyroid hormone again drops below what the body needs, the anterior pituitary ramps up its production of TSH, which turns the production of thyroid hormone back up, and the process continues.

Regulation of red blood cell production or erythropoiesis. The kidneys monitor oxygen levels in the blood. When oxygen levels are too low, the kidneys produce and release a hormone called erythropoietin (EPO). EPO stimulates red bone marrow to produce red blood cells. As blood oxygen levels return to normal, the kidneys slow the release of EPO, resulting in decreased erythropoiesis.

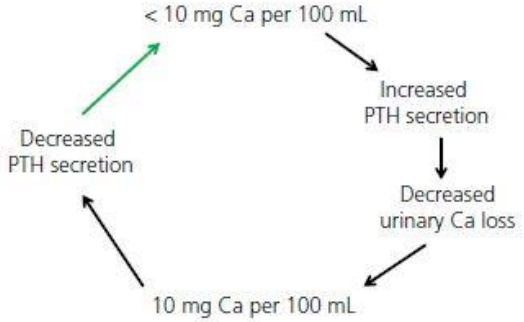
Non feedback related control mechanism for hormone secretion:

One endocrine gland uses a totally different, direct stimulation from the nervous system. The secretion of hormones from the **medulla of the adrenal gland** is directly stimulated by **sympathetic nerve impulses** when an animal feels threatened. The adrenal medullary hormones that are released into the bloodstream as a result of this stimulation contribute to the whole-body fight-or-flight response that prepares the animal's body for intense physical activity.

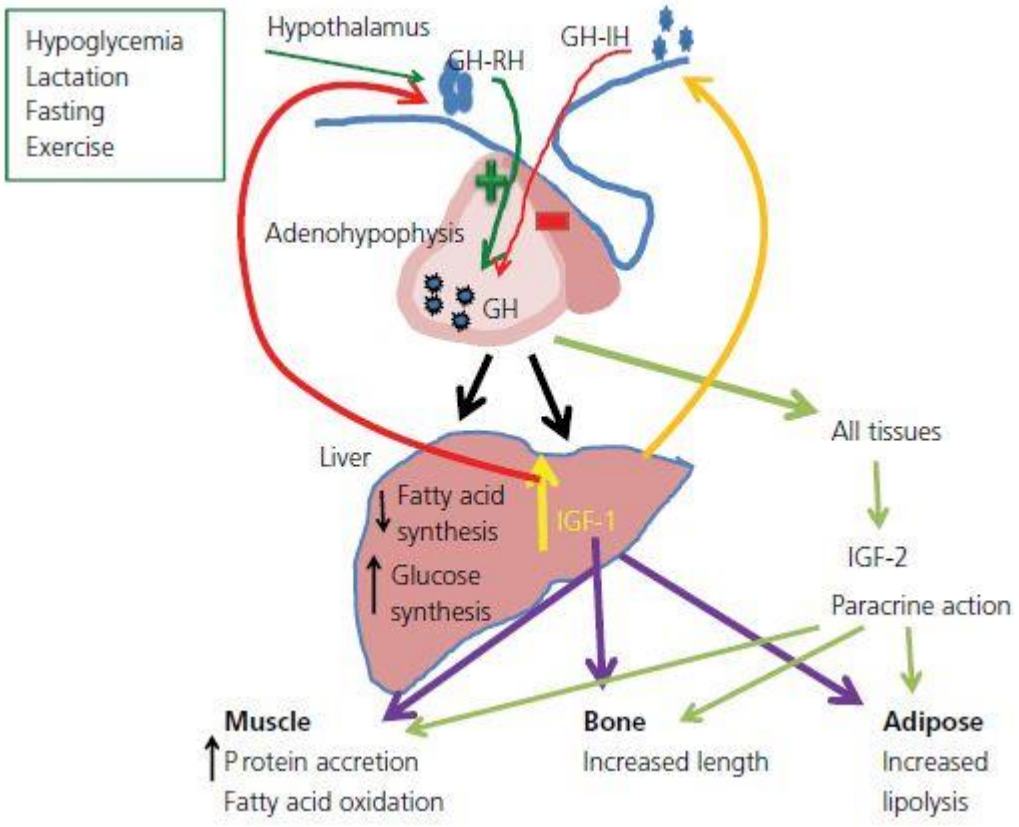
Thyroid hormone Regulation:



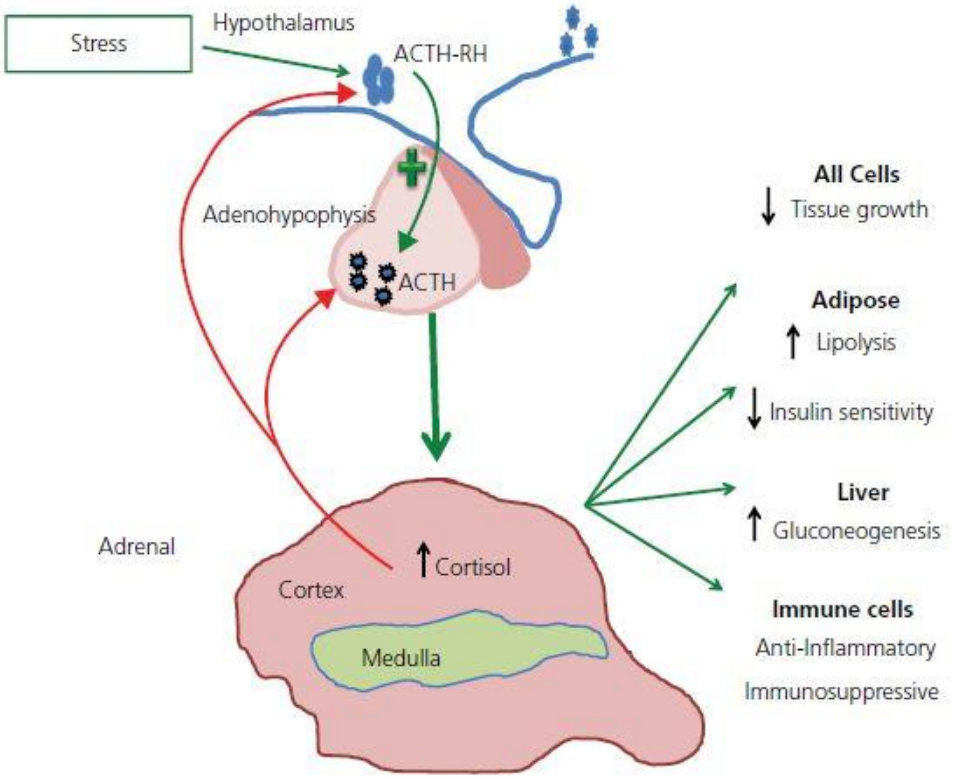
Negative feedback in calcium metabolism: The homeostatic set point for blood calcium is 10 mg/dL. If blood calcium falls below this concentration, it stimulates secretion of parathyroid hormone, which acts on renal tubular epithelium to increase renal reabsorption of calcium. This reduces calcium lost to urine and may bring enough calcium back into the blood to return blood calcium to 10 mg/dL, which is sufficient to stop parathyroid hormone secretion until the next time the calcium concentration falls below 10 mg/dL.



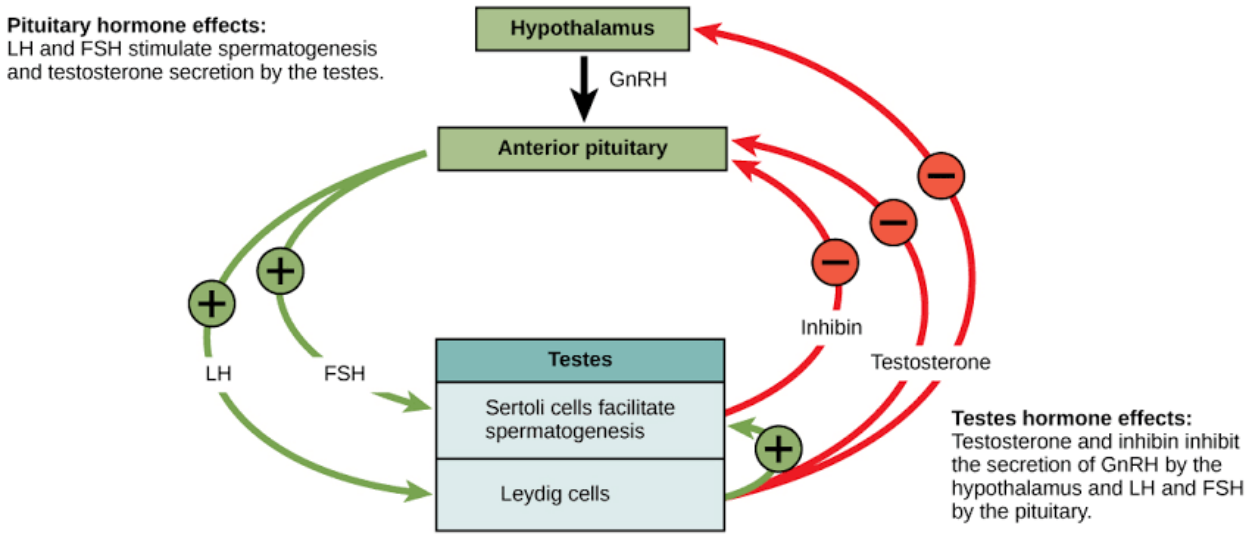
Growth hormone (GH) Regulation: GH is secreted from the adenohypophysis and causes the liver to secrete a hormone called insulin-like growth factor (IGF) -1. IGF-1 acts on muscle, bone, and adipose tissues and modifies their metabolism. These tissues, as well as many other cells of the body, can also respond directly to GH by producing IGF-2. IGF-2 acts in a paracrine fashion to modulate metabolism in target cells. GH secretion is stimulated by growth hormone releasing hormone (GH-RH) produced in the hypothalamus in response to factors such as hypoglycemia, lactation, fasting, and exercise. IGF-1 feeds back on the hypothalamus causing hypothalamic neurons to secrete growth hormone inhibitory hormone (GH-IH), which reduces GH secretion from the adenohypophysis.



Adrenal Glucocorticoid Regulation: Stress and other factors cause the hypothalamus to secrete adrenocorticotropic-releasing hormone (ACTH-RH) which enters the hypothalamo-hypophyseal portal system and acts on the corticotrophs of the adenohypophysis, resulting in secretion of adrenocorticotropic hormone (ACTH). ACTH then stimulates the adrenal zona fasciculata cells to produce and secrete cortisol. Cortisol then interacts with glucocorticoid receptors in the nucleus of target cells and affects metabolism of a wide variety of cells. High cortisol concentrations in the blood feedback on the adenohypophysis and the hypothalamus to inhibit secretion of ACTH and ACTH-RH, respectively.

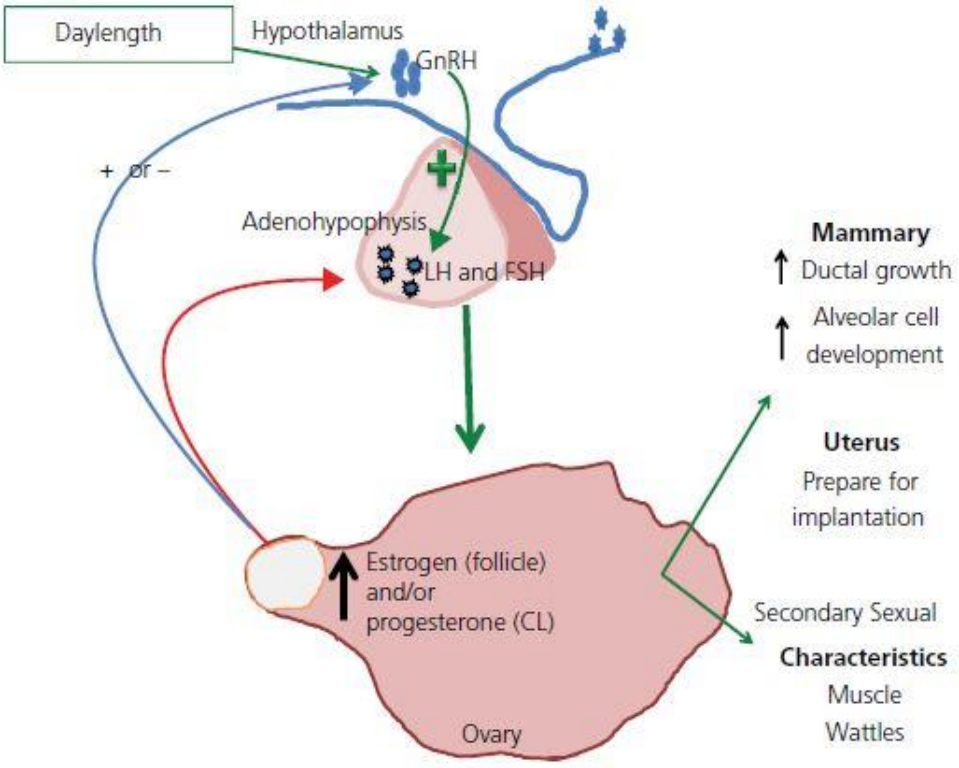


Regulation of sex steroid production in Male

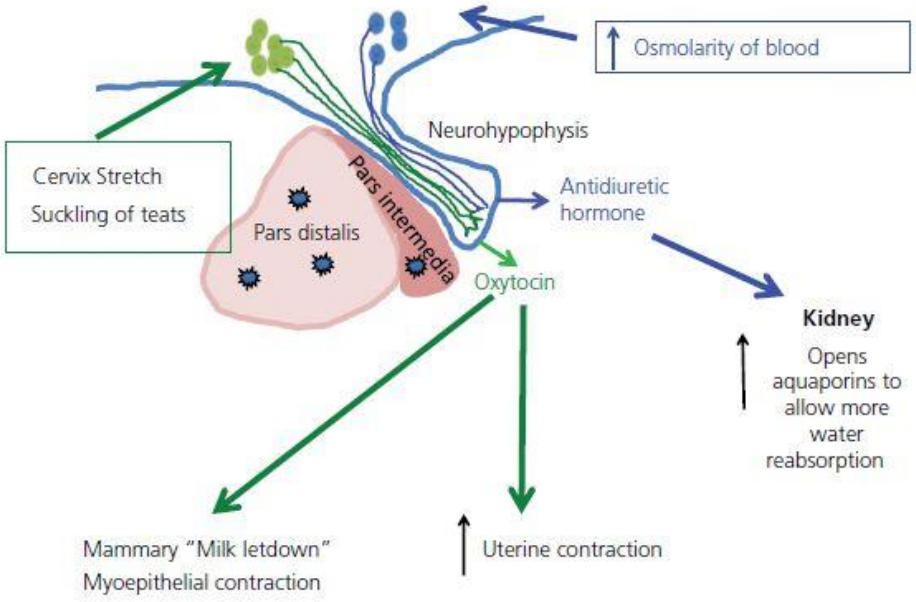


Regulation of sex steroid production in the female:

Daylength, age, plane of nutrition, and other factors stimulate hypothalamic neurons to produce gonadotropin-releasing hormone (GnRH). GnRH reaches the adenohypophysis via the hypothalamo-hypophyseal portal system and stimulates release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the adenohypophysis. FSH circulates to the ovary and causes one or more follicles to begin to mature. FSH stimulates the granulosa cells in the wall of the developing follicle to secrete estrogen. Estrogens can influence the growth of the uterus and the mammary gland. Estrogen has a stimulatory effect on hypothalamic secretion of GnRH. This positive feedback eventually reaches an end point where sufficient GnRH secretion has been stimulated to cause a spike in LH secretion resulting in ovulation of the mature follicle. At other times in an animal's reproductive life, estrogen inhibits LH and FSH secretion by the adenohypophysis. LH stimulates the ovulated follicle to become a corpus luteum (CL). The luteinized granulosa cells now produce proges-terone. Progesterone is vital for preparation of the uterus for implantation of the conceptus. It also plays a role in alveolar cell development in the mammary gland. Progesterone feeds back on the hypothalamus and adenohypophysis to inhibit GnRH and FSH and LH secretion, respectively.

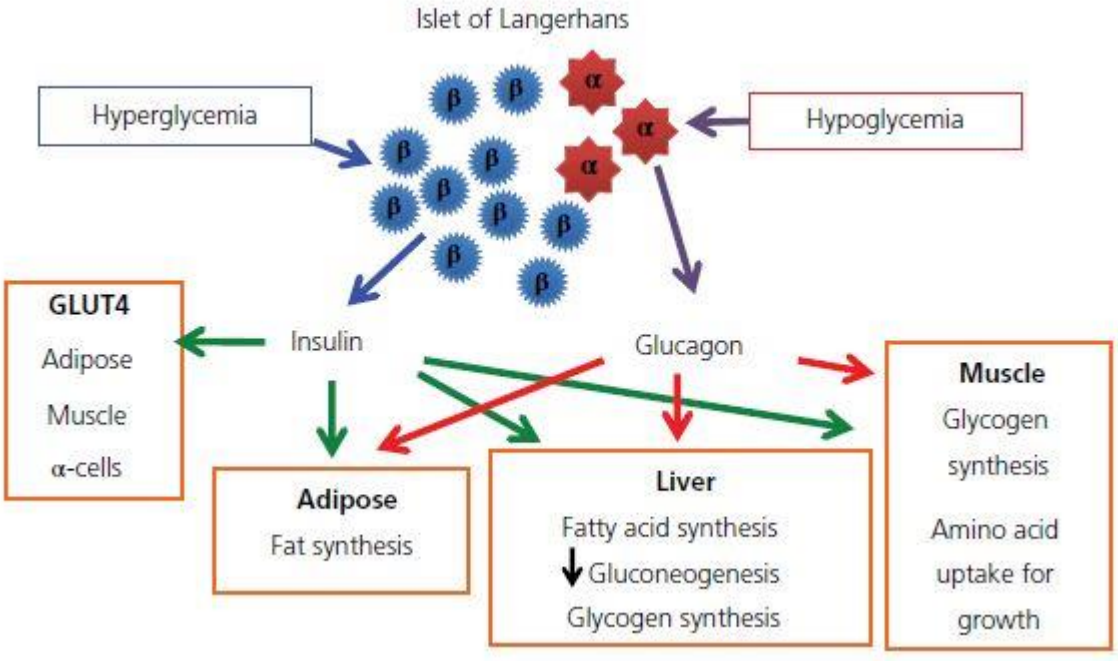


Regulation of neurohypophyseal neurohormone secretion:



Oxytocin secretion by hypothalamic neurons is stimulated by suckling of the teat or stretch of the cervix during parturition. Oxytocin is secreted from the nerve terminals of the neurohypophysis and carried by the hypophyseal vein to the uterus where it stimulates increased contractions, or to the mammary gland to stimulate milk letdown. Hypothalamic osmoreceptor neurons initiate secretion of antidiuretic hormone (ADH) whenever the osmolarity rises above the normal set point. ADH causes aquaporins in the renal collecting ducts to open and allow water to flow to the renal interstitium from the tubular fluid. This adds water to the extracellular fluid, reducing the osmolarity.

Regulation of insulin and glucagon secretion: Insulin-secreting β cells are very sensitive to changes in extracellular fluid glucose concentration. Whenever it rises above the normal set point, the β cells secrete insulin. Insulin has a variety of effects aimed at utilizing the surplus glucose for growth and fat synthesis as well as uptake of glucose from blood by muscle and adipose tissue. The actions of insulin reduce blood glucose concentration to the normal concentration. Glucagon is secreted by α cell of the pancreatic islets. These cells sense a decline in blood glucose



concentration (which is dependent on presence of insulin since α-cell GLUT-4 requires insulin). Glucagon has the opposite effects on tissues that insulin has. Glucagon inhibits fatty acid synthesis and glycogen synthesis and reduces uptake of amino acids for growth. It also stimulates gluconeogenesis, actions aimed at increasing blood glucose concentration back to normal concentrations.

Pineal gland function and regulation: The pineal gland is located in the center of the brain and receives input from the retina (in mammals) or through the skull (birds and lower vertebrates). Light inhibits the pineal gland from producing melatonin, while darkness promotes melatonin secretion. Melatonin then diffuses to the hypothalamus and regulates secretion of hormones involved in seasonal breeding, circadian rhythms, and other functions that require the animal to know what season of the year it is and the number of hours of daylight.