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Cells to Systems Lecture 16: Principles of Cell Communication Video 1

VETS30015 / VETS90121

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Lecture 16: ILOs

- Define the terms autocrine, paracrine, endocrine and synaptic signalling and explain why these different types of signalling processes exist
- Describe the anatomical and functional arrangement of the Hypothalamo-Pituitary axis and how this axis regulates the release of pituitary hormones
- List the hormones produced by the anterior and posterior pituitary and describe their main functions

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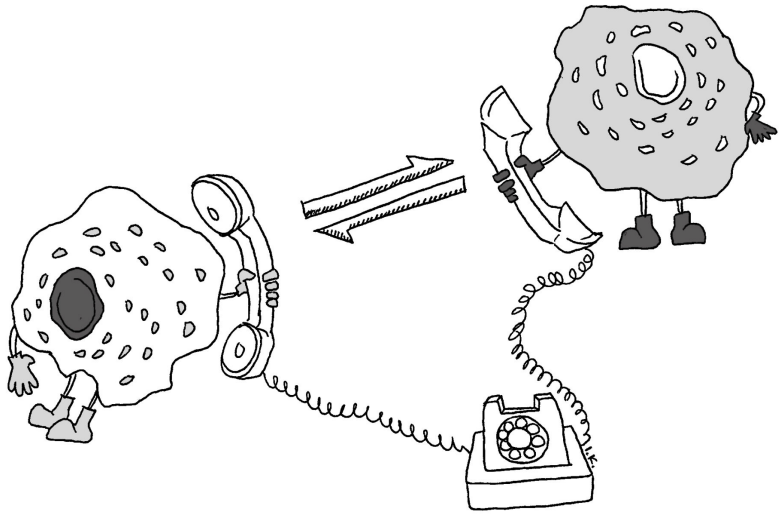
Communication between cells

- Ability of cells to communicate with each other is critical to coordinate activities required for homeostasis, growth and development

- So, how do cells ‘talk’ to each other?
- Direct contact: gap junctions and cell surface signalling molecules
- Through chemical messengers: autocrine, paracrine, hormonal, synaptic signalling

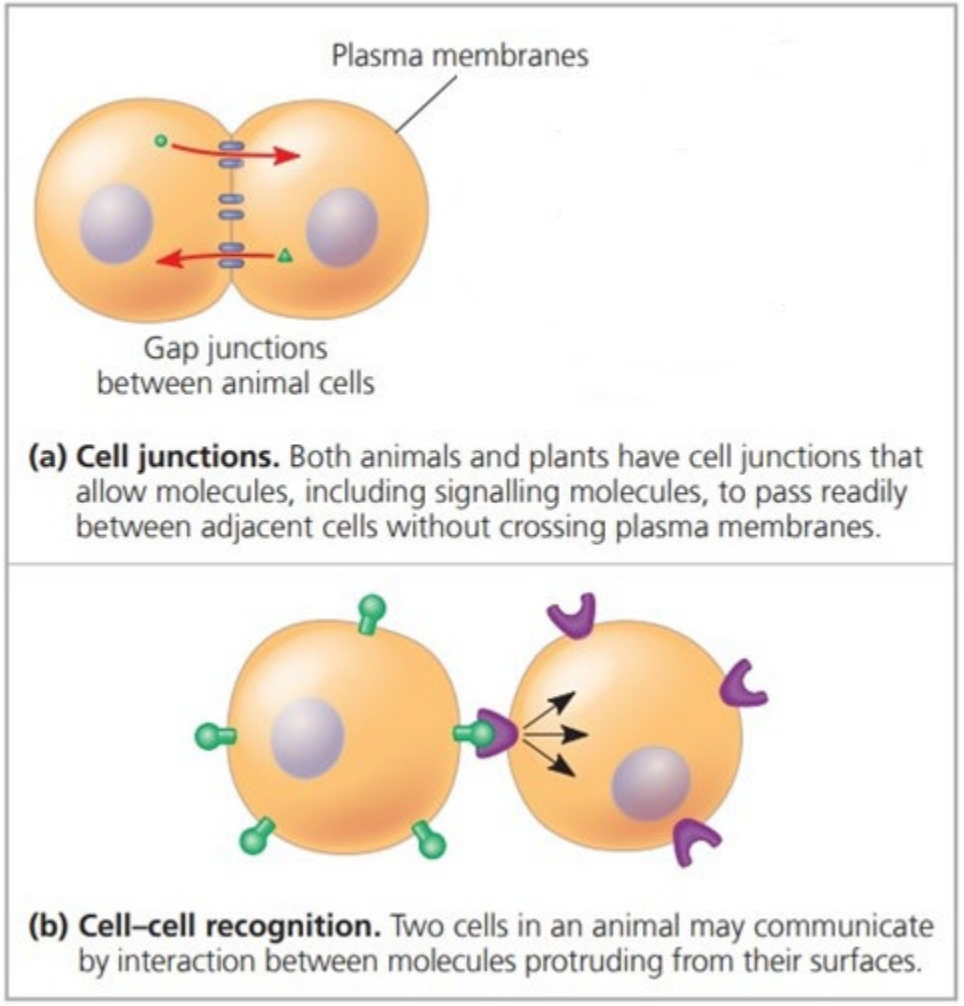


https://yaledailynews.com/blog/2018/02/13/study-shows-how-cell-types-communicate/

Cell communication: direct contact

- **Gap junctions** enable direct communication between adjacent cells – signals passed between cell cytosols → allows for quick signals for coordinated functions (e.g gap junctions between cardiomyocytes enable action potentials to propagate)
- **Cell-cell recognition/interaction** involves signalling molecule presented on one cell with receptor on in-contact cell, allows site-specific binding (e.g. leukocyte binding to endothelial cells)

Figure 11.4 Communication by direct contact between cells.



(a) Cell junctions. Both animals and plants have cell junctions that allow molecules, including signalling molecules, to pass readily between adjacent cells without crossing plasma membranes.

(b) Cell–cell recognition. Two cells in an animal may communicate by interaction between molecules protruding from their surfaces.

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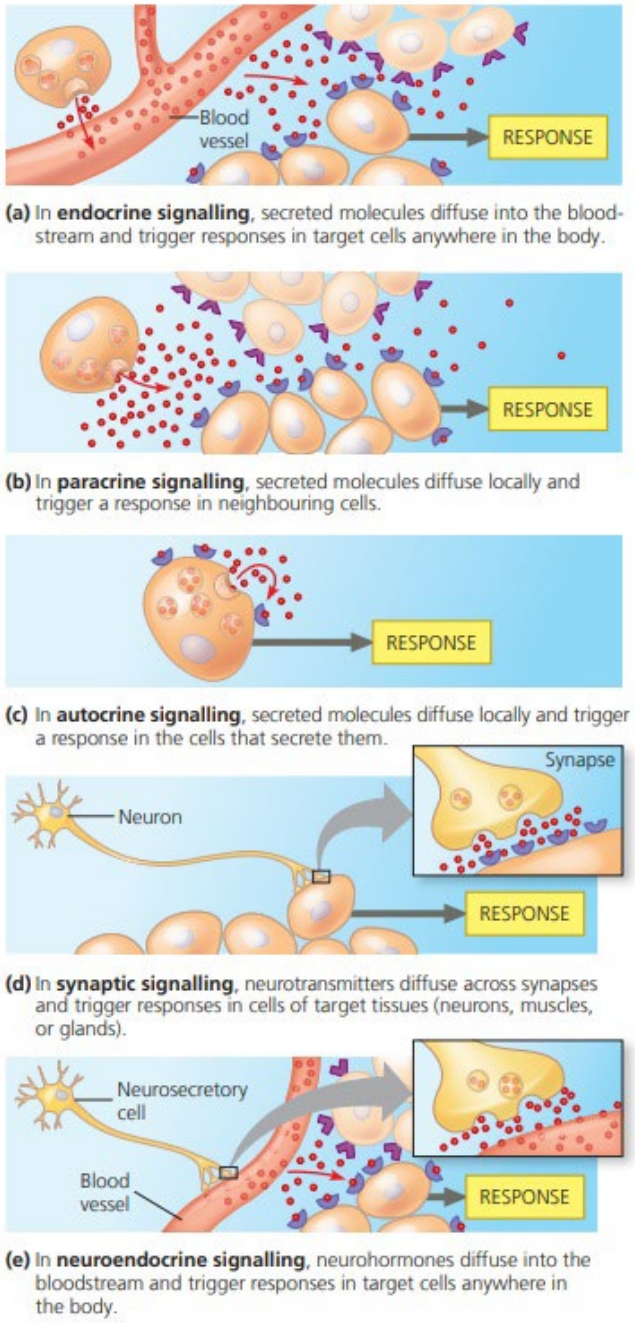
Cell communication:
signalling molecules

- Most common communication processes use extracellular chemical messengers

- Specific chemical messenger is synthesised in specialised cells to be released for action on target cells

- Five signalling processes for intercellular communication:
    1. Autocrine
    2. Paracrine
    3. Endocrine
    4. Synaptic
    5. Neuroendocrine



(a) In **endocrine signalling**, secreted molecules diffuse into the blood-stream and trigger responses in target cells anywhere in the body.

(b) In **paracrine signalling**, secreted molecules diffuse locally and trigger a response in neighbouring cells.

(c) In **autocrine signalling**, secreted molecules diffuse locally and trigger a response in the cells that secrete them.

(d) In **synaptic signalling**, neurotransmitters diffuse across synapses and trigger responses in cells of target tissues (neurons, muscles, or glands).

(e) In **neuroendocrine signalling**, neurohormones diffuse into the bloodstream and trigger responses in target cells anywhere in the body.

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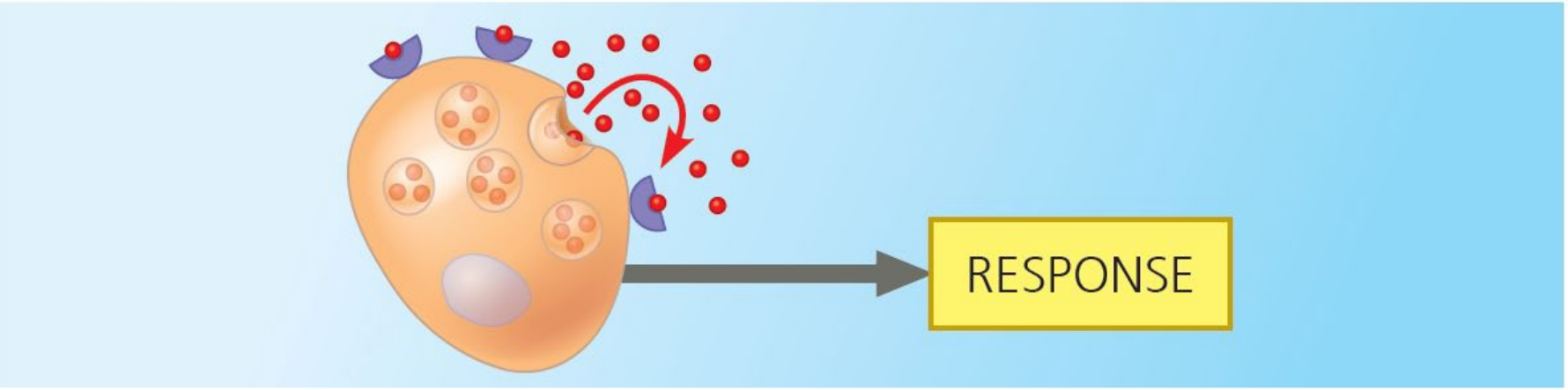
1. Autocrine Signalling



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In **autocrine signalling**, secreted molecules diffuse locally and trigger a response in the cells that secrete them.

- Cell releases a signalling molecule that binds to receptors on its own surface – the cell is talking to itself!
- Common mechanism in cells of the immune system

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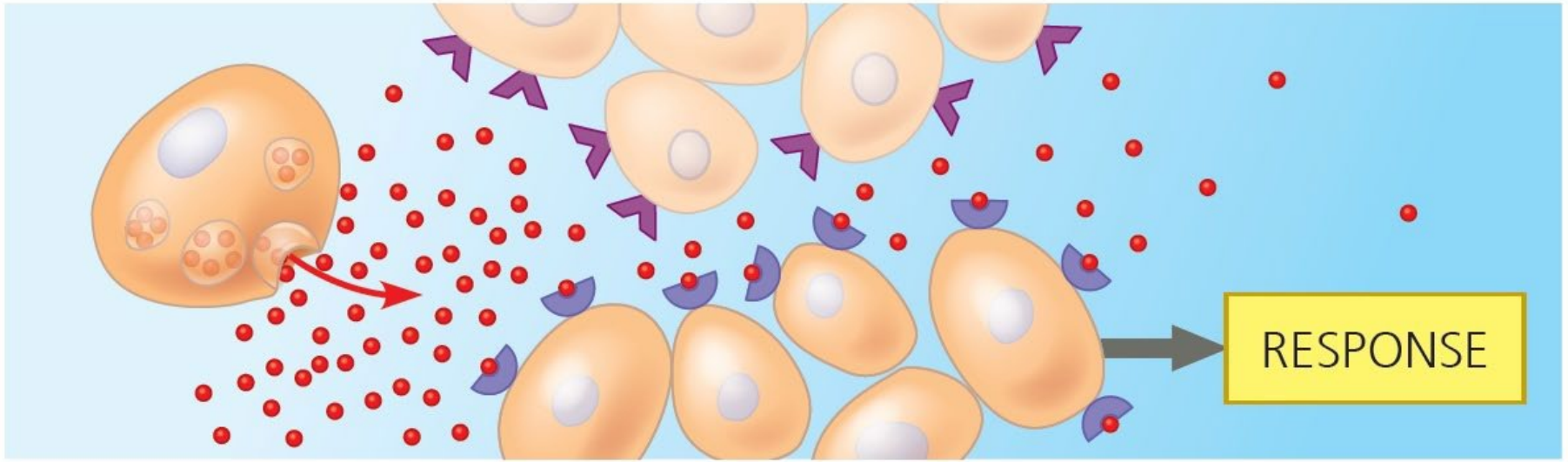
2. Paracrine Signalling



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In **paracrine signalling**, secreted molecules diffuse locally and trigger a response in neighbouring cells.

- Signal acts on neighbouring cells
- Distributed by simple diffusion – action restricted to short distances
- Molecule rapidly taken up by cells or degraded by extracellular enzymes → can create a signalling concentration gradient

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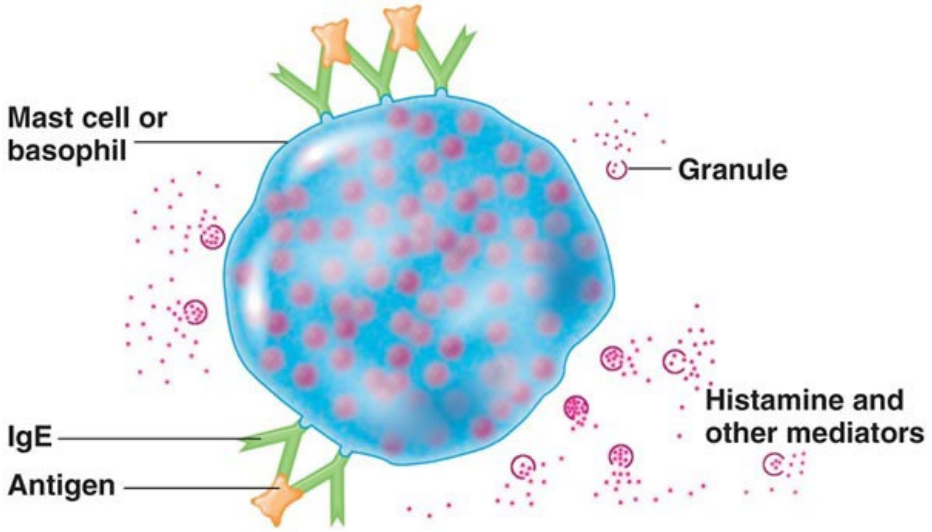
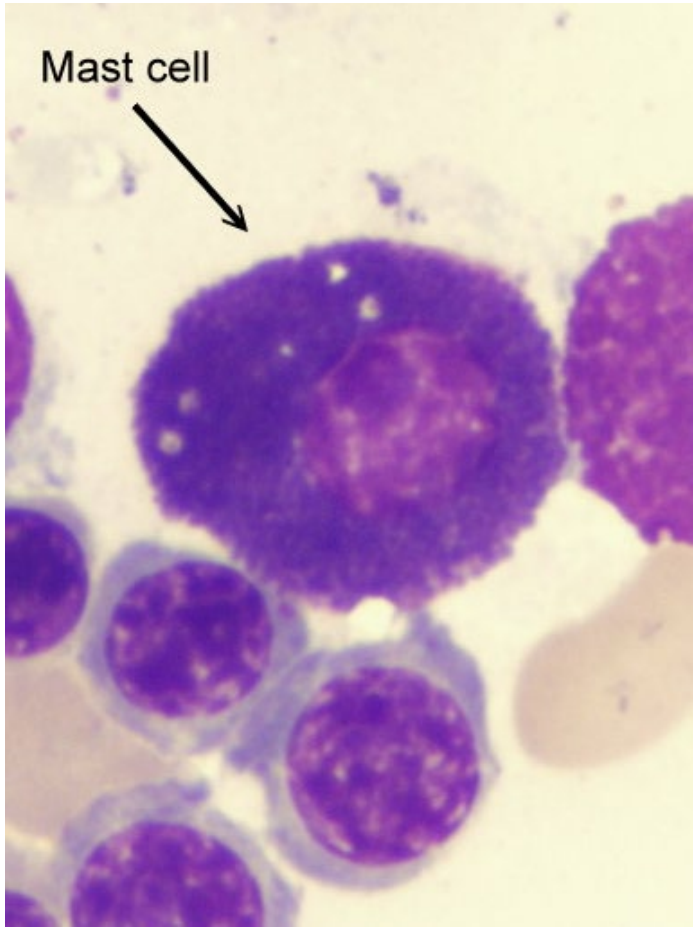
2. Paracrine Signalling

Example: histamine release from mast cells

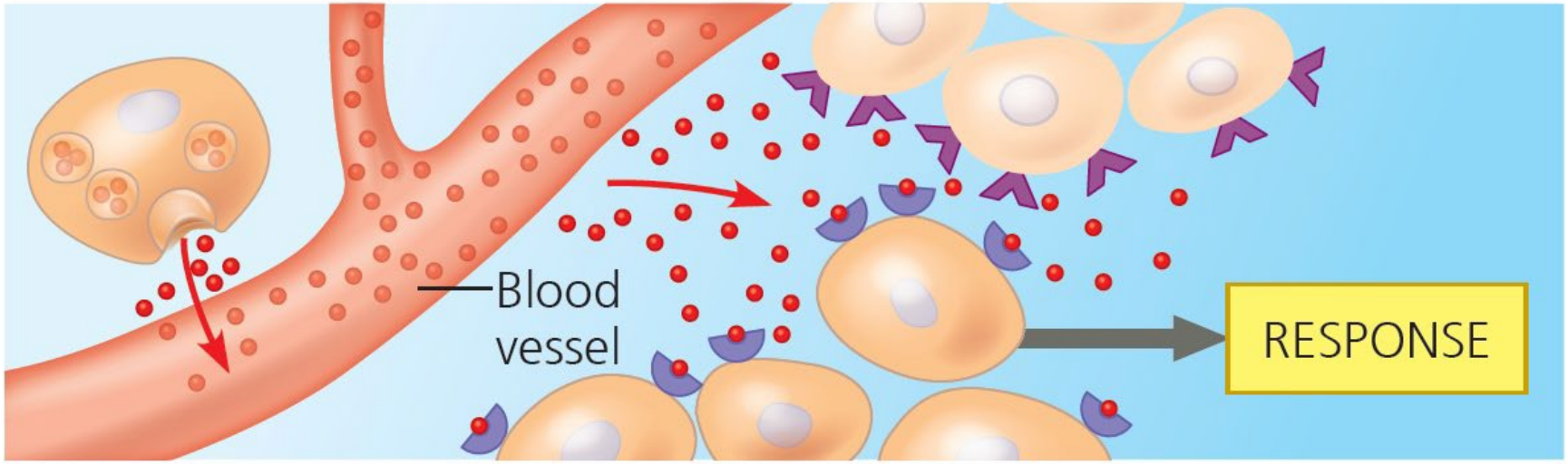


(a) IgE antibodies, produced in response to an antigen, coat mast cells and basophils. When an antigen bridges the gap between two adjacent antibody molecules of the same specificity, the cell undergoes degranulation and releases histamine and other mediators.



Localised response!

3. Endocrine Signalling



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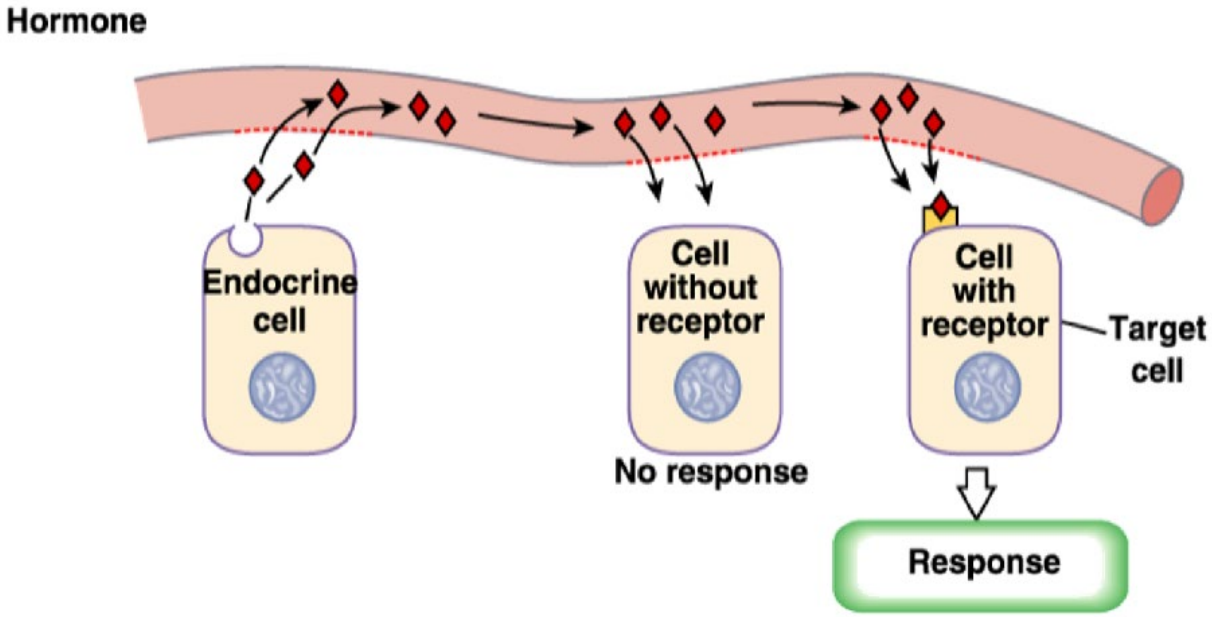
In **endocrine signalling**, secreted molecules diffuse into the blood-stream and trigger responses in target cells anywhere in the body.

- Secreted hormones are long-distance chemical messengers that travel in the bloodstream
- Exert their effect on target cells in distant sites

3. Endocrine signalling



- Only the target cells of a hormone have the specific membrane receptors for that hormone
- Non-target cells are not influenced by hormones that contact them

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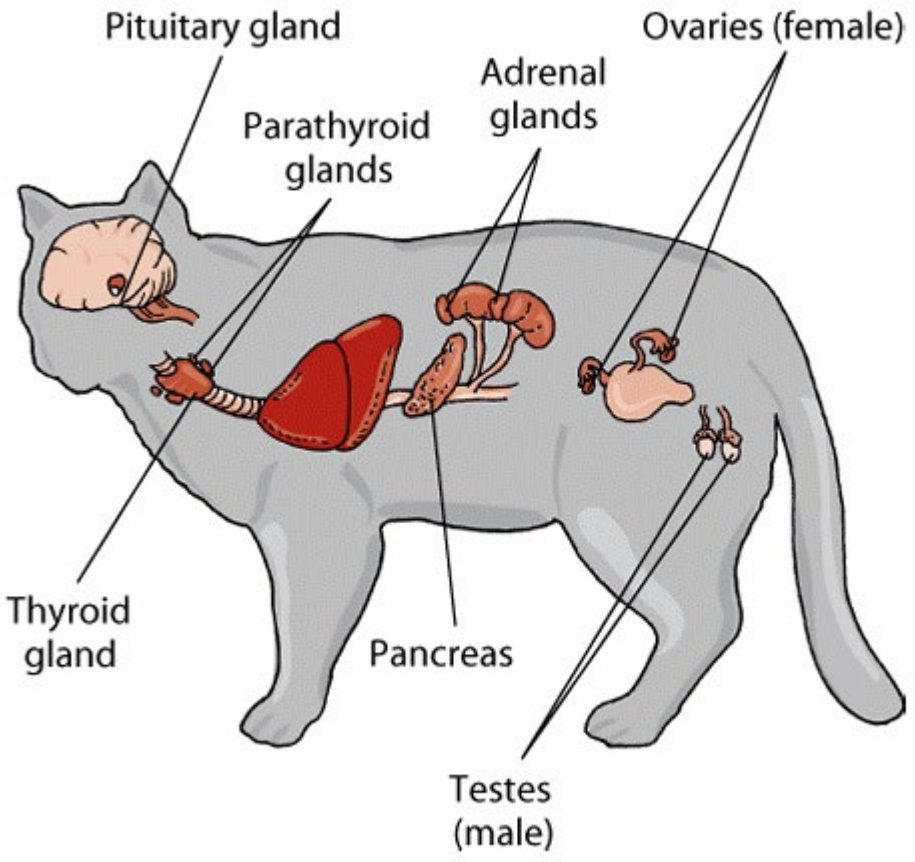
Which organs produce hormones?

Major endocrine glands:

- Hypothalamus & Pituitary gland (see next video)
- Pineal gland (melatonin)
- Thyroid gland (TH) and Parathyroid gland (PTH)
- Adrenal gland (cortisol, adrenalin/epinephrine, aldosterone)
- Pancreas (insulin, glucagon)
- Ovaries (oestrogen, progesterone)
- Testes (testosterone)

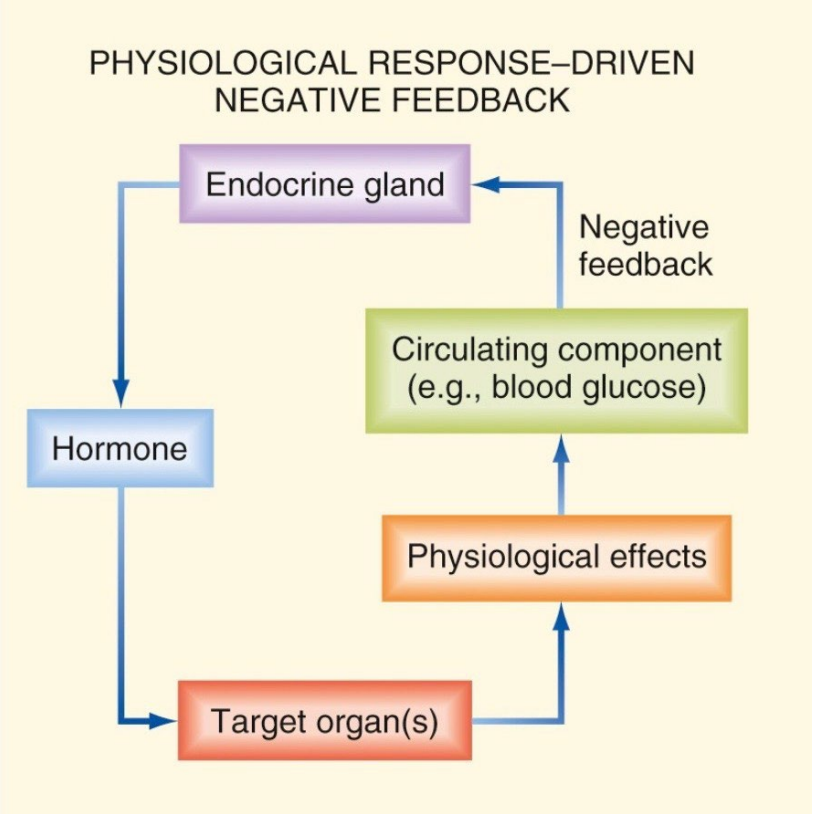


Merckvetmanual.com

Feedback control loops regulate hormone secretion

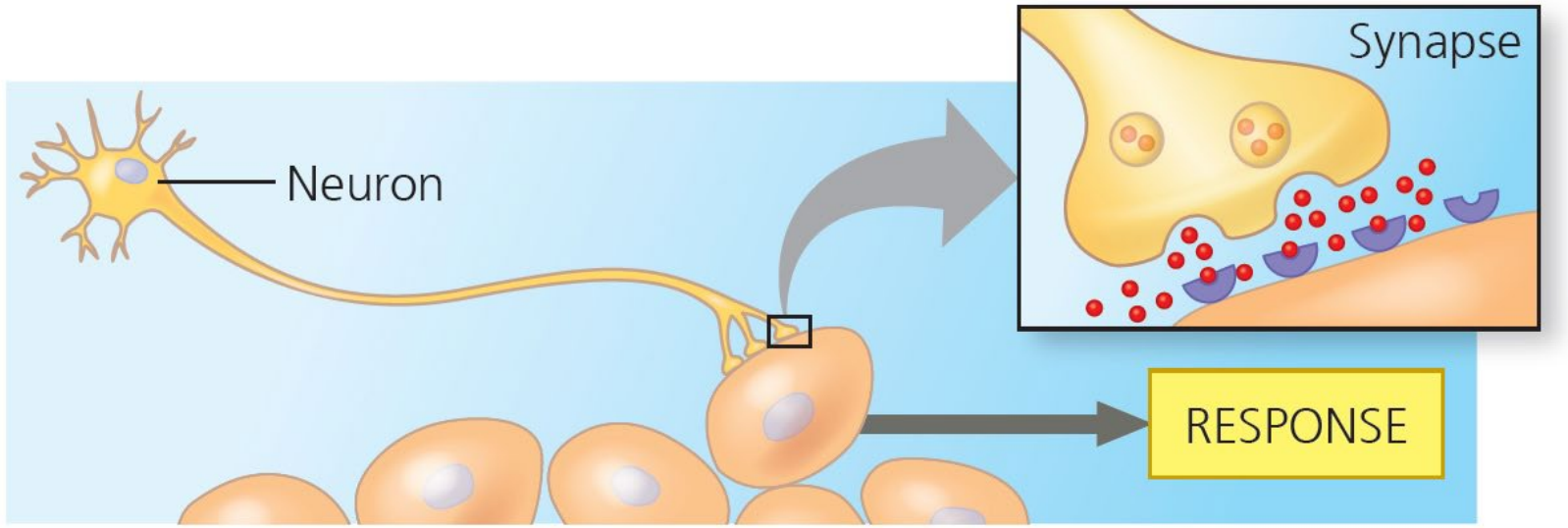
- Endocrine signalling contributes to maintenance of homeostasis, regulating a wide range of processes including:
    - Blood pressure and volume
    - Solute concentrations and body fluids
    - Growth and development

- Negative feedback loops maintain hormone concentrations within a narrow range under normal conditions



Modified from Berne & Levy 2018

4. Synaptic signalling



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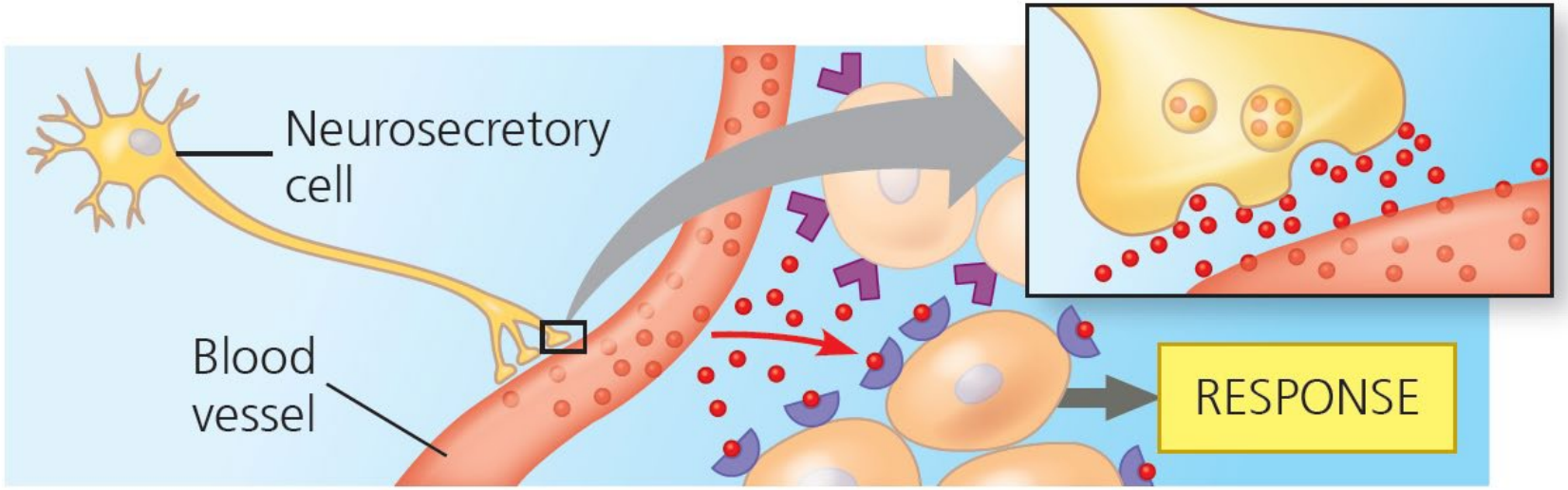
In **synaptic signalling**, neurotransmitters diffuse across synapses and trigger responses in cells of target tissues (neurons, muscles, or glands).

- Neurons communicate with cells they innervate (target cells) by releasing neurotransmitters

- Neurotransmitters are short-range chemical messengers released in response to electrical signals

5. Neuroendocrine signalling



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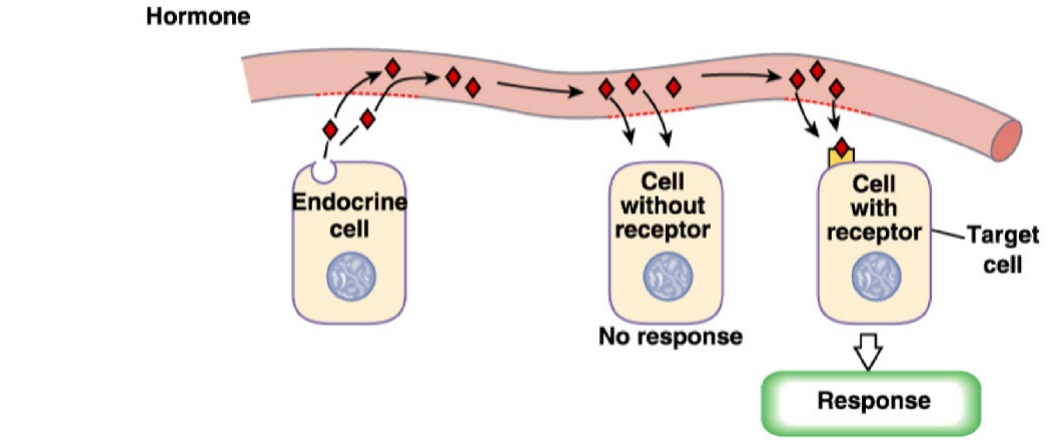
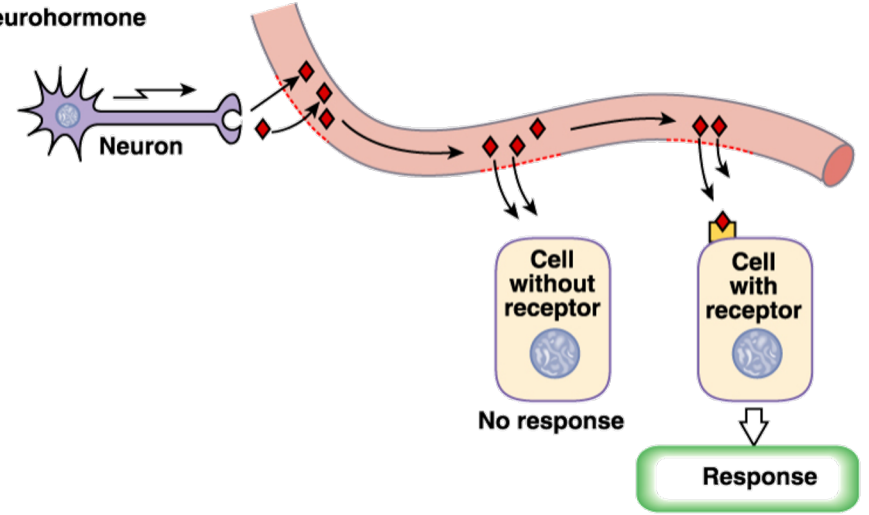
In **neuroendocrine signalling**, neurohormones diffuse into the bloodstream and trigger responses in target cells anywhere in the body.

- Neurohormones are released into the bloodstream by neurosecretory neurons to act at distant sites
- Neurosecretory neurons respond to an electrical signal

Neuroendocrine signalling

- Neurohormones act like classical hormones, but are released from neurons





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Lecture 16: ILOs

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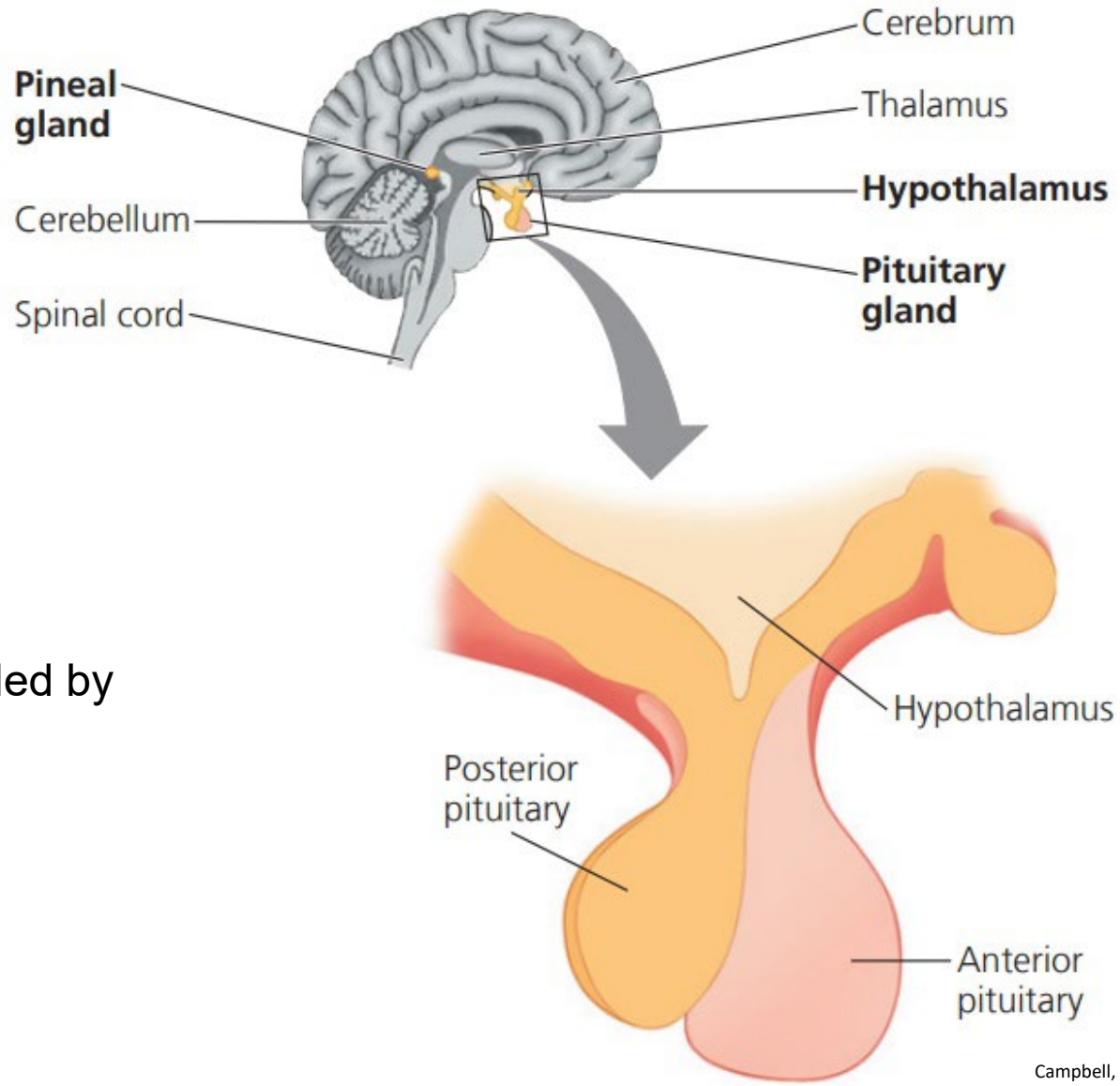
Hypothalamus & Pituitary

- Located at the base of the brain
- Hypothalamus is a part of the brain
- Pituitary gland is a small endocrine gland
- They are connected by a thin connecting stalk
- Release of hormones from pituitary is directly controlled by the hypothalamus



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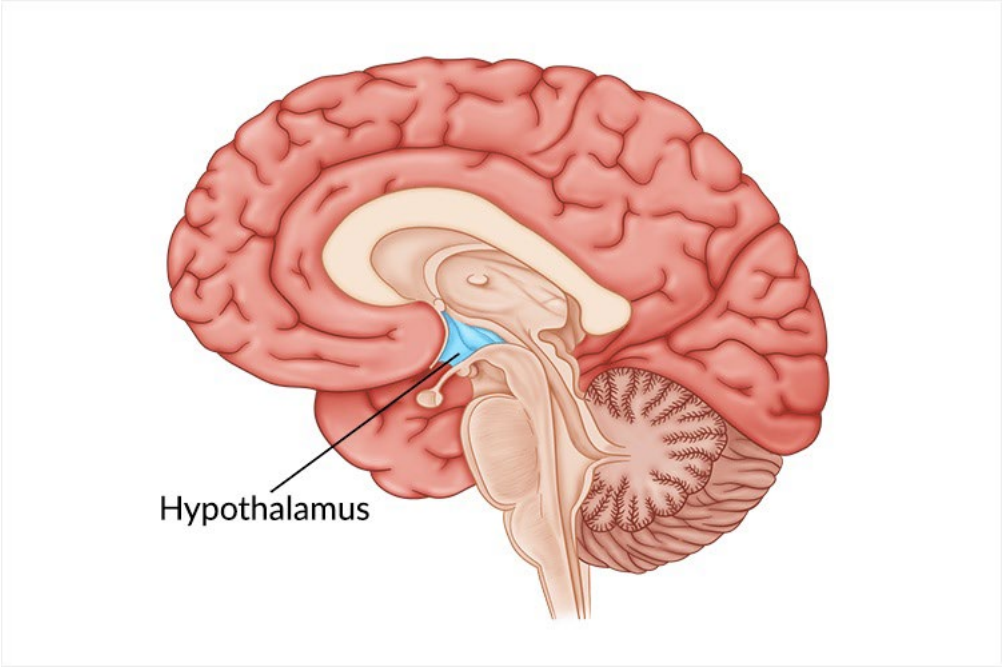
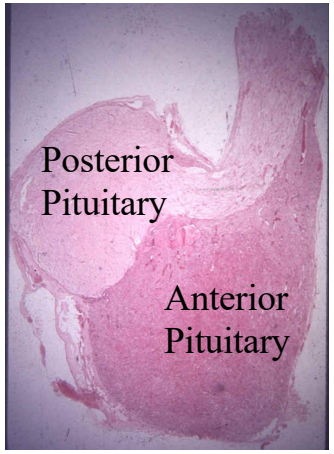
Hypothalamus

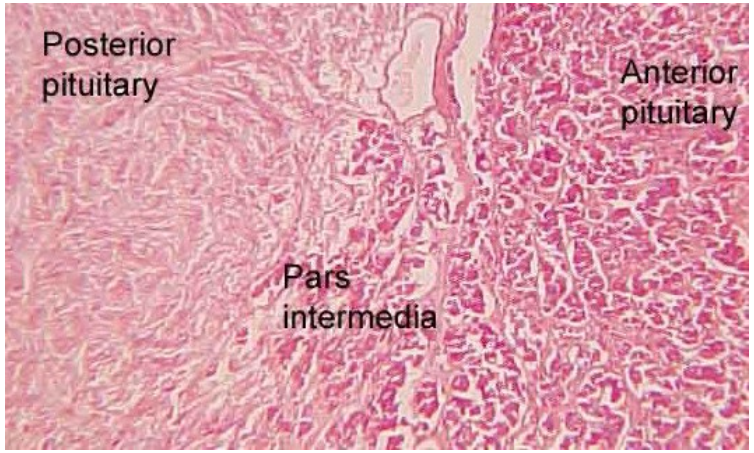
- Hypothalamus receives information from nerves throughout the body
- Initiates neuroendocrine signalling in response
- This signalling controls the functions of the pituitary gland

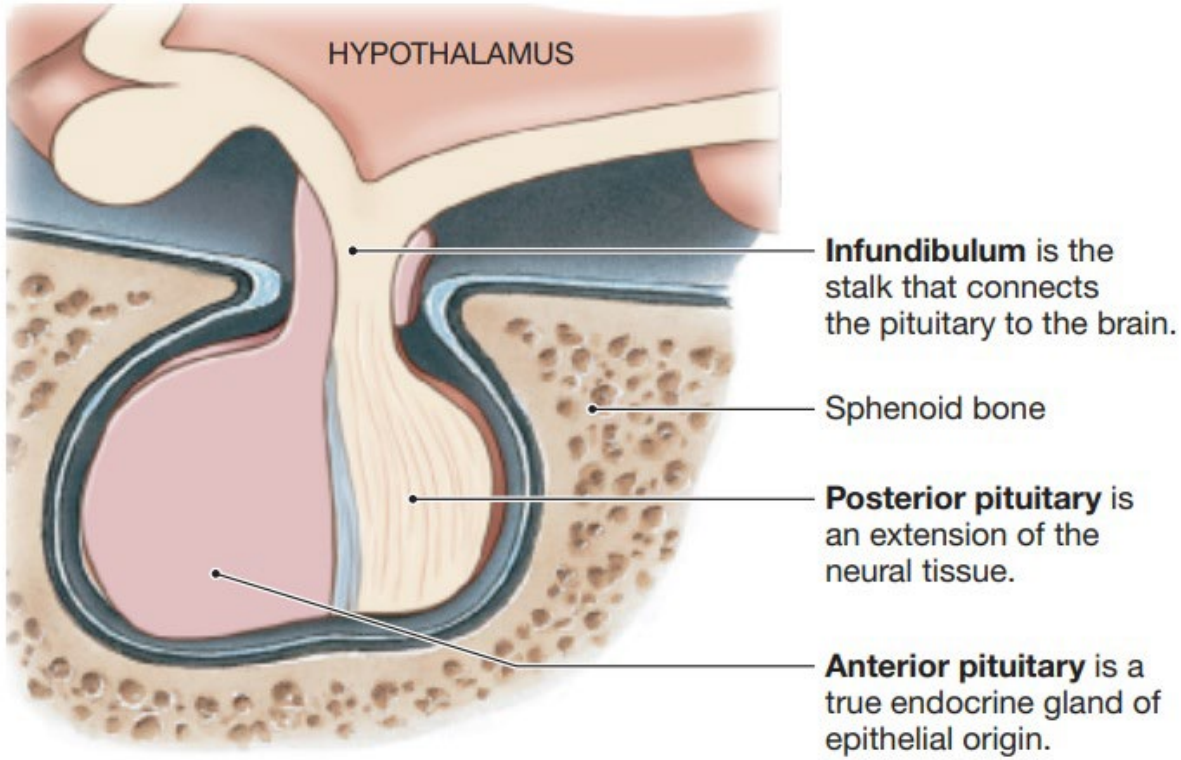


Pituitary: two distinct lobes

- Two anatomically & functionally distinct lobes:
- Anterior pituitary consists of glandular epithelial tissues
- Posterior pituitary is composed of neural tissue







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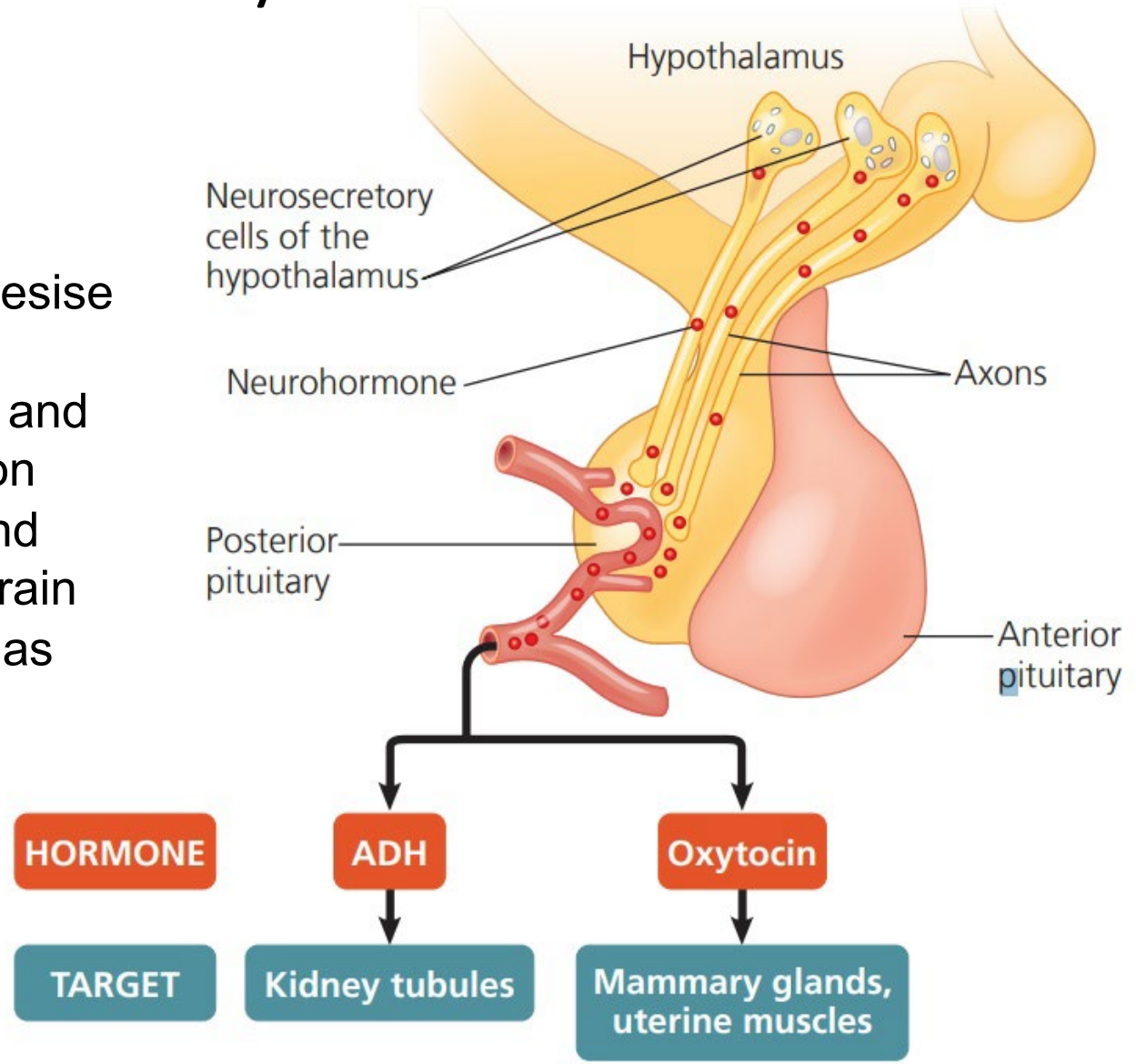
Posterior Pituitary

- Extension of neural tissue in hypothalamus
- Neurosecretory cells in hypothalamus synthesise ADH and oxytocin
- These are packaged into secretory vesicles and transported to posterior pituitary along the axon
- These are stored in the posterior pituitary and released in response to nerve signals in the brain
- Enter into a plexus of blood capillaries – act as neurohormones



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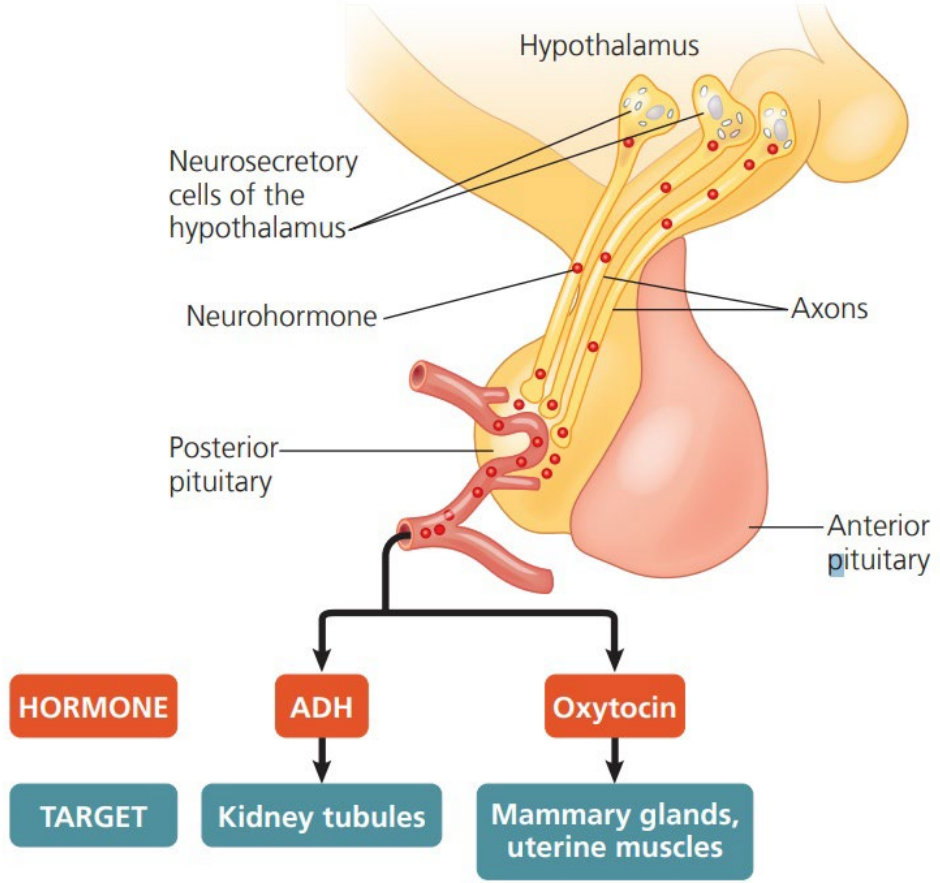
Posterior Pituitary Hormones

- Antidiuretic hormone (ADH,also known as ‘vasopressin’) main functions:
  1. Retention of H_2O in the kidneys
  2. Contraction of arteriolar smooth muscle

- Oxytocin main functions:
  1. Controls ejection of milk during breast-feeding
  2. Contraction of the uterus during labour



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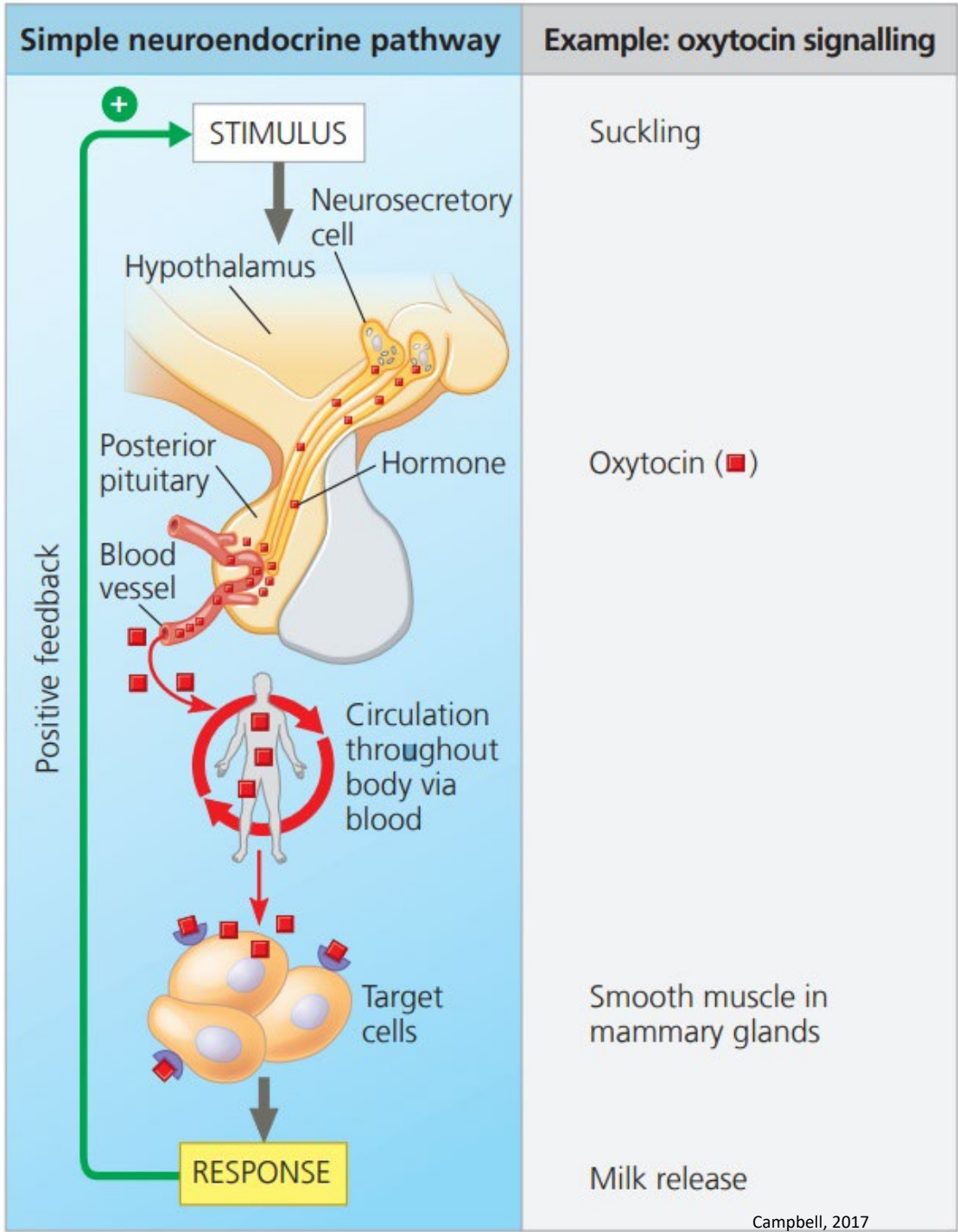
Oxytocin:
an example of a simple neuroendocrine pathway



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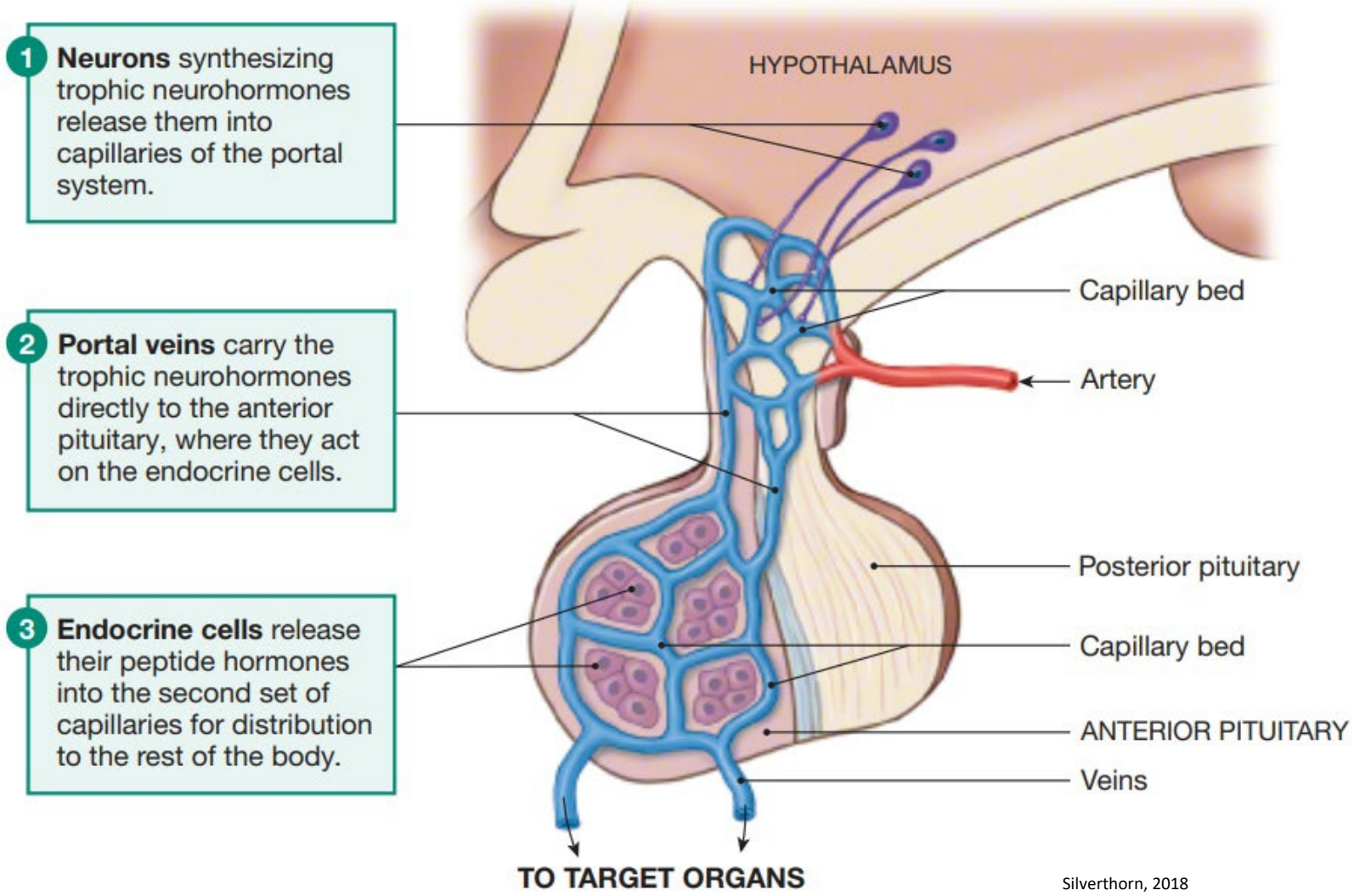
Anterior Pituitary

- Hypothalamic neurons release neurohormones
- Neurohormones travel directly to the anterior pituitary in the portal system
- They trigger the release of hormones from endocrine cells located in the anterior pituitary



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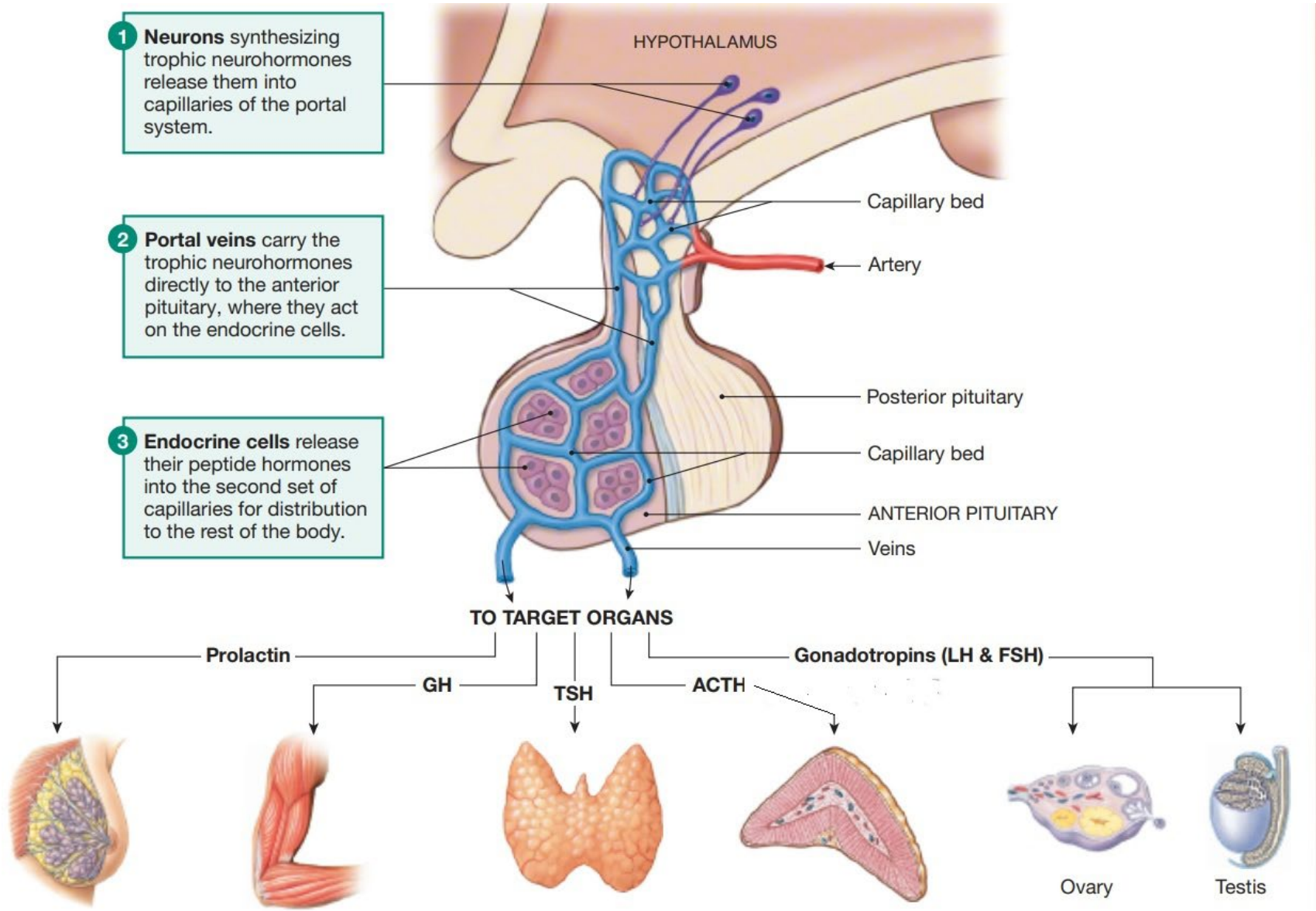
Anterior pituitary is an endocrine gland that secretes six hormones



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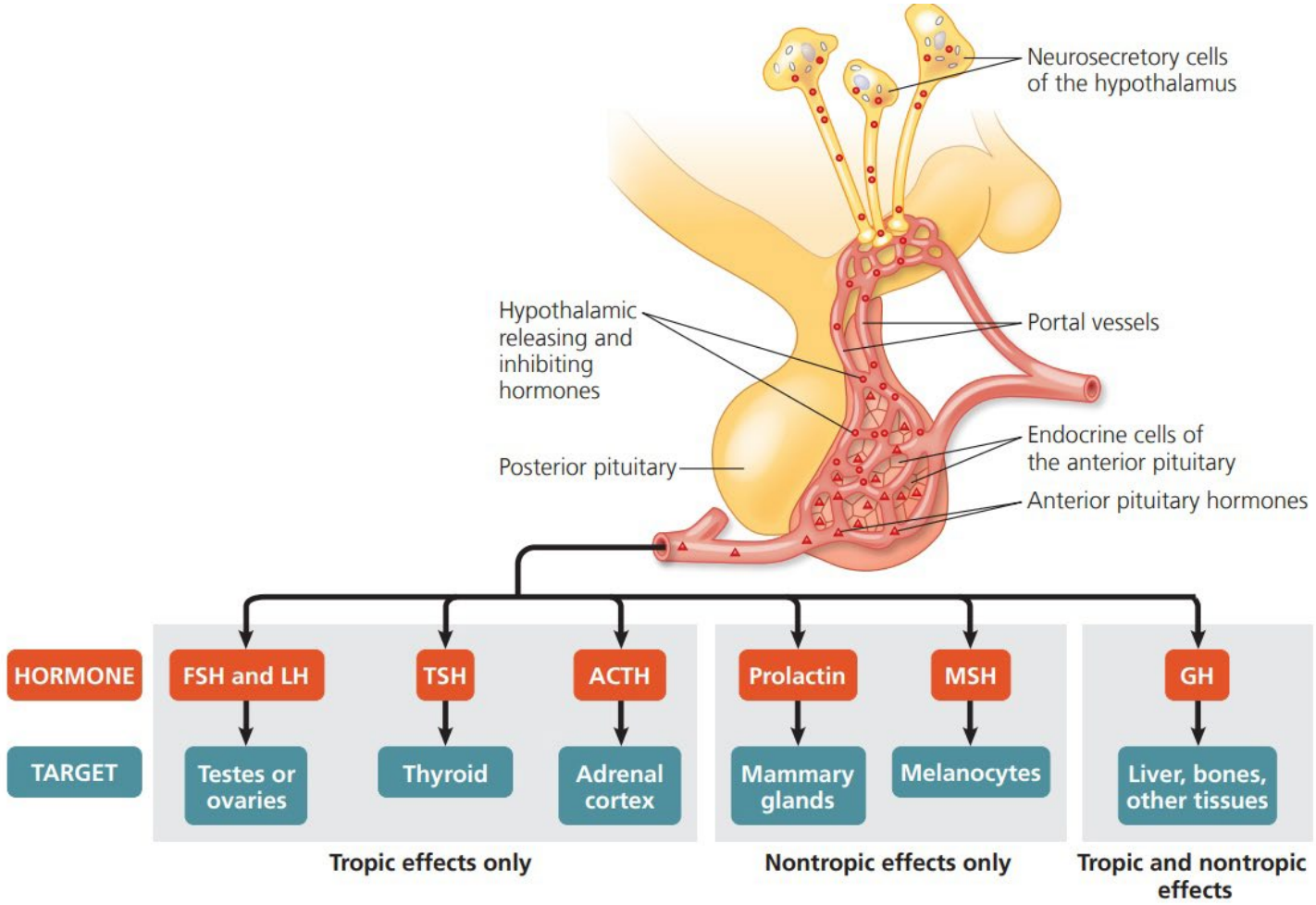
Summary: Anterior Pituitary Hormones

Pituitary cell	Hormone produced	Main target	Primary function
Thyrotrophs	Thyroid stimulating hormone (TSH)	Thyroid gland	Stimulates release & production of thyroid hormones
Corticotrophs	Adreno-corticotropic hormone (ACTH)	Adrenal gland	Stimulates release & production of glucocorticoids
Lactotrophs	Prolactin (PRL)	Mammary gland	Stimulates and sustains milk production
Gonadotrophs	Follicle stimulating hormone (FSH)	Ovaries & testes	Females: stimulates egg formation (growth & development of ovarian follicles) Males: helps stimulate sperm formation
	Luteinising hormone (LH)	Ovaries & testes	Females: stimulates ovulation, corpus luteum formation, estrogen & progesterone secretion Males: promotes testosterone secretion, sperm release
Somatotrophs	Growth hormone (GH)	Most cells	Stimulates postnatal somatic growth & development (IGF-I & II) Mobilizes fat stores, stimulates protein synthesis, inhibits insulin

Anterior Pituitary: Regulation

Two main factors that regulate the production of anterior pituitary hormones:

1. **Hypothalamic hormones**
   - Hypothalamic hormones are called releasing or inhibiting hormones
   - Each of the six anterior pituitary hormones is controlled by a releasing hormone or an inhibiting hormone – or both
2. **Feedback from target gland hormones**



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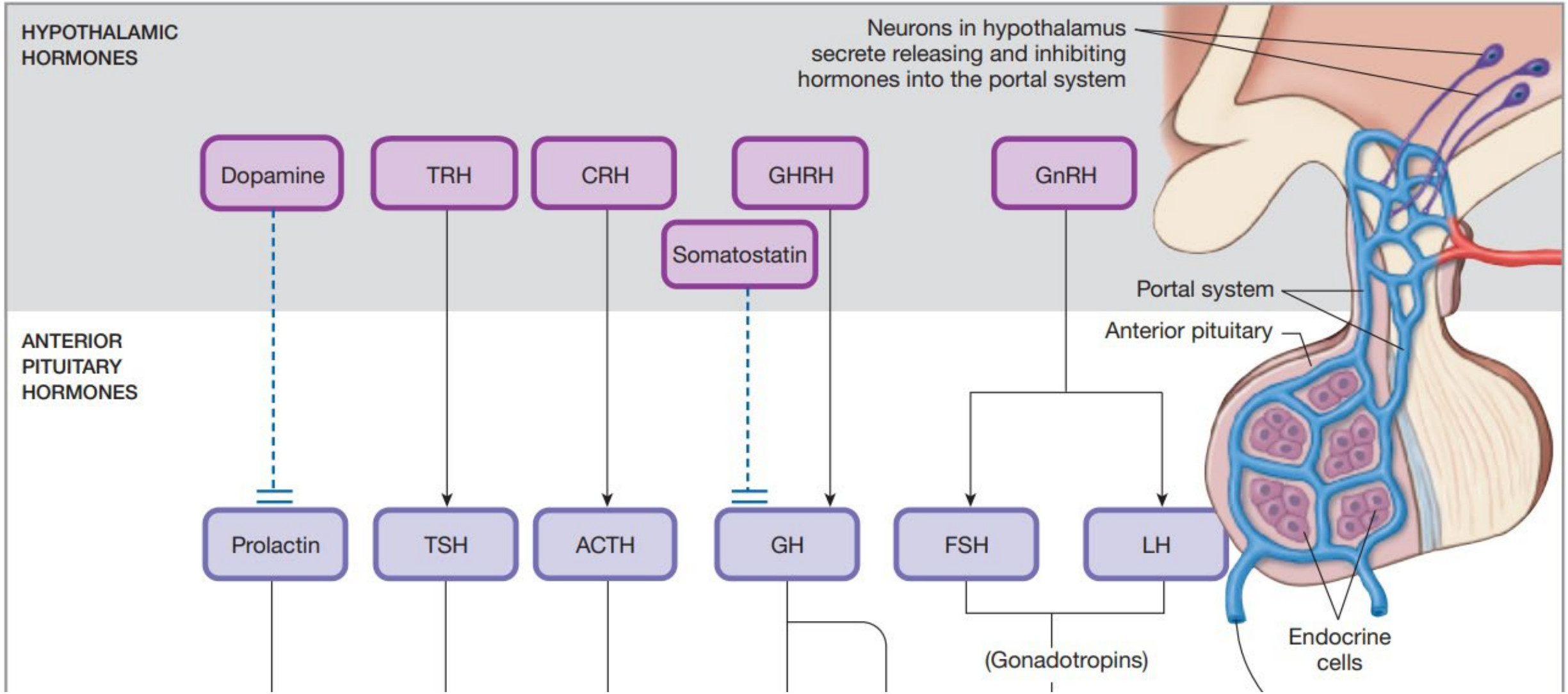
Anterior Pituitary: Regulation



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Anterior Pituitary: Regulation

Anterior Pituitary Hormone	Hypothalamic Releasing Hormone	Hypothalamic Inhibiting Hormone
Prolactin (PRL)		Dopamine (PIH)
Thyrotropin, Thyroid-stimulating hormone (TSH)	Thyrotropin-releasing hormone (TRH)	
Adrenocorticotropin, Adrenocorticotrophic hormone (ACTH)	Corticotropin-releasing hormone (CRH)	
Growth hormone (GH), Somatotropin	GHRH (dominant)	Somatostatin (SS), also called growth hormone-inhibiting hormone (GHIH)
Gonadotropins: Follicle-stimulating hormone (FSH) Luteinizing hormone (LH)	Gonadotropin-releasing hormone (GnRH)	

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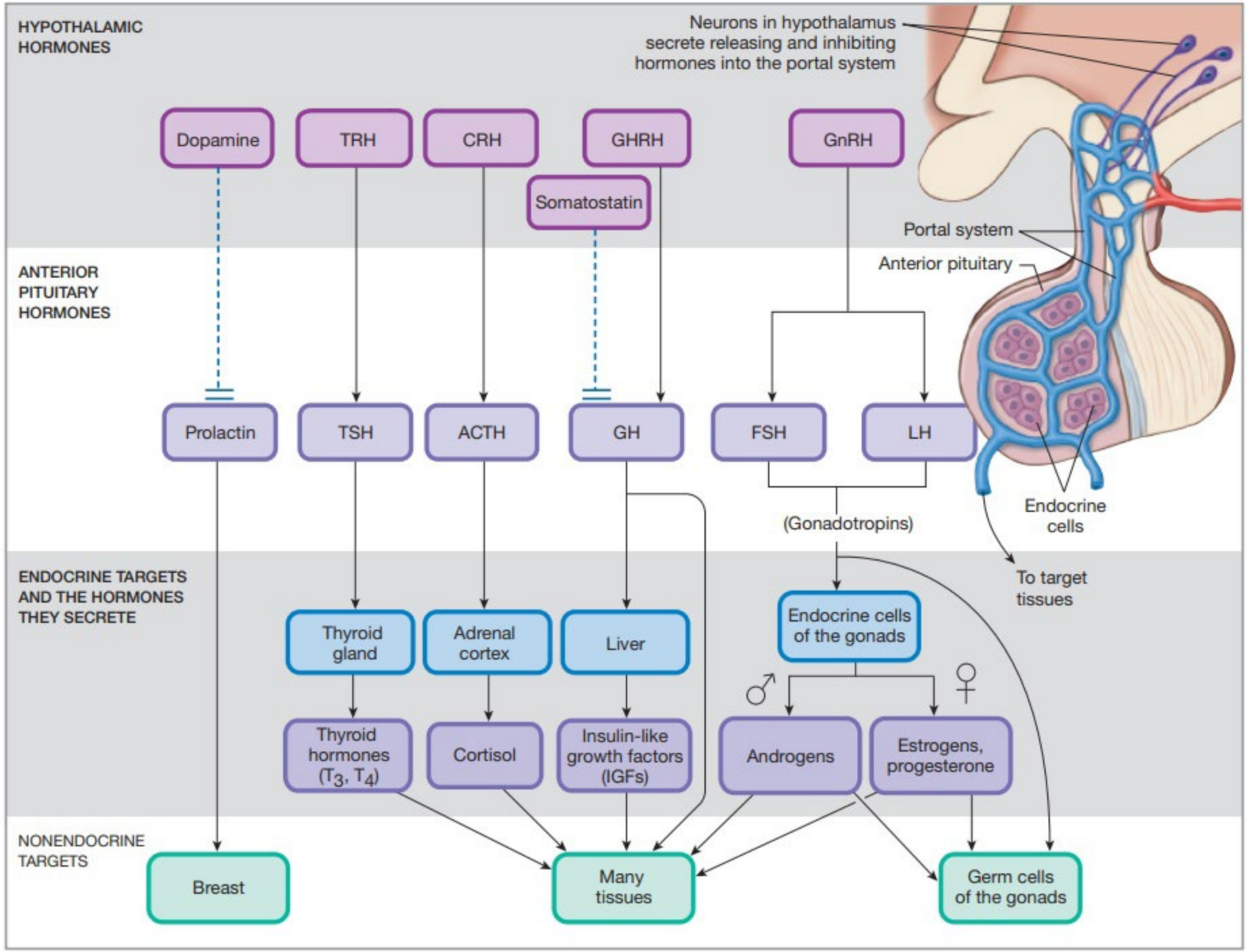

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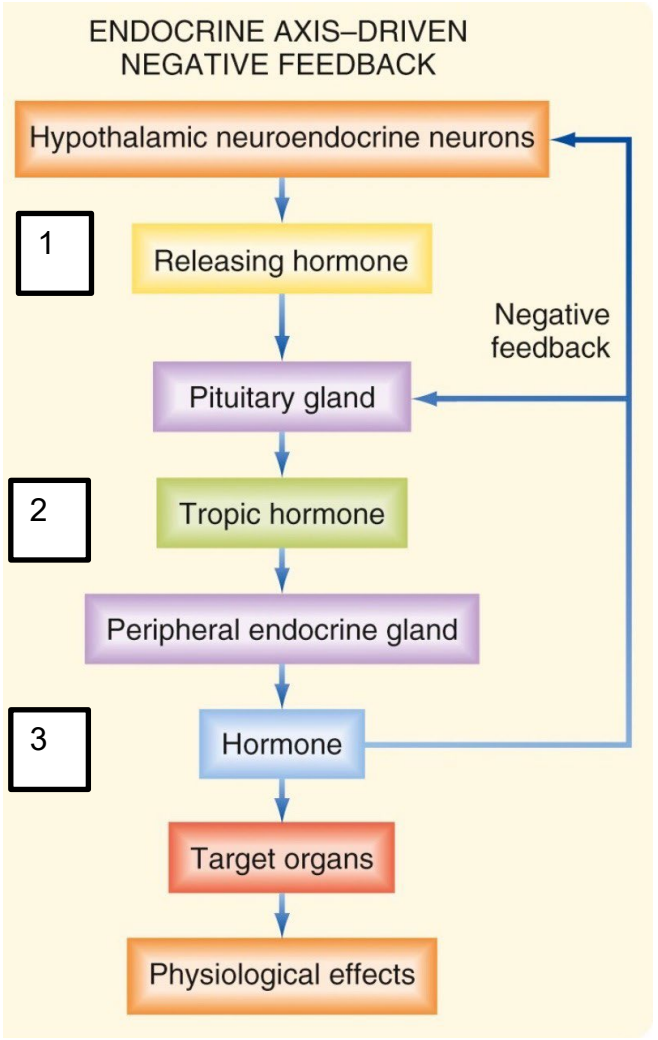
Anterior pituitary: feedback

Three-tiered response:

1. Hypothalamic releasing & inhibiting hormones
2. Production of hormones in anterior pituitary
3. Production and secretion of hormones from peripheral glands



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Hormones act as feedback signals:

'long loop' and 'short loop' feedback

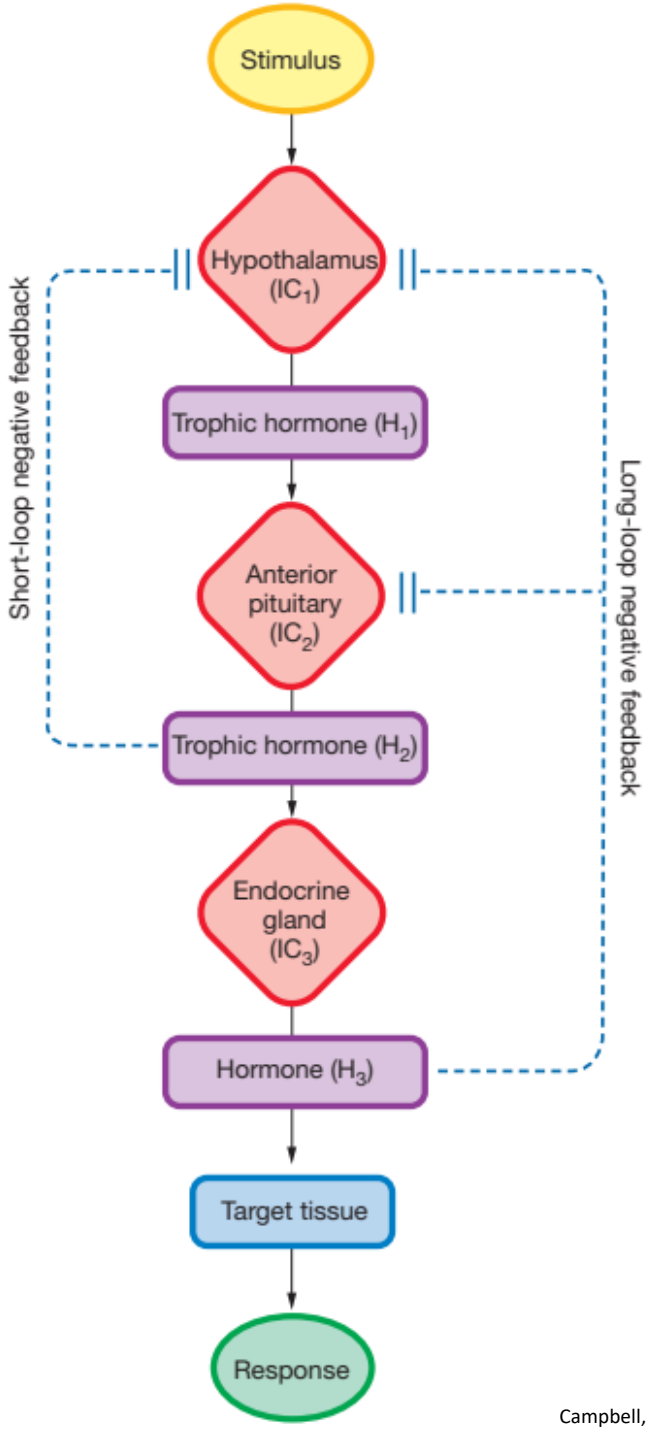

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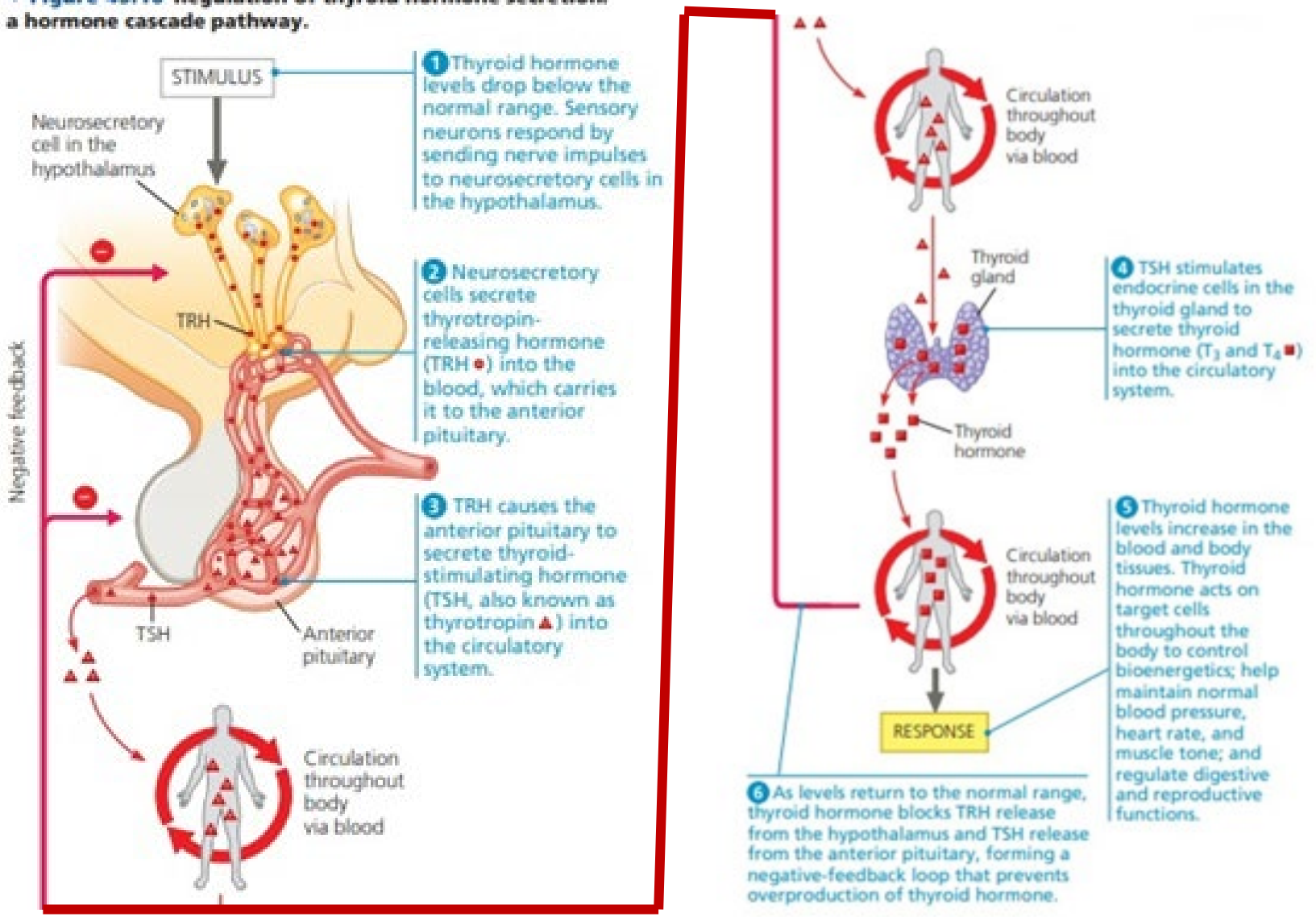
Figure 45.16 Regulation of thyroid hormone secretion: a hormone cascade pathway.



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