

Pituitary Gland

Anatomy • Histology • Endocrine regulation • Clinicopathologic correlations

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Learning outcomes

- Identify the anterior and posterior pituitary compartments and their embryologic origins.
- Map major pituitary cell types to their hormones and transcription-factor lineages.
- Explain hypothalamic control, target-organ responses and feedback regulation.
- Apply gland anatomy and physiology to common patterns of pituitary disease.

Structure

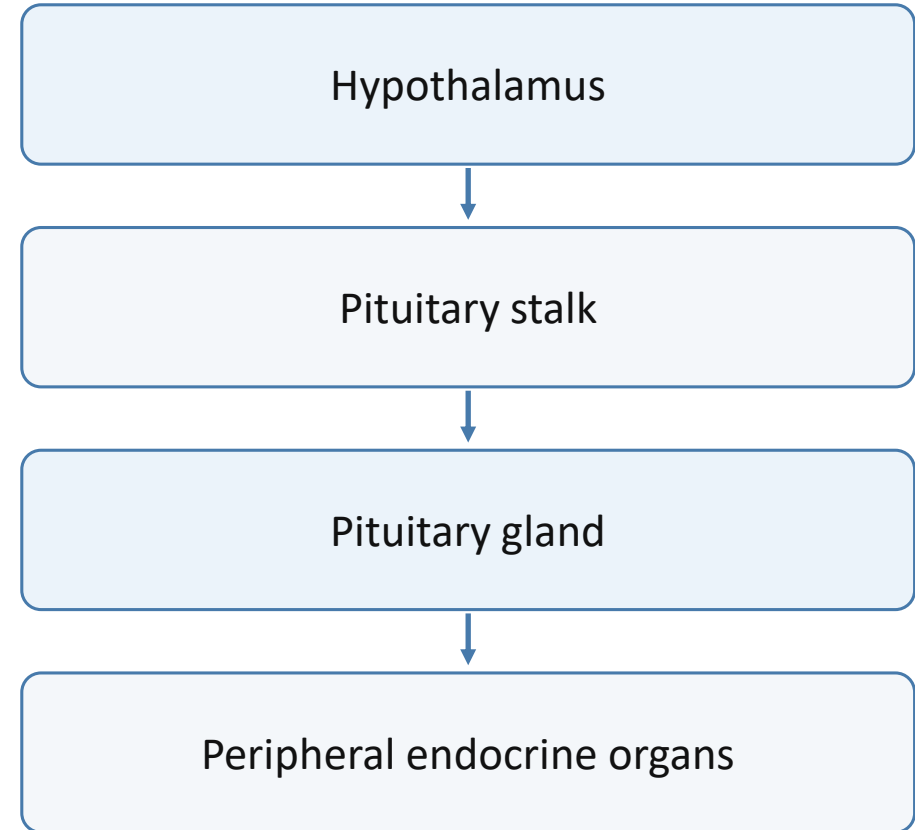
Cell types

Hormonal axes

Clinical logic

The pituitary is the endocrine relay at the brain base

- The gland occupies the sella turcica beneath the hypothalamus.
- The pituitary stalk provides neural and vascular links to the hypothalamus.
- These connections permit coordinated control of multiple endocrine targets.



The sella determines the clinical anatomy

- The sella turcica provides the bony compartment for the pituitary.
- The optic chiasm lies close to the sellar region.
- Expansion in this constrained region can produce neurologic signs as well as endocrine abnormalities.

Sellar compartment

**Suprasellar optic
pathway**

Two lobes, two distinct mechanisms

- Adenohypophysis: Epithelial endocrine cells synthesize and secrete tropic hormones.
- Neurohypophysis: Neuronal axon terminals release hormones synthesized in the hypothalamus.
- The lobes differ in embryology, structure, regulation and pathology.

**Anterior: Synthesis
in endocrine cells**

**Posterior: Storage
and release at axons**

The anterior pituitary dominates gland volume

- The adenohypophysis constitutes approximately 80% of the pituitary.
- Its cellular parenchyma comprises several differentiated hormone-producing lineages.
- It regulates thyroid, adrenal, gonadal, growth and lactational functions.

Anterior lobe ≈80%

Posterior lobe ≈20%

Tropic hormones regulate other endocrine tissues

- TSH drives secretion from the thyroid gland.
- ACTH stimulates adrenal cortical hormone production.
- FSH and LH regulate ovarian and testicular functions.
- Growth hormone and prolactin also act on nonendocrine target tissues.

TSH → thyroid

ACTH → adrenal
cortex

FSH/LH → gonads

GH/PRL → tissues

The hypothalamus coordinates pituitary output

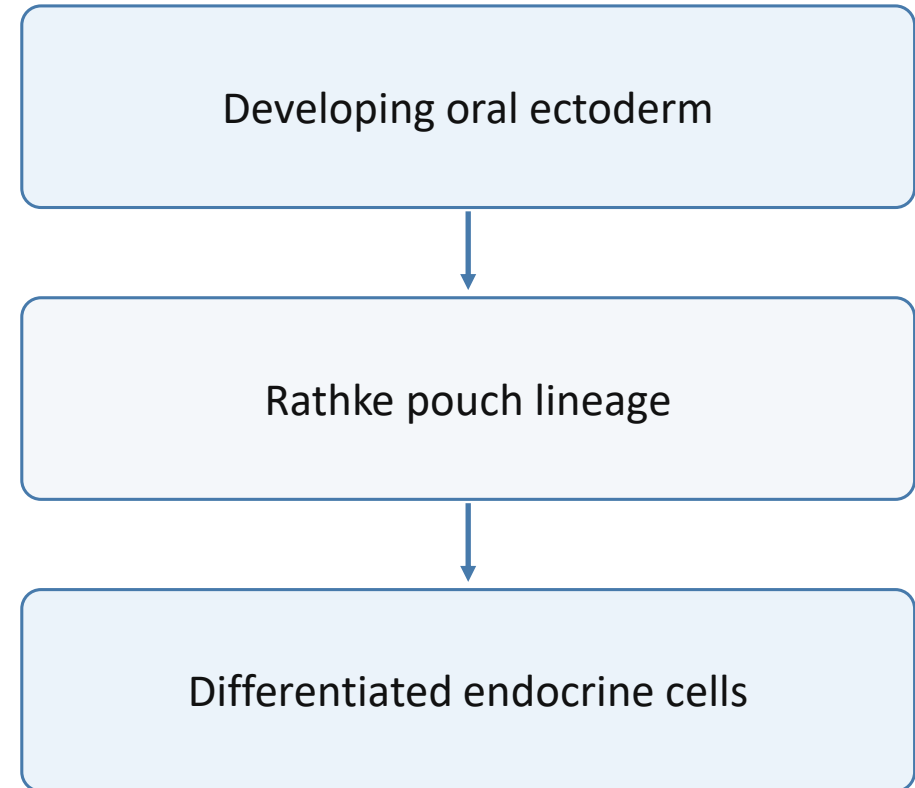
- Neural inputs and circulating feedback signals converge on the hypothalamus.
- Hypothalamic releasing or inhibitory factors adjust anterior pituitary secretion.
- Hypothalamic neurons directly generate posterior pituitary hormones.

**Anterior: Portal
hormones**

**Posterior: Axonal
transport**

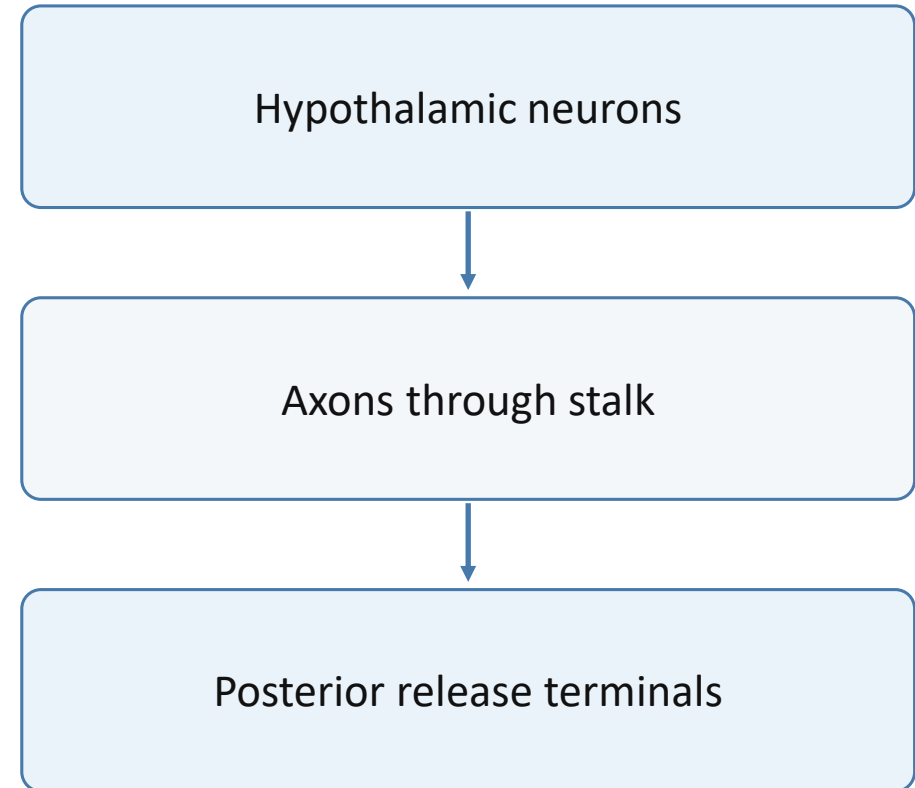
The adenohypophysis has oral ectodermal origin

- Anterior pituitary epithelial cells originate from the developing oral cavity.
- During embryogenesis, Rathke pouch precursors acquire lineage-specific transcription factors.
- These factors direct the mature hormone-producing cell identities.



The neurohypophysis is a neural extension

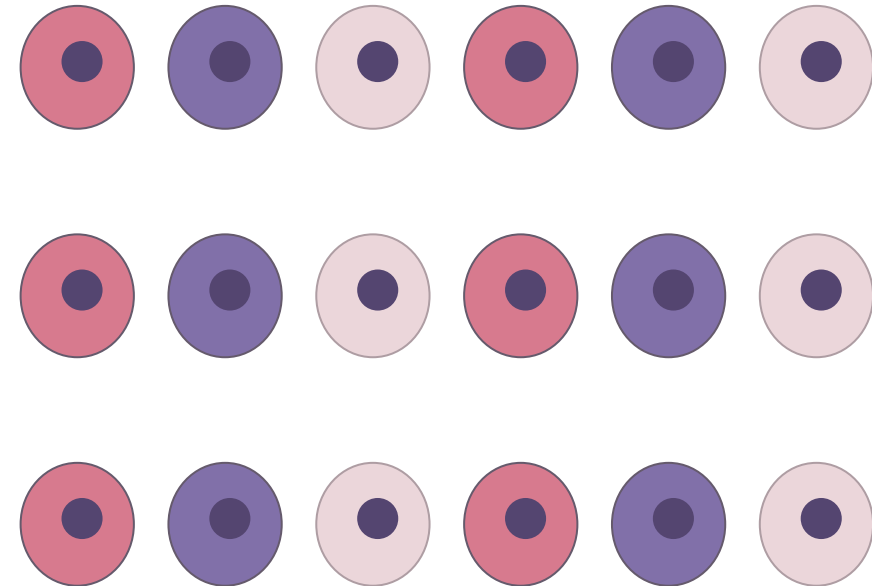
- The posterior lobe develops as part of the hypothalamic neural system.
- It contains axons descending through the stalk and specialized glial cells.
- Its major secretory function is release of hypothalamic peptide hormones.



Normal anterior pituitary is cytologically diverse

- Routine H&E shows endocrine cells with different cytoplasmic staining properties.
- Acidophils have eosinophilic cytoplasm; Basophils have basophilic cytoplasm.
- Chromophobes are relatively pale or poorly staining cells.
- The mixture is expected in normal adenohypophyseal tissue.

H&E cell-color concept — schematic, not a specimen



● Acidophil

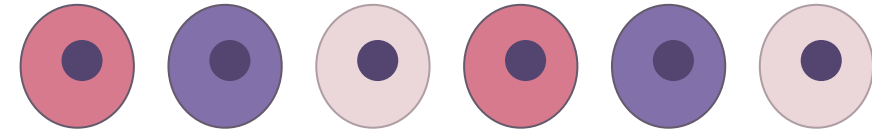
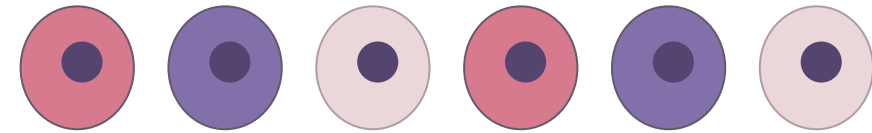
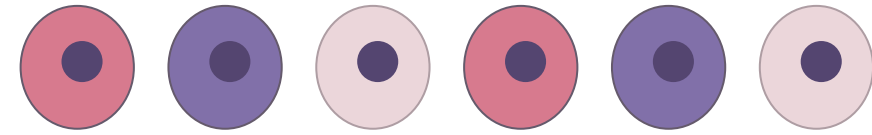
● Basophil

● Chromophobe

Acidophils: Eosinophilic cytoplasmic staining

- Acidophils show relatively pink-red cytoplasm on H&E.
- The staining reflects features of cytoplasmic hormone storage and composition.
- H&E appearance alone does not establish a definitive hormone-specific cell identity.

H&E cell-color concept — schematic, not a specimen



● Acidophil

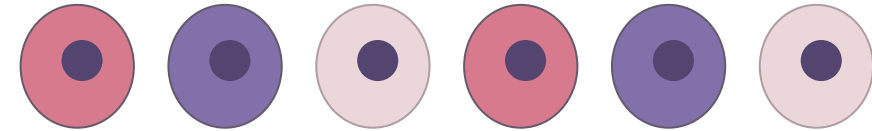
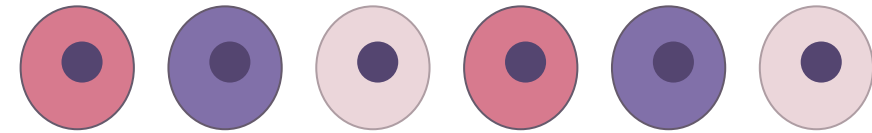
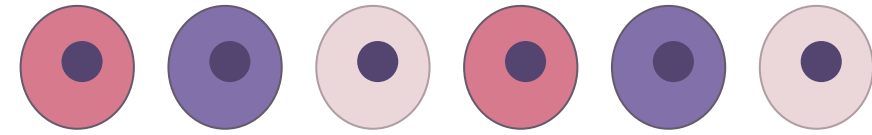
● Basophil

● Chromophobe

Basophils: More intensely basophilic cytoplasm

- Basophils stain more purple-blue with conventional histologic preparations.
- Normal tissue contains intermingled populations rather than a single homogeneous cell type.
- Immunohistochemistry and lineage markers provide greater specificity than color alone.

H&E cell-color concept — schematic, not a specimen



 Acidophil

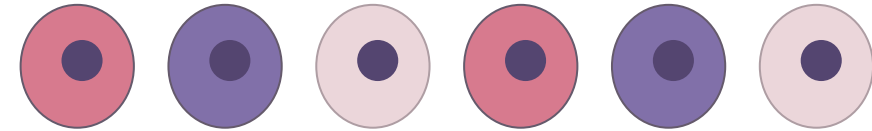
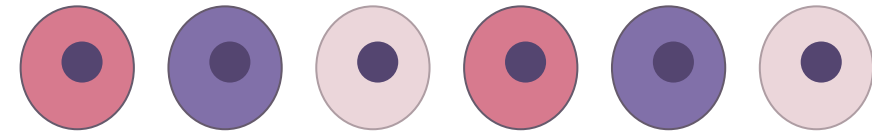
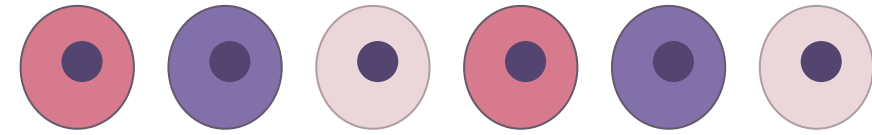
 Basophil

 Chromophobe

Chromophobes: Cytoplasm may stain poorly

- Chromophobe cells appear relatively pale on routine sections.
- Cellular appearance varies with hormone granulation and functional state.
- The chromophobe designation is a staining phenotype, not a unique endocrine lineage.

H&E cell-color concept — schematic, not a specimen



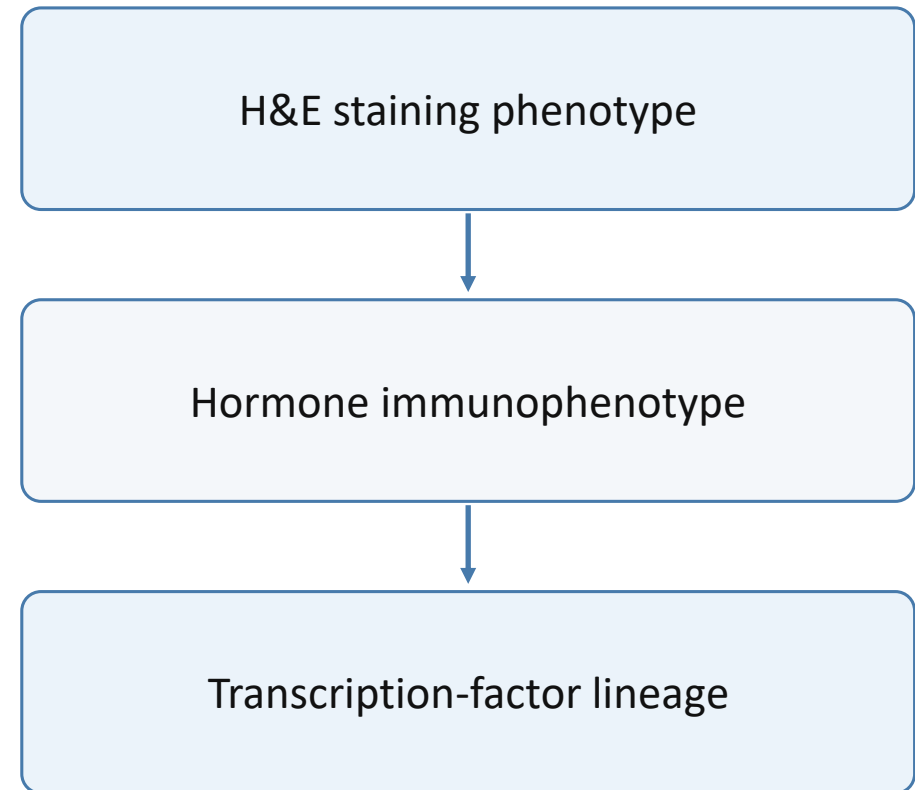
 Acidophil

 Basophil

 Chromophobe

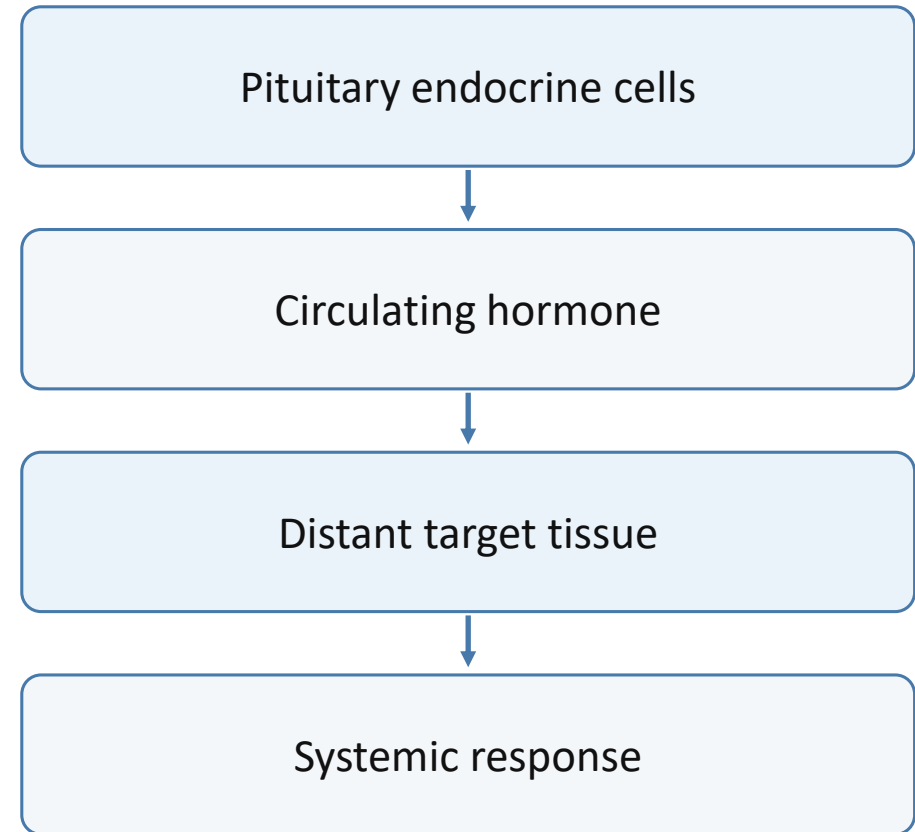
Morphology and hormone identity are related but not identical

- Histologic stains divide pituitary cells into broad phenotypic categories.
- Hormone expression establishes functional differentiation.
- Lineage-specific transcription factors establish developmental identity and support tumor classification.



The endocrine parenchyma serves systemic targets

- Anterior pituitary cells release hormones directly into the circulation.
- The gland requires close vascular communication with the hypothalamus and peripheral tissues.
- This explains why endocrine histology must be interpreted alongside biochemical data.



Six differentiated anterior pituitary cell types

- Somatotrophs, mammosomatotrophs and lactotrophs form a related hormonal group.
- Corticotrophs, thyrotrophs and gonadotrophs complete the major mature cell classes.
- A cell type is defined functionally by the hormone or hormones it synthesizes.

Somatotroph

Mammosomatotroph

Lactotroph

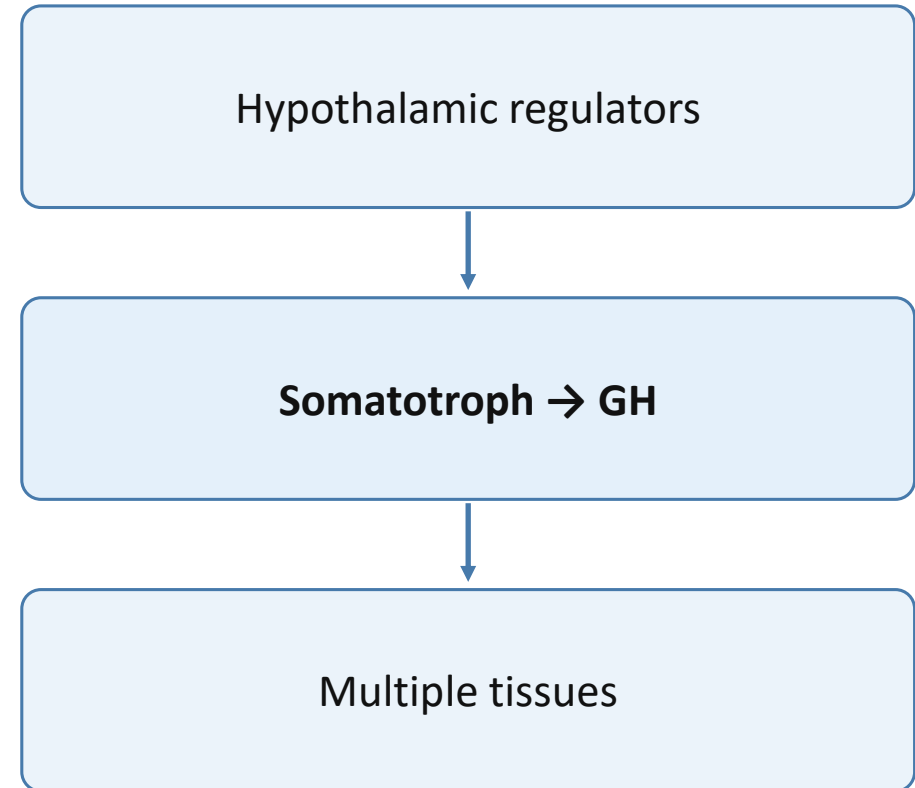
Corticotroph

Thyrotroph

Gonadotroph

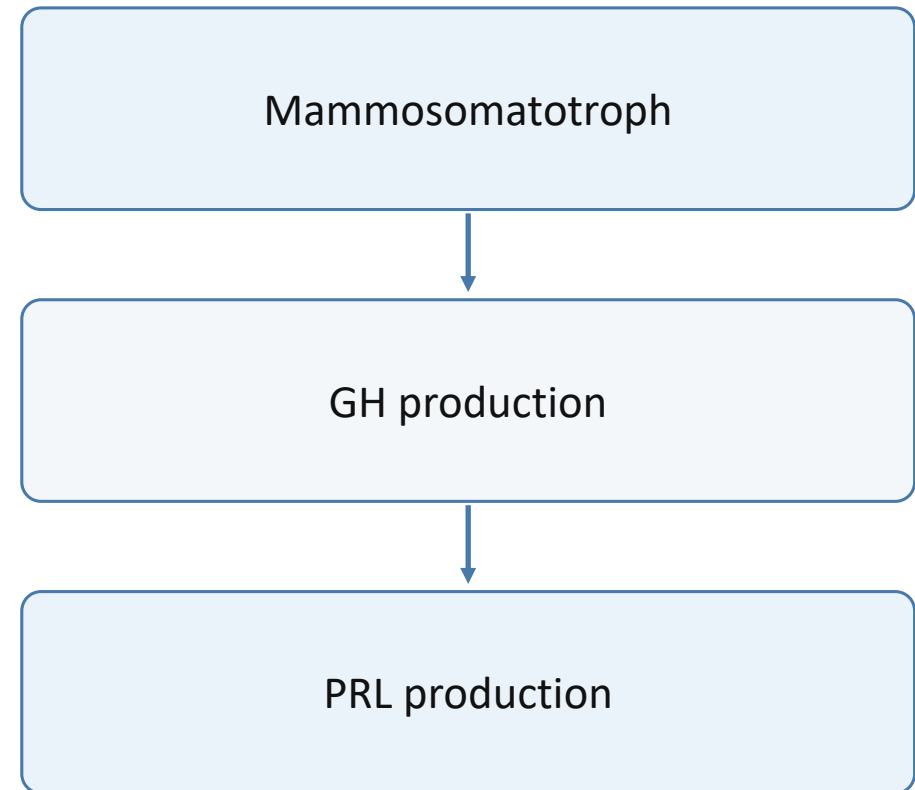
Somatotrophs synthesize growth hormone

- Somatotrophs produce growth hormone (GH).
- GH acts on multiple tissues and has systemic growth and metabolic effects.
- Its secretion is adjusted by stimulatory and inhibitory hypothalamic inputs.



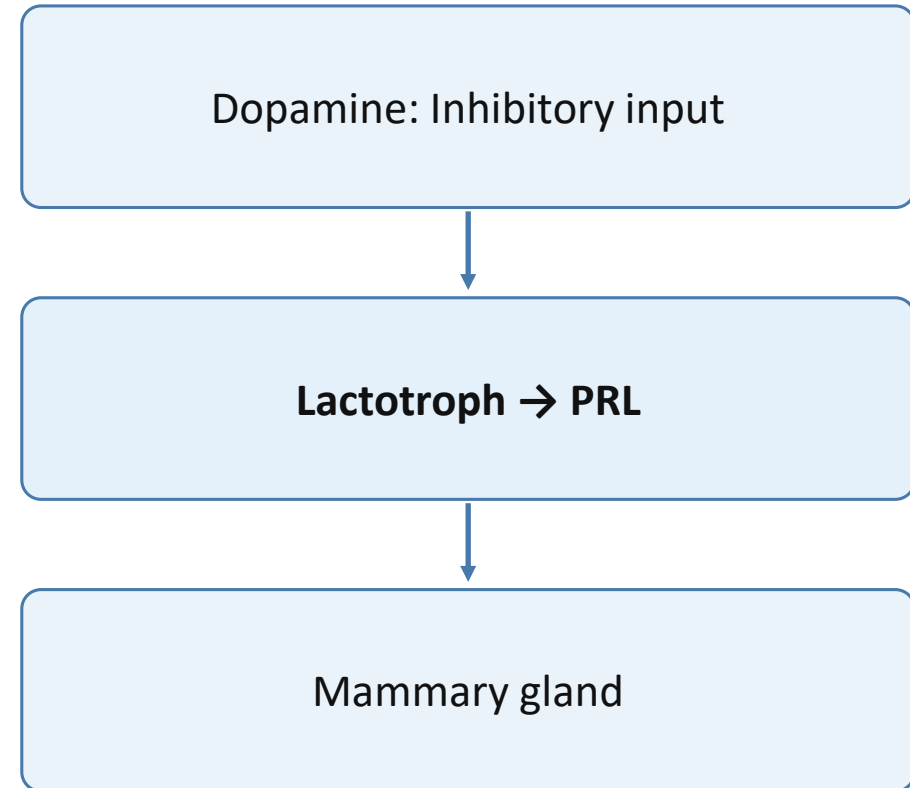
Mammomatotrophs express two hormone programs

- Mammomatotrophs synthesize both GH and prolactin (PRL).
- This is a recognized differentiated cell type rather than two neighboring cells.
- Its dual-hormone identity matters when interpreting hormone expression in the pituitary.



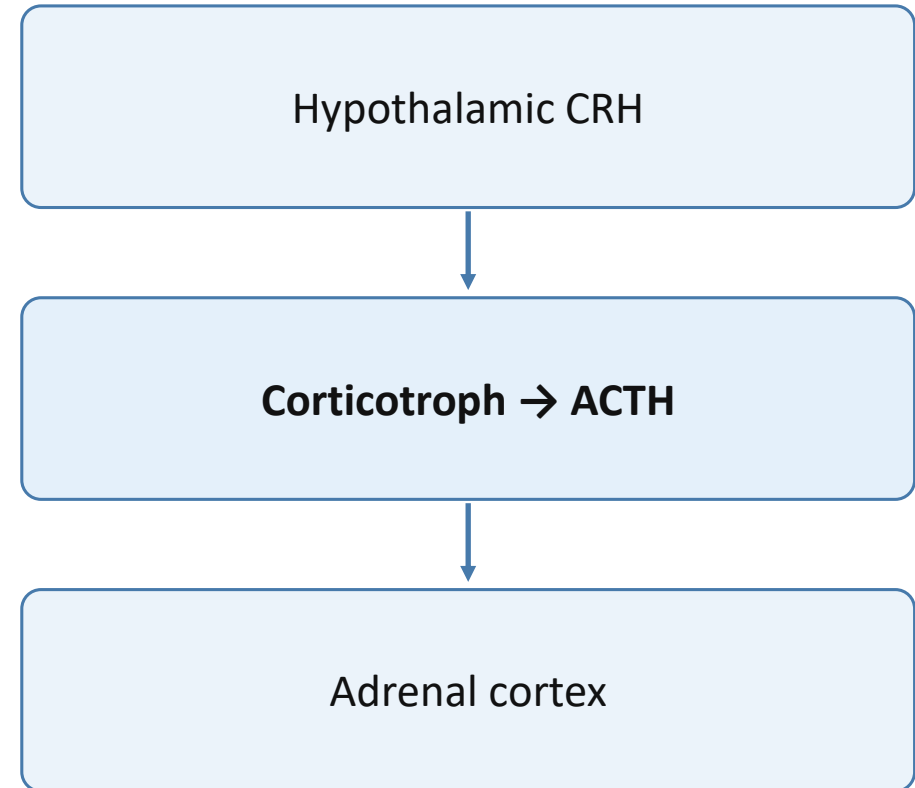
Lactotrophs synthesize prolactin

- Lactotrophs produce prolactin (PRL).
- PRL acts predominantly on the mammary gland and has reproductive physiological effects.
- Unlike several anterior hormones, prolactin secretion is strongly restrained by hypothalamic dopamine.



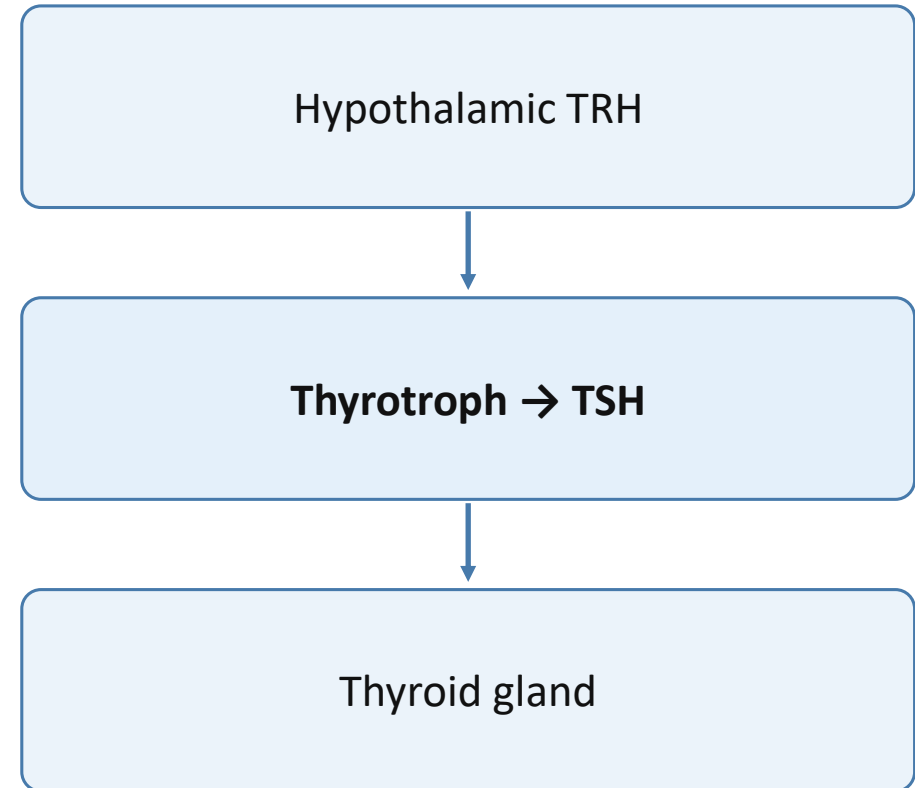
Corticotrophs synthesize ACTH

- Corticotrophs produce adrenocorticotrophic hormone (ACTH, corticotropin).
- ACTH is a tropic signal to the adrenal cortex.
- The corticotroph lineage is associated with the transcription factor TPIT.



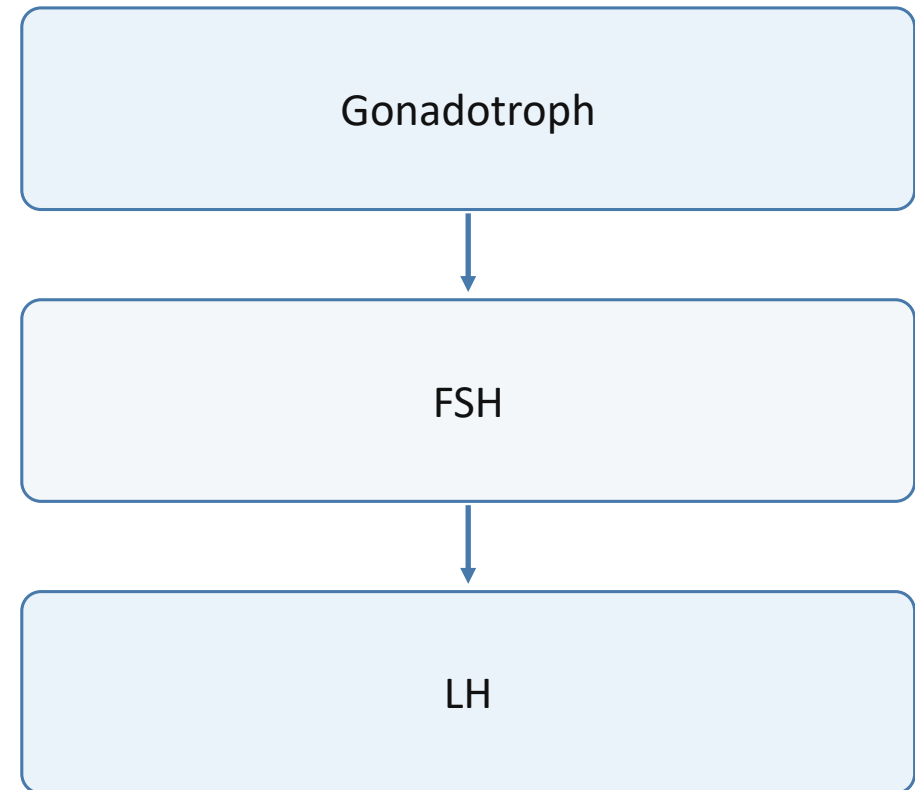
Thyrotrophs synthesize TSH

- Thyrotrophs produce thyroid-stimulating hormone (TSH).
- TSH stimulates thyroid follicular hormone production.
- These cells share a POU1F1/PIT-1-associated developmental lineage with several other anterior cell types.



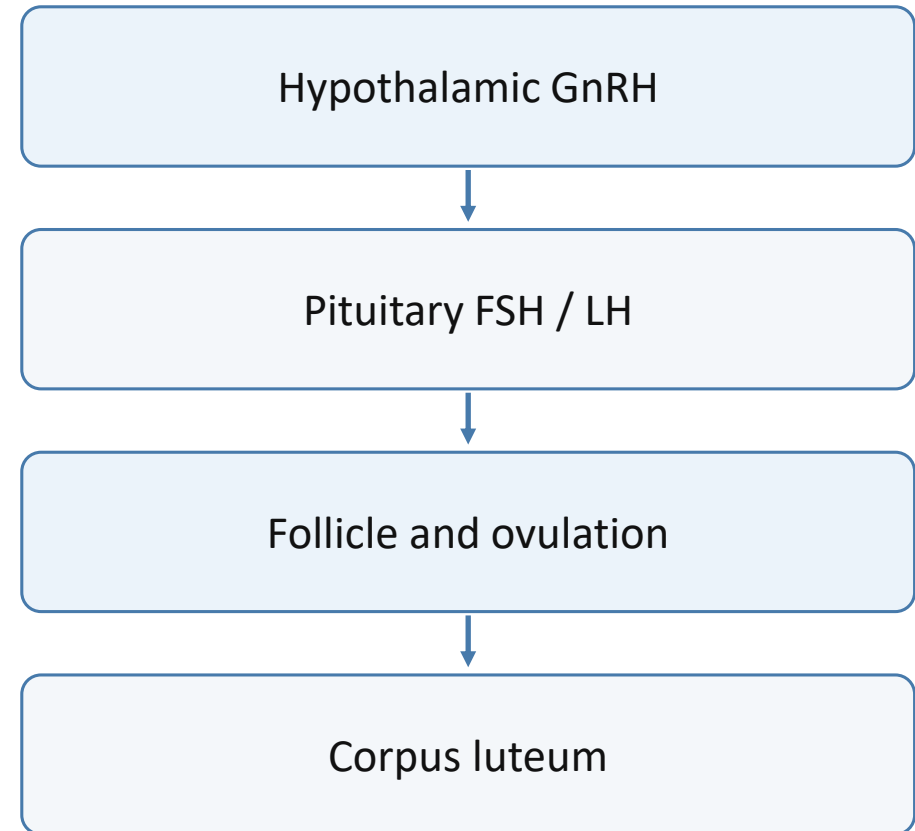
Gonadotrophs synthesize FSH and LH

- Gonadotrophs make follicle-stimulating hormone (FSH) and luteinizing hormone (LH).
- The two hormones regulate different but coordinated aspects of gonadal function.
- Gonadotroph precursor cells express SF-1 and GATA-2.



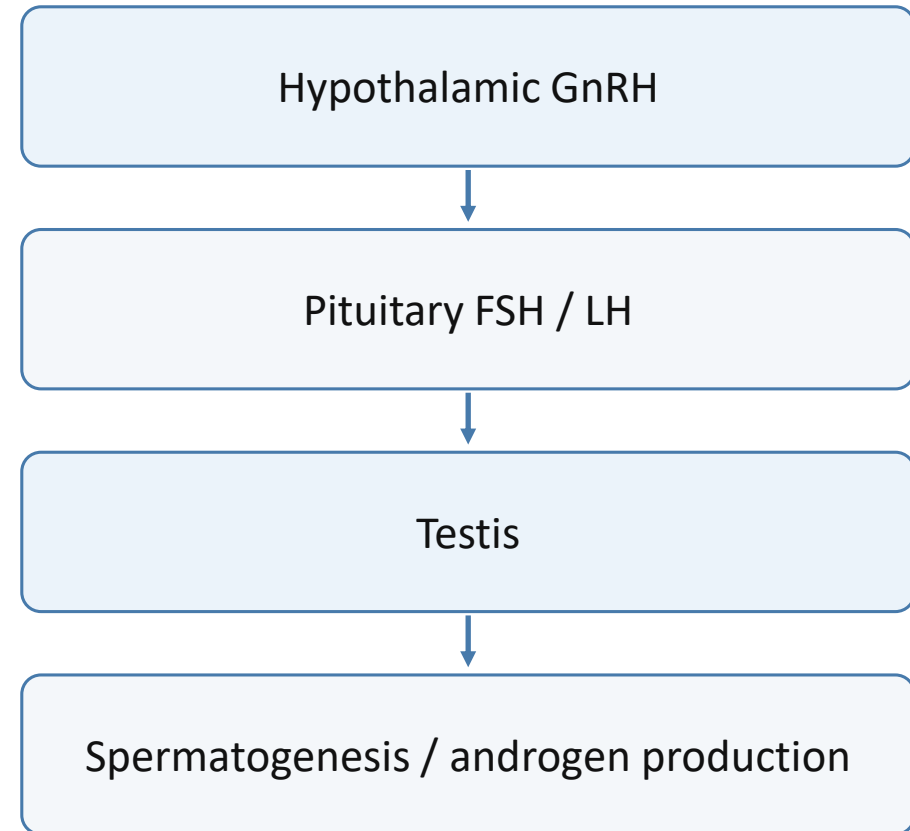
FSH and LH coordinate female reproduction

- FSH supports formation and maturation of ovarian follicles.
- LH induces ovulation and formation of the corpus luteum.
- Both hormones are released under hypothalamic gonadotropin-releasing hormone control.



FSH and LH coordinate male reproductive function

- Gonadotropins regulate spermatogenesis and testosterone production in males.
- Pituitary output links hypothalamic inputs to testicular physiology.
- Deficient secretion therefore disrupts reproductive function.



Hormone identity distinguishes anterior cell classes

- GH and PRL identify somatotroph/lactotroph differentiation, with a dual-producing mammosomatotroph class.
- ACTH identifies corticotroph function; TSH identifies thyrotroph function.
- FSH and LH identify gonadotroph differentiation.

GH: Somatotroph

GH + PRL:
Mammosomatotroph

PRL: Lactotroph

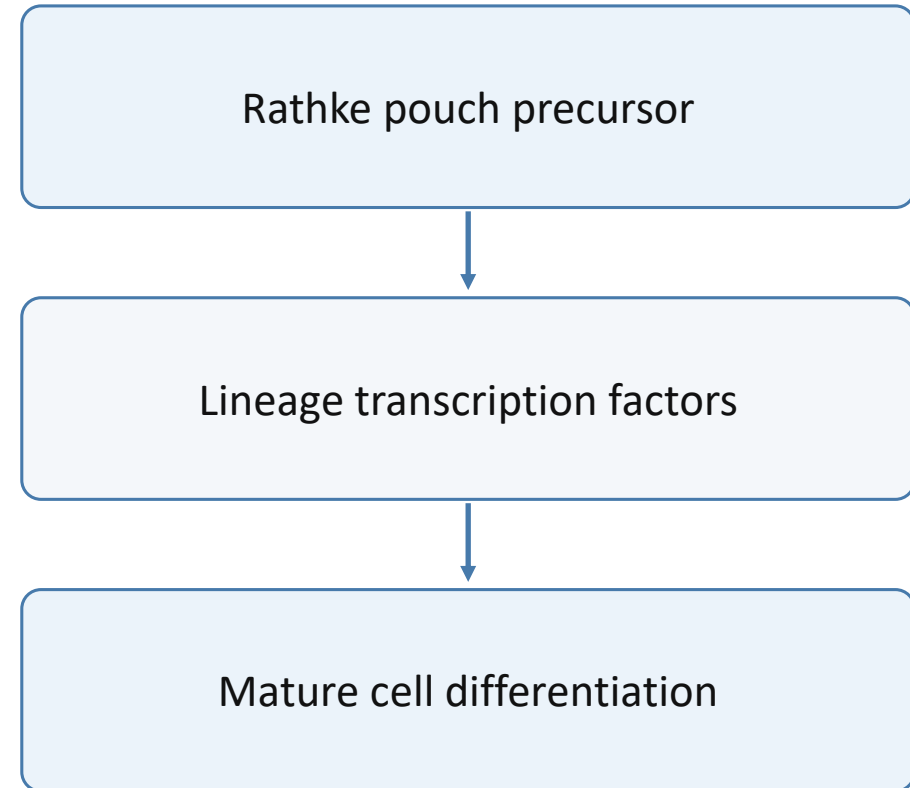
ACTH: Corticotroph

TSH: Thyrotroph

FSH/LH:
Gonadotroph

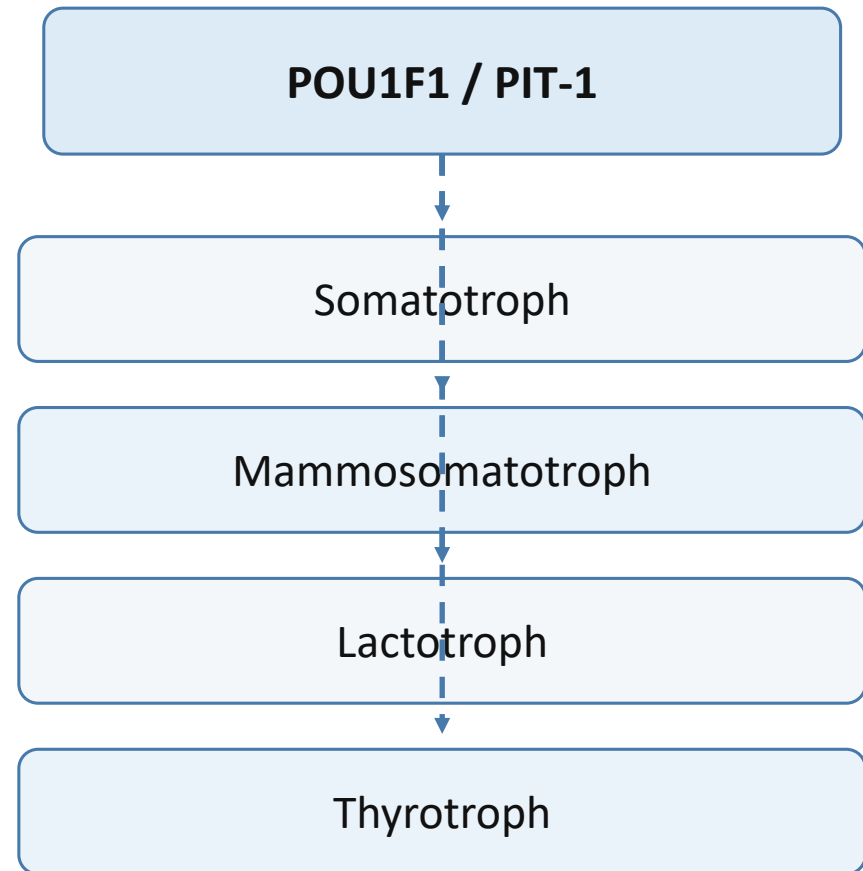
Lineage determination starts in Rathke pouch

- Anterior endocrine lineages arise from embryonic multipotent precursors.
- Specific transcription factors channel precursors toward hormone-specific programs.
- Mature cell identity reflects developmental lineage as well as secretory phenotype.



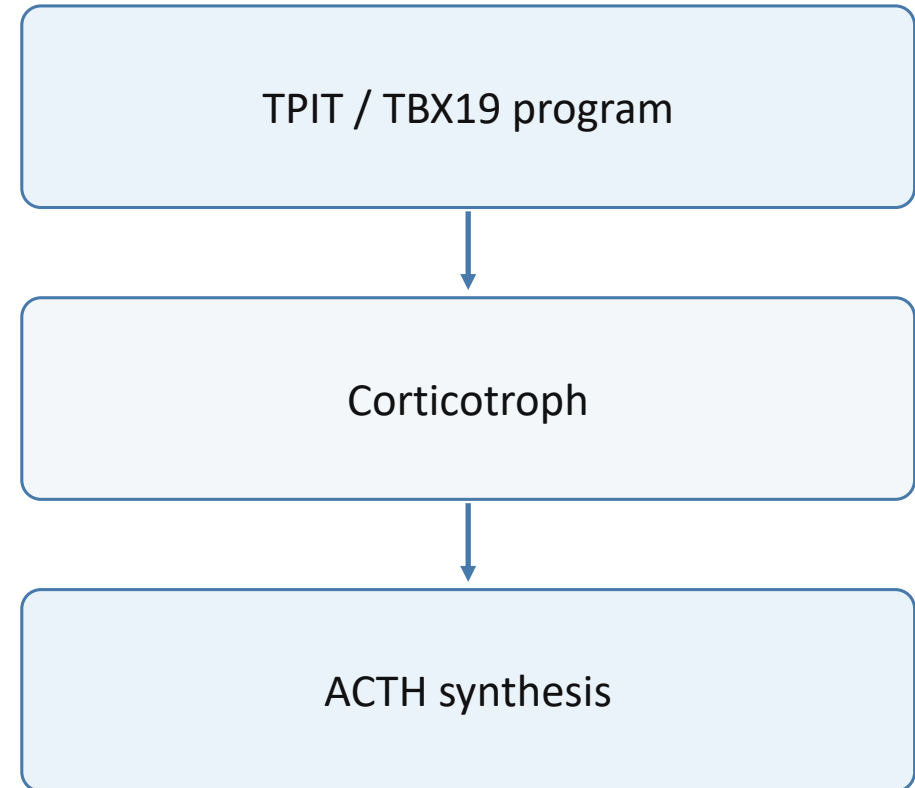
POU1F1/PIT-1 defines a shared lineage

- Somatotrophs, mammosomatotrophs, lactotrophs and thyrotrophs derive from POU1F1-expressing precursors.
- PIT-1 is the alternative name of the POU1F1 transcription factor.
- This shared program clarifies how different hormone-producing cells can be biologically related.



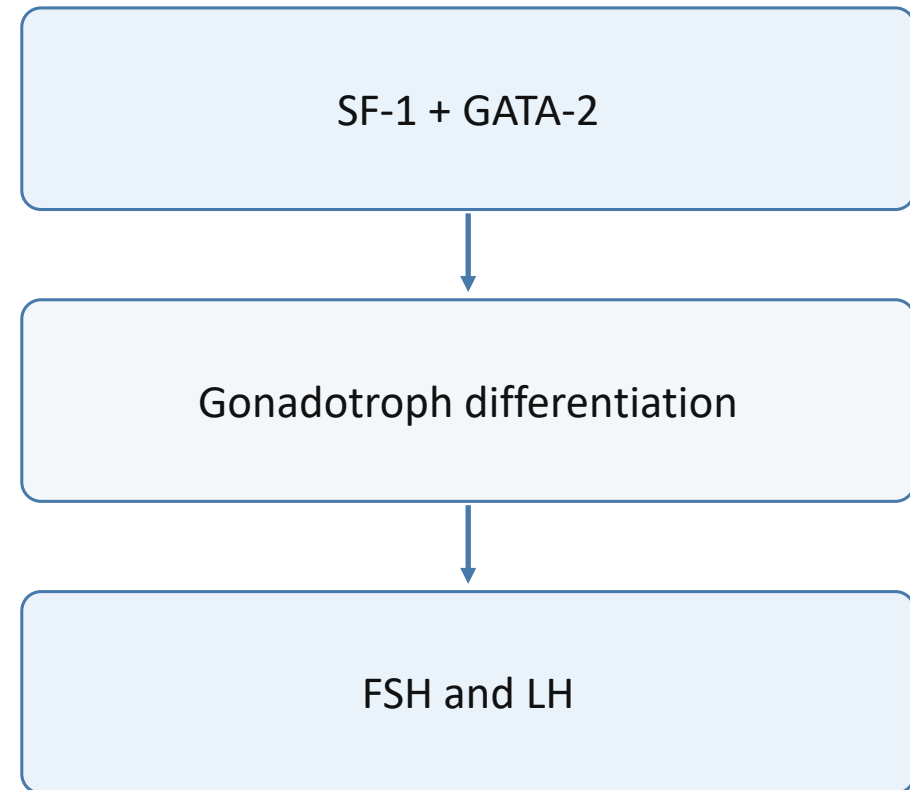
TPIT specifies corticotroph differentiation

- Corticotrophs derive from progenitors expressing TPIT.
- TPIT is also designated TBX19 (T-box protein 19).
- This program is distinct from the PIT-1 and gonadotroph lineages.



SF-1 and GATA-2 specify gonadotroph differentiation

- Gonadotroph precursor cells express steroidogenic factor-1 (SF-1).
- GATA-2 is another transcription factor associated with this lineage.
- The mature gonadotroph produces FSH and LH.



Lineage map organizes the anterior gland

- The PIT-1 lineage gives rise to GH-, PRL- and TSH-related cells.
- The TPIT lineage yields ACTH-producing corticotrophs.
- The SF-1/GATA-2 program yields FSH/LH-producing gonadotrophs.

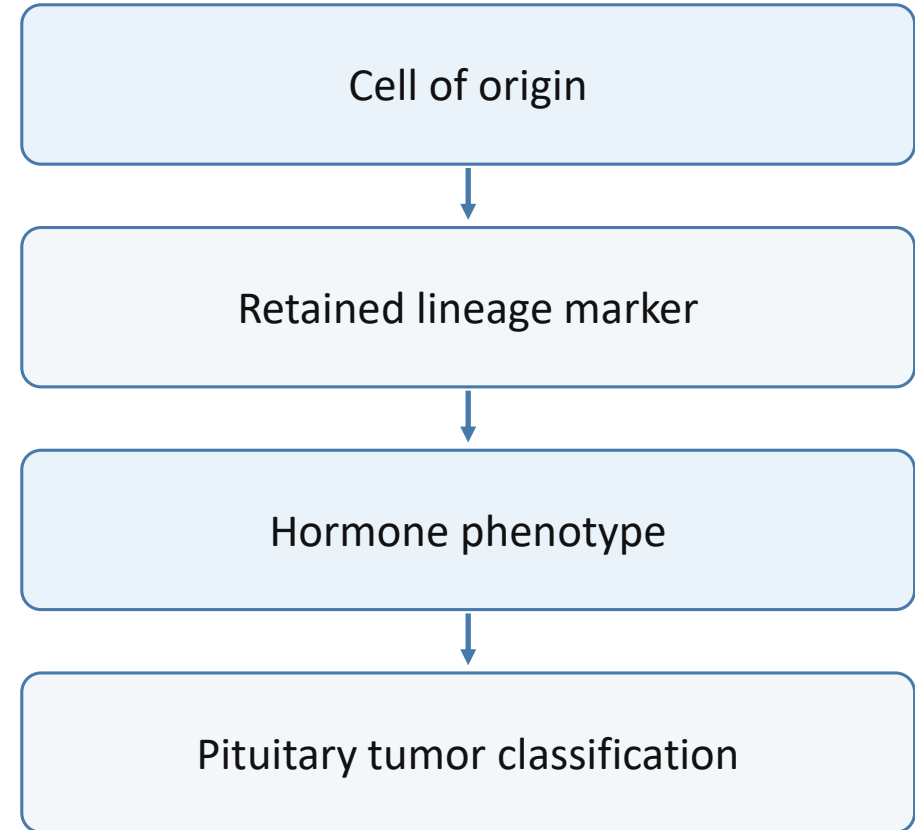
PIT-1 → GH /
PRL / TSH

TPIT → ACTH

SF-1/GATA-2
→ FSH / LH

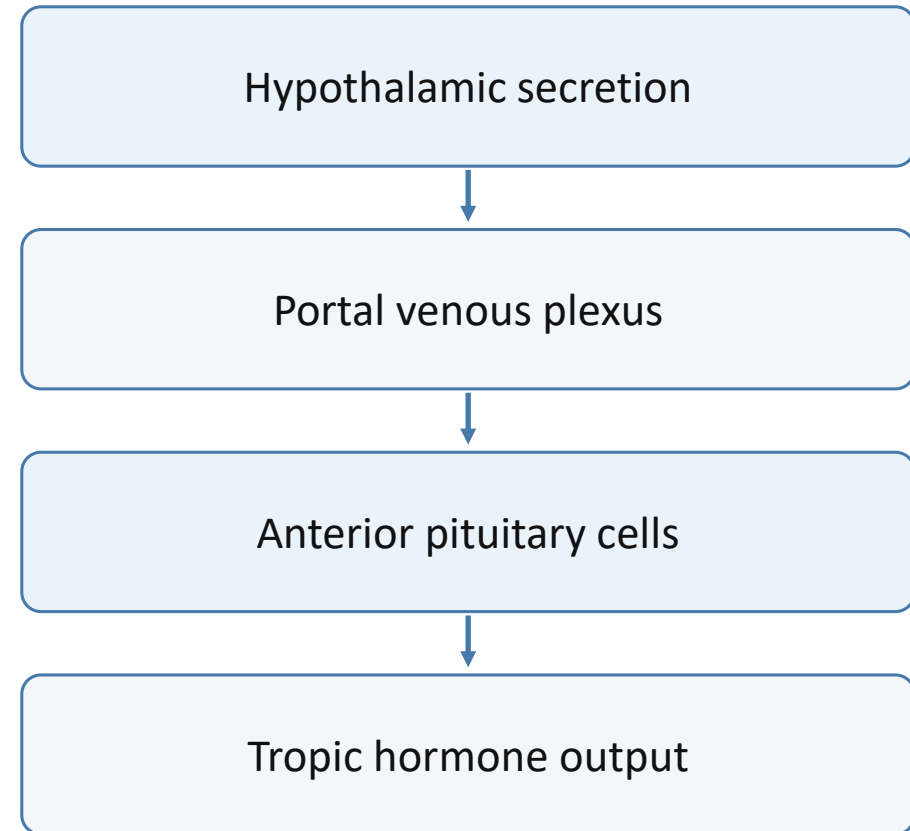
Lineage factors are relevant to pituitary pathology

- Lineage-specific transcription factors can be retained in pituitary neuroendocrine tumors.
- They are used with hormonal phenotype to classify pituitary tumors.
- Thus, cell biology directly informs diagnostic pathology beyond routine H&E morphology.



Anterior secretion is controlled through portal blood

- The hypothalamus releases regulatory factors into the hypophyseal portal venous plexus.
- These signals reach anterior pituitary endocrine cells through vascular transport.
- Their effects can be stimulatory or inhibitory depending on the hormone axis.



The portal pathway differs from neuronal release

- Anterior pituitary: Hypothalamic factors travel in portal vessels to target endocrine cells.
- Posterior pituitary: Hormones travel from hypothalamic cell bodies along neuronal axons.
- The separate routes explain distinct patterns of disease and injury.

Anterior: Blood-borne regulation

Posterior: Axonal hormone transport

Releasing factors generally stimulate pituitary secretion

- Thyrotropin-releasing hormone (TRH) stimulates the thyrotroph axis.
- Corticotropin-releasing hormone (CRH) stimulates the corticotroph axis.
- Growth hormone–releasing hormone (GHRH) and GnRH stimulate their respective axes.

TRH

CRH

GHRH

GnRH

Inhibitory factors limit secretion

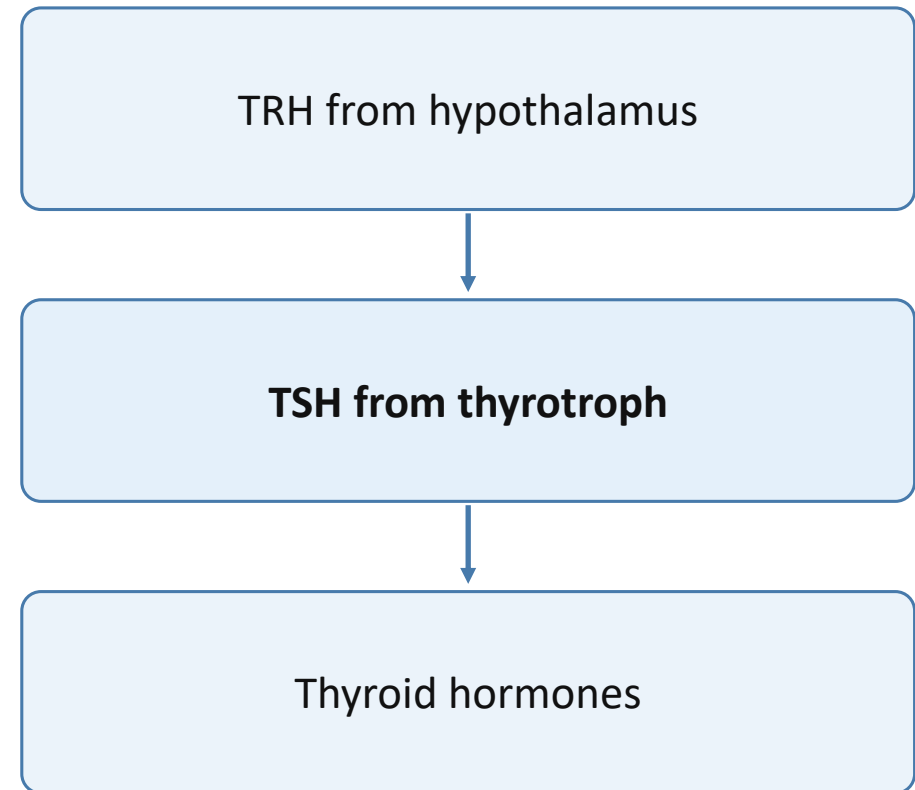
- Somatostatin (growth hormone–inhibiting hormone) restrains GH secretion.
- Dopamine acts as prolactin-inhibiting factor and restrains PRL secretion.
- Hypothalamic input therefore includes both positive and negative control.

Somatostatin $\rightarrow$ GH

Dopamine $\rightarrow$ PRL

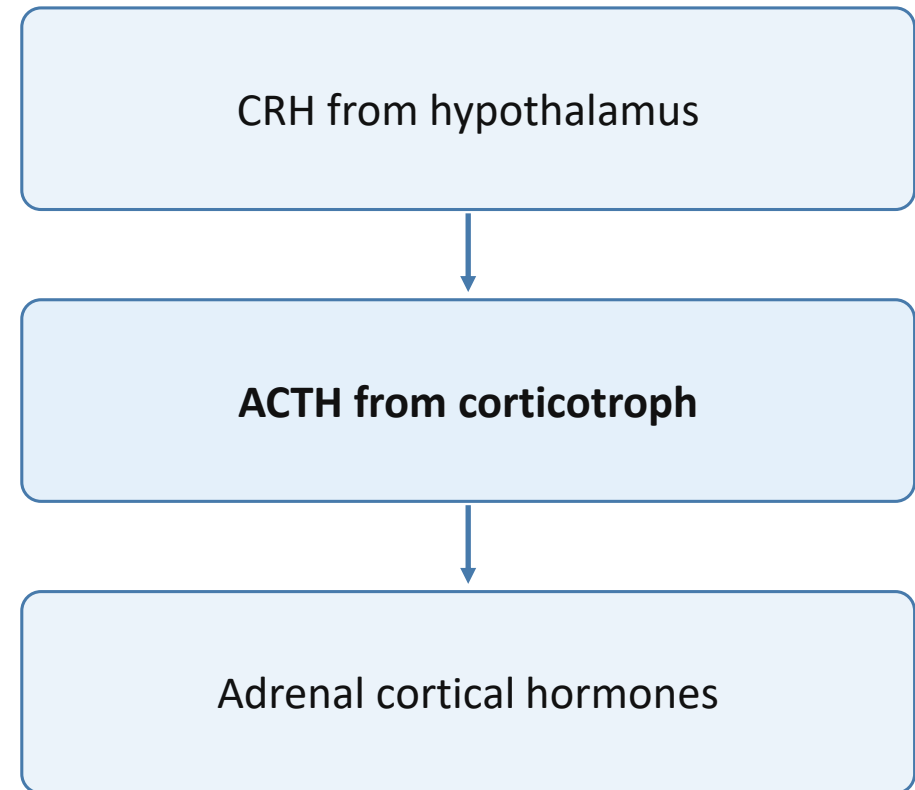
The thyroid axis illustrates tropic hormone logic

- Hypothalamic TRH promotes pituitary TSH release.
- TSH stimulates the thyroid gland.
- Peripheral thyroid hormones feed back to restrain hypothalamic–pituitary activity.



The adrenal axis illustrates endocrine relay

- Corticotropin-releasing hormone stimulates pituitary corticotrophs.
- ACTH acts on the adrenal cortex.
- Adrenal cortical products signal the physiological state of this axis through feedback.



The growth axis receives opposing inputs

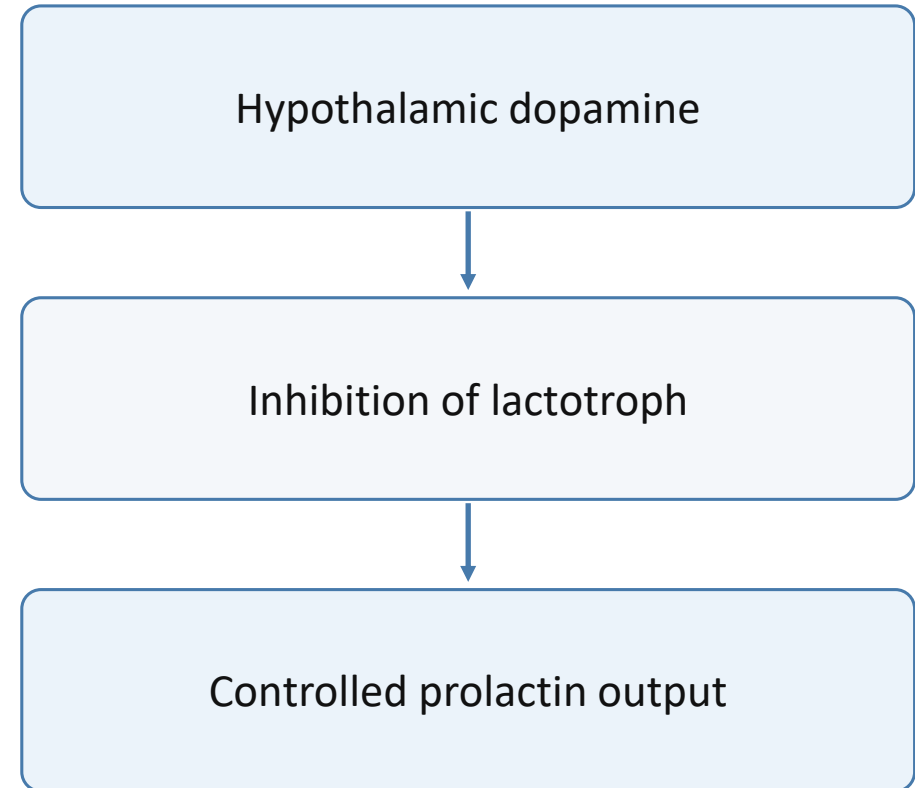
- GHRH promotes GH secretion from somatotrophs.
- Somatostatin provides inhibitory hypothalamic input.
- GH has widespread tissue effects; Endocrine control therefore requires integration of both signals.

**GHRH → GH
stimulation**

**Somatostatin ⊣ GH
inhibition**

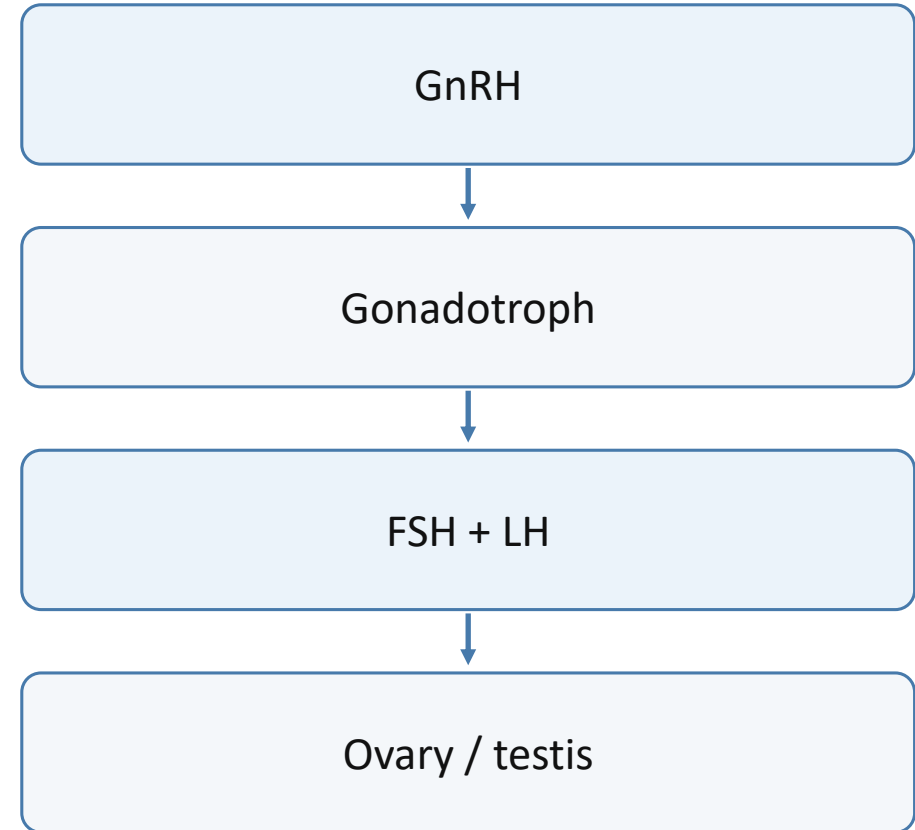
Prolactin control is strongly inhibitory

- Dopamine released by hypothalamic neurons restrains lactotroph secretion.
- Loss of dopaminergic restraint can increase PRL release.
- This contrasts with the predominantly releasing-hormone control of several other pituitary axes.



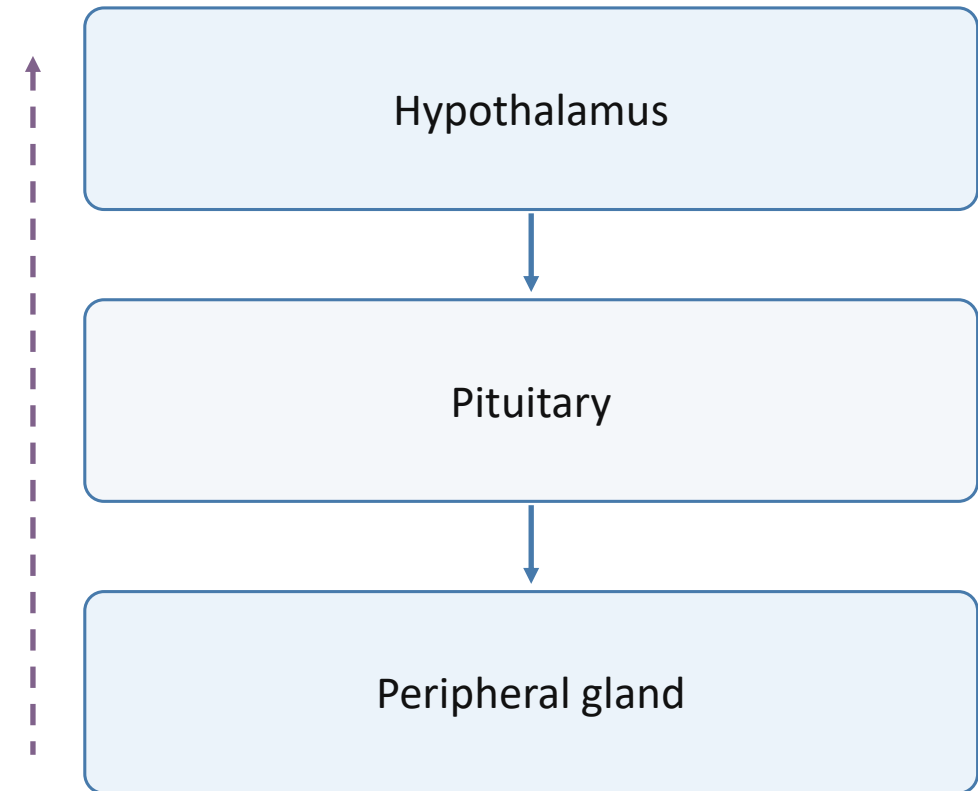
GnRH drives a dual gonadotropin response

- Hypothalamic GnRH acts on gonadotrophs.
- The pituitary secretes FSH and LH rather than a single output hormone.
- The biological response differs by target organ and reproductive state.



Negative feedback stabilizes endocrine function

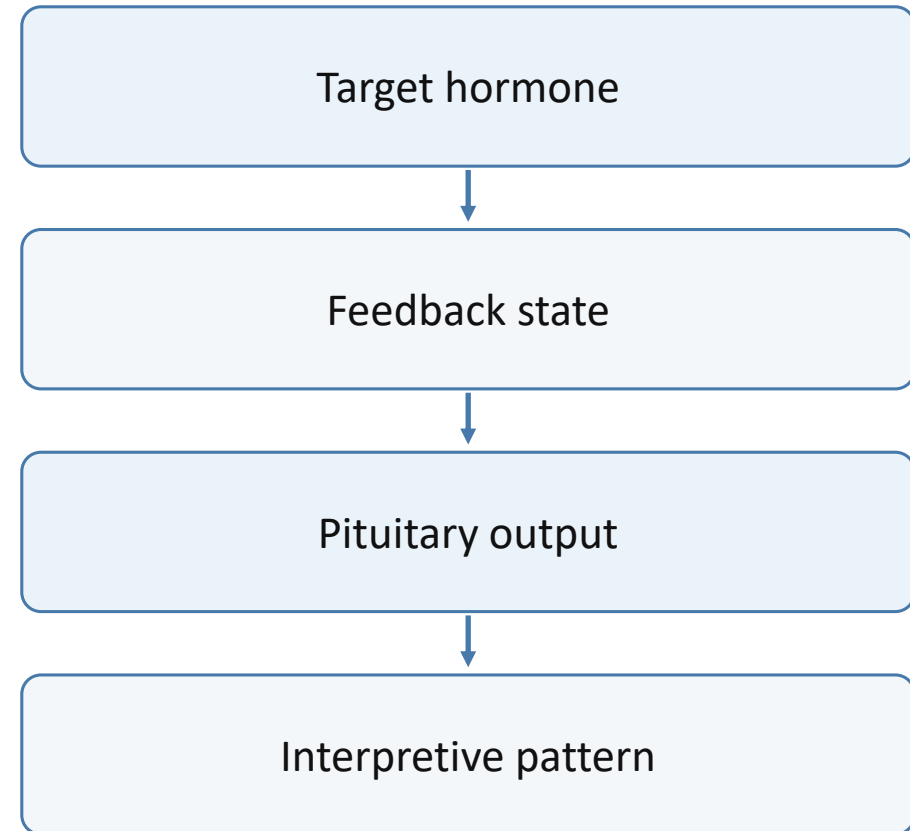
- A tropic hormone promotes secretion by a peripheral endocrine gland.
- The peripheral hormone inhibits upstream hypothalamic/pituitary release.
- Loss of feedback can change tropic hormone levels even when the pituitary itself is normal.



Negative feedback

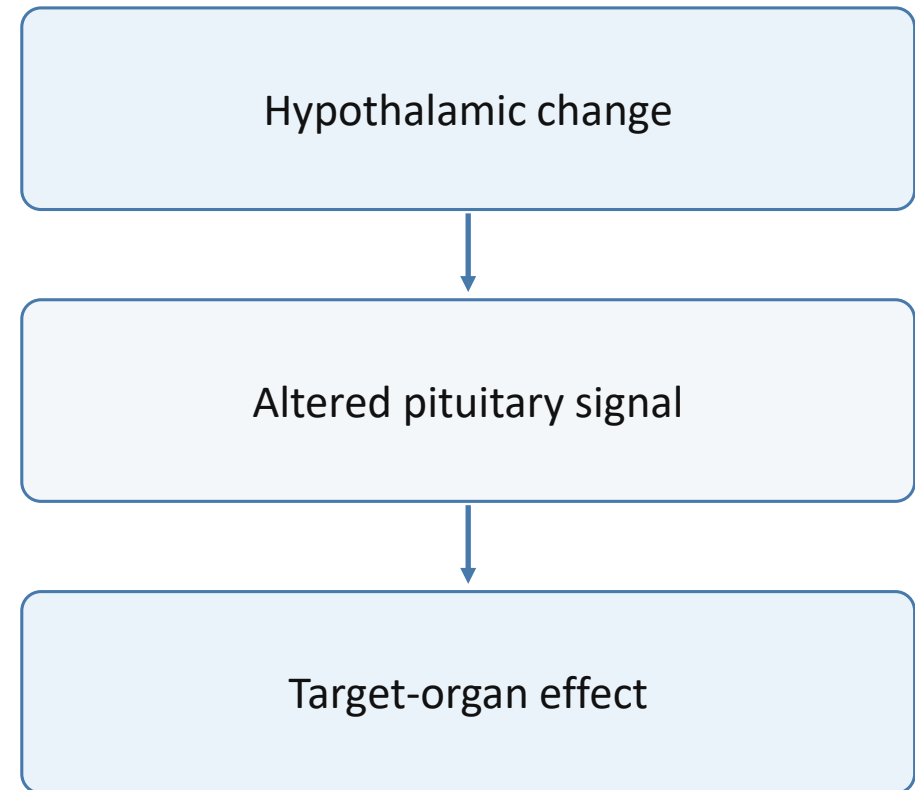
Endocrine interpretation requires paired measurements

- A pituitary hormone value must be interpreted in relation to the corresponding target-organ hormone.
- Abnormal target-organ function can alter pituitary secretion by feedback.
- Laboratory findings must therefore be combined with anatomy and clinical presentation.



Hypothalamic abnormalities can mimic pituitary disease

- Overproduction or underproduction of hypothalamic factors may disturb pituitary secretion.
- An altered anterior hormone level does not by itself establish a primary pituitary lesion.
- The full axis must be considered when assigning the level of dysfunction.



Anterior lobe: Integrate cells, axes and blood supply

- Hormone-specific epithelial cells generate anterior output.
- Portal blood conveys hypothalamic stimulation or inhibition.
- Peripheral feedback closes each control loop.
- This organization explains most anterior pituitary endocrine presentations.

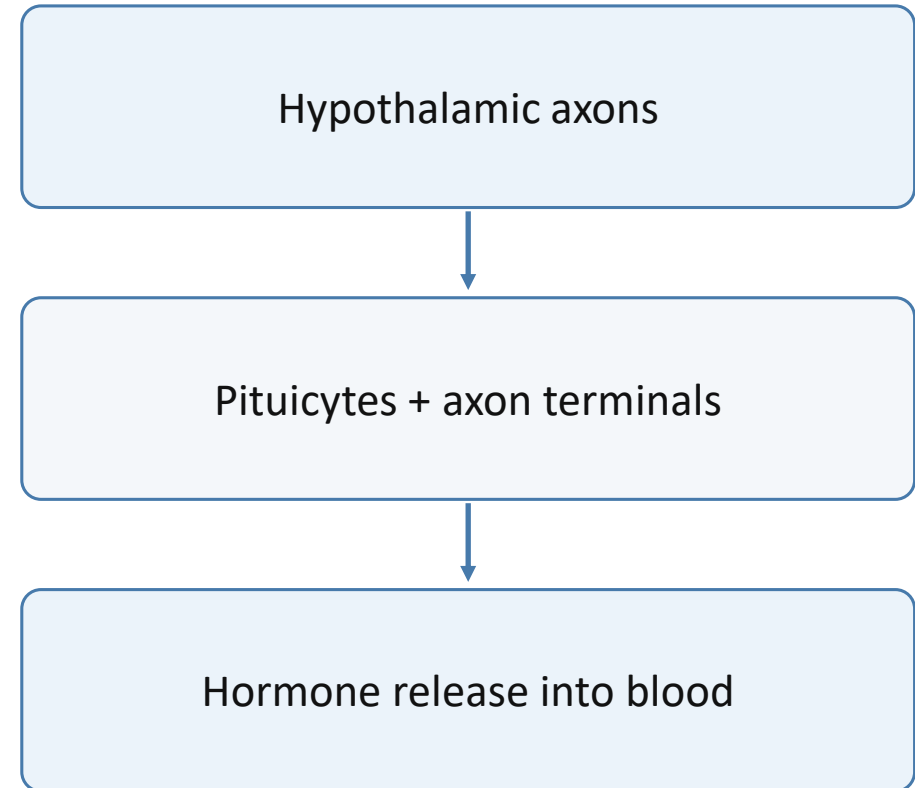
**Cells and
lineages**

**Portal
regulation**

**Peripheral
feedback**

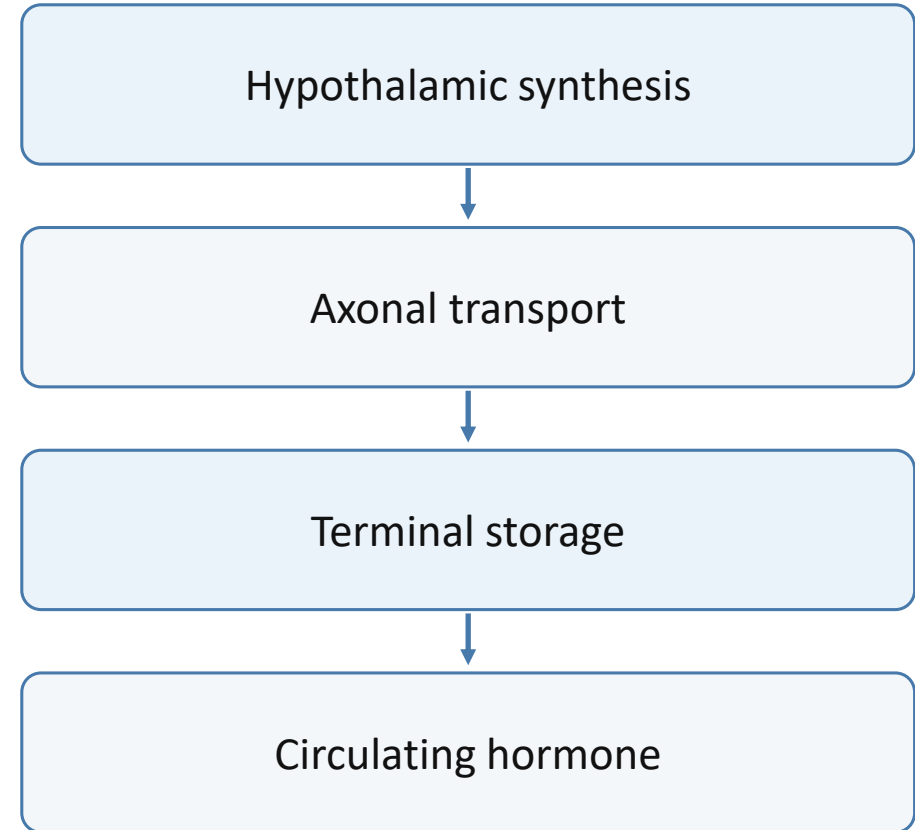
Posterior pituitary has neural parenchyma

- The neurohypophysis contains pituicytes, modified glial cells.
- Axonal processes descend from hypothalamic neurons through the stalk.
- Hormone storage and systemic release occur at posterior pituitary terminals.



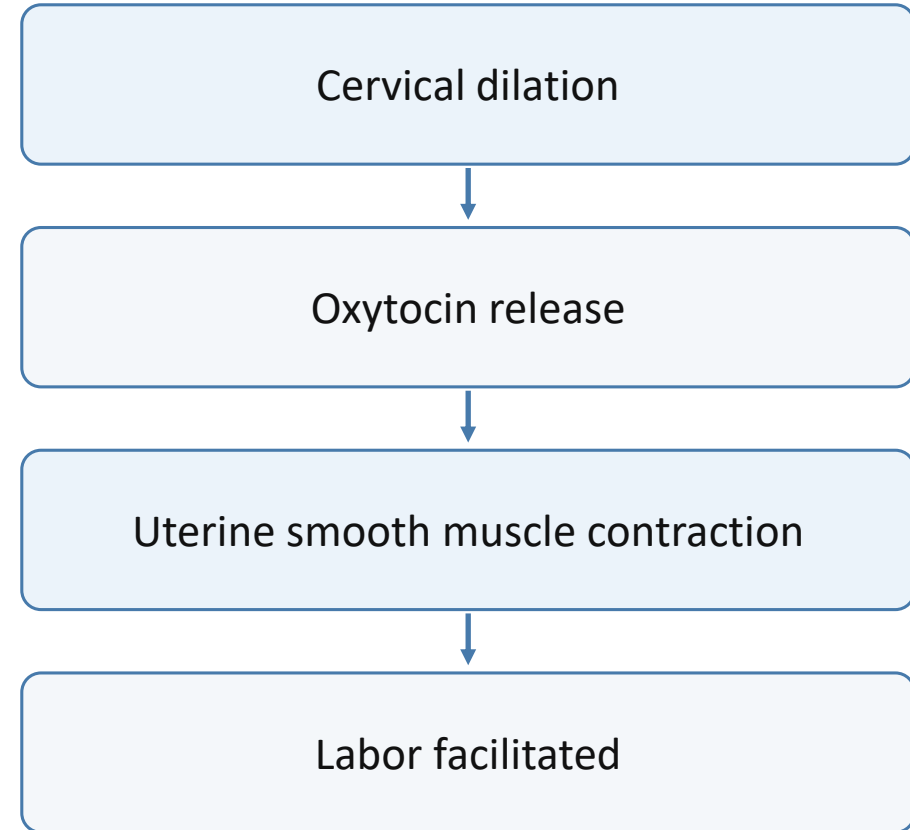
Posterior hormones are synthesized in the hypothalamus

- Oxytocin and antidiuretic hormone are synthesized by hypothalamic neurons.
- These peptides are transported through axons rather than synthesized by pituicytes.
- The posterior gland releases already formed hormone in response to physiologic stimuli.



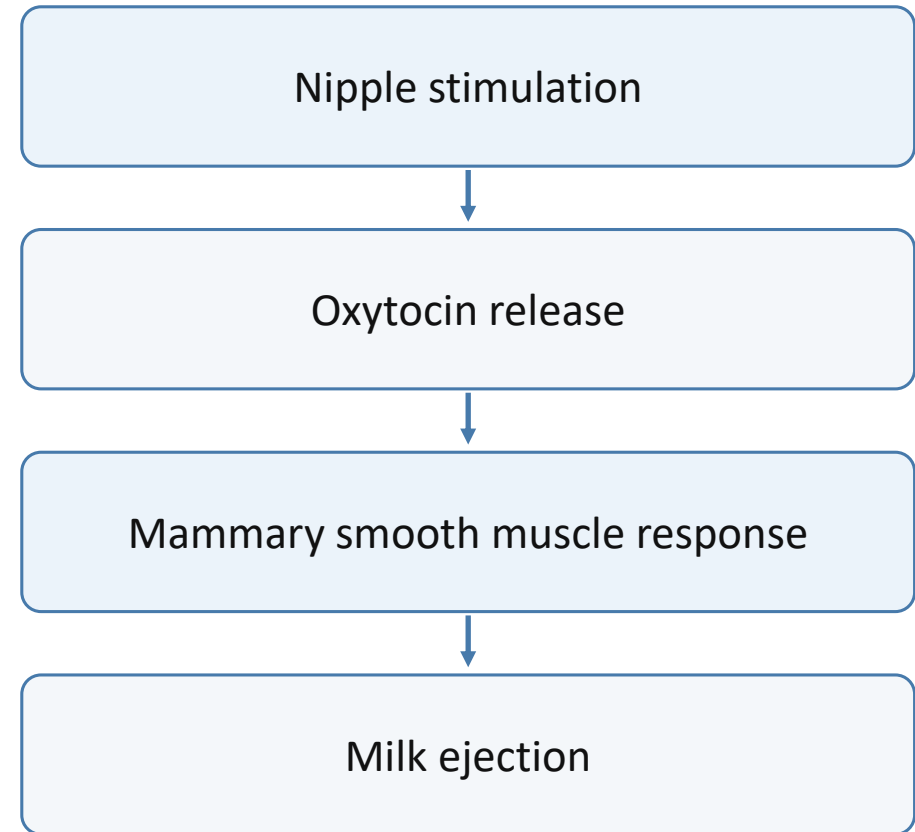
Oxytocin promotes uterine contraction in labor

- Cervical dilation stimulates oxytocin release.
- Oxytocin acts on uterine smooth muscle to facilitate parturition.
- The anatomical relay is hypothalamic synthesis followed by posterior release.



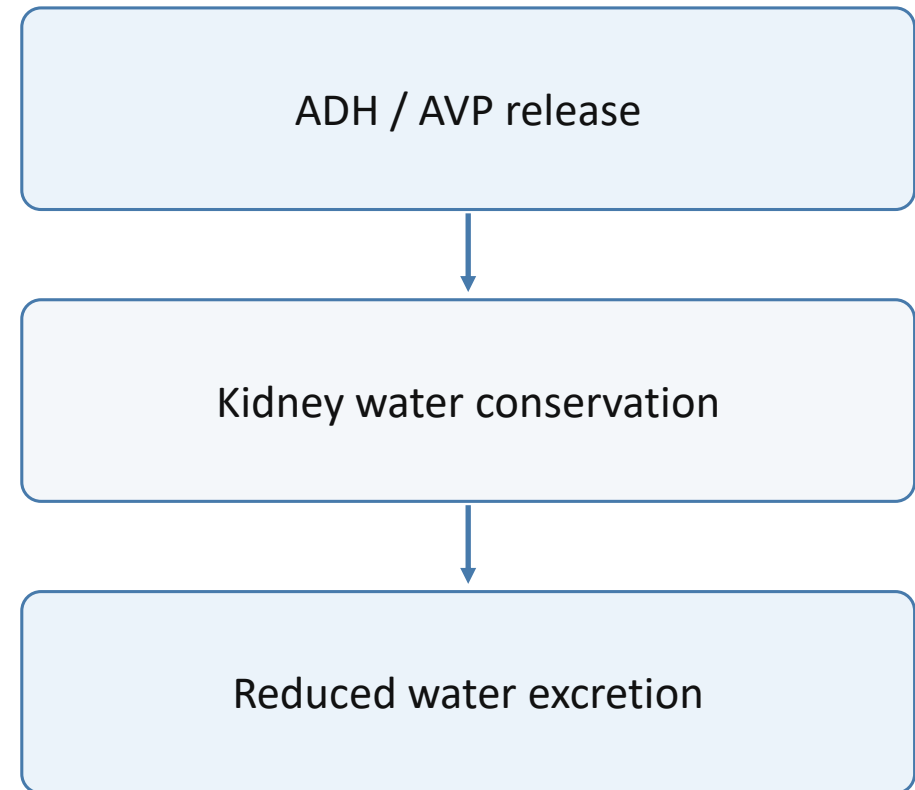
Oxytocin facilitates milk ejection

- Nipple stimulation triggers oxytocin secretion.
- Oxytocin acts on smooth muscle associated with lactiferous structures of the breast.
- This facilitates milk ejection and supports lactation after childbirth.



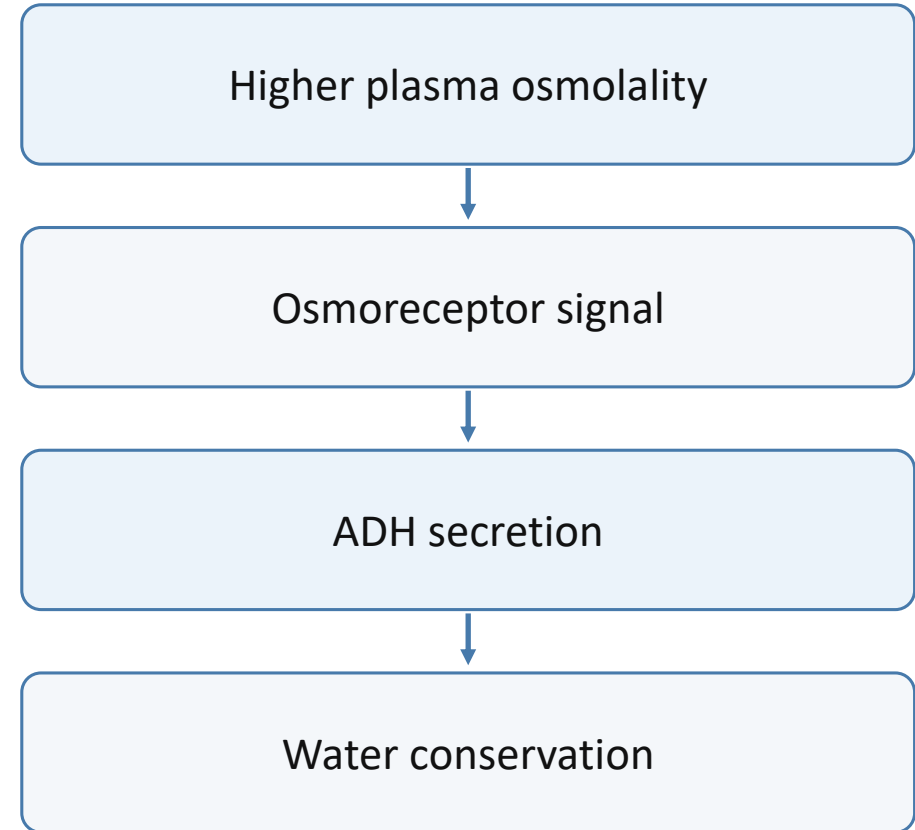
ADH maintains water conservation

- Antidiuretic hormone (ADH) is also called arginine vasopressin (AVP).
- Its key action is to restrict renal water loss during dehydration or hypovolemia.
- Posterior pituitary disorders may therefore cause marked fluid-balance abnormalities.



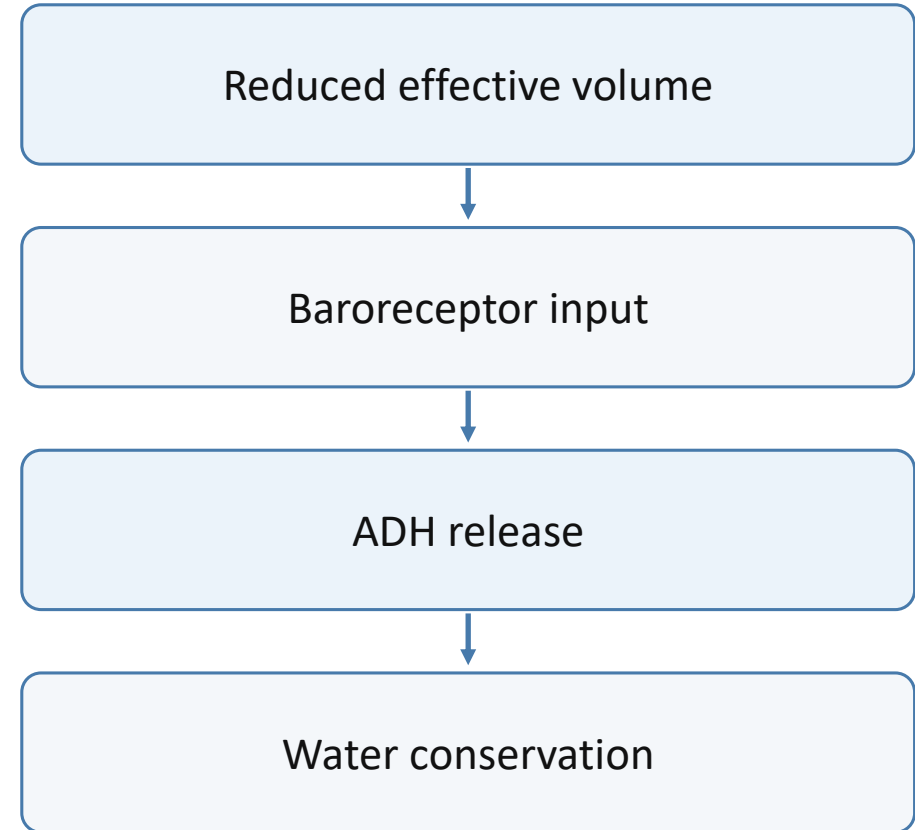
Increased osmolality promotes ADH release

- Osmoreceptors detect increases in plasma osmotic pressure.
- This stimulus promotes posterior pituitary ADH release.
- The response helps limit further loss of body water.



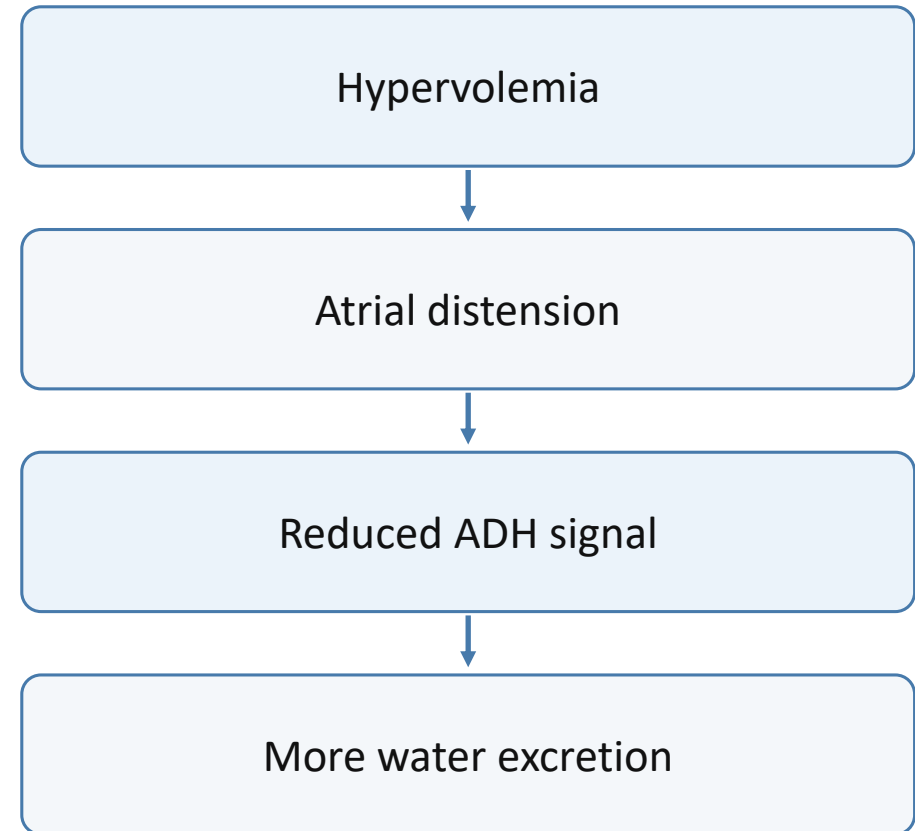
Low circulating volume also stimulates ADH

- Reduced blood pressure is sensed by baroreceptor systems.
- Baroreceptor inputs stimulate ADH secretion when effective volume falls.
- ADH integrates both osmotic and circulatory homeostatic demands.



Hypervolemia restrains ADH secretion

- Increased atrial distension signals expanded circulatory volume.
- Under such conditions, ADH secretion is inhibited.
- This regulation favors elimination of excess free water.



Oxytocin and ADH have different target effects

- Oxytocin mediates uterine and mammary smooth-muscle responses.
- ADH primarily regulates renal water conservation.
- Both are synthesized in the hypothalamus and released at posterior terminals.

**Oxytocin: Smooth
muscle**

**ADH: Renal water
handling**

Lobe-specific pathology follows lobe-specific physiology

- Anterior disease typically changes tropic hormone production and peripheral endocrine function.
- Posterior disease classically produces disturbances in water balance and ADH secretion.
- An expanding sellar lesion can also injure surrounding structures independently of hormone secretion.

**Anterior:
Hormone
excess / loss**

**Posterior: ADH
imbalance**

**Sellar region:
Mass effect**

Three broad clinical patterns organize pituitary disease

- Hyperpituitarism reflects excess secretion of pituitary hormones.
- Hypopituitarism reflects deficiency of pituitary hormones.
- Mass effects cause neurologic consequences in the sellar/suprasellar region.

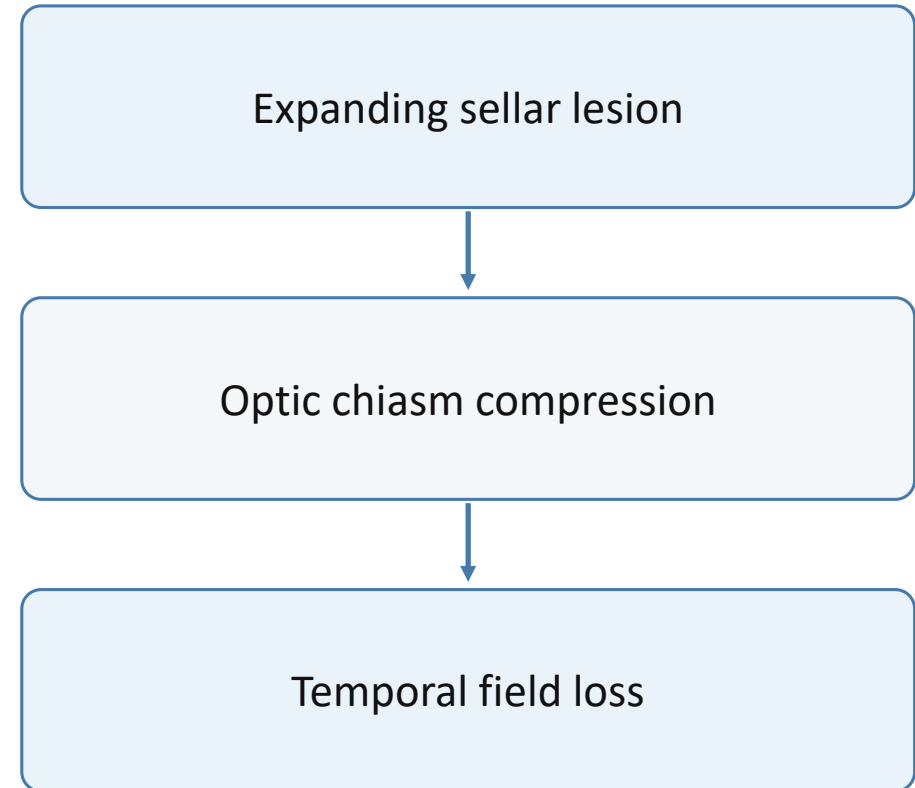
**Hormone
excess**

**Hormone
deficiency**

**Local mass
effect**

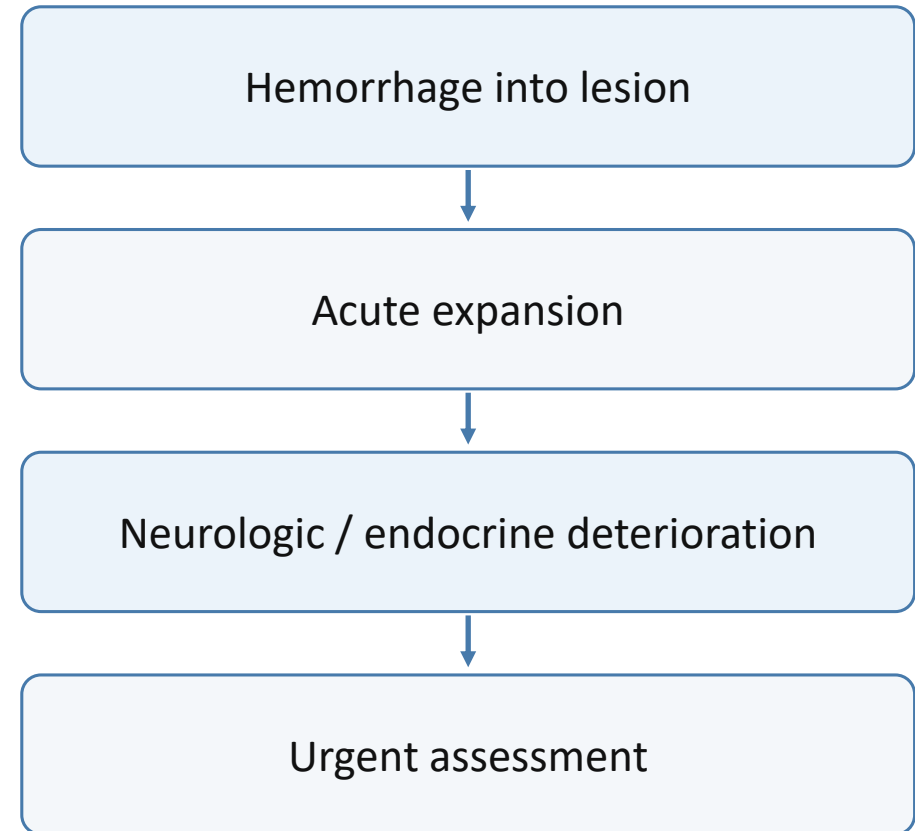
An enlarging sellar mass can disrupt vision

- The optic chiasm lies adjacent to the pituitary region.
- Expanding pituitary lesions can compress crossing optic nerve fibers.
- The classical visual field defect is bitemporal hemianopia.



Pituitary apoplexy is an acute lesion complication

- Hemorrhage into a pituitary lesion can cause abrupt enlargement.
- Sudden expansion may rapidly worsen pituitary insufficiency or neurologic symptoms.
- This presentation may be a neurosurgical emergency.



Posterior hormone disorders present through fluid balance

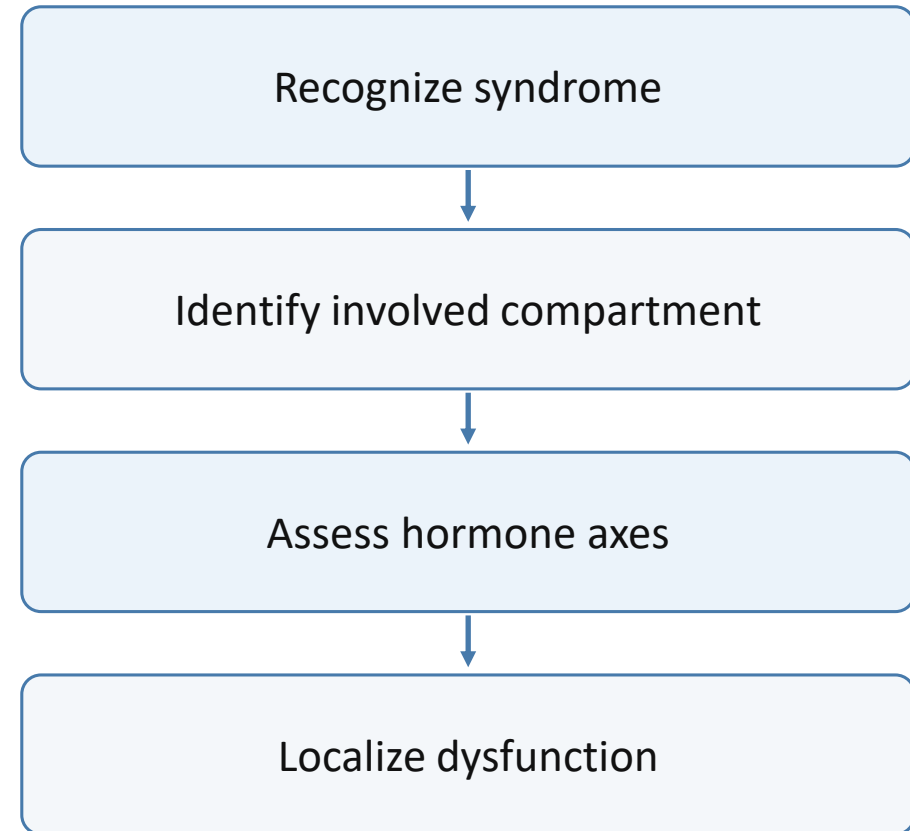
- Reduced ADH activity can lead to impaired renal water conservation.
- Excess ADH activity shifts water and electrolyte balance in the opposite direction.
- The clinical syndrome must be interpreted with fluid and electrolyte findings.

Reduced ADH effect

Excess ADH effect

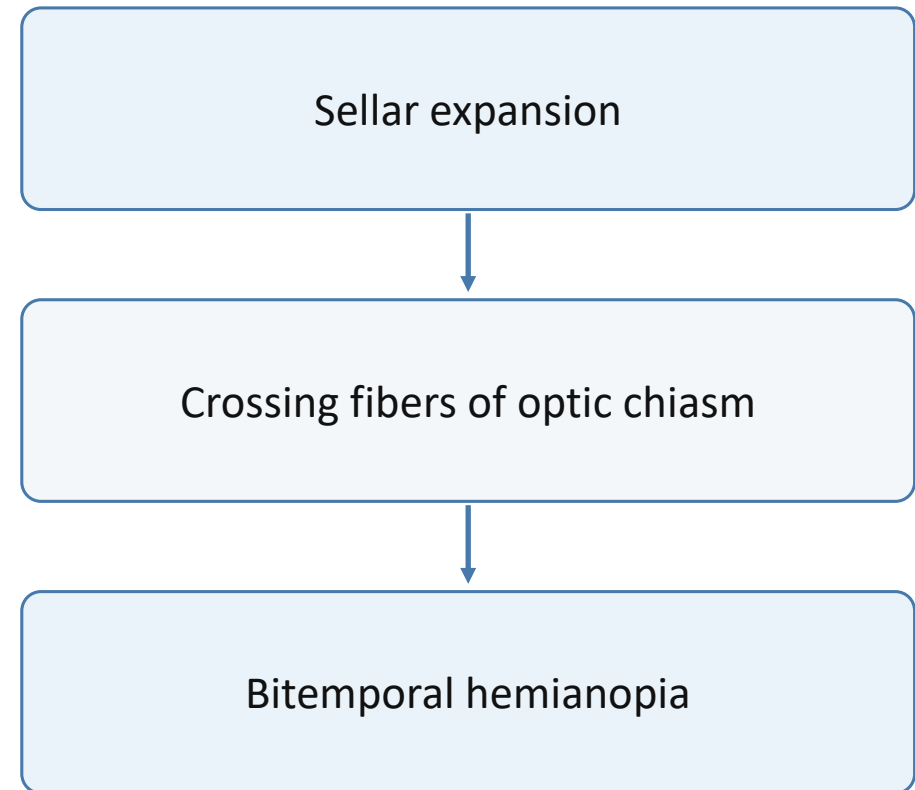
Use a compartment-based diagnostic framework

- First decide whether the phenotype reflects hormone excess, deficiency or mass effect.
- Next identify whether the anterior axis, posterior water-regulating axis or adjacent anatomy is involved.
- Finally localize dysfunction to hypothalamus, pituitary or peripheral target where possible.



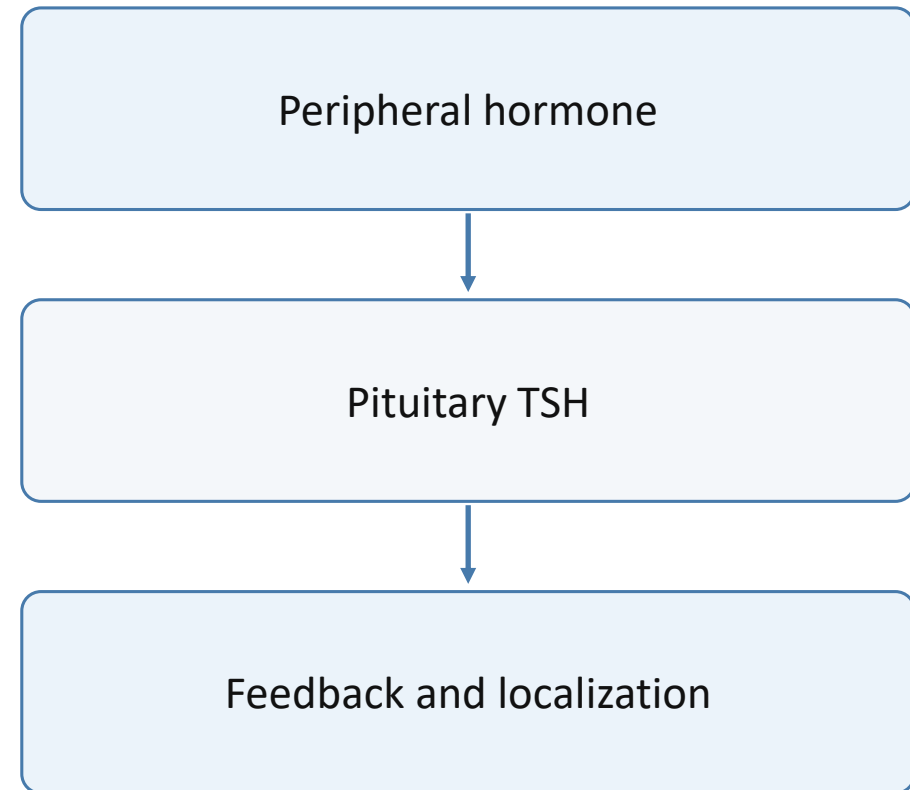
Case: Headache with bilateral temporal visual loss

- A patient develops persistent headache and loss of temporal visual fields.
- The endocrine profile is still unknown.
- What local anatomical relationship best explains the visual finding?



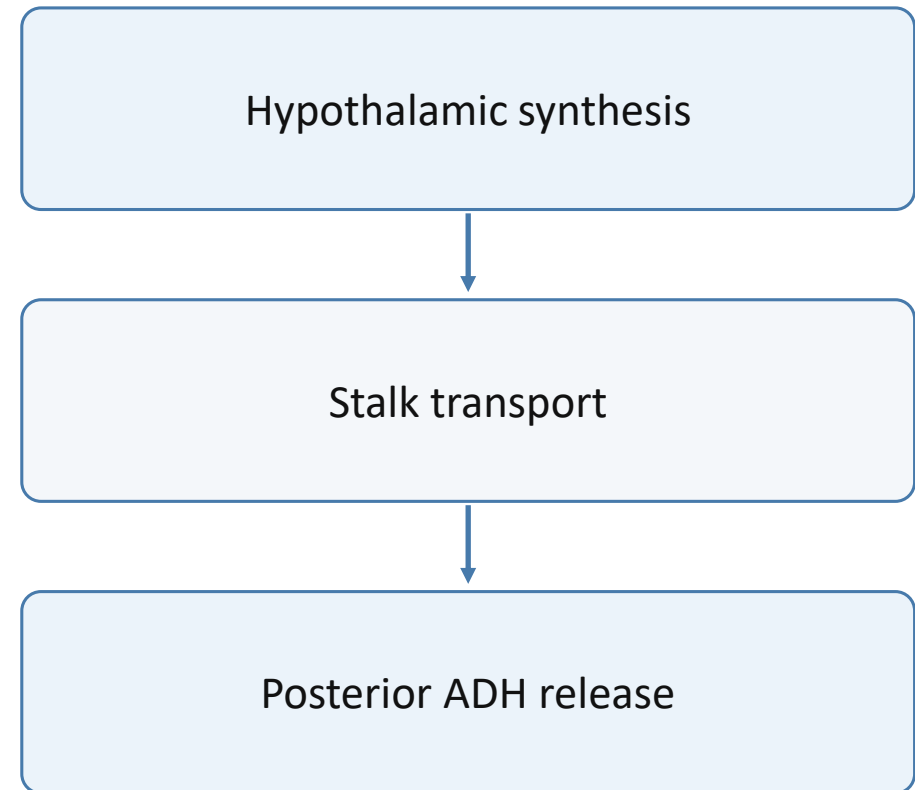
Case: A patient with low free thyroid hormone

- A patient has a low circulating thyroid hormone level.
- Interpretation of TSH is necessary before assigning a primary thyroid versus upstream disorder.
- Why is simultaneous evaluation of the target-organ hormone and tropic hormone essential?



Case: Abrupt polyuria following stalk injury

- A patient develops high-volume dilute urine after an injury involving the pituitary stalk.
- The clinical concern is impaired posterior water-conserving function.
- Which hypothalamic hormone pathway should be considered first?



Integrative summary

- Anterior pituitary: Epithelial cells, six endocrine phenotypes and lineage transcription factors.
- Posterior pituitary: Hypothalamic axons, pituicytes, oxytocin and ADH release.
- The hypothalamus controls both lobes by different routes.
- Hormone excess, deficiency and mass effect provide a clinicopathologic framework.

Structure

Differentiation

Physiology

Clinicopathology

References and source boundaries

- Primary: Robbins, Cotran & Kumar, Pathologic Basis of Disease, 11th edition, Chapter 24.
- Core section: “Pituitary Gland” (printed p. 971–972).
- Limited clinical context: “Clinical Manifestations of Pituitary Disease” (p. 972).
- Normal pituitary source figures were not reproduced from the copyrighted textbook.