Lecture 6
Neuroendocrinology 2

PSYC 304

Designing a behavioural endocrine study

More on the HPA axis later.

Behavioural Endocrinology

Designing an experiment

- Goal: Establish a relationship between a particular hormone and behaviour
- Where to start?
- Design an experiment!

Behavioural Endocrinology today

Designing an experiment

- Goal: Establish a relationship between a particular hormone and behaviour
- Where to start?
  - Observe behaviour → Remove source of hormone (endocrine gland) → observe change in behaviour

Behavioural Endocrinology

An example – Testosterone and mating behaviour in mice

Step 1

- Observe several individuals (a representative sample)
- Results: most male adult rats will try to mount and copulate with a receptive female in their cage

Step 2

- Remove endocrine gland (testes) and observe behaviour
- Results: The male rat will stop its copulatory behaviour

- Conclusion: testosterone loss leads to reduction in copulatory behaviour.

Behavioural endocrinology

Are you happy with this conclusion?

- Did you eliminate alternate explanations?

Next steps – Building evidence

- Return of behaviour with return of hormone
  - Inject castrated mice with testosterone → return of behaviour
- Eliminate functionality of the hormone in a different way
  - Make a **knock-out** organism – *knock out* the gene that encodes the testosterone receptor

Behavioural endocrinology

Next question?

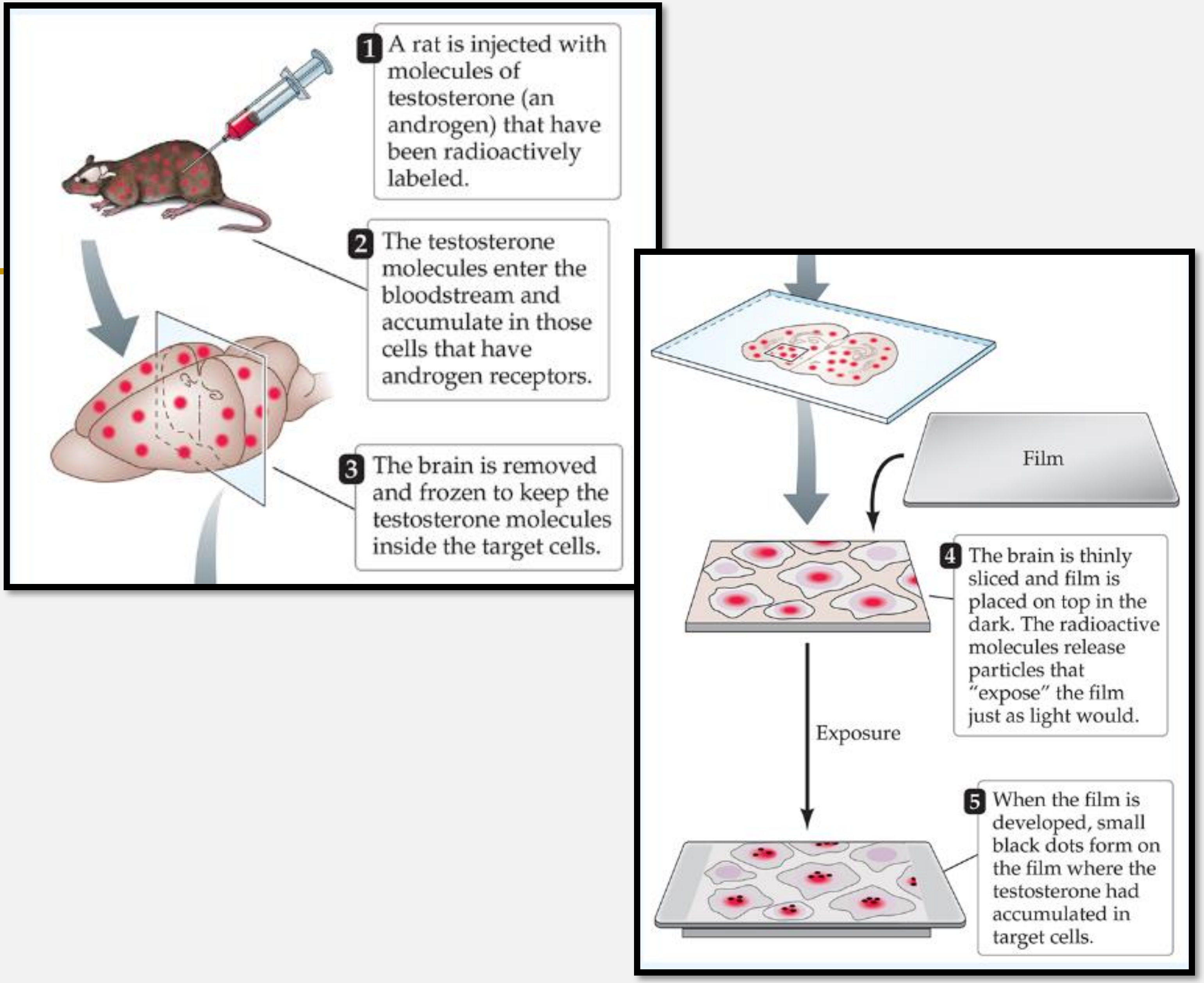
- We have established a relationship between copulatory behaviour and testosterone. But what is it?
- Does copulatory behaviour frequency correlate with levels of testosterone?
- Technique – observe behaviour and measure circulating testosterone: **Autoimmunoassay –** label hormone of interest (testosterone) with an antibody
    - Turns out: copulatory behaviour does not correlate with circulating testosterone levels
    - Testosterone permits the behaviour, but does not determine how much of the behaviour the individual exhibits

Behavioural endocrinology

Perhaps a side question?

- How does testosterone permit sexual behaviour?
- Where in the brain does testosterone have an effects?
- ***Autoradiography (as imaged)***
- ***Immunohistochemistry***
- ***In-situ hybridization***

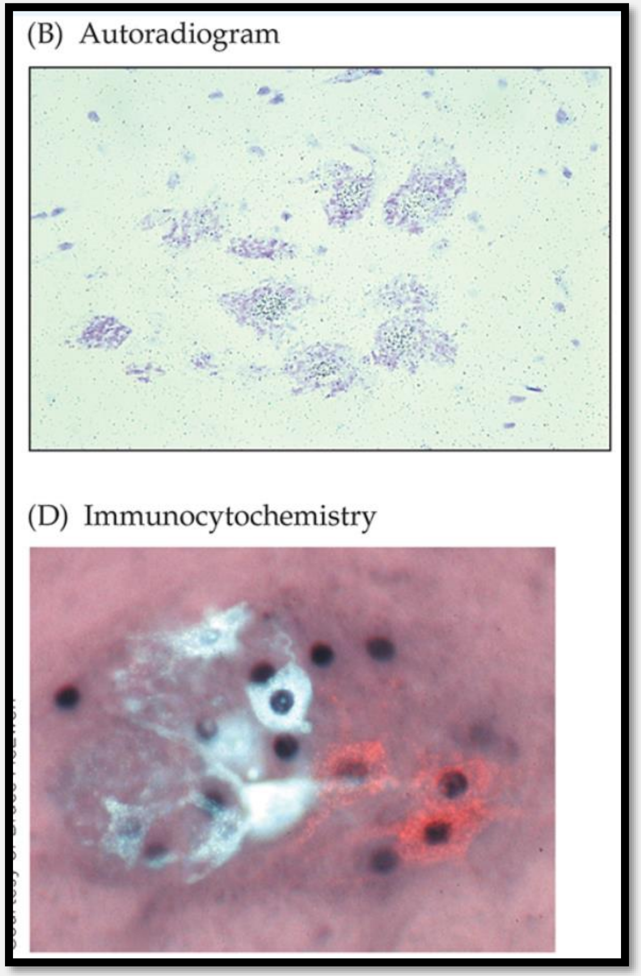
Labelled mRNA complimentary to mRNA making receptors for testosterone



Behavioural endocrinology

Autoradiograms & immunohistochemistry

- Locate the active sites for testosterone in the brain
- Then…
  - Place small pellets of testosterone in those areas of the brain in castrated mice and observe recovery of behaviour of interest
- In male mice – Preoptic area of the hypothalamus (mPOA)
- Then….
  - Study the mPOA – how does testosterone effect change (anatomically, physiologically, protein production, etc.)



Endocrine glands

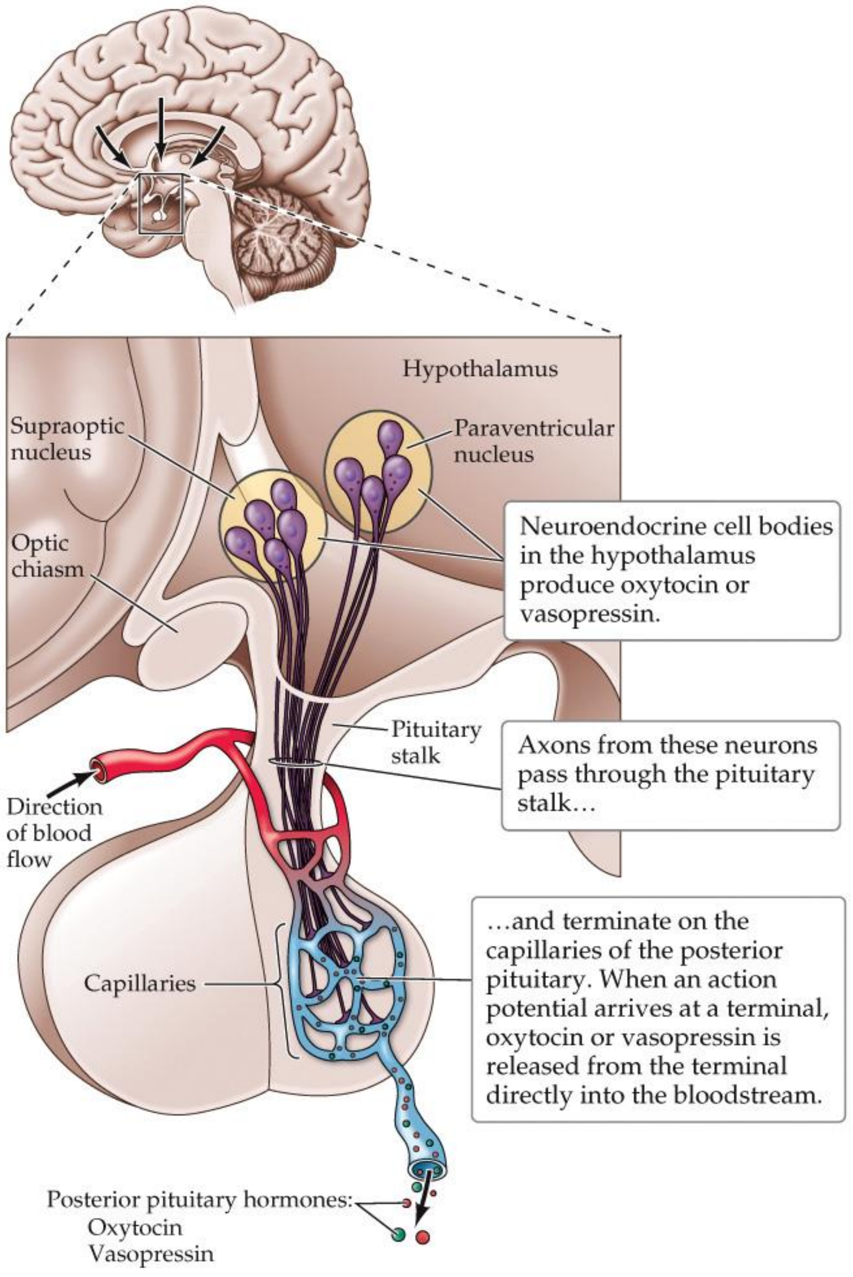
Endocrine glands

The pituitary gland (hypophysis)

- **Anterior pituitary** (adenohypophysis)
- **Posterior pituitary** (neurohypophysis)
- The two parts are separate in function.

The pituitary stalk (infundibulum)

- connects the pituitary to the hypothalamus; contains many axons that extend only to the posterior pituitary.
- Blood vessels carry information only to the anterior pituitary.



BEHAVIORAL NEUROSCIENCE 10e, Figure 5.12

Endocrine Glands

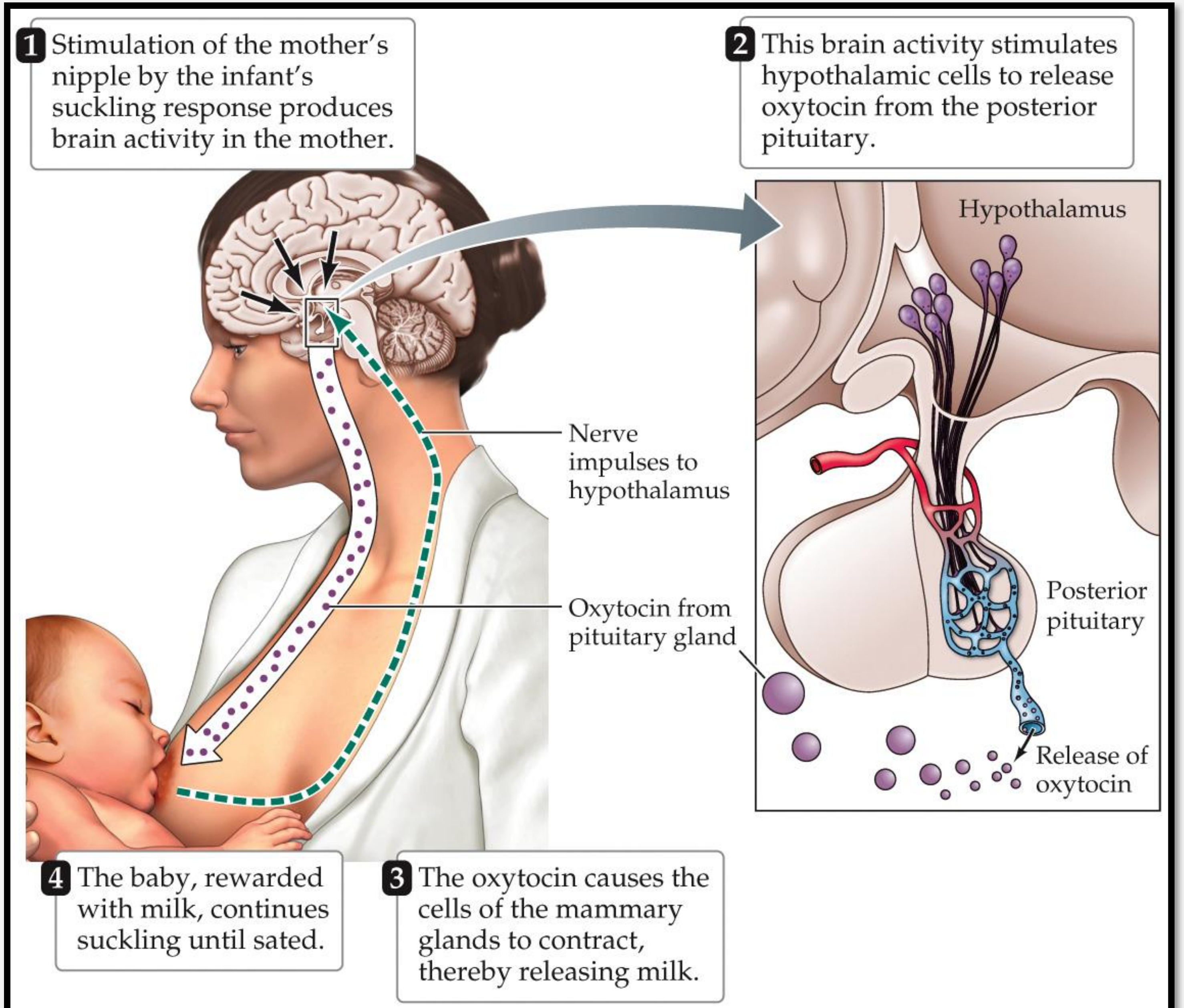
Posterior Pituitary

- secretes oxytocin and vasopressin.
- Neurons in the supraoptic nuclei and paraventricular nuclei of the hypothalamus synthesize these hormones and transport them along the axons in the stalk.

Endocrine Glands

Posterior pituitary

- **Oxytocin** is involved in reproductive and parenting behavior, uterine contraction, and the **milk letdown reflex**.
- Reflex can be conditioned to a baby's cries



BEHAVIORAL NEUROSCIENCE 10e, Figure 5.13

Endocrine glands

Arginine vasopressin (AVP), or vasopressin, or antidiuretic hormone (ADH)

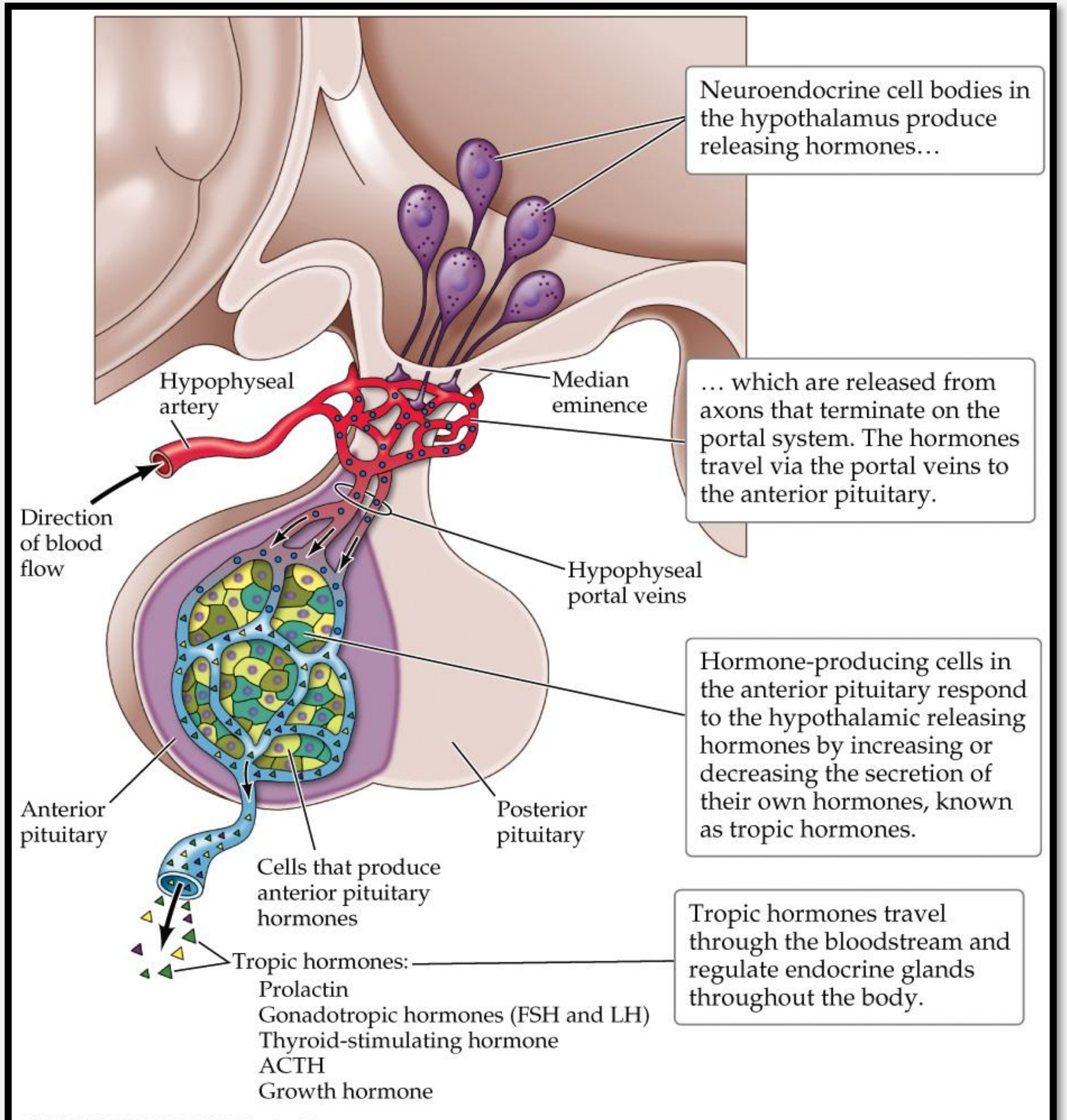
- increases blood pressure and inhibits urine formation.

Vasopressin and oxytocin can also serve as neurotransmitters from hypothalamic cells projecting widely through the nervous system.

Endocrine Glands

Hypothalamic neurons

- synthesize **releasing hormones.**
- Axons from these cells converge on the **median eminence**, above the pituitary stalk.
- Releasing hormones are secreted into blood vessels called the **hypophyseal portal system**, and are carried to the anterior pituitary, which then releases tropic hormones.



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Endocrine Glands

Hypothalamic neuroendocrine cells

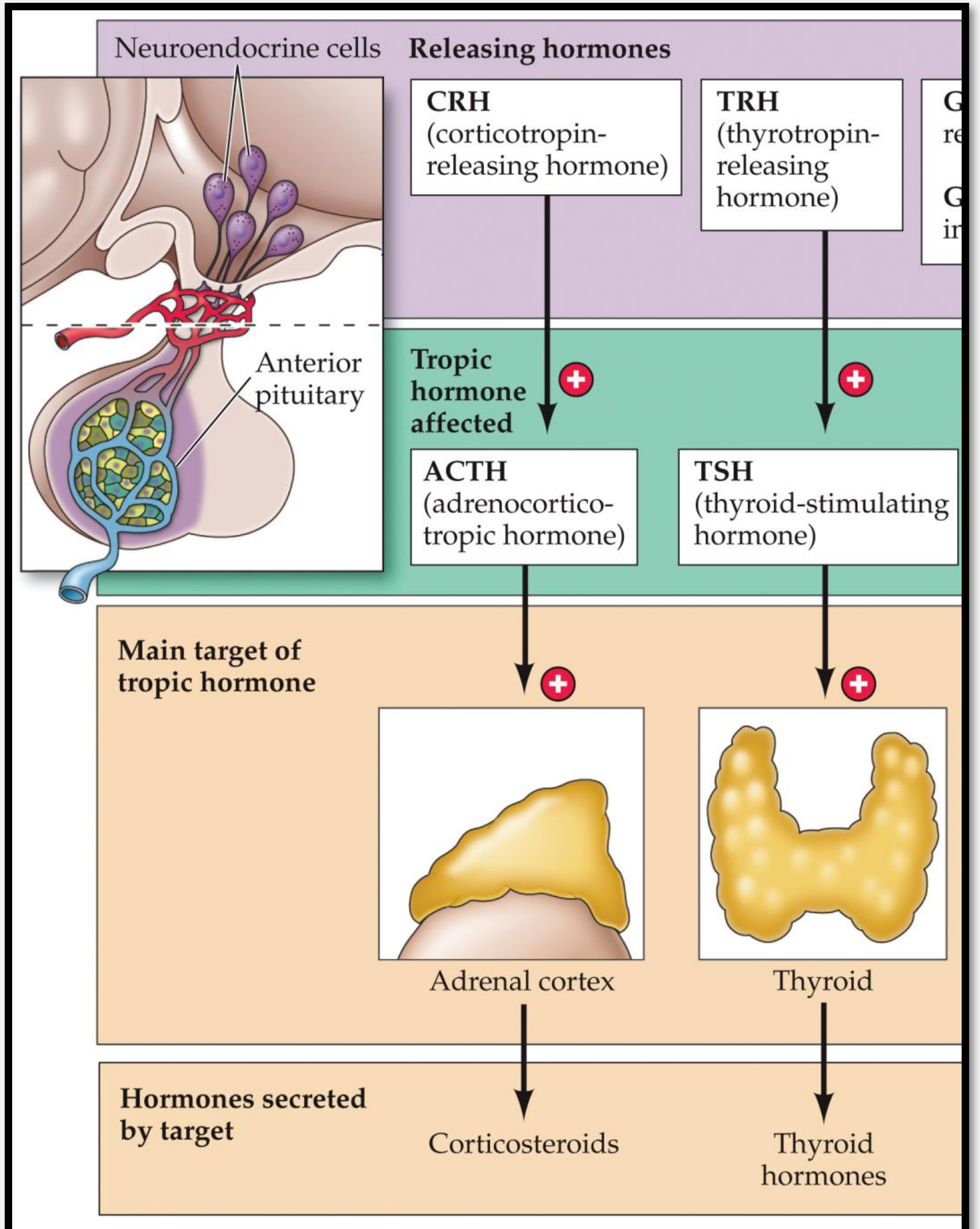
- Influenced by circulating messages, such as other hormones, blood sugar, and immune system products
- Synaptic inputs from other brain areas.

Endocrine Glands

The anterior pituitary

- releases six tropic hormones:

1. **Adrenocorticotropic hormone** (**ACTH**) controls production and release of adrenal cortex steroid hormones.
2. **Thyroid-stimulating hormone** (**TSH**) increases thyroid hormone release.



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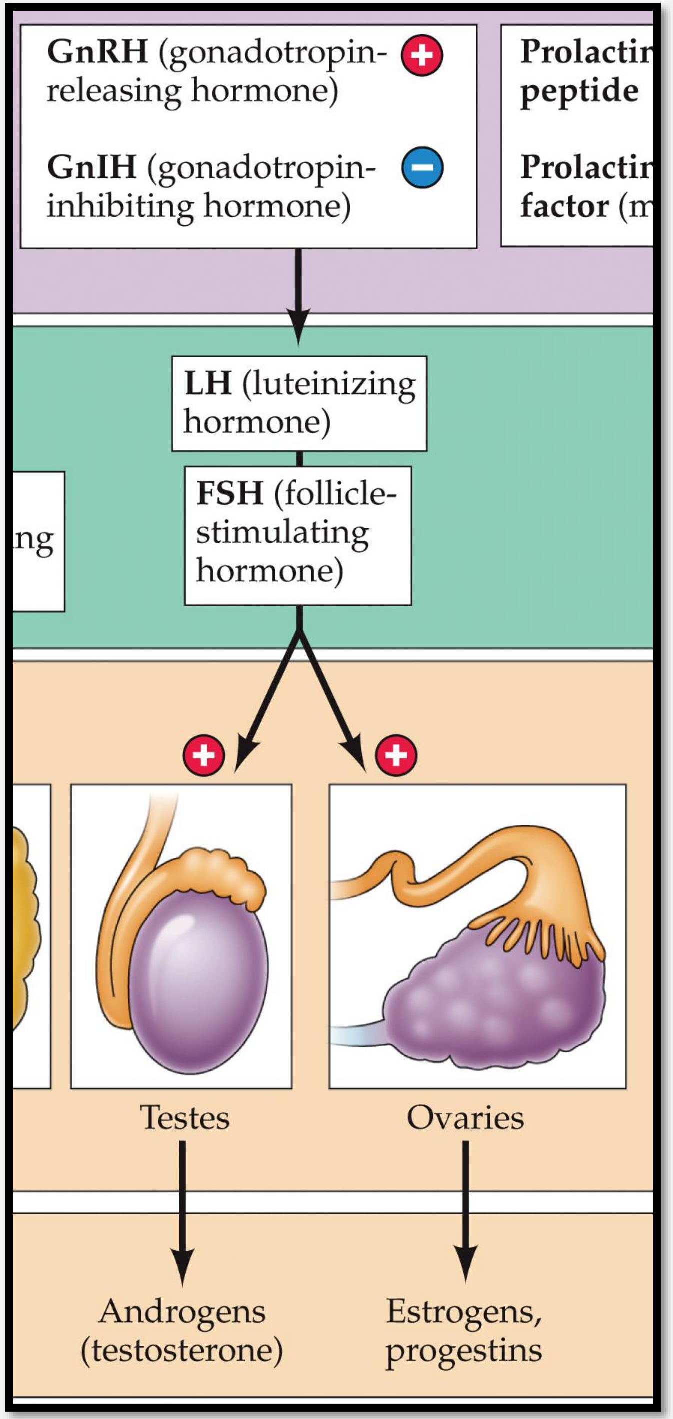
Endocrine Glands

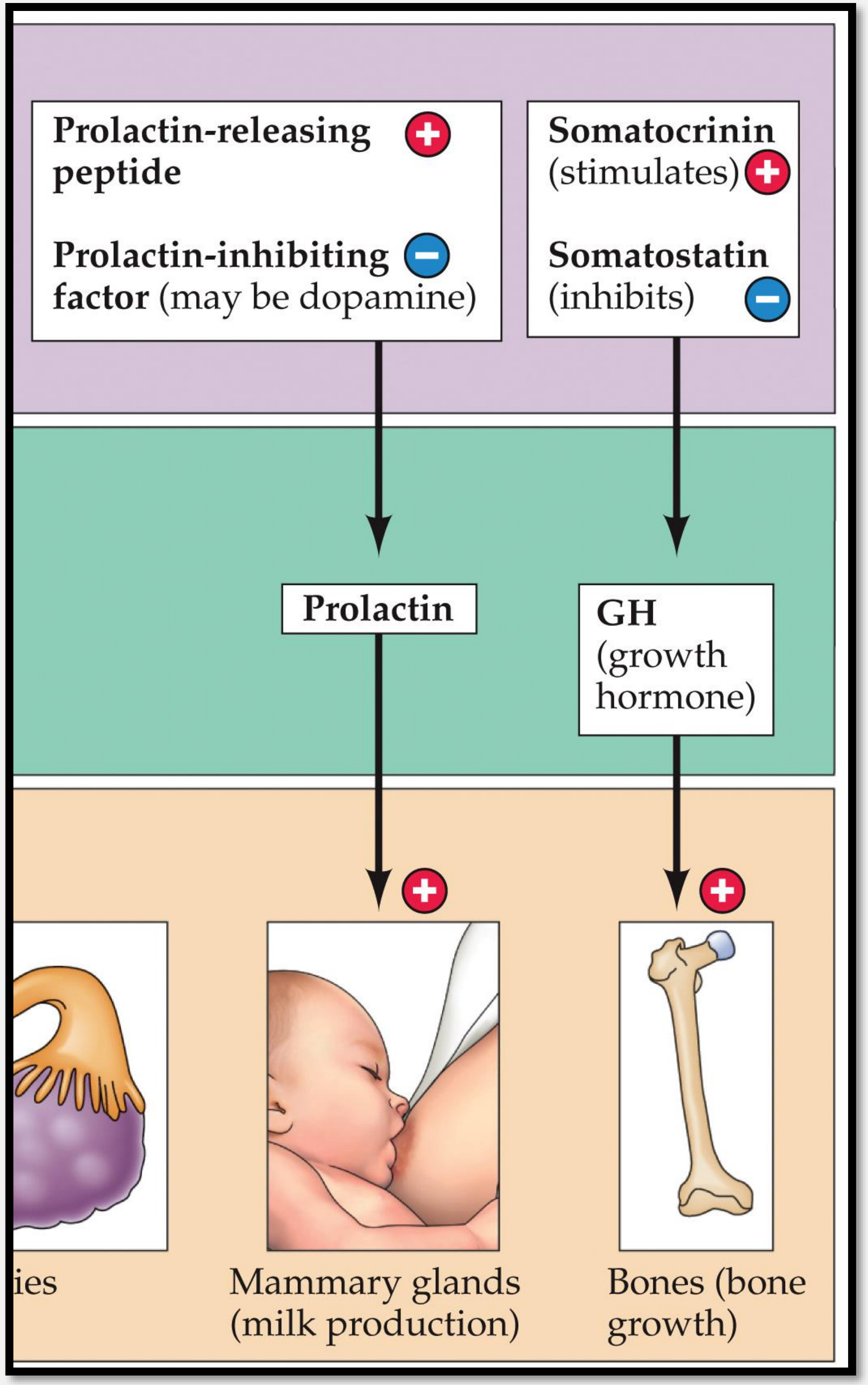
Gonadotropins influence the gonads:

3. **Follicle-stimulating hormone** (**FSH**) stimulates egg-containing follicles in ovaries or sperm production in males.
4. **Luteinizing hormone** (**LH**) stimulates follicles to form the corpora lutea in ovaries and testosterone production by the testes.



Endocrine Glands

5. **Prolactin** stimulates lactation in females and is involved in parental behavior.
6. **Growth hormone** (**GH**) (somatotropin) influences growth, mostly during sleep. The stomach hormone ghrelin also evokes GH release.



Major endocrine glands

Endocrine Glands

Adrenal glands

- are located on top of each kidney.

Adrenal cortex

- secretes steroid hormones (**adrenocorticoids**).
- **Glucocorticoids** are a subgroup involved with glucose metabolism.
- **Cortisol** is a glucocorticoid stress hormone that increases blood glucose and breaks down protein.

Adrenal medulla

- releases the amine hormones **epinephrine** (adrenaline) and **norepinephrine** (noradrenaline).
- These are controlled by the sympathetic nervous system.

Endocrine Glands

Mineralocorticoids affect ion concentrations in tissues.

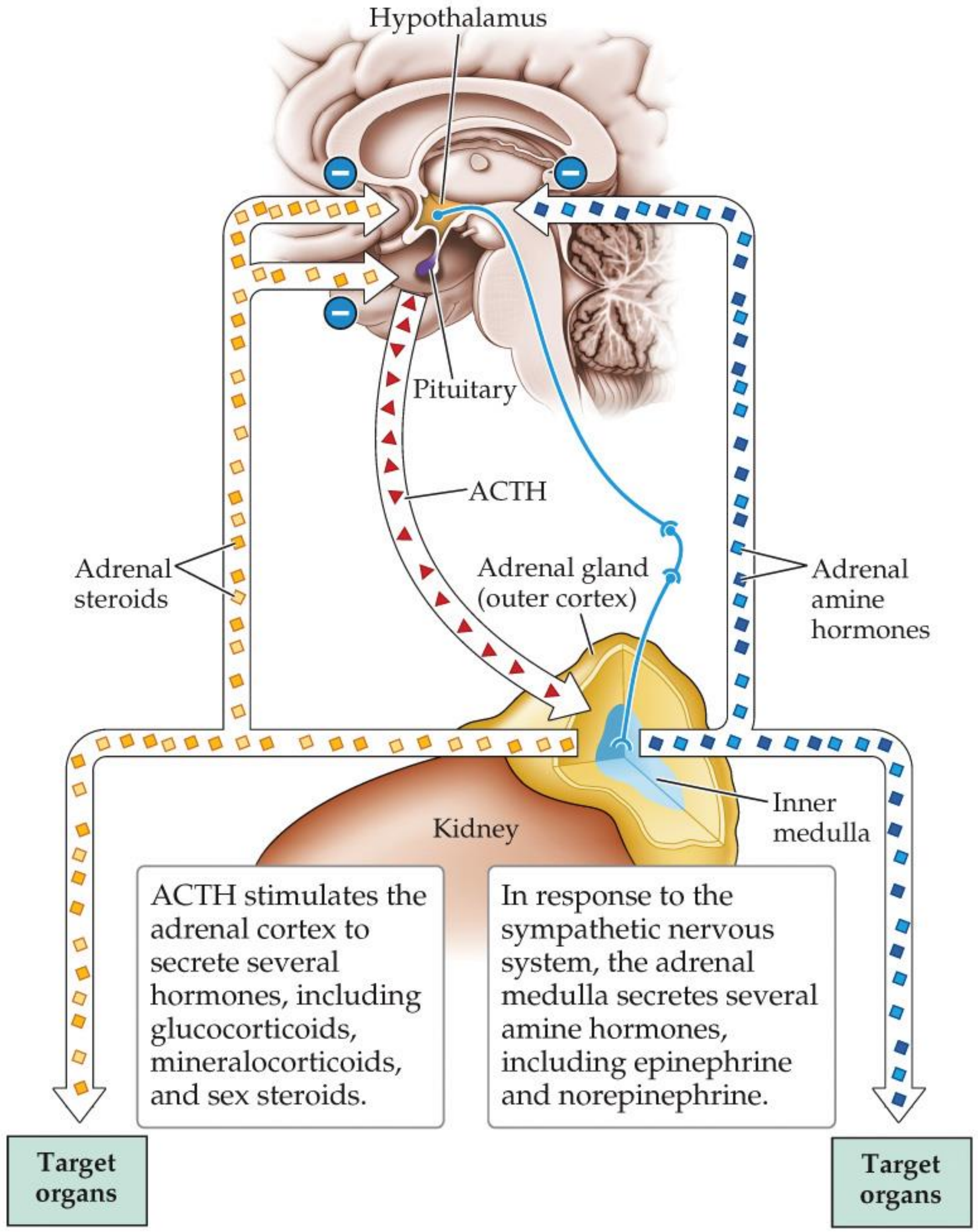
Aldosterone acts on the kidneys to retain sodium.

Sex steroids, such as androstenedione, contribute to the adult pattern of body hair in men and women.

Endocrine glands

Regulation of adrenal cortical hormones:

- ACTH promotes steroid synthesis in the adrenal gland. The steroids in turn exert a negative feedback effect on ACTH release.



BEHAVIORAL NEUROSCIENCE 10e, Figure 5.17

Each Endocrine Glands

Thyroid-stimulating hormone (TSH)

- is secreted by the pituitary.
- release is controlled by negative feedback from blood levels and by **thyrotropin-releasing hormone** (**TRH**) from the hypothalamus.

Endocrine Glands

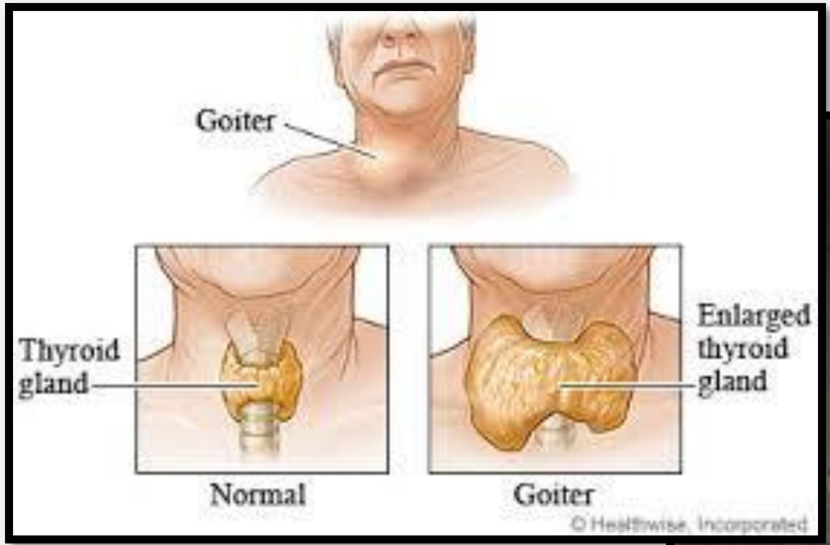
TSH

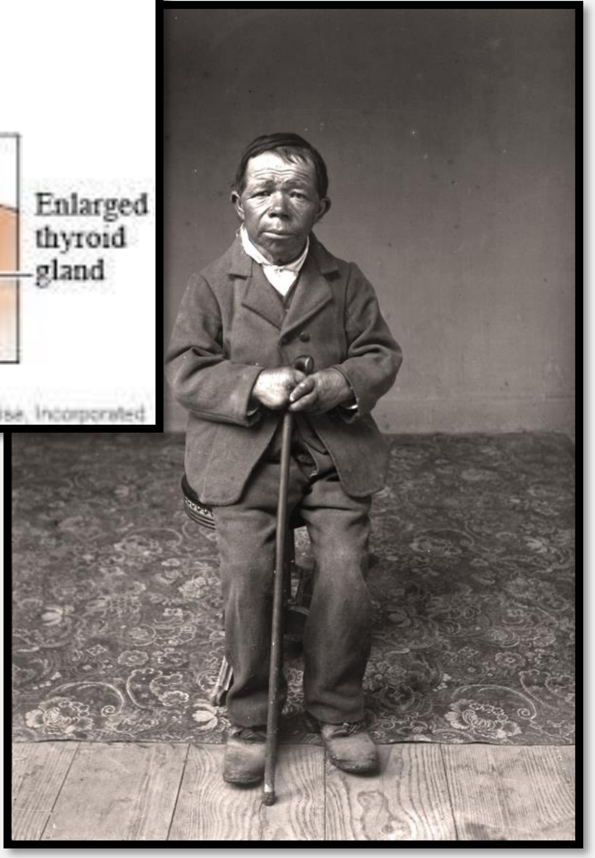
- causes the thyroid gland to produce **thyroid hormones**: thyroxine (tetraiodothyronine) and triiodothyronine.
- The thyroid gland also produces calcitonin, which promotes calcium deposition in bones.

Endocrine Glands

Thyroid hormones

- contain iodine and depend on its supply.
- **Goiter** is a swelling of the thyroid gland resulting from iodine deficiency.
- Early thyroid deficiency can result in cretinism, or **congenital hypothyroidism**, accompanied by intellectual disability.

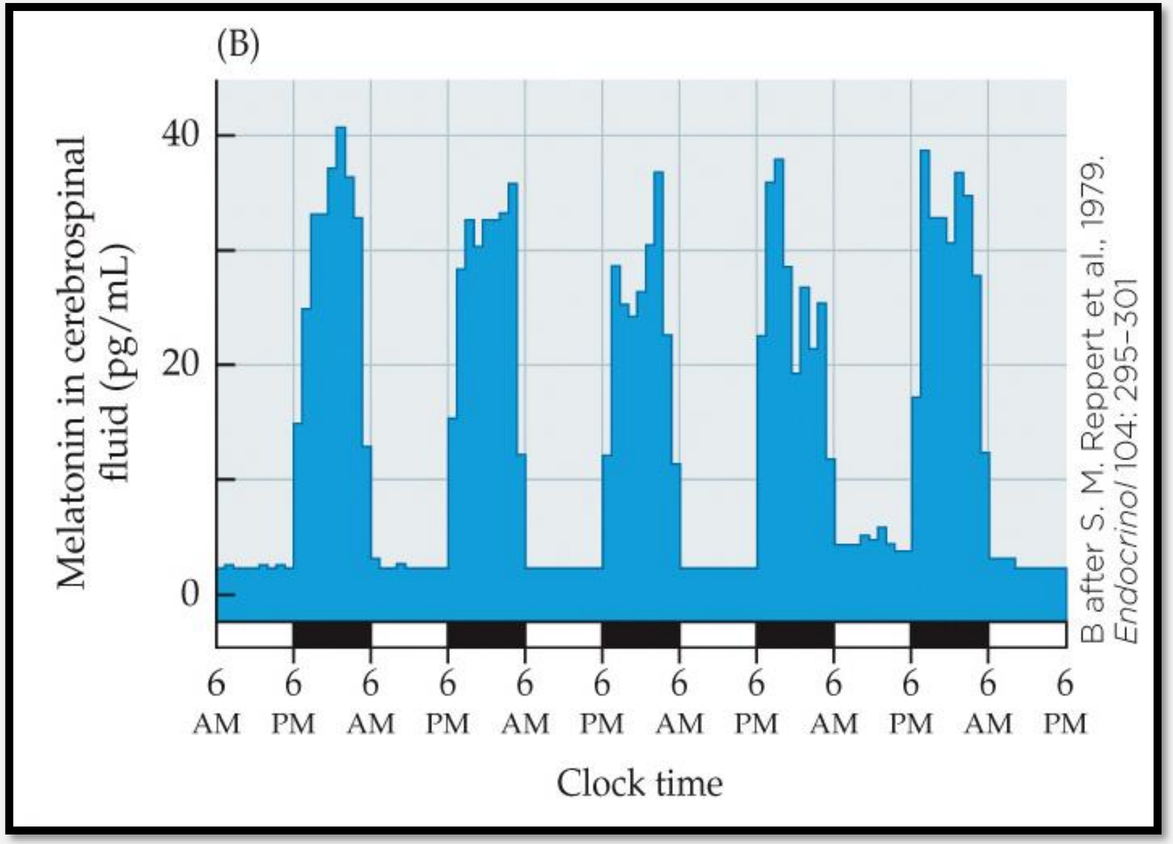




Endocrine Glands

Pineal gland:

- secretes an amine hormone, **melatonin**, almost exclusively at night.
- Melatonin provides a signal that tracks day length and the seasons and plays a role in biological rhythms.
- Innervated by the sympathetic nervous system.



Endocrine Glands

Gonads—ovaries and testes

- produce sex steroids.
- The hypothalamus controls gonadal hormone production by releasing **gonadotropin releasing-hormone** (**GnRH**).
- GnRH stimulates the anterior pituitary to release FSH or LH.

Endocrine Glands

GnRH neurons

- are stimulated by a hypothalamic peptide, **kisspeptin**, involved in the onset of puberty.
- The hypothalamus also uses **gonadotropin-inhibiting hormone** (**GnIH**) to inhibit gonadotropic secretion.

Endocrine Glands

Testes

- produce and secrete **testosterone**, one of many hormones called **androgens**.
- Testosterone is regulated by LH which is regulated by gonadotropin releasing-hormone (GnRH).
- Sperm production is regulated by FSH.

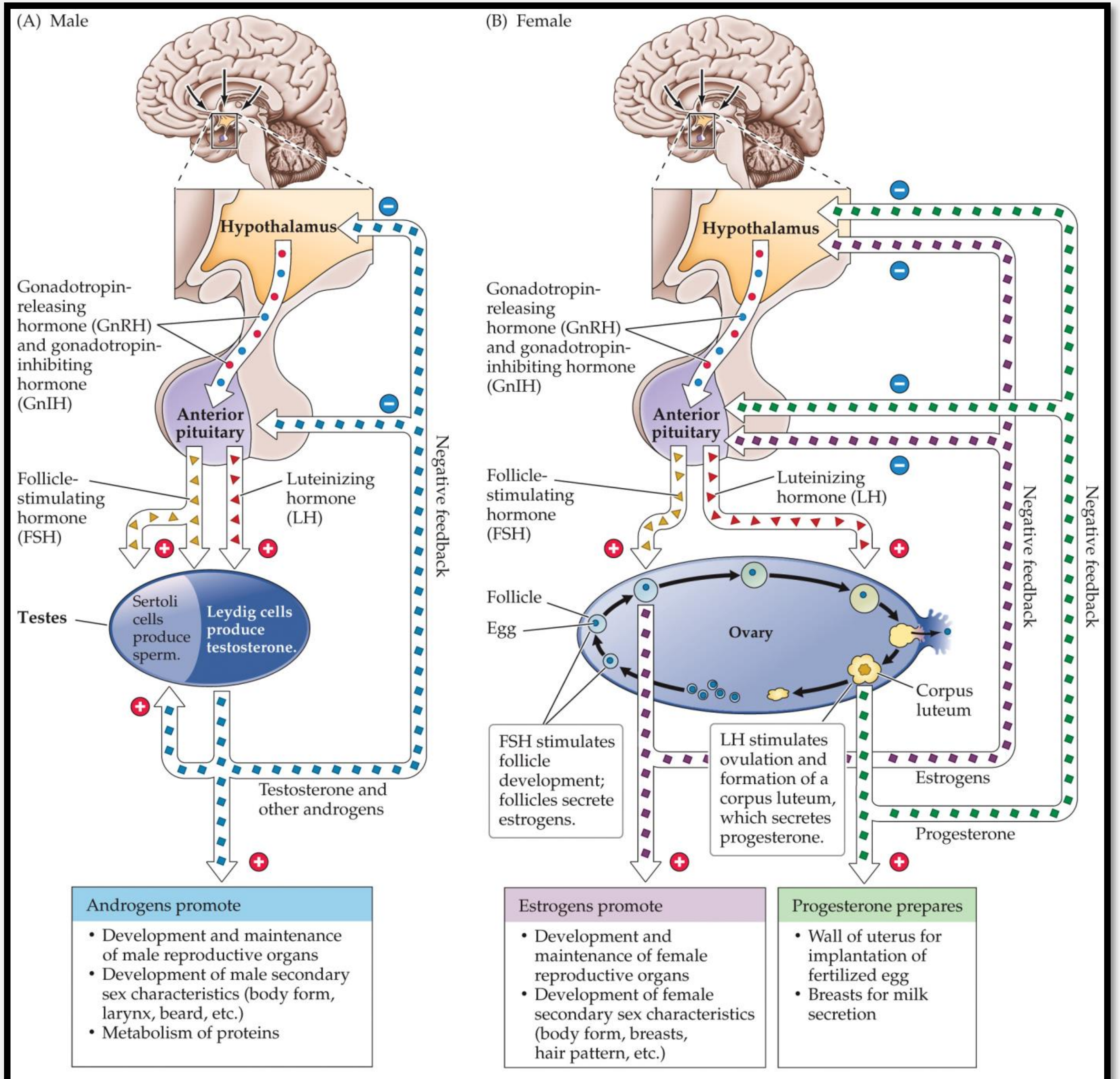
Endocrine Glands

Ovaries

- produce hormones in cycles: **progestins**, such as progesterone, and **estrogens** such as **17β-estradiol**.
- Ovarian hormone release is controlled by LH and FSH, which are controlled by GnRH.

Regulation of Gonadal Steroid Hormones

- No steroid is found exclusively in either males or females;
- Rather, the two sexes differ in the proportion of these steroids.



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Hormones and behaviour

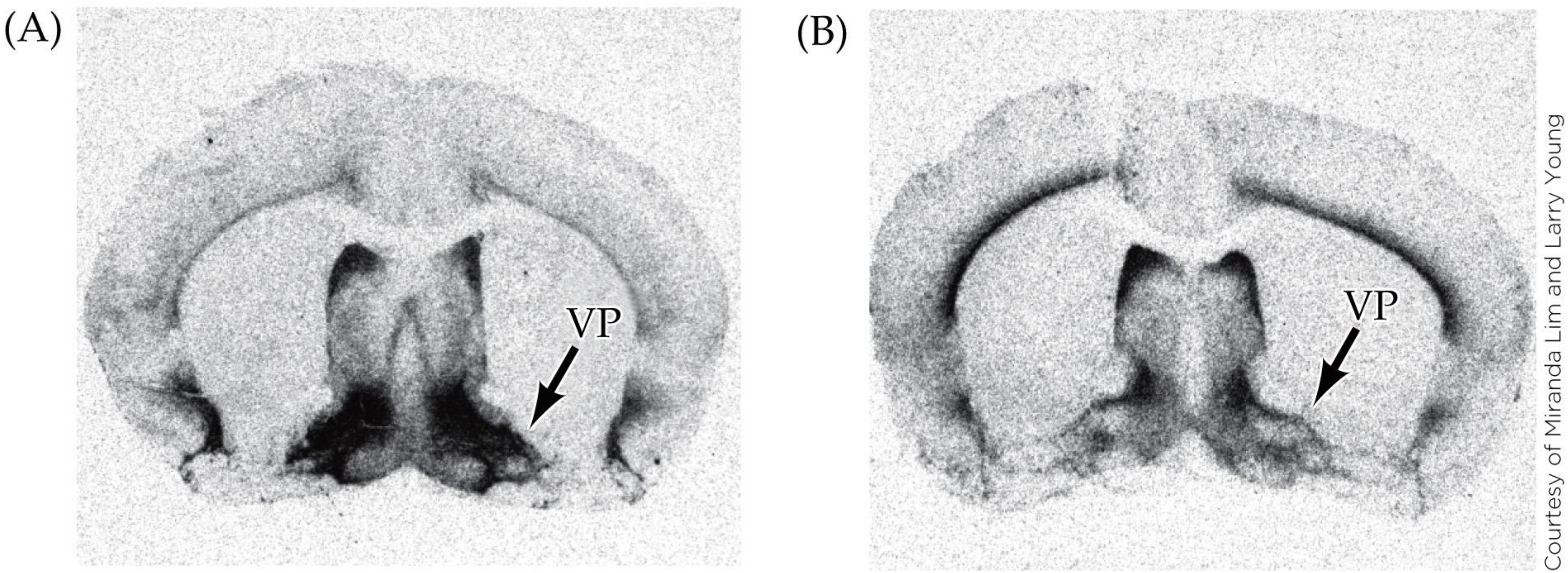
Oxytocin

- is released during nursing and during orgasm; in female prairie voles, it promotes pair-bonds

Vasopressin

- facilitates formation of pair-bonds in male prairie voles.
- In closely related meadow voles that don't form pair bonds, males have far fewer vasopressin receptors in the brain.

Vasopressin and the Monogamous Brain

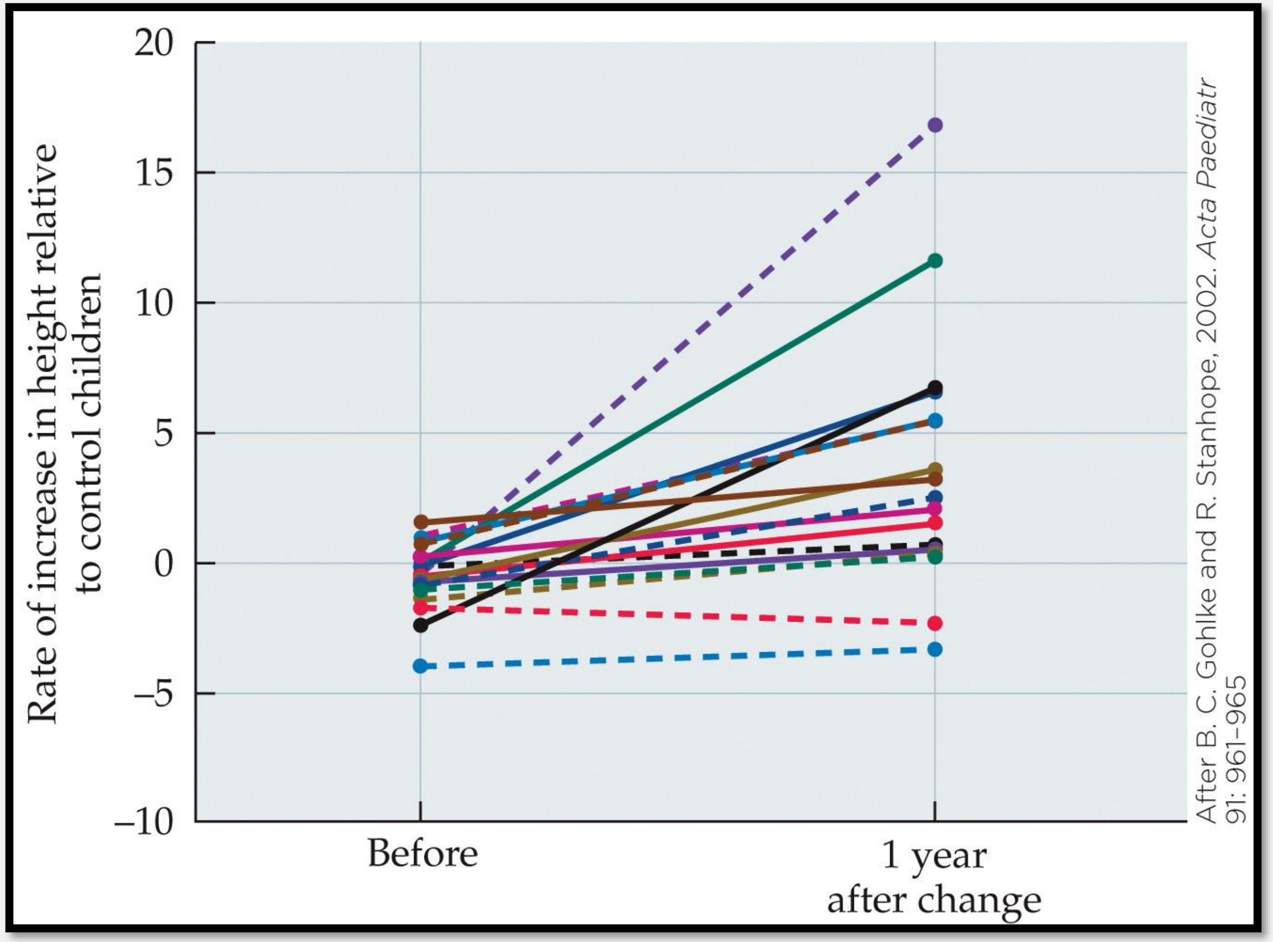


BEHAVIORAL NEUROSCIENCE 10e, Figure 5.21

Hormones and behaviour

Psychosocial dwarfism:

- growth failure due to stress and neglect in early childhood; mediated through the CNS and its control over endocrine functions.
- Removal of the stress allows normal growth to resume.
- Growth impairments appear to be mediated by changes in cortisol, GH, and *somatomedins* (normally released by the liver in response to GH).



Hormonal-neuronal interactions

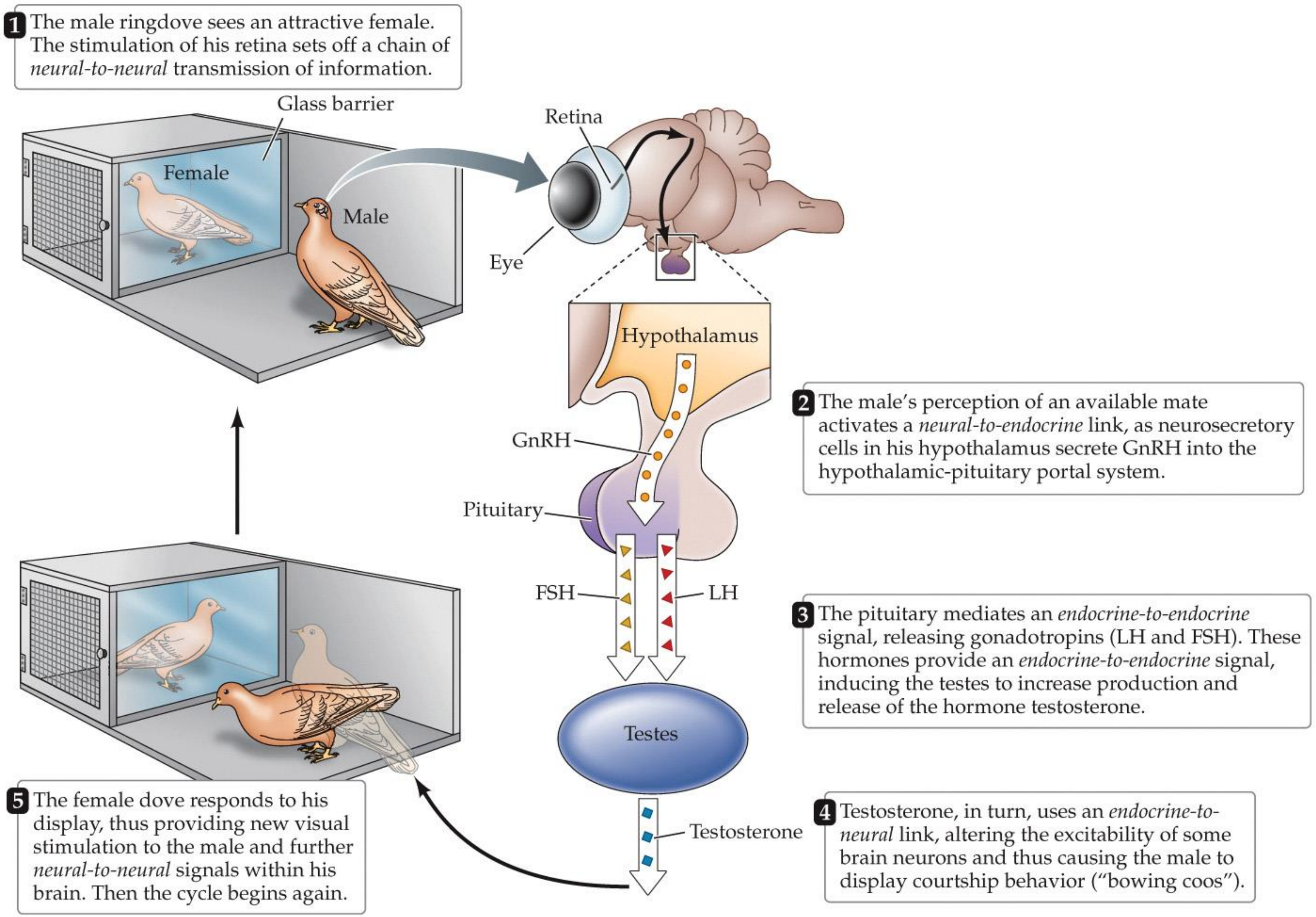
- Hormonal and neural systems interact to produce responses.
  Example: the milk letdown reflex.

Communication signals can be:

- Neural-to-neural
- Neural-to-endocrine
- Endocrine-to-endocrine
- Endocrine-to-neural

- All are illustrated in courtship behavior of ringdoves.

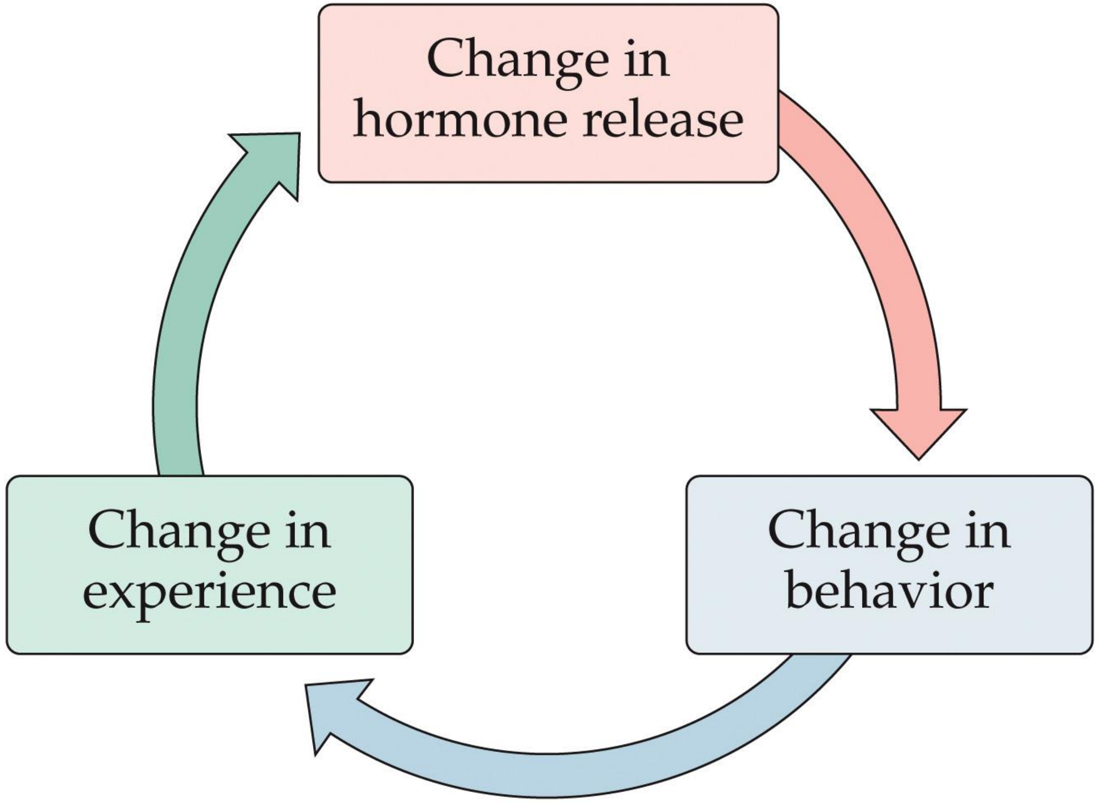
FIGURE 5.24 Interactive Signals between the Nervous System and the Endocrine System (1)



BEHAVIORAL NEUROSCIENCE 10e, Figure 5.24

Hormonal-neuronal interaction

- The hormonal and neural systems exert reciprocal influences on each other.
- Experience affects hormone secretion, hormones affect behavior, and behavior affects future experiences.



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