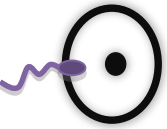
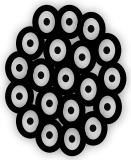
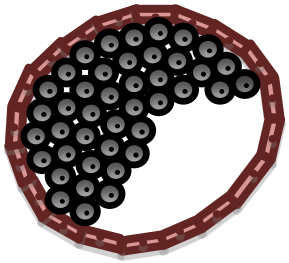
The reproductive system

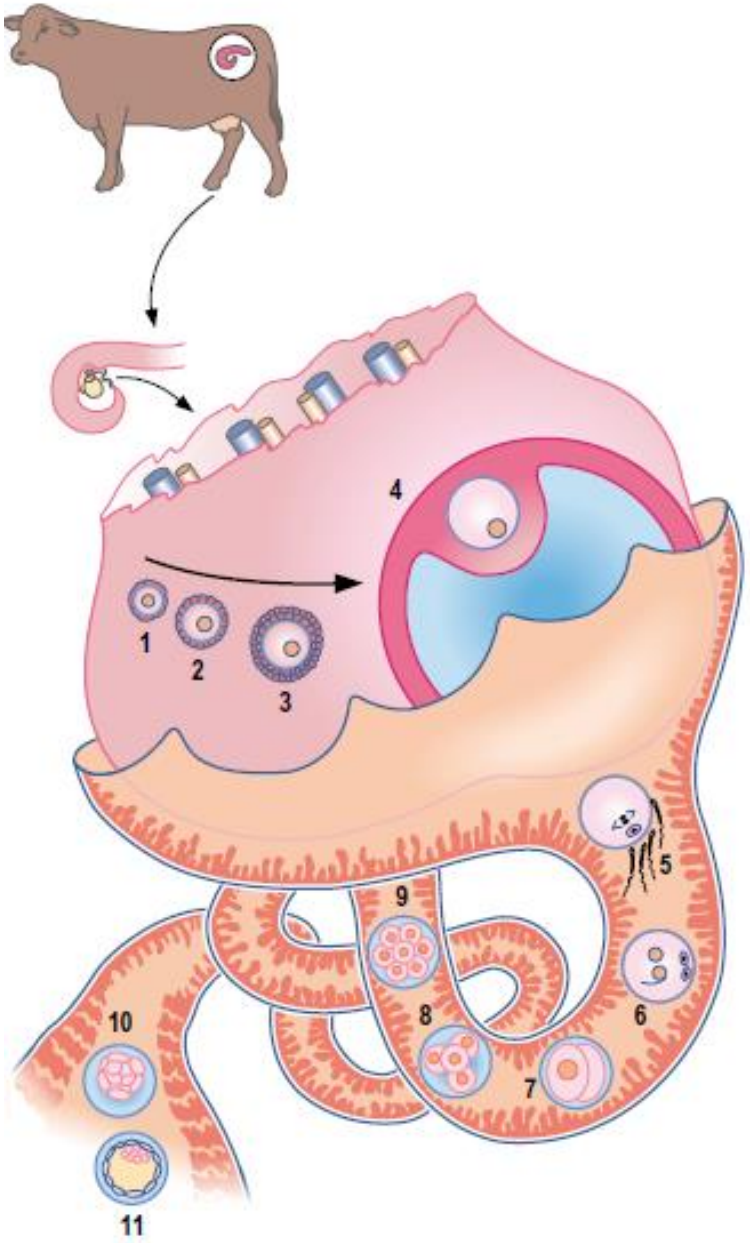
THE STORY OF LIFE…



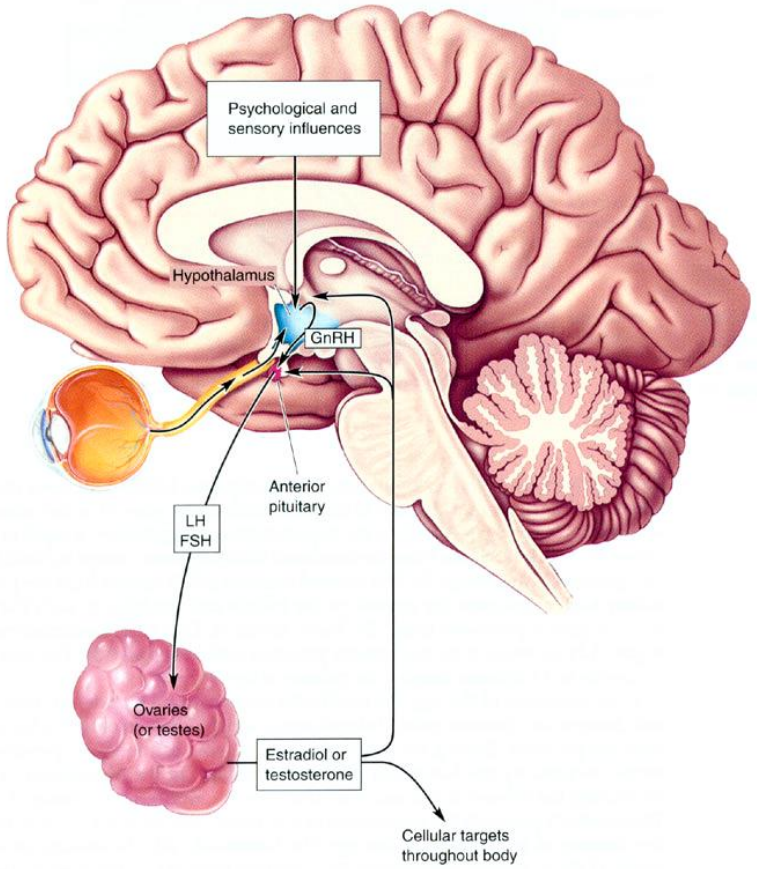




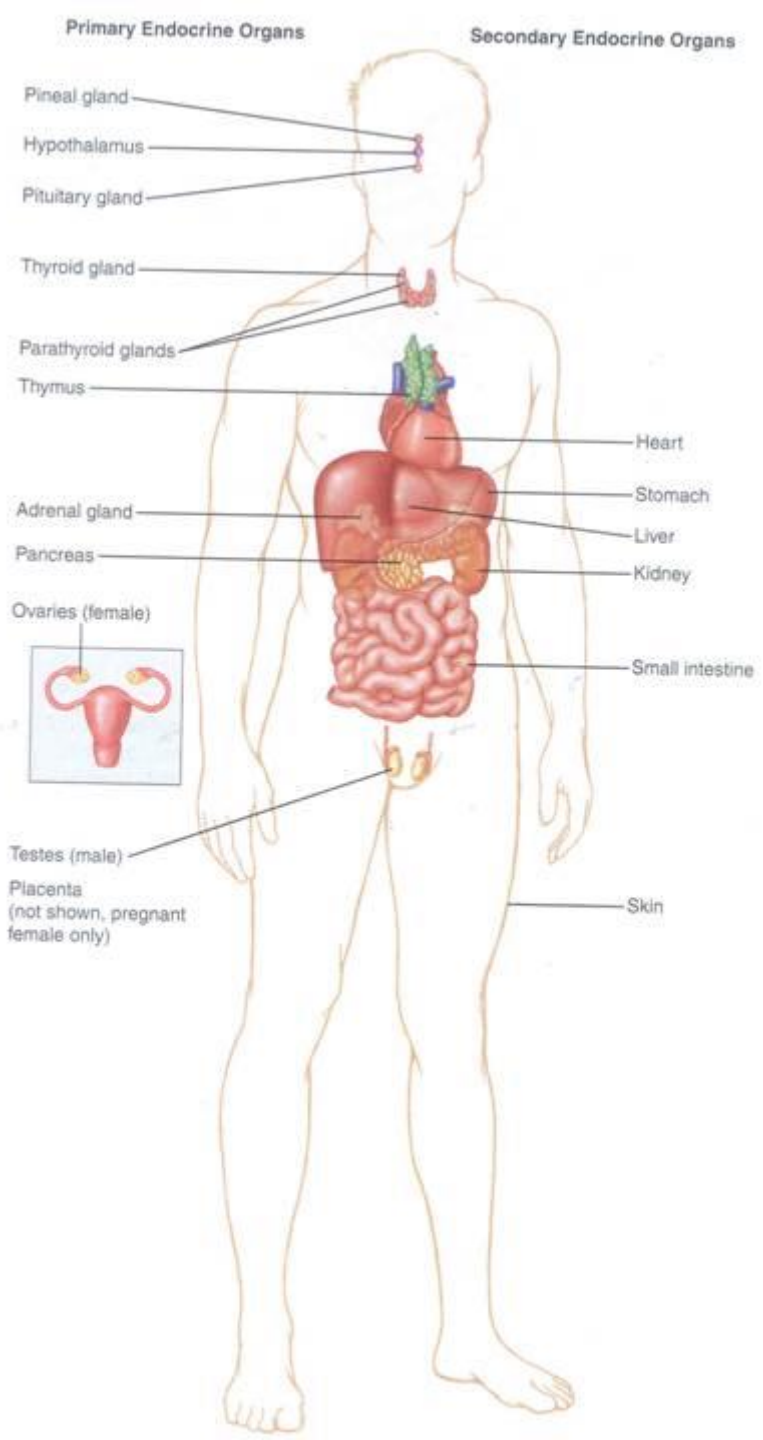
THE OVARIAN CYCLE



HORMONAL REGULATION OF OOGENSIS AND OVULATION



hypothalamic-pituitary-ovary axis


Primary Endocrine Organs
Secondary Endocrine Organs
Pineal gland
Hypothalamus
Pituitary gland
Thyroid gland
Parathyroid glands
Thymus
Heart
Stomach
Liver
Kidney
Adrenal gland
Pancreas
Ovaries (female)
Small intestine
Testes (male)
Placenta
(not shown, pregnant
female only)
Skin

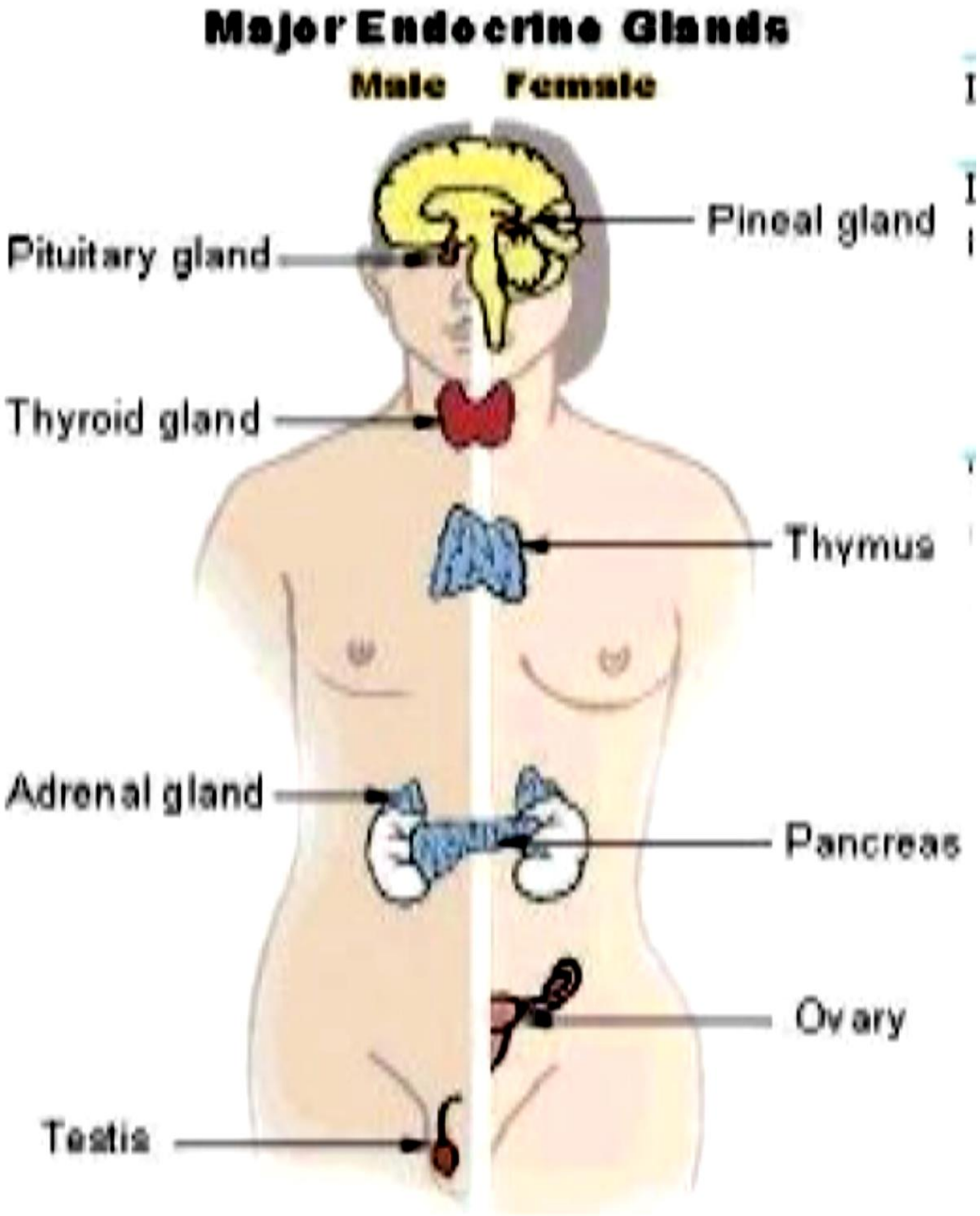
Overview of the structures of the endocrine system

Principal functions of the endocrine system

- Maintenance of the internal environment in the body (maintaining the optimum biochemical environment)

- Integration and regulation of growth and development

- Control, maintenance and instigation of sexual reproduction, including gametogenesis, coitus, fertilization, fetal growth and development and nourishment of the newborn

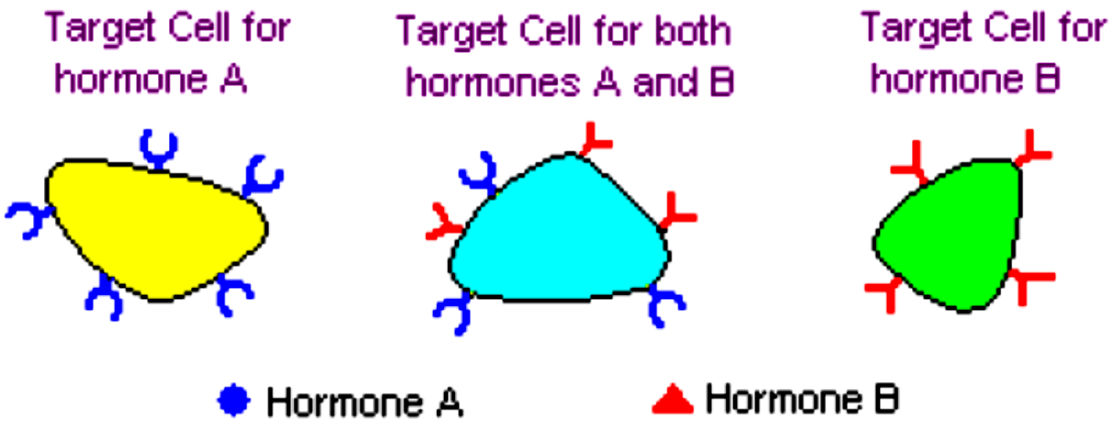

Major Endocrine Glands
Male
Female
Pituitary gland
Pineal gland
Thyroid gland
Thymus
Adrenal gland
Pancreas
Ovary
Testis

Hormones

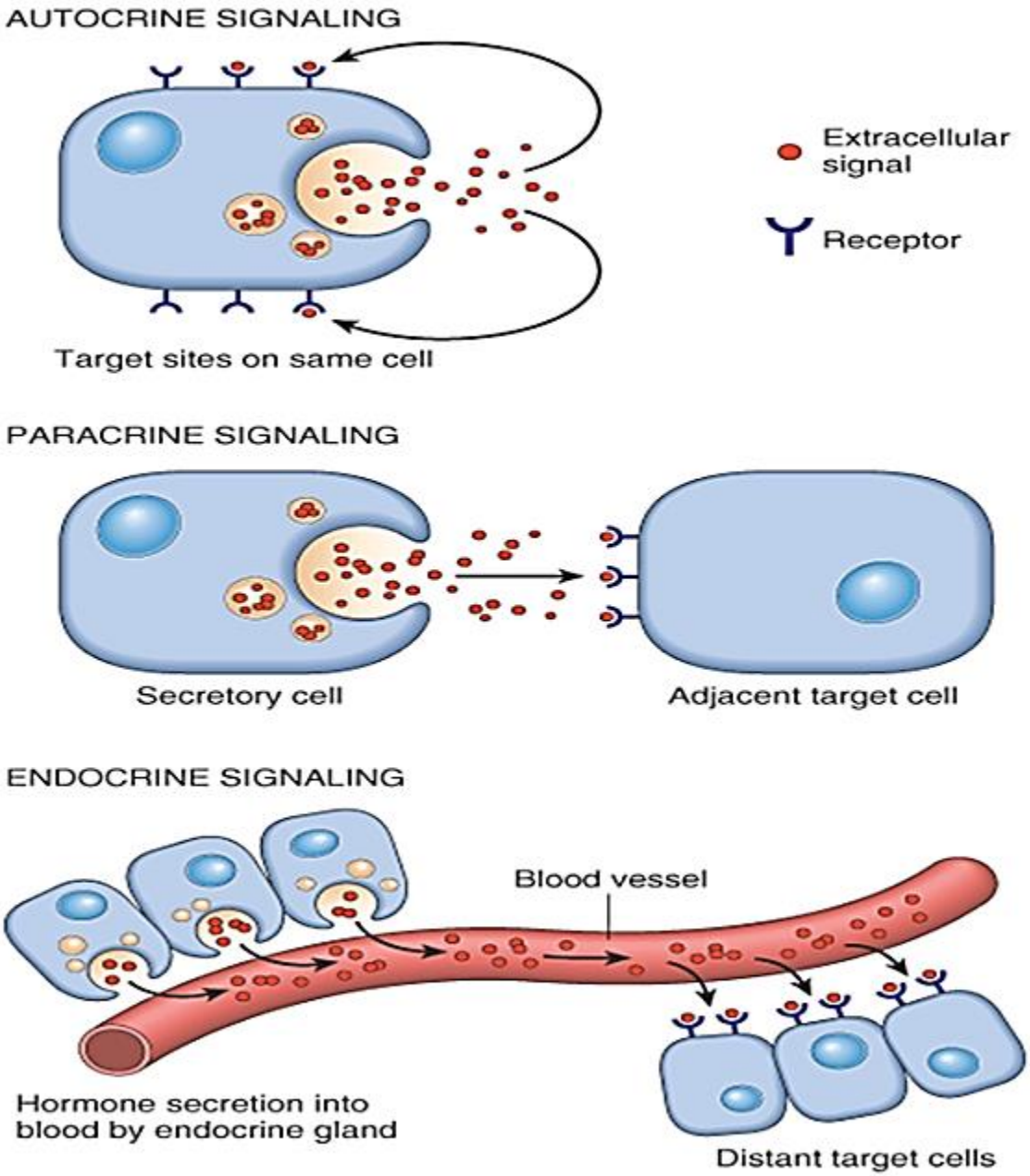
- A chemical released from living cells that travels some distance to target tissues to have a biological effect:
  - Secreted in very small amounts
  - Transported, usually, in the blood
  - Target cells have specific receptors

A cell is a target because it has a specific receptor for the hormone

Most hormones circulate in the blood, coming into contact with essentially all cells. However, a given hormone usually affects only a limited number of cells, which are called **target cells**. A target cell responds to a hormone because it bears **receptors** for the hormone.



Hormonal signaling



Hormone Chemistry

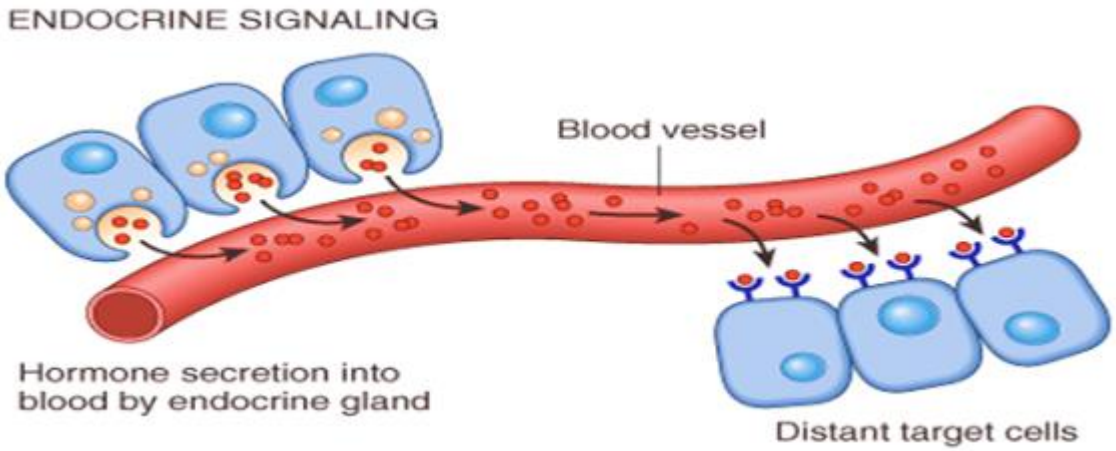
Most commonly, hormones are categorized into three structural groups:

Peptides and proteins

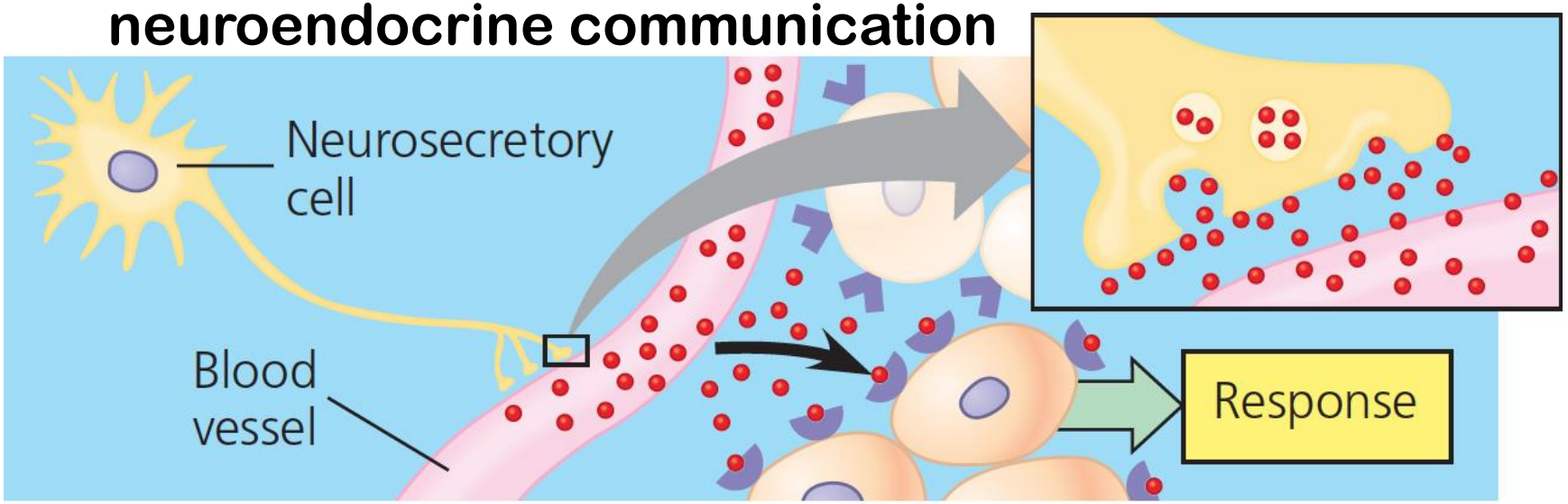
Steroids

Fatty acid derivatives

Types of hormonal communication



neuroendocrine communication



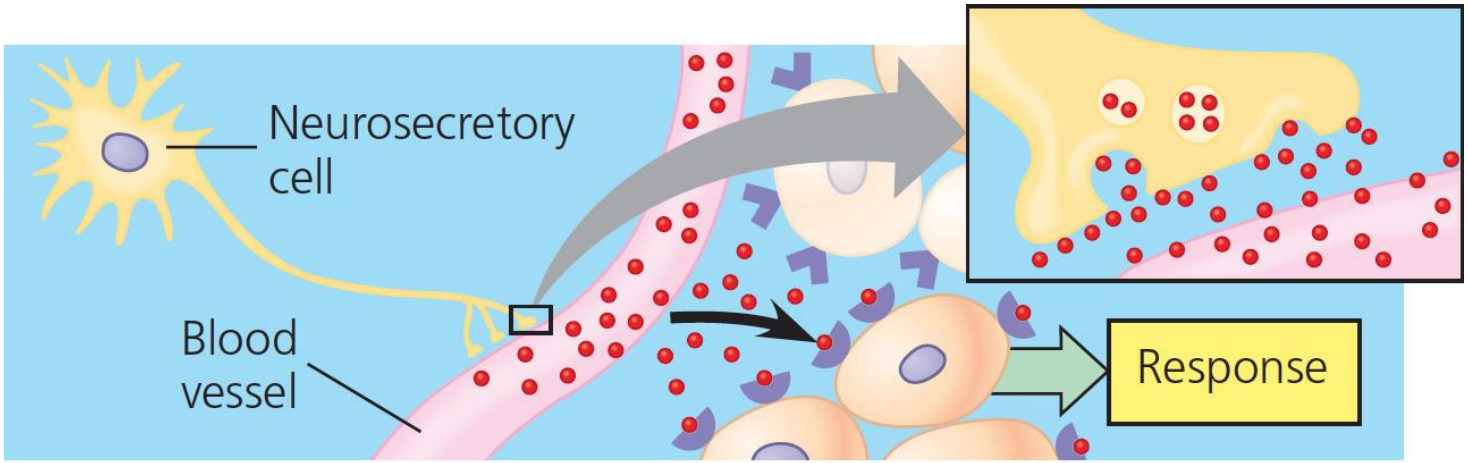
NEUROENDOCRINE RELATIONS

We usually contrast nervous system structures with endocrine structures. But…

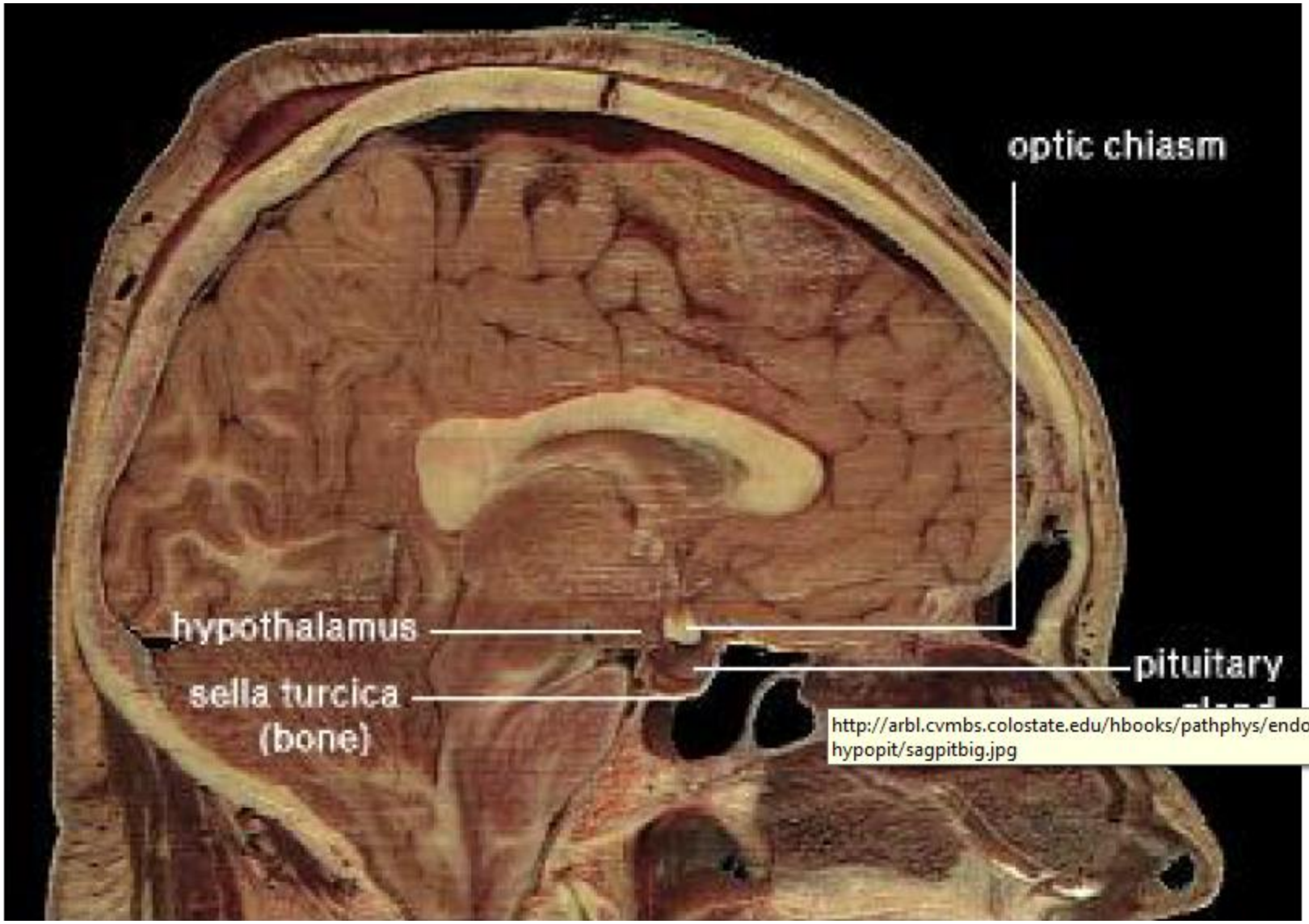
…certain nervous system cells act as endocrine cells.

Nerve cells that produce hormones and secrete them into the bloodstream are called NEUROSECRETORY CELLS.

Neurosecretory cells are found in the HYPOTHALAMUS.



HYPOTHALAMUS



Hypothalamus

- Integrates functions that maintain chemical and temperature homeostasis
- Functions with the limbic system
- Controls the release of hormones from the anterior and posterior pituitary

Hypothalamus

- Synthesizes releasing hormones in cell bodies of neurons
- Hormones are transported down the axon and stored in the nerve endings
- Hormones are released in pulses

Hypothalamic Releasing Hormones

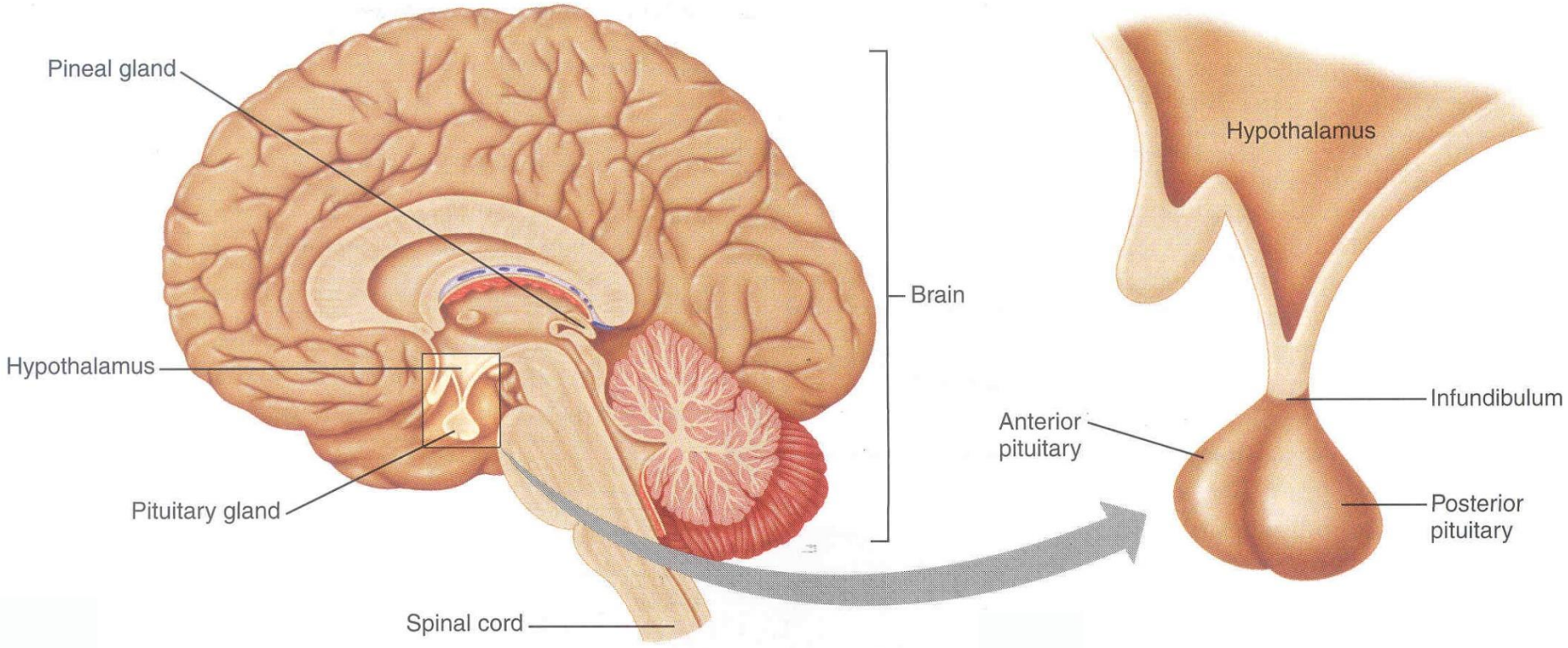
Seven releasing hormones are made in the hypothalamus

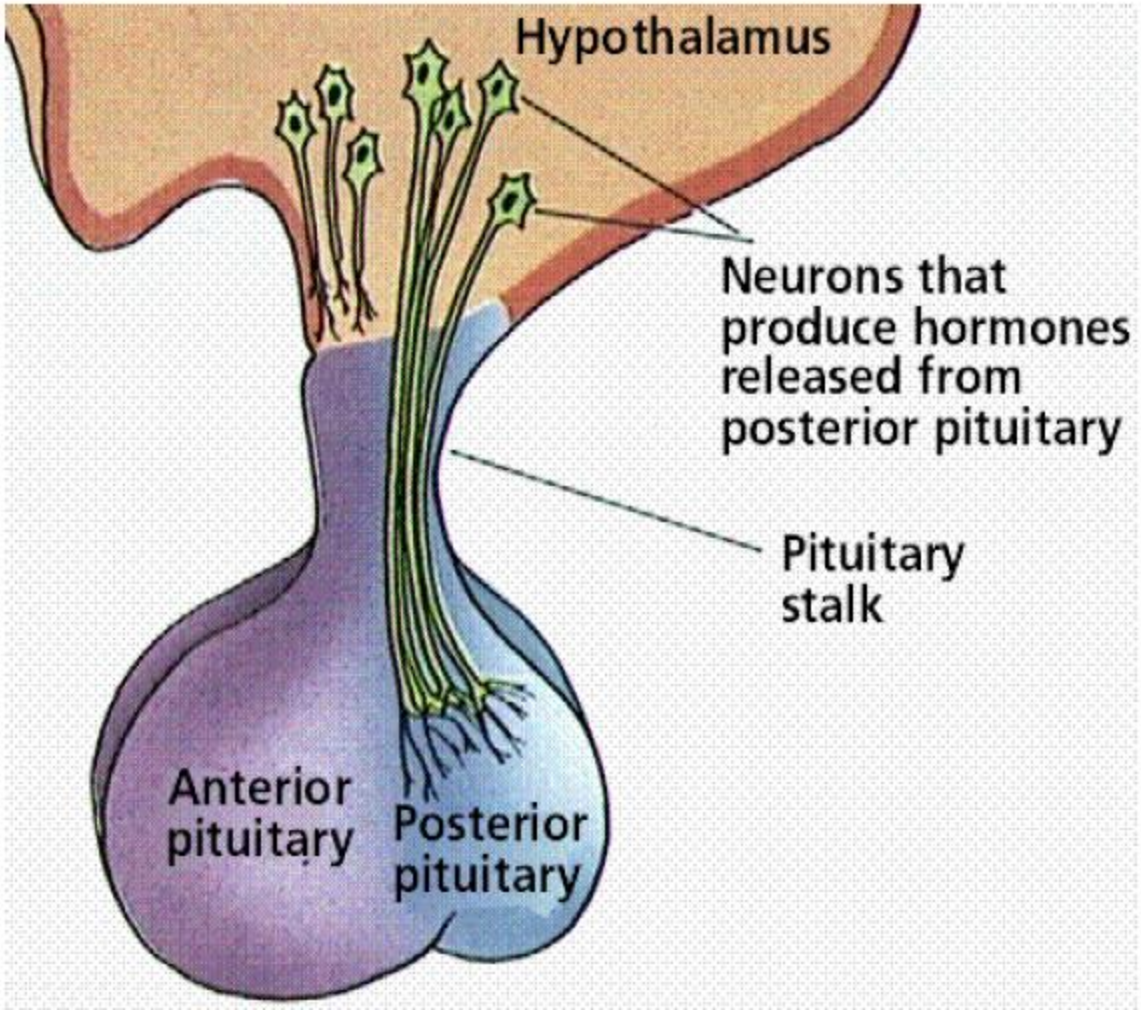
- Thyrotropin-releasing hormone (TRH)
- Corticotropin-releasing hormone (CRH)
- **Gonadotropin-releasing hormone (GnRH)**
- Growth hormone-releasing hormone (GHRH)
- Growth hormone-release inhibiting hormone (GHIH)
- Prolactin-releasing factor (PRF)
- Prolactin-inhibiting hormone (PIH)

Hypothalamus Releasing Hormones: Secretion

- Is influenced by emotions
- Can be influenced by the metabolic state of the individual
- Delivered to the anterior pituitary via the hypothalamic-hypophyseal portal system

PITUITARY GLAND (HYPOPHISIS)




Hypothalamus
Neurons that produce hormones released from posterior pituitary
Pituitary stalk
Anterior pituitary
Posterior pituitary

Frontal view of a pig pituitary gland and hypothalamus

Anterior Pituitary

Is also called the Adenohypophysis

Secretes tropic hormones in a pulsatile fashion

Synthesizes various hormones in various specific cell populations

Anterior Pituitary Hormones

Each of anterior pituitary hormone is synthesized by a cell population.

Corticotropes - ACTH

Lactotropes - Prolactin

Somatotropes - GH

Thyrotropes - Thyrotropin

Gonadotropes - FSH, LH

ANTERIOR PITUITARY GLAND HORMONES

GROWTH HORMONE (GH) – regulates growth; affects protein, fat and carbohydrate metabolism.

THYROID STIMULATING HORMONE (TSH) – controls secretion of thyroxin.

ADRENOCORTICOTROPIC HORMONE (ACTH) – controls secretion of hormones released by adrenal cortex.

FOLLICLE-STIMULATING HORMONE (FSH) – in females, stimulates maturation of egg cells and estrogen secretion by ovaries.

LUTENIZING HORMONE (LH) – in males, stimulates secretion of testosterone and sperm production by testes. In females, stimulates release of ovum by ovary.

MELANOCYTE-STIMULATING HORMONE (MSH) – along with ACTH, affects pigment release in skin.

PROLACTIN (PRL) – stimulates milk production.

Anterior Pituitary Hormones

Follicle-stimulating Hormone (FSH): **Females:** stimulates growth & development of ovarian follicles, promotes secretion of estrogen by ovaries. **Males:** required for sperm production

Luteinizing Hormone (LH): **Females:** responsible for ovulation, formation of corpus luteum in the ovary, and regulation of ovarian secretion of female sex hormones. **Males:** stimulates cell in the testes to secrete testosterone

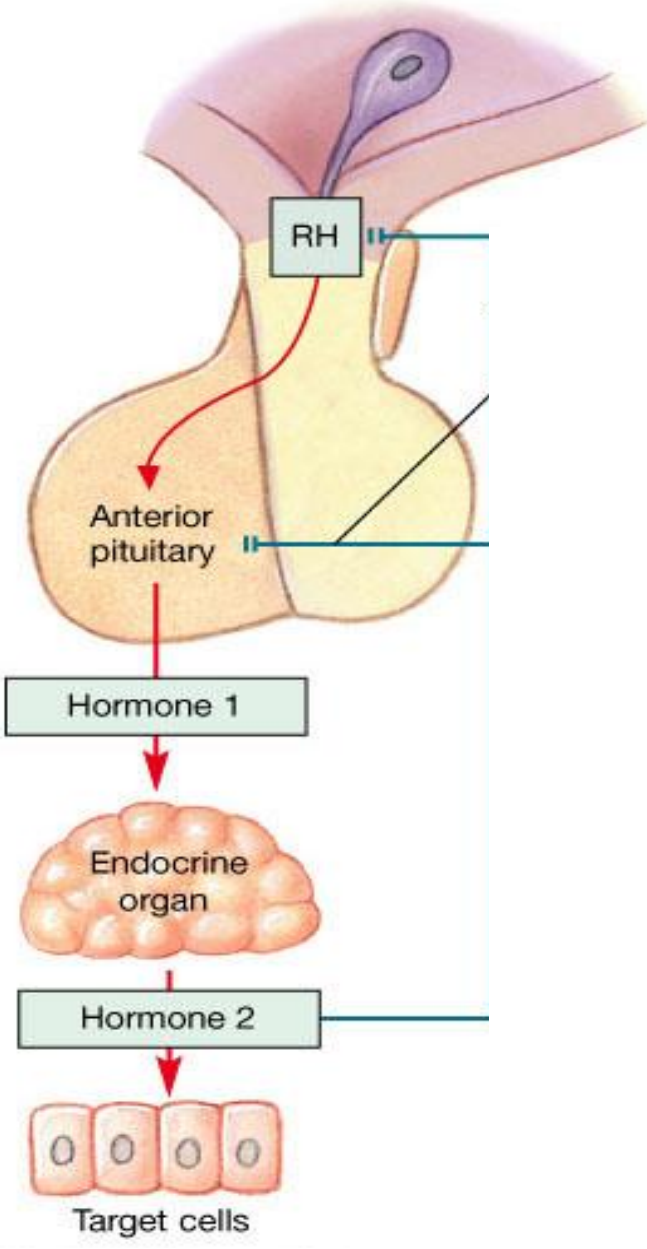
Prolactin: **Females:** stimulates breast development and milk production. **Males:** involved in testicular function

Most hormonal interactions of the hypothalamus-pituitary complex follow a common pattern:

1. **A hypothalamic hormone effects control over the secretion of an anterior pituitary hormone;**

2. **The corresponding anterior pituitary hormone controls secretion of the hormone of another endocrine gland; and**

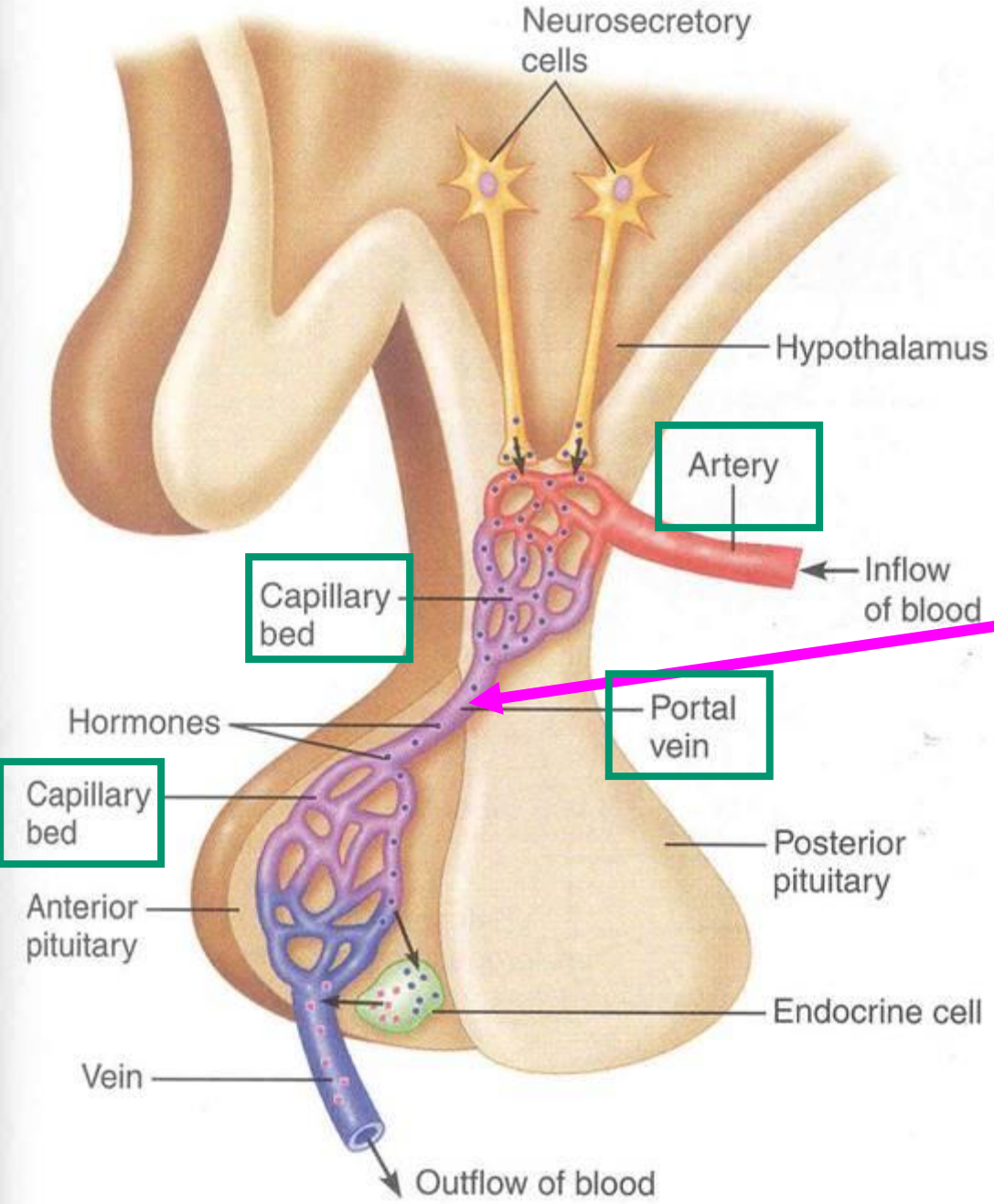
3. **That secretion of that gland affects other target tissues/organs.**



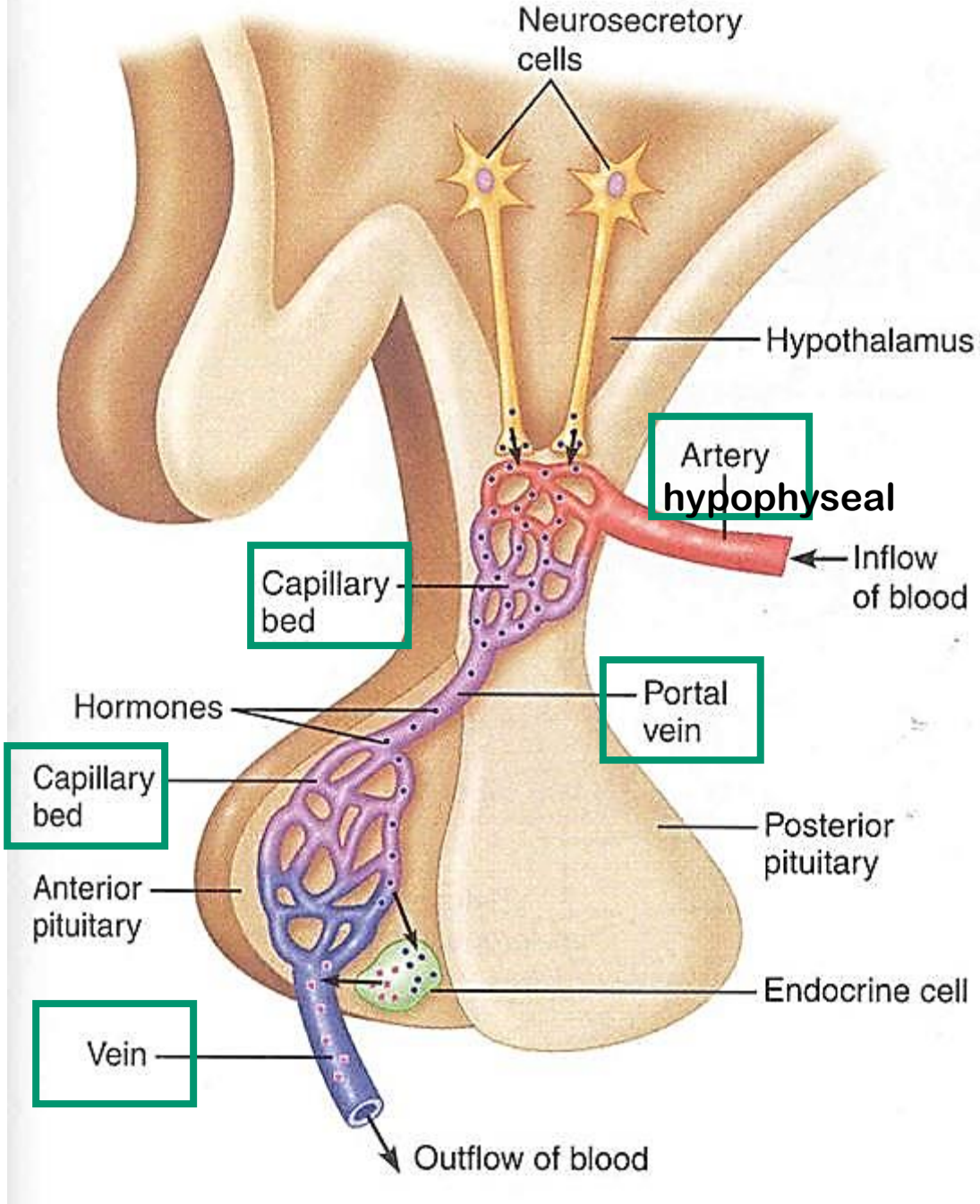
HYPOTHALAMUS HORMONES (FUNCTION)

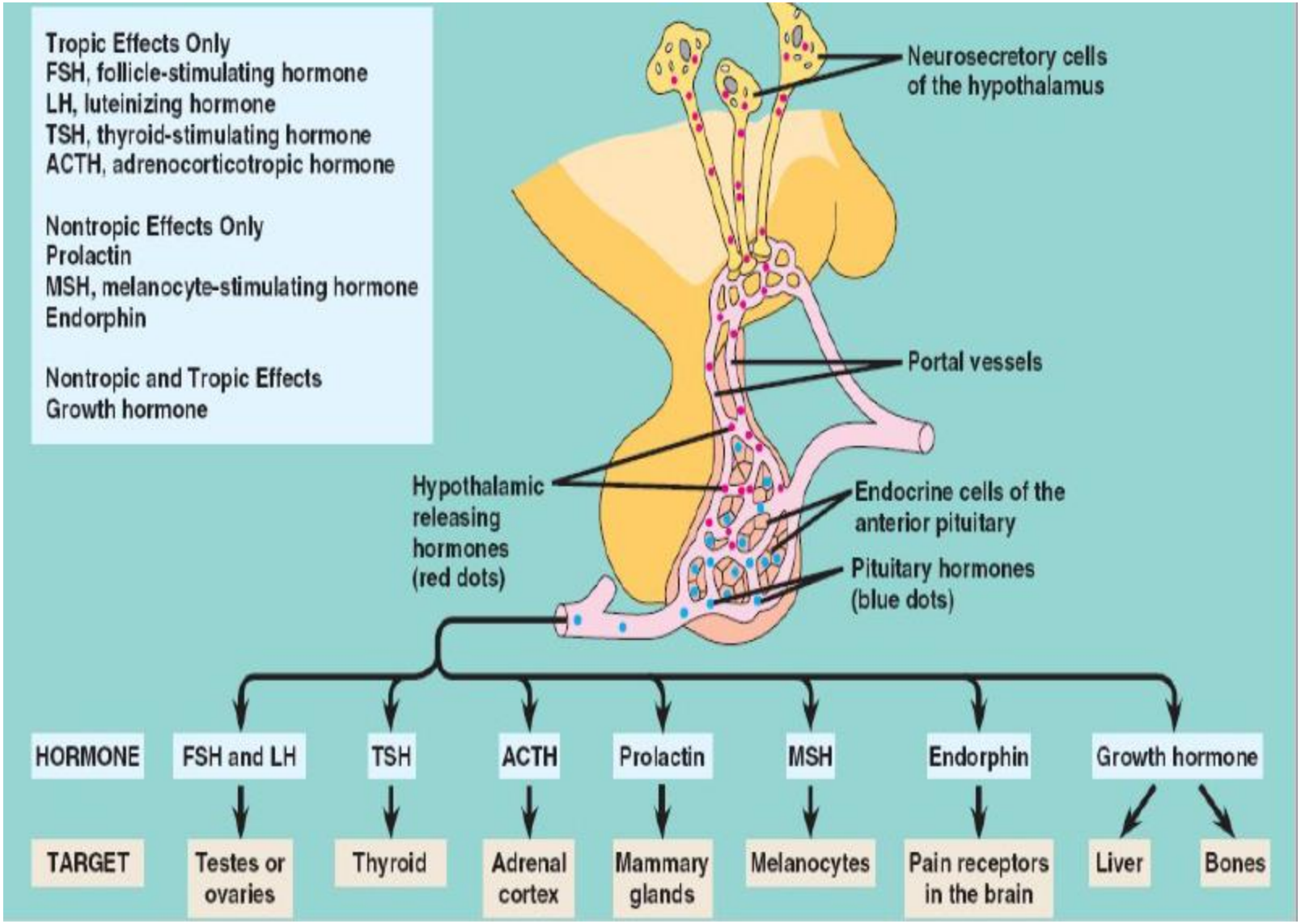
So…
Hypothalamic hormones can have effect of stimulating or inhibiting the release of anterior pituitary hormones.

Called RELEASING HORMONES (“RH”) or INHIBITING HORMONES (“IH”) respectively.

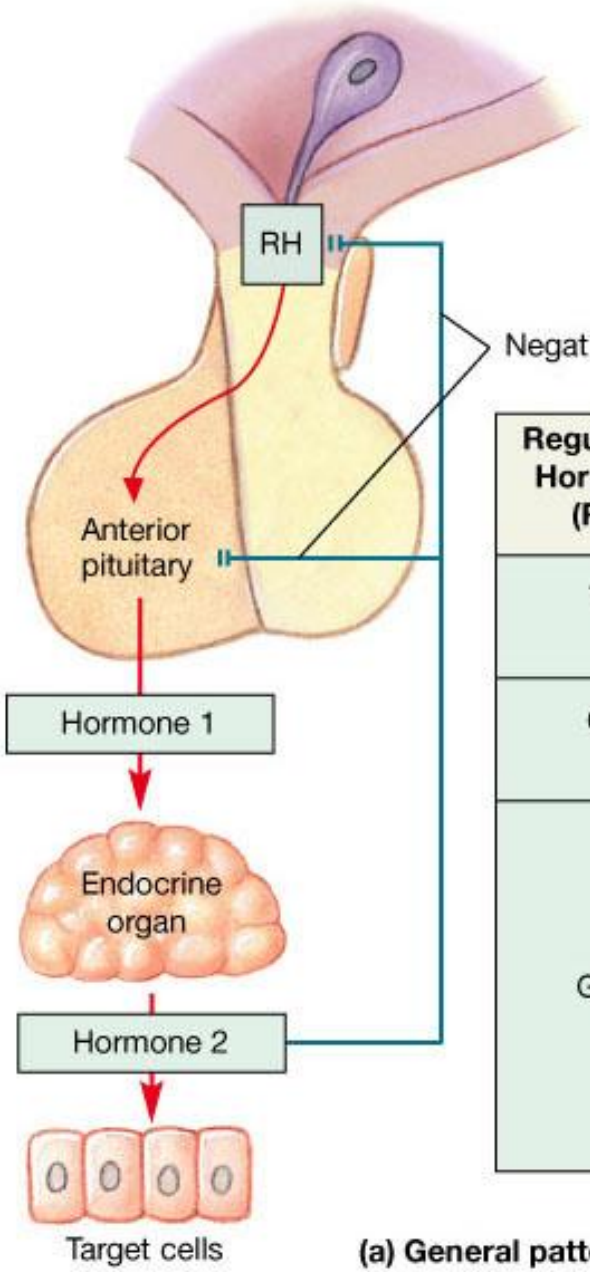


Portal Vascular System!!


Neurosecretory cells
Hypothalamus
Artery
hypophyseal
Inflow of blood
Capillary bed
Portal vein
Hormones
Capillary bed
Posterior pituitary
Anterior pituitary
Endocrine cell
Vein
Outflow of blood


Tropic Effects Only
FSH, follicle-stimulating hormone
LH, luteinizing hormone
TSH, thyroid-stimulating hormone
ACTH, adrenocorticotropic hormone
Nontropic Effects Only
Prolactin
MSH, melanocyte-stimulating hormone
Endorphin
Nontropic and Tropic Effects
Growth hormone
Neurosecretory cells of the hypothalamus
Portal vessels
Hypothalamic releasing hormones (red dots)
Endocrine cells of the anterior pituitary
Pituitary hormones (blue dots)
HORMONE
FSH and LH
TSH
ACTH
Prolactin
MSH
Endorphin
Growth hormone
TARGET
Testes or ovaries
Thyroid
Adrenal cortex
Mammary glands
Melanocytes
Pain receptors in the brain
Liver
Bones

Feedback control mechanisms



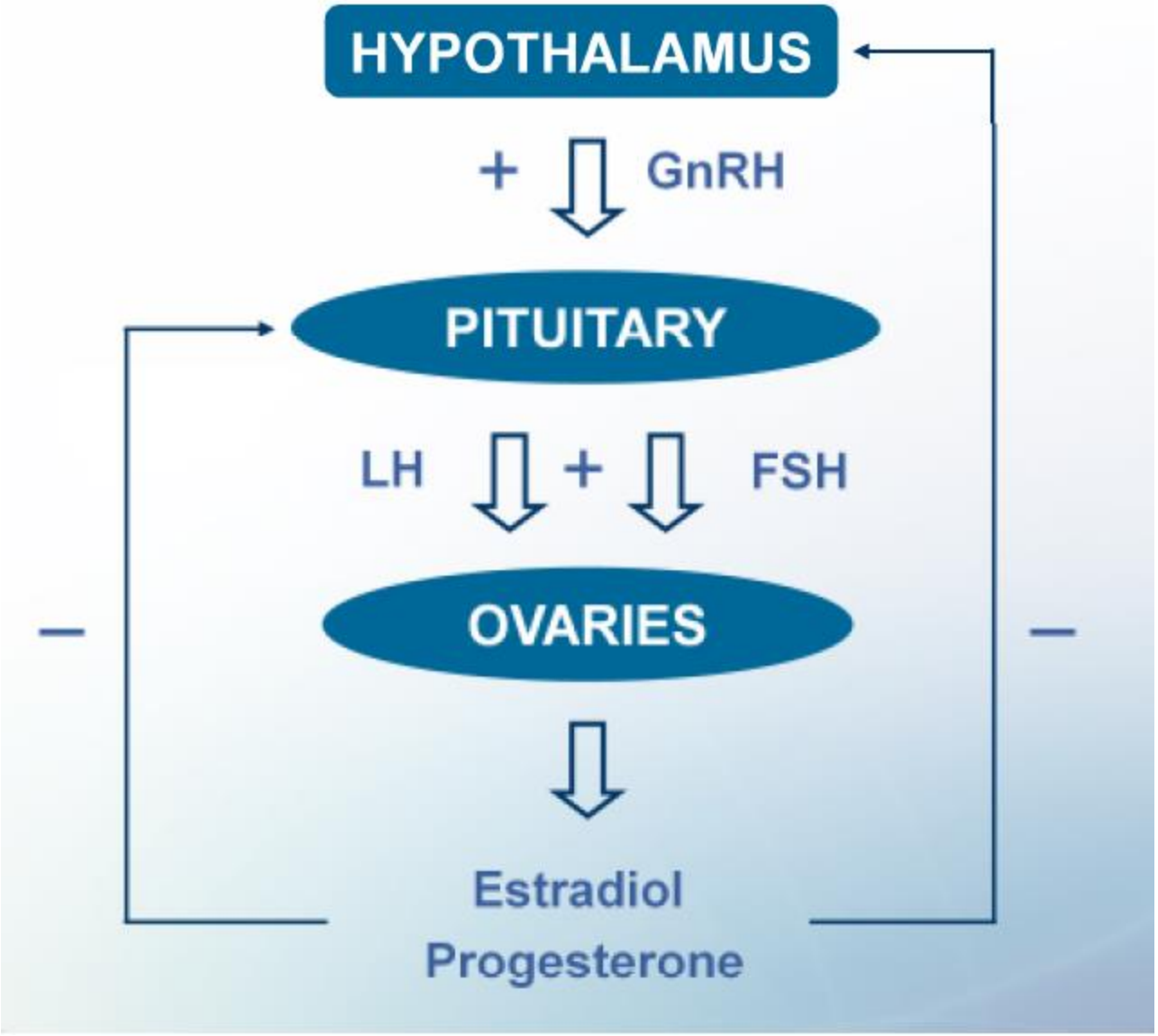
KEY
Stimulation
Inhibition

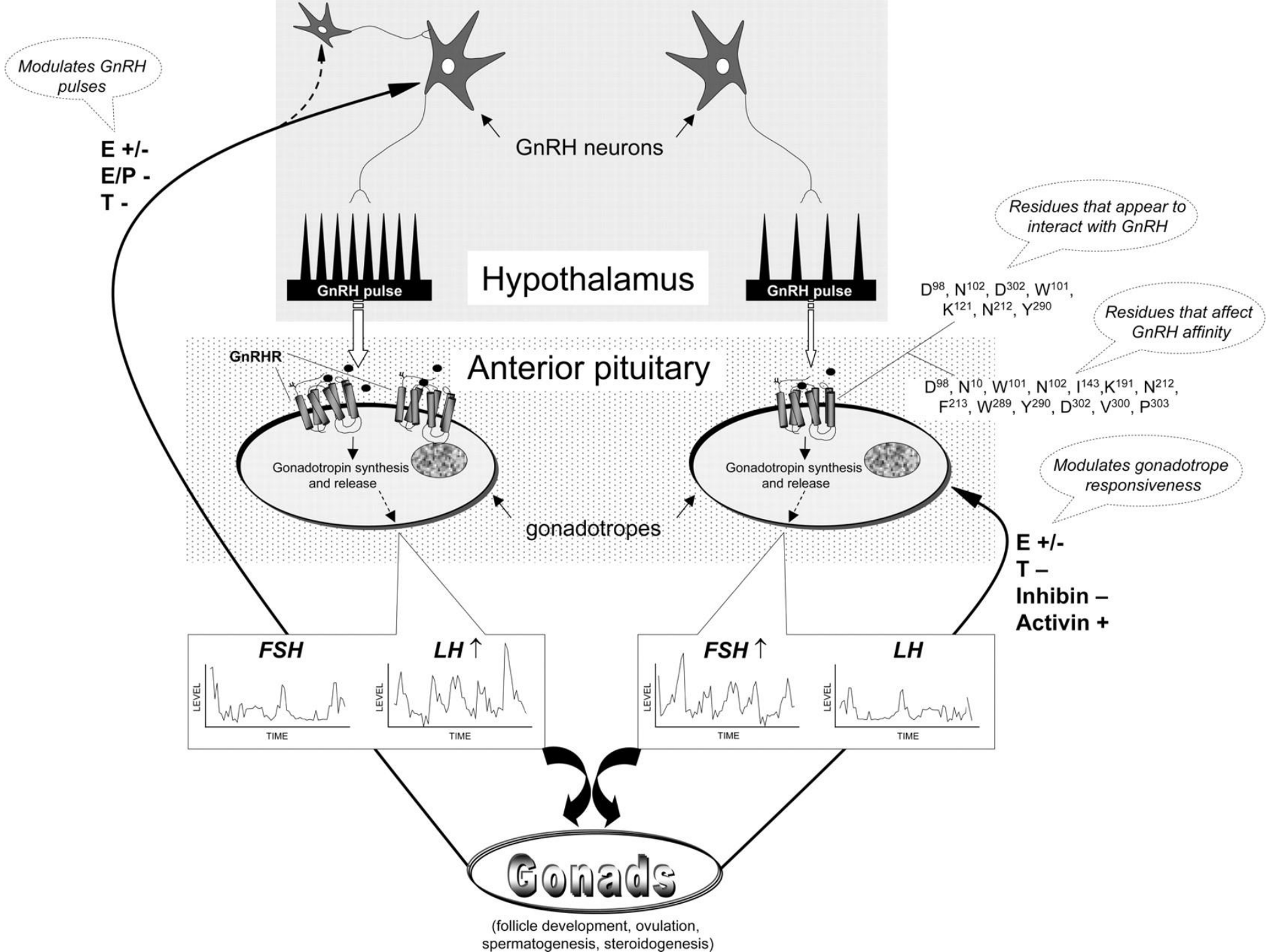
Negative feedback

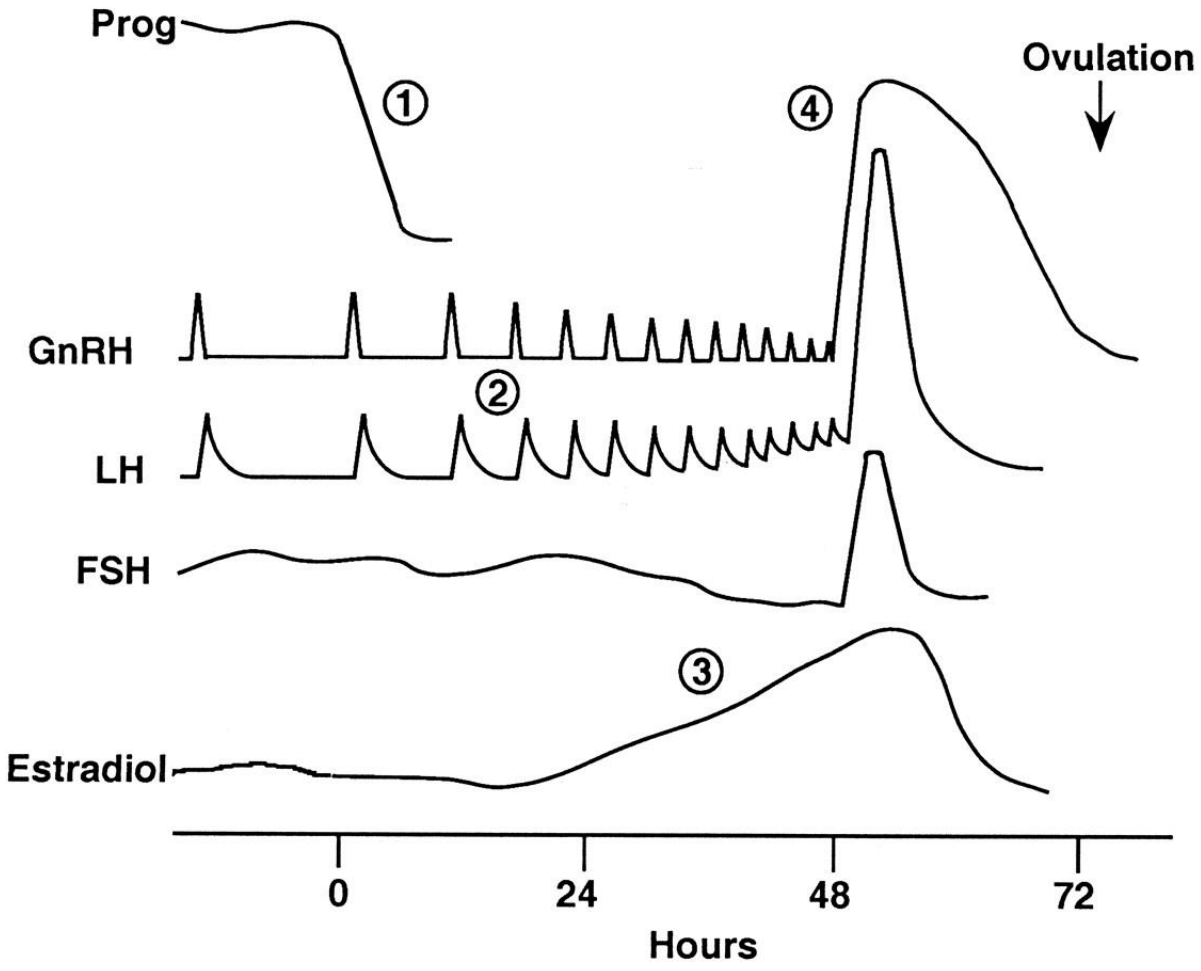
Regulatory Hormone (RH)	Hormone 1 (from Pituitary)	Endocrine Target Cells	Hormone 2 (from Target organ)
TRH	TSH	Thyroid gland	Thyroid hormones
CRH	ACTH	Adrenal cortex	Gluco-corticoids
GnRH	FSH	Testes	Inhibin
		Ovaries	Inhibin, Estrogens
	LH	Ovaries	Progestins, Estrogens
		Testes	Androgens

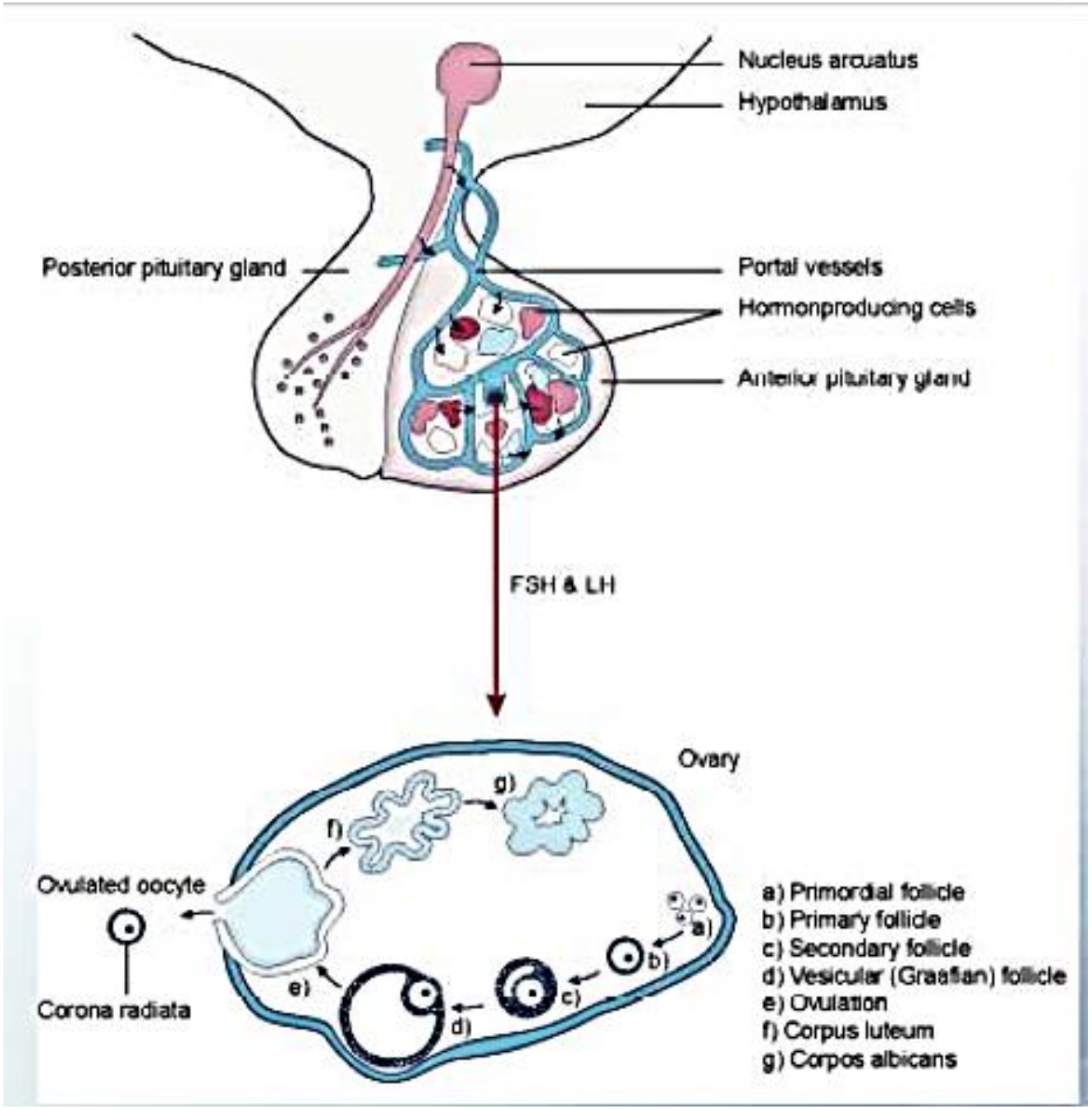
(a) General pattern

Female reproductive axis




Modulates GnRH pulses
E +/-
E/P -
T -
GnRH neurons
GnRH pulse
Hypothalamus
GnRH pulse
Residues that appear to interact with GnRH
D98, N102, D302, W101, K121, N212, Y290
Residues that affect GnRH affinity
D98, N10, W101, N102, I143, K191, N212, F213, W289, Y290, D302, V300, P303
GnRHR
Anterior pituitary
Gonadotropin synthesis and release
Gonadotropin synthesis and release
gonadotropes
Modulates gonadotrope responsiveness
E +/-
T –
Inhibin –
Activin +
FSH
LH ↑
FSH ↑
LH
LEVEL
TIME
Gonads
(follicle development, ovulation, spermatogenesis, steroidogenesis)


Prog
①
④
Ovulation
GnRH
②
LH
FSH
③
Estradiol
0
24
48
72
Hours

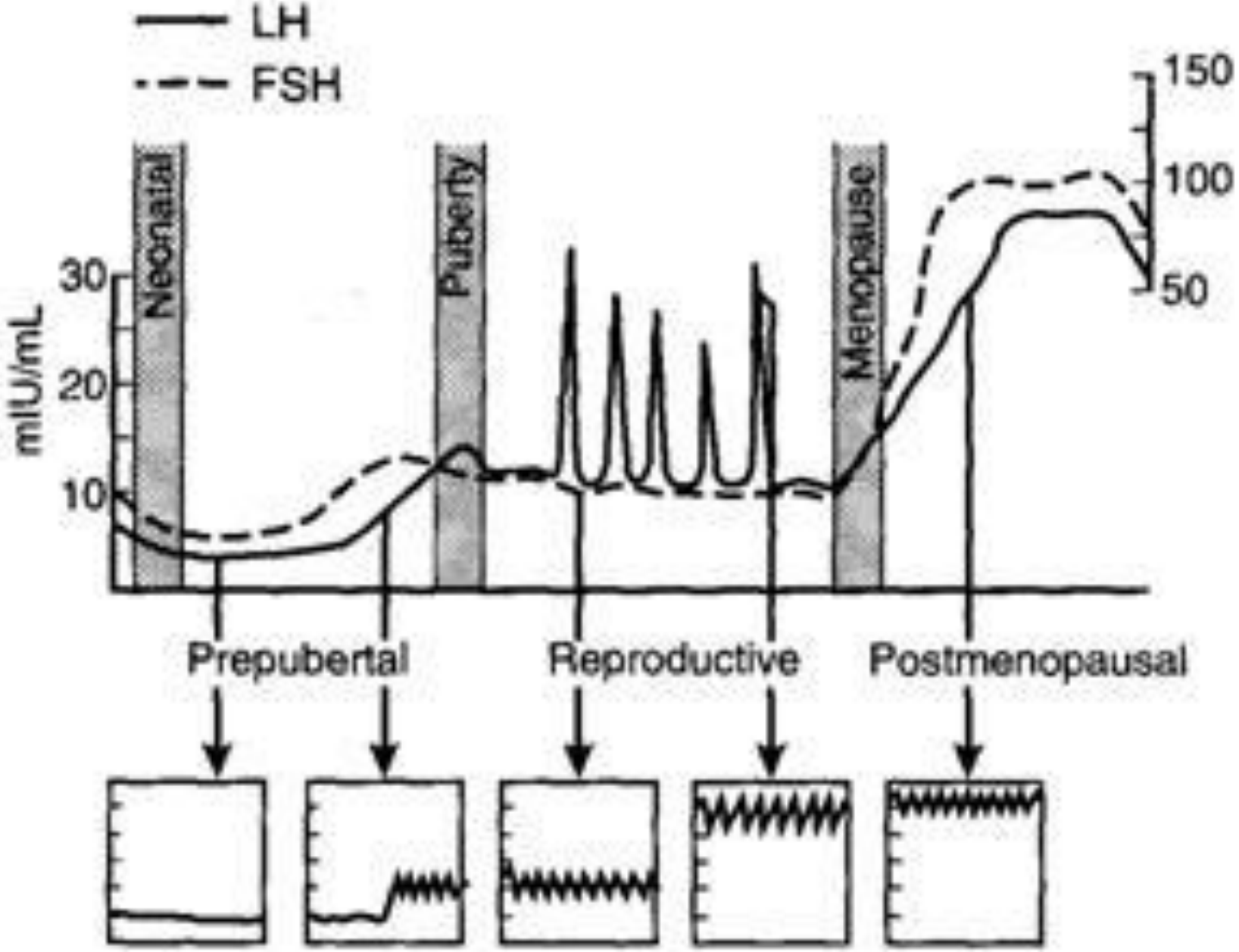

Nucleus arcuatus
Hypothalamus
Posterior pituitary gland
Portal vessels
Hormonproducing cells
Anterior pituitary gland
FSH & LH
Ovary
g)
f)
Ovulated oocyte
Corona radiata
a)
b)
c)
d)
e)
a) Primordial follicle
b) Primary follicle
c) Secondary follicle
d) Vesicular (Graafian) follicle
e) Ovulation
f) Corpus luteum
g) Corpos albicans

Age at puberty in common domestic animal species

Species	Age at puberty
Cattle	8–18 months
Horse	10–24 months
Swine	6–8 months
Sheep	6–15 months
Goat	4–8 months
Dog	6–20 months
Cat	5–12 months

Establishing the Ovarian Cycle

- During childhood, ovaries grow and secrete small amounts of estrogens that inhibit hypothalamic release of GnRH
- As puberty nears, GnRH released; FSH and LH released by pituitary, and act on ovaries
- These events continue until an adult cyclic pattern achieved and menarche occurs


LH
FSH
150
100
50
30
20
10
mIU/mL
Neonatal
Puberty
Menopause
Prepubertal
Reproductive
Postmenopausal