

# Endocrine System

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# Endocrine System Lecture Objectives

- Describe the location, histologic components, and embryologic origin of the pituitary gland.
- List the hormones produced by the anterior and posterior pituitary and know their general function.
- Describe the location, histologic components, and embryologic origin of the thyroid gland.
- List the hormones made by the thyroid gland and know their general function.
- Describe the location, cell types and hormone of the parathyroid glands.

# Endocrine System Lecture Objectives

- Describe the location, cortical layers, and medulla of the adrenal glands.
- List the hormones made in the cortex and medulla, and know their general function.
- Describe the location of the pancreas, and the structure and cellular components of a typical pancreatic islet.
- List the hormones made by the islet cells and know their general function.
- Describe the location, cell types, and hormone produced by the pineal gland.

# Endocrine System Lecture Outline

- Introduction
- Pituitary
- Thyroid
- Parathyroid
- Adrenal
- Pancreas
- Pineal

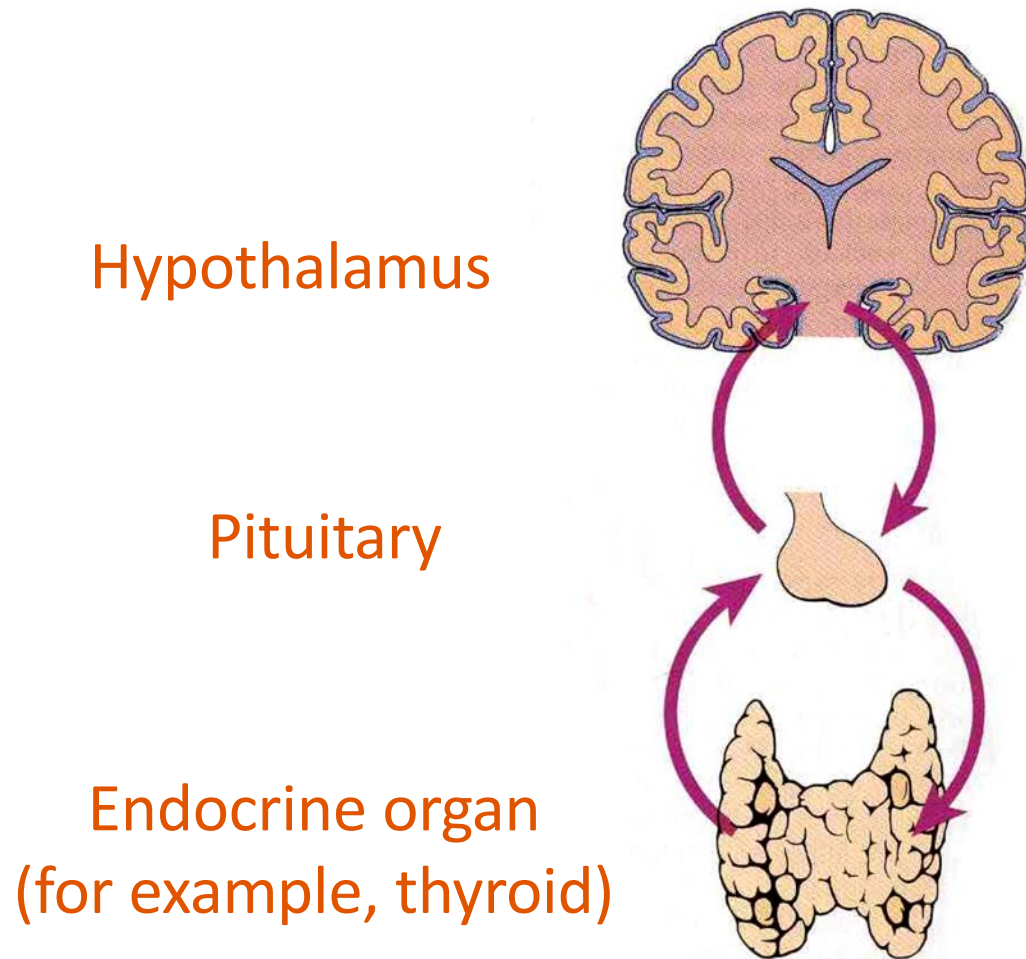
# Endocrine System Lecture Outline

- Introduction

# General Features of the Endocrine System

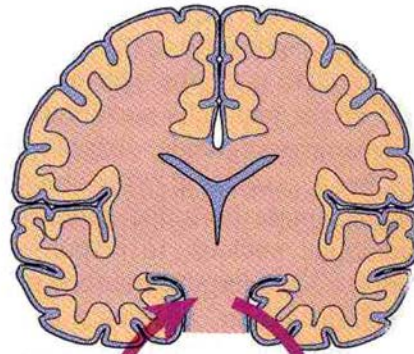
- Endocrine organs secrete hormones through the blood (no ducts!).
- Hormones travel elsewhere and have effects on different tissues.
- The classical endocrine system consists of all the organs we will discuss in this lecture.
- Male and female reproductive systems also have endocrine functions (we'll discuss these later).

# Endocrine System in a Nutshell



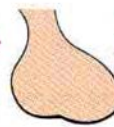
# Endocrine System in a Nutshell

Hypothalamus



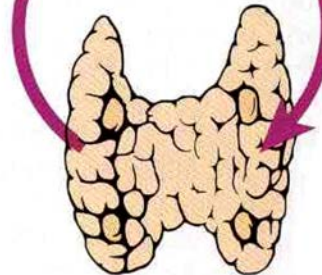
The hypothalamus tells the pituitary what to do

Pituitary



The pituitary tells the endocrine organ what to do

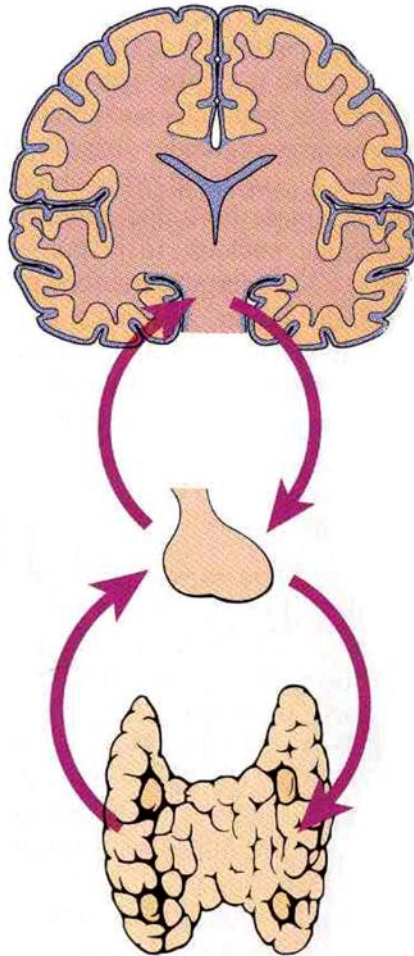
Endocrine organ  
(thyroid)



The endocrine organ releases hormone



# Endocrine System in a Nutshell



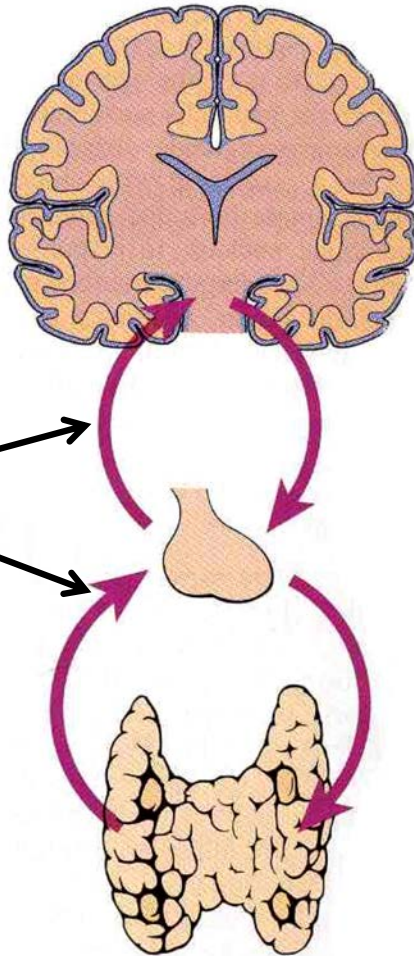
The hypothalamus is like a CEO but we don't talk about it much (not many diseases there)

The pituitary is like a COO. It basically tells everyone what to do.

The endocrine organ is the worker drone. Poor guy.

# Endocrine System in a Nutshell

There are negative feedback loops that tell the system when to stop producing hormone.



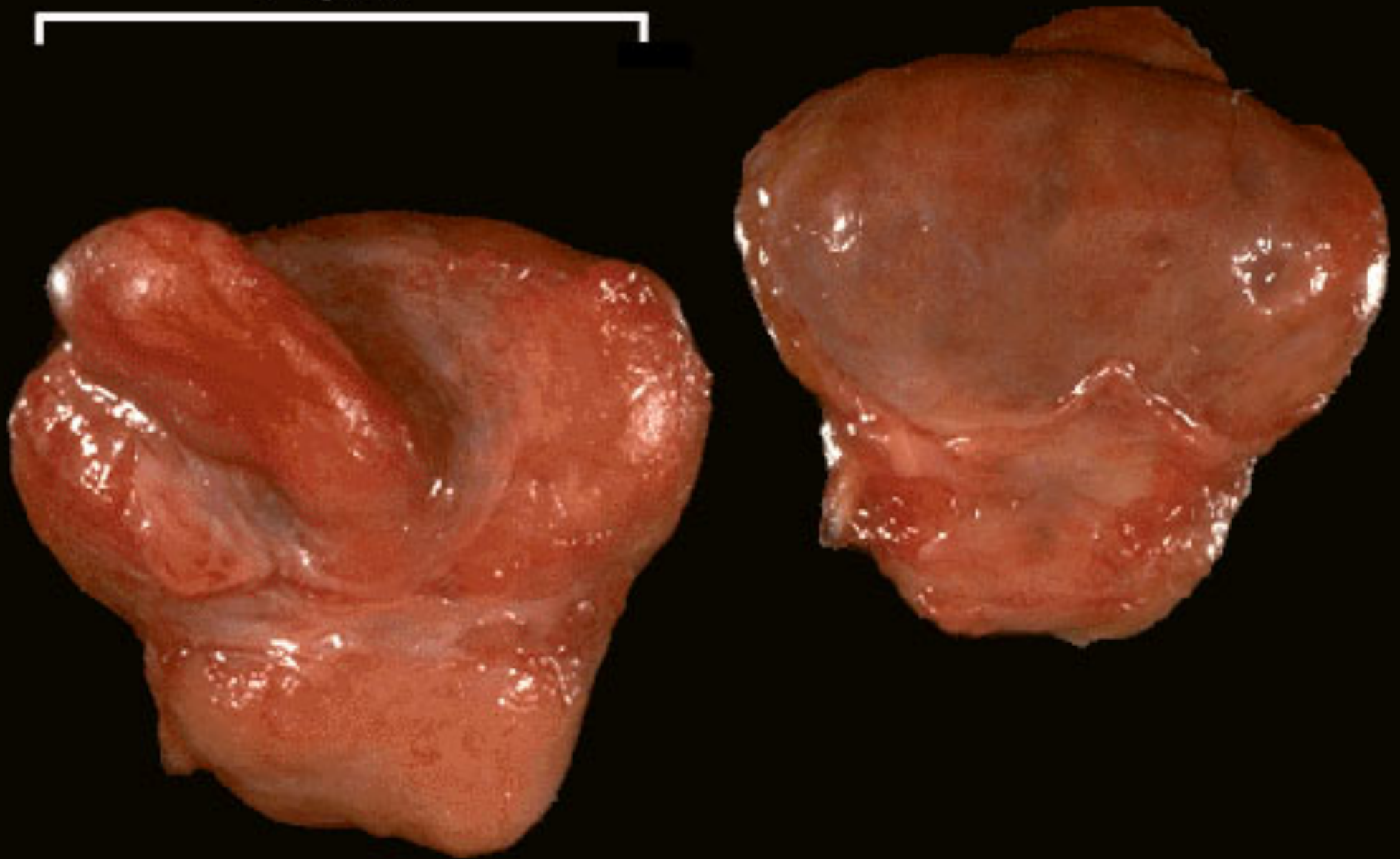
# Endocrine System Lecture Outline

- Introduction
- Pituitary

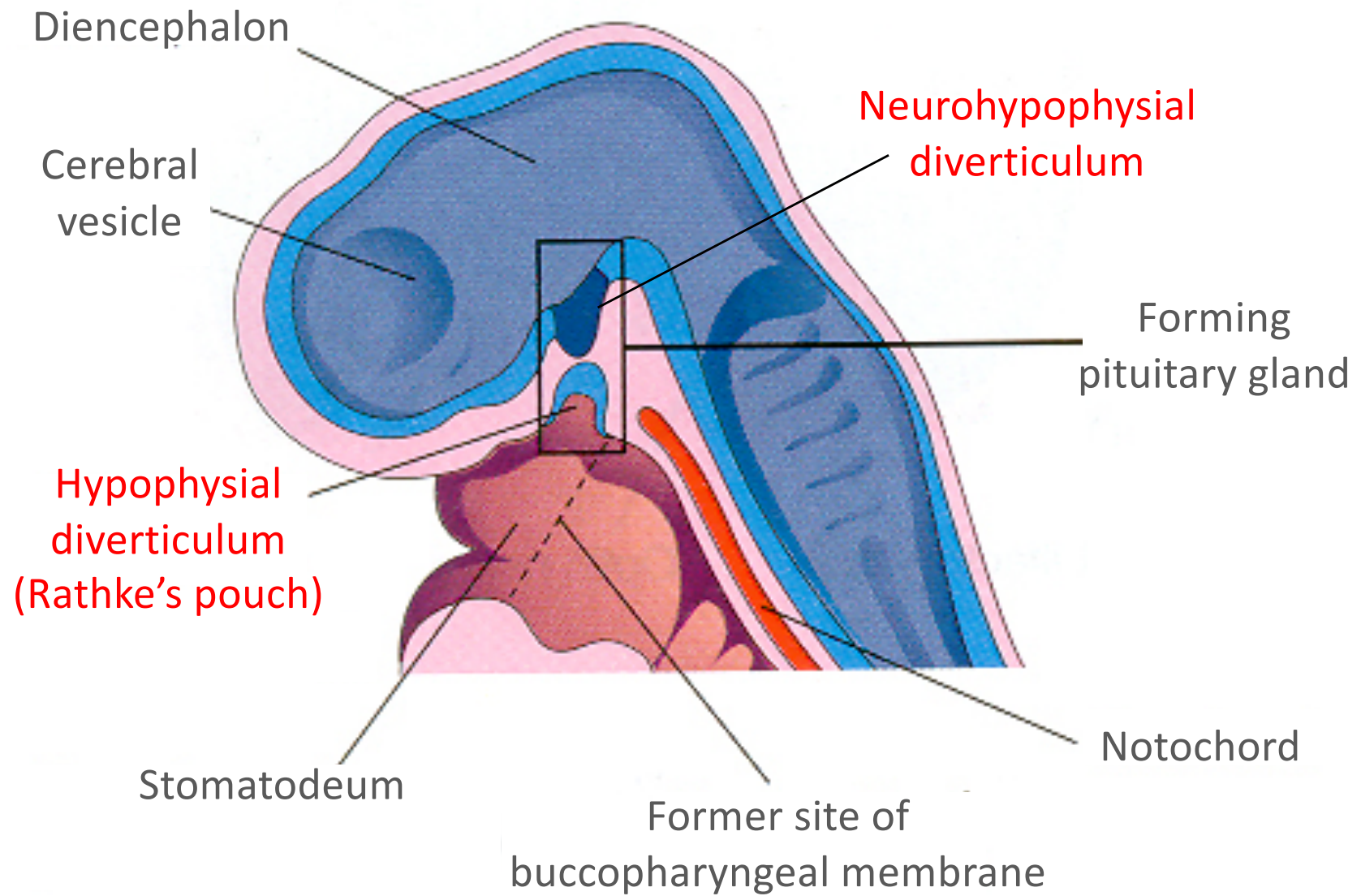
# Pituitary Gland

- Located in the sella turcica (Turkish saddle) in the sphenoid bone.
- Connected to the hypothalamus
- Two lobes:
  - Anterior (adenohypophysis)
  - Posterior (neurohypophysis)

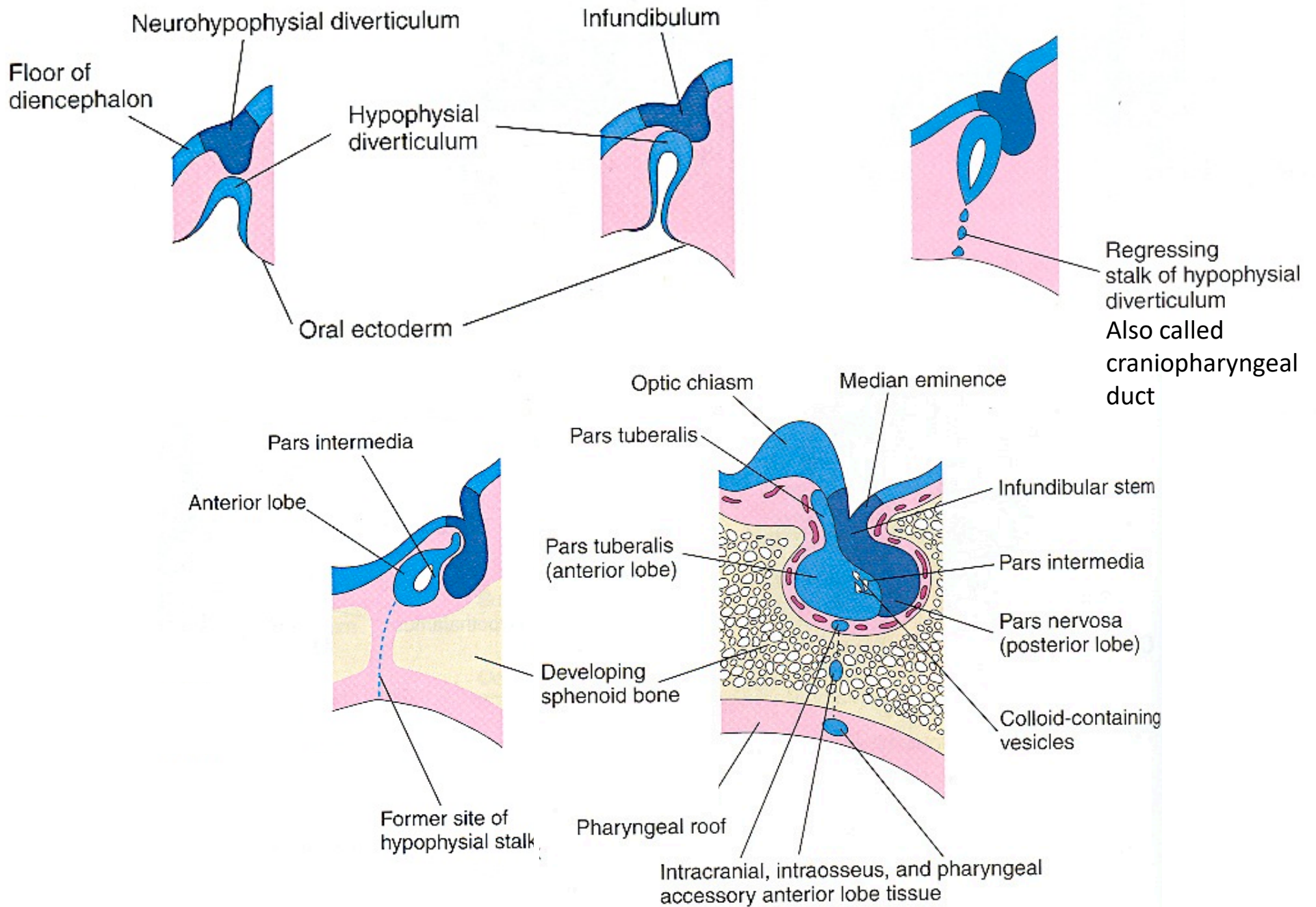
1 cm



Pituitary gland

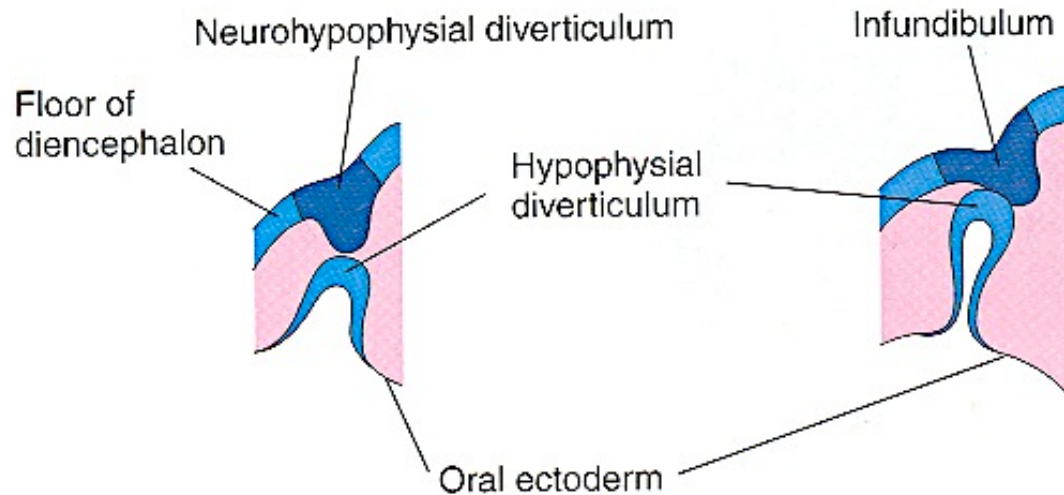


## Development of the Pituitary Gland



# Development of the Pituitary Gland

Ugh! Just give me the bottom line.

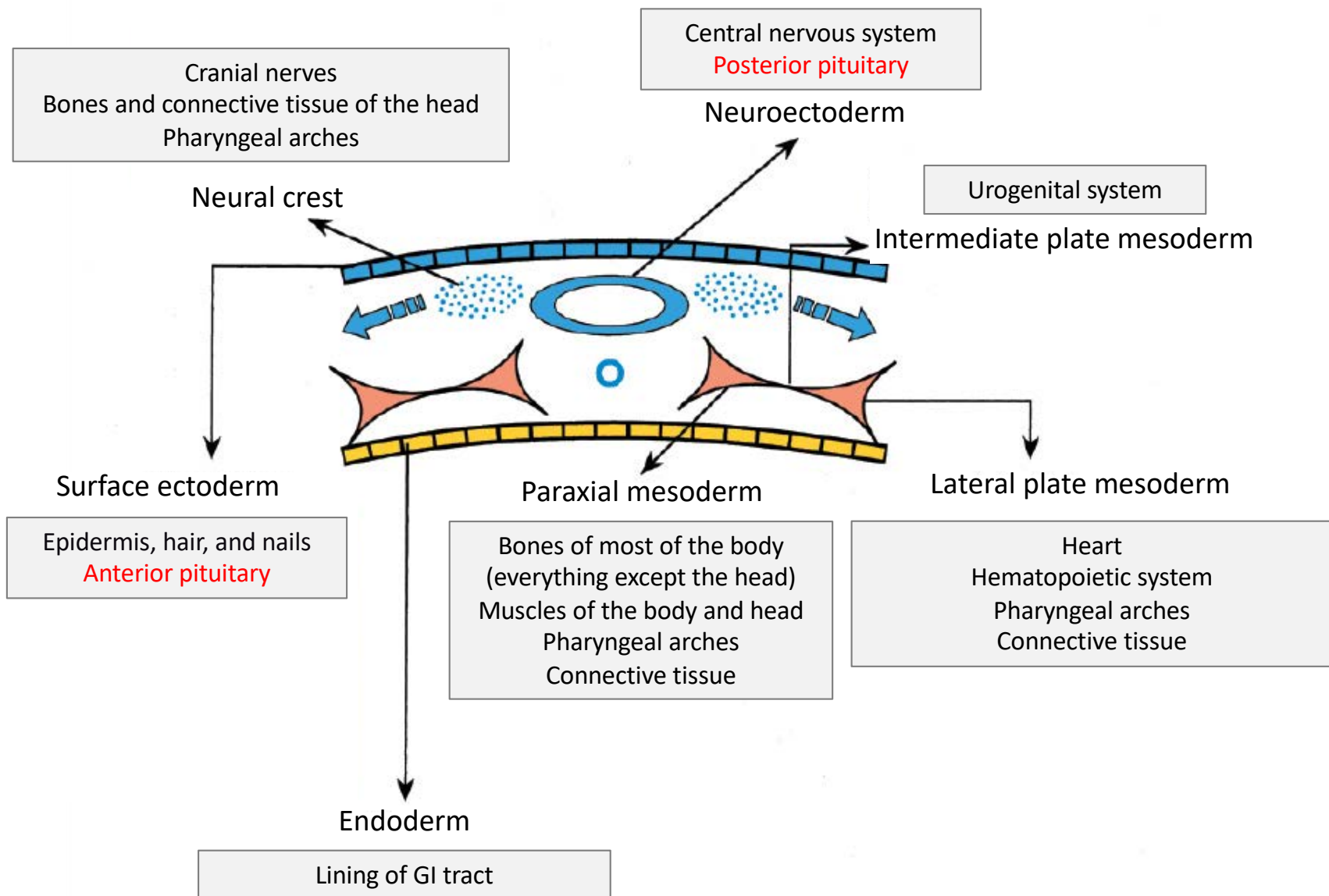


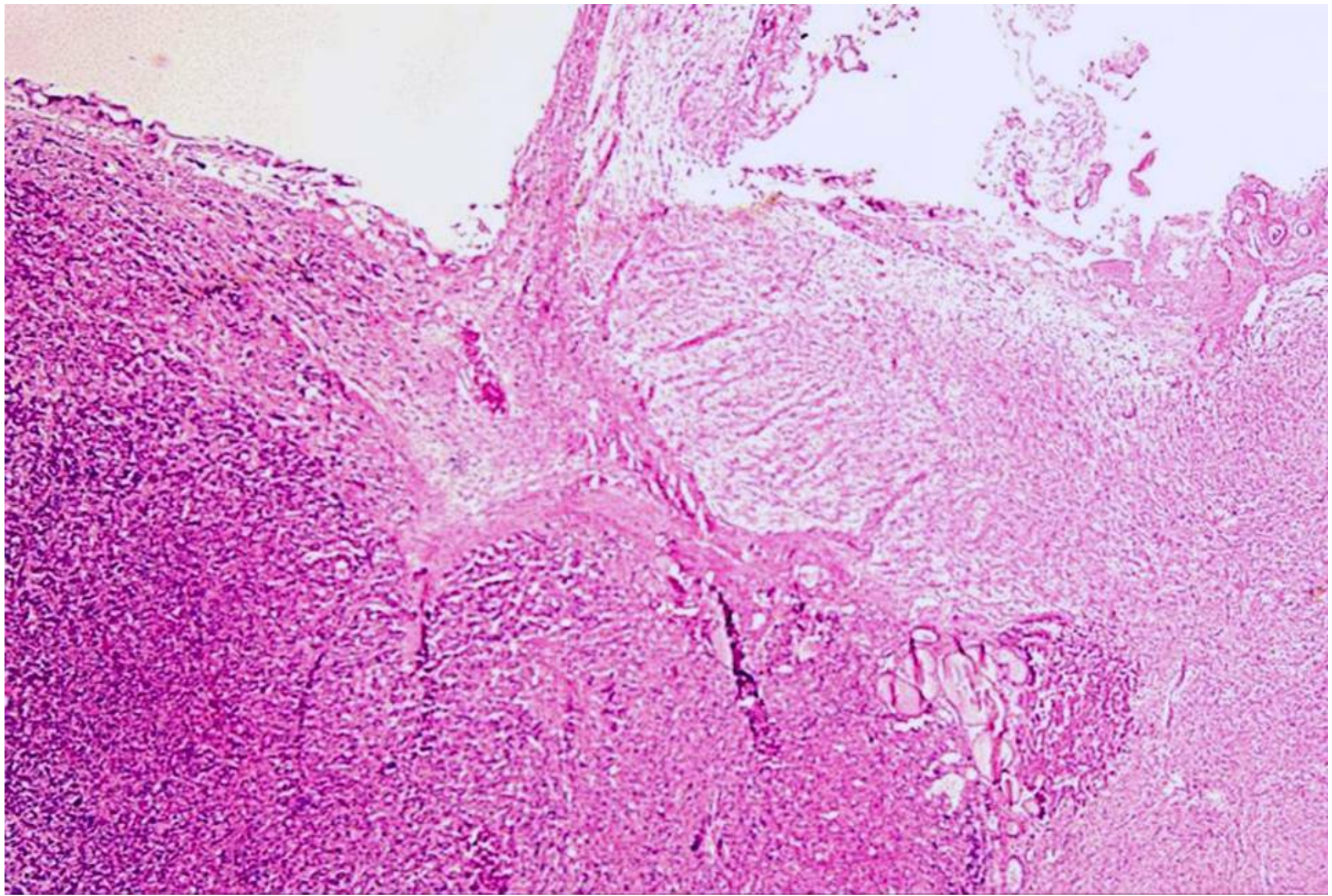
Anterior pituitary: derived from oral ectoderm.

Posterior pituitary: derived from floor of developing brain.

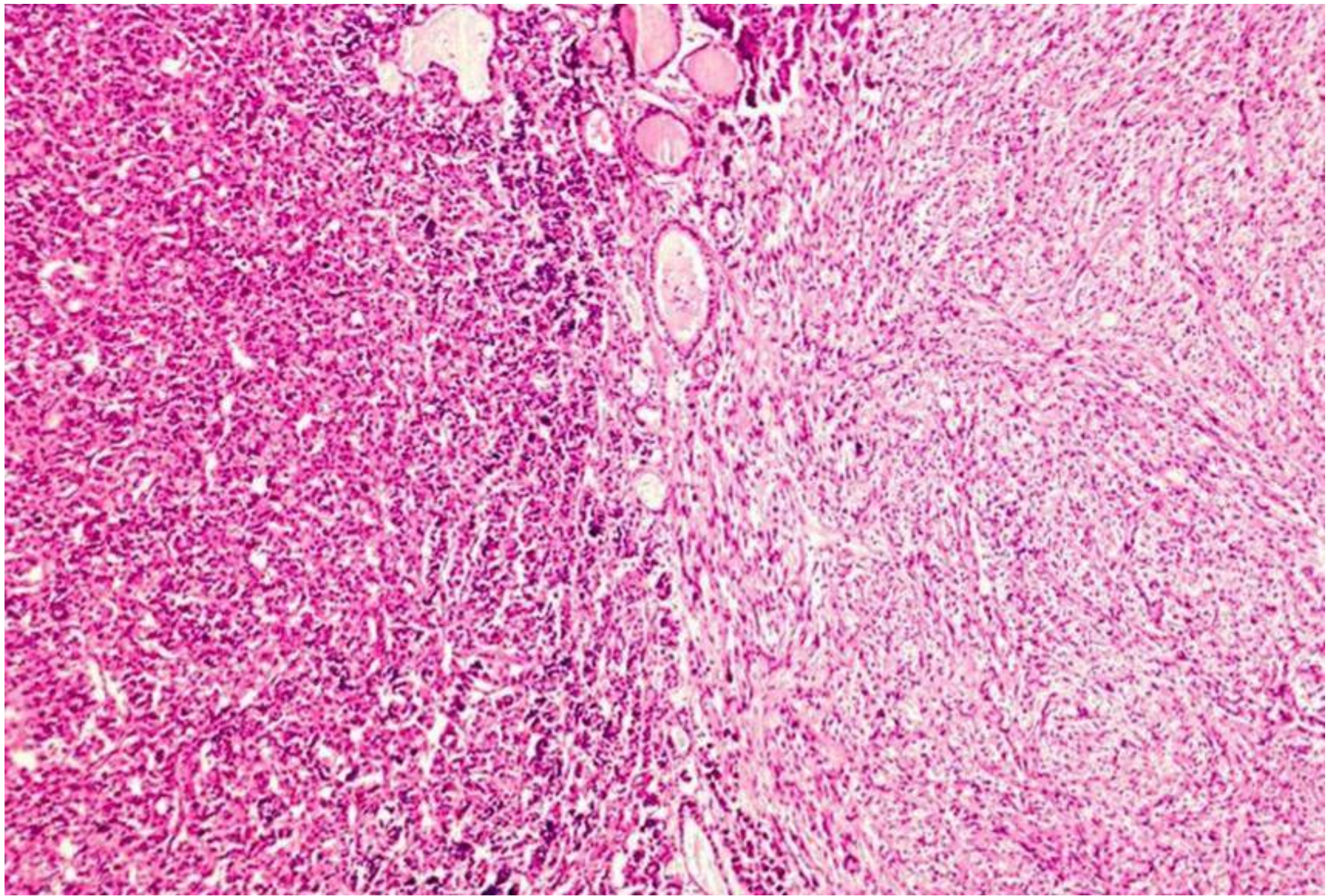
This makes sense, given what the lobes look like (anterior = glandular epithelium, posterior = neural tissue).







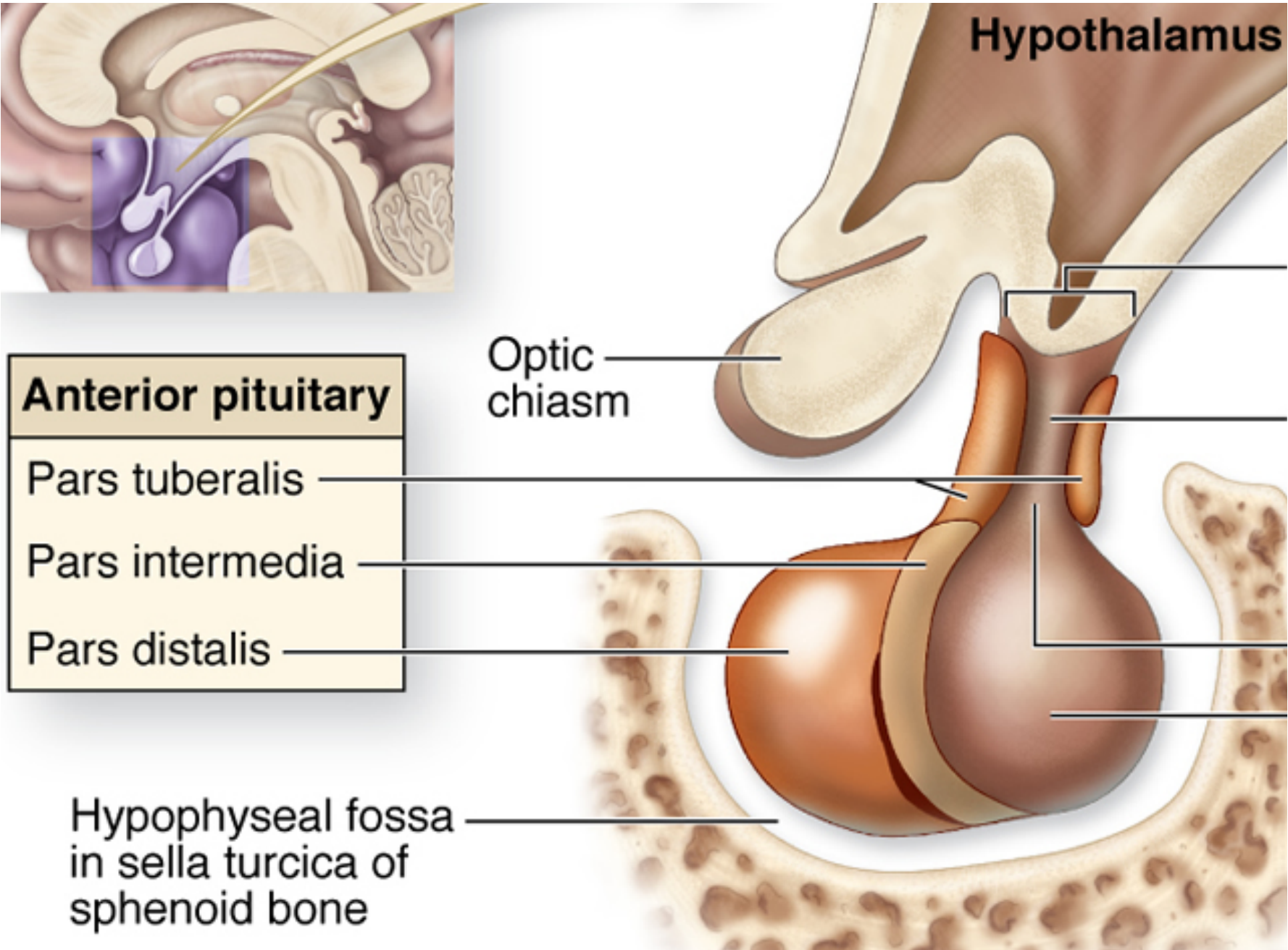
Anterior and posterior pituitary



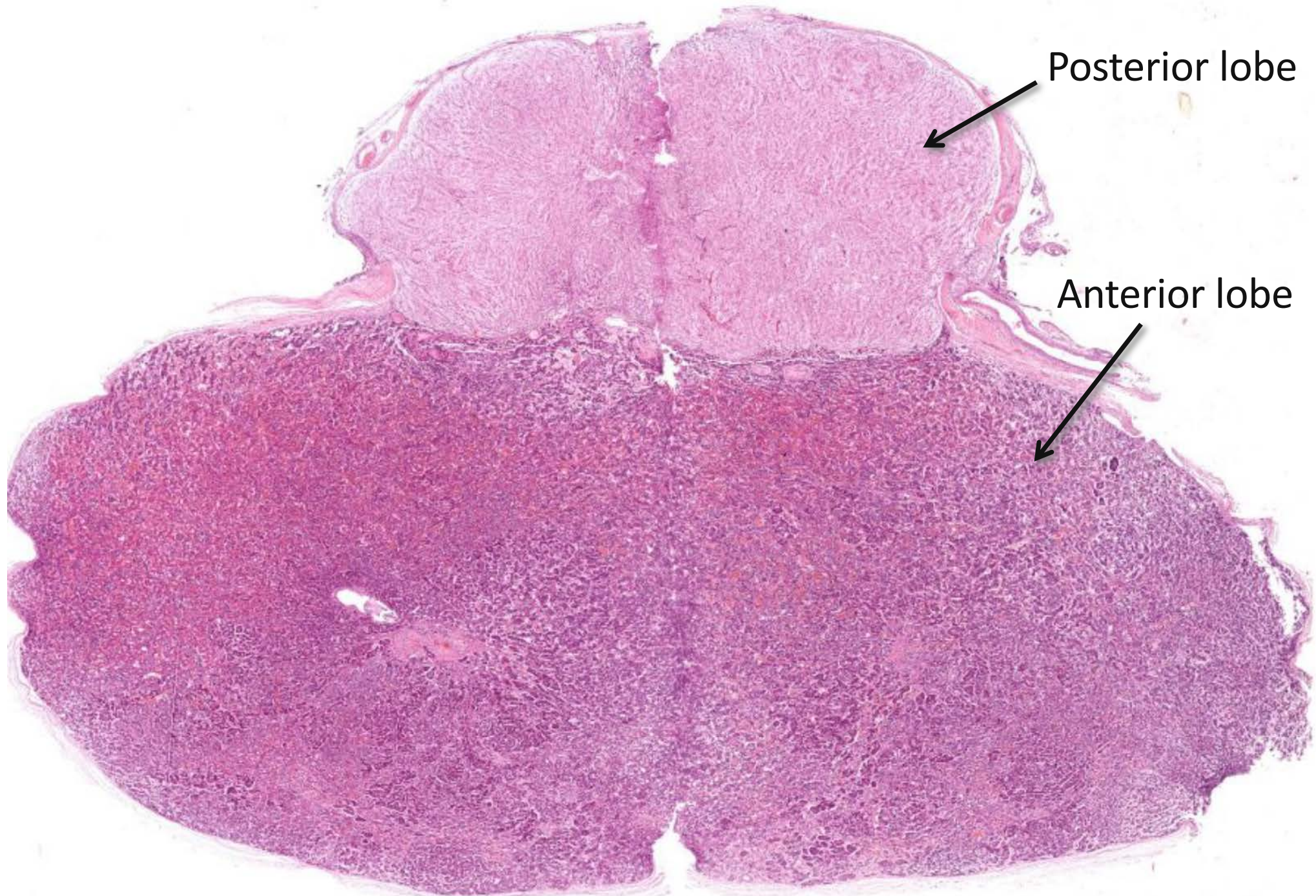
Anterior and posterior pituitary

# Anterior Pituitary (Adenohypophysis)

- Composed of cords of glandular epithelial cells separated by capillaries.
- Makes and secretes a bunch of hormones.
- Subdivisions
  - Pars distalis (biggest and most important part)
  - Pars tuberalis (superior extension of pars distalis)
  - Pars intermedia (separates pars distalis from pars nervosa)



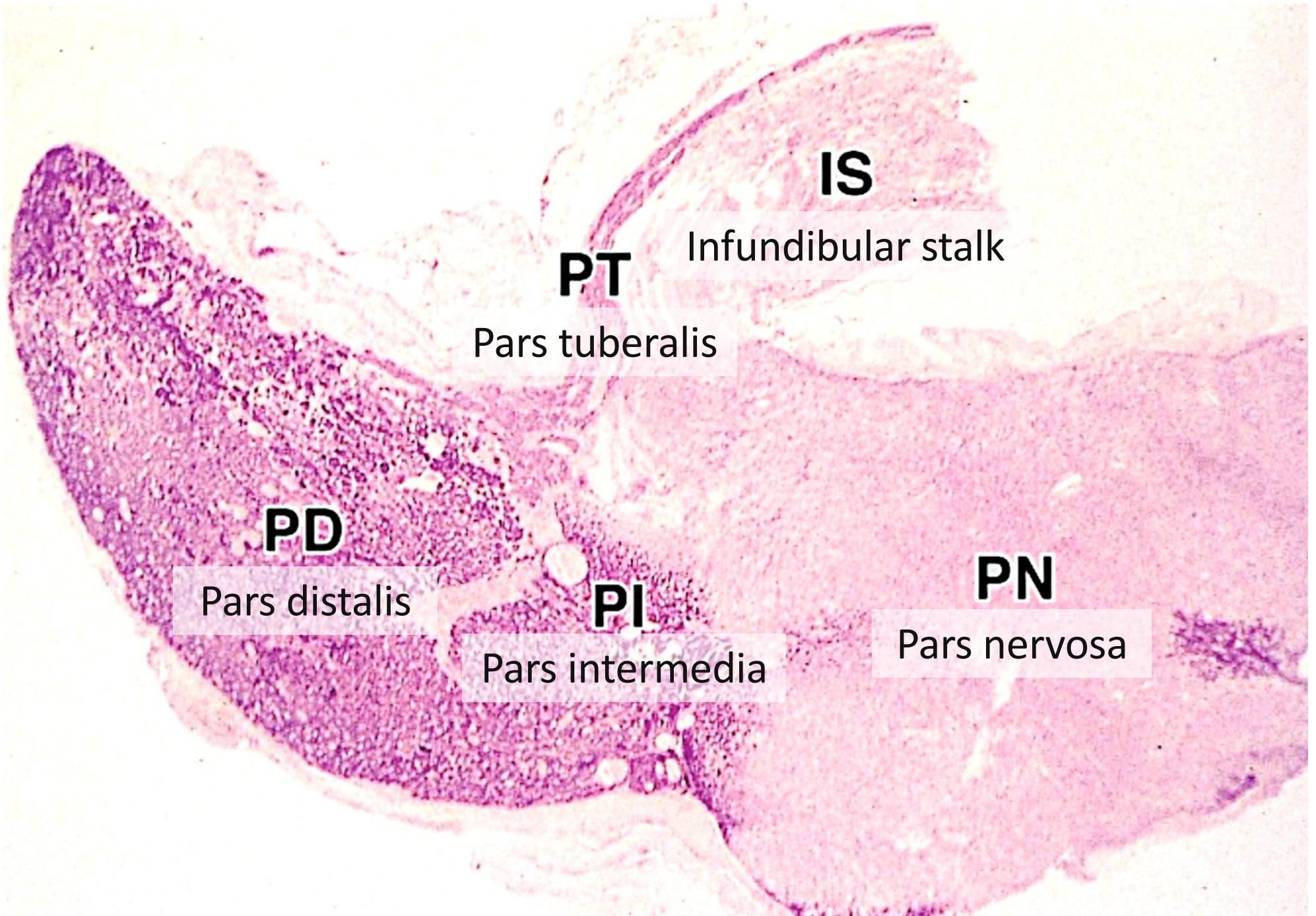
**Anterior pituitary**



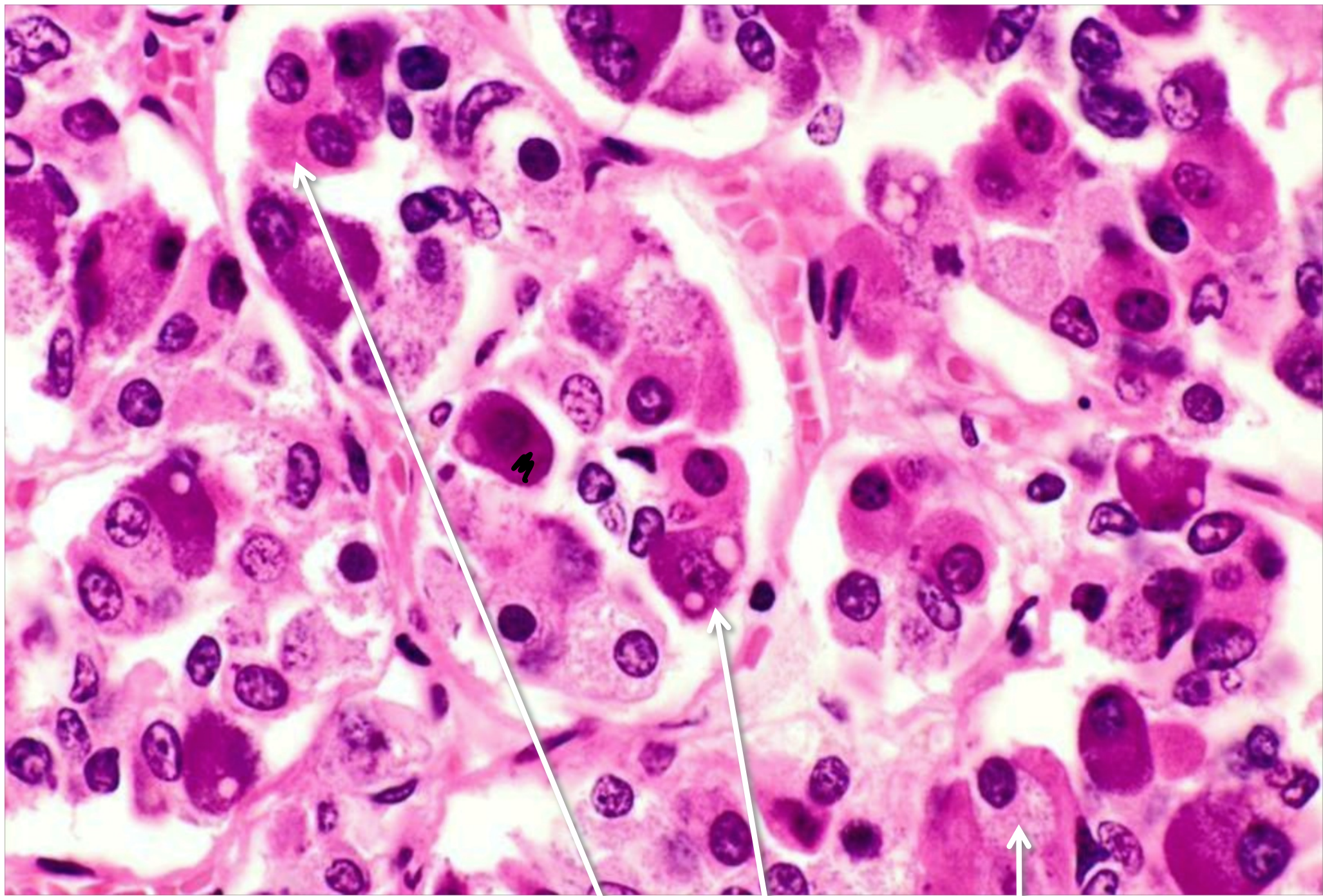
Posterior lobe

Anterior lobe

Pituitary: super low-power view



Pituitary: super low-power view



Anterior pituitary: acidophils, basophils, chromophobes



# Hormones of the Anterior Pituitary

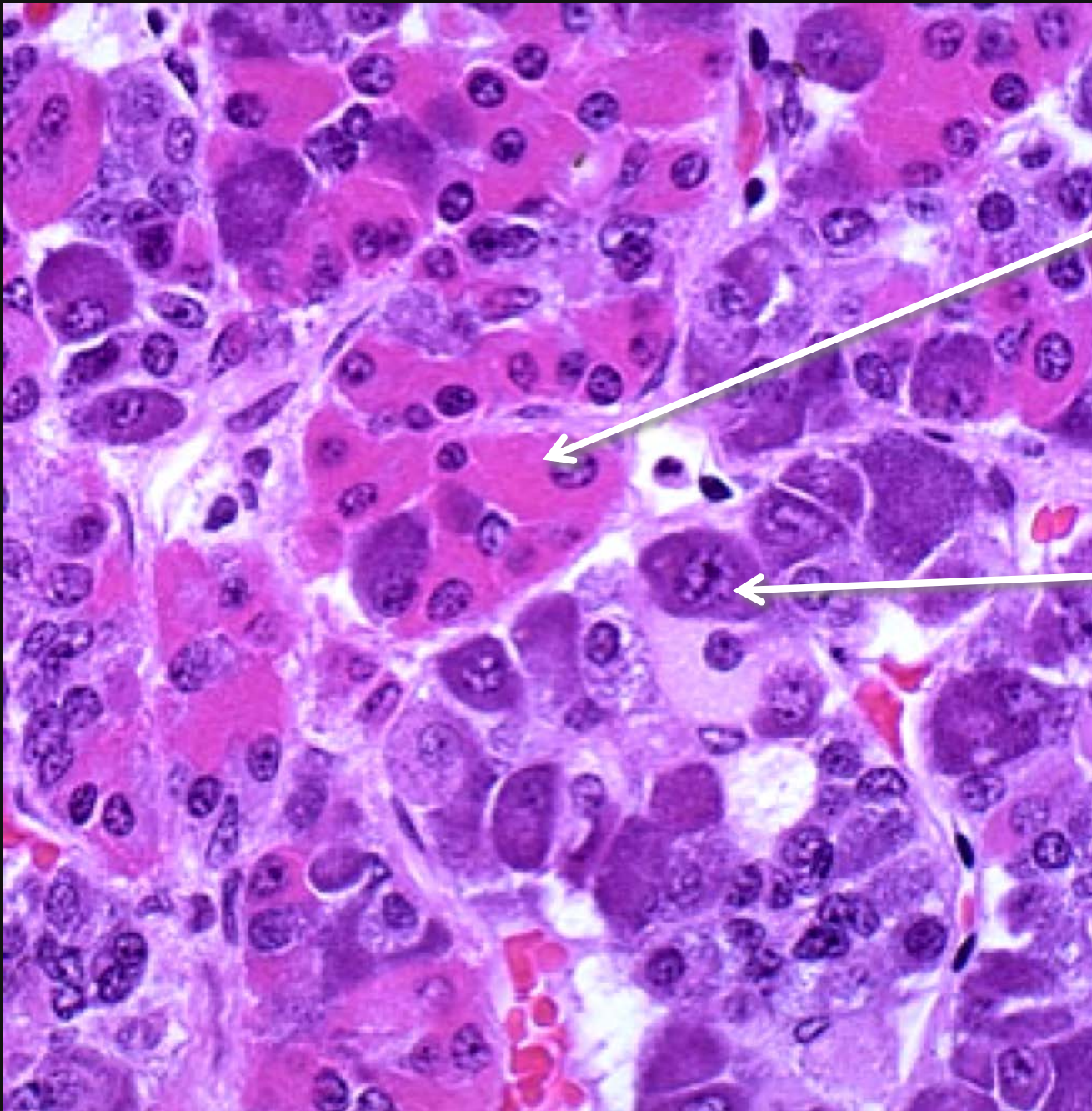
Anterior pituitary makes and secretes:

- Growth hormone (GH)
- Prolactin (PL)
- Follicle-stimulating hormone (FSH)
- Luteinizing hormone (LH)
- Adrenocorticotrophic hormone (ACTH)
- Thyroid stimulating hormone (TSH)

# ROS\* of Anterior Pituitary Hormones

Hormone	Stimulates
GH	Growth of bones and many other functions
PL	Milk secretion
FSH	Females: ovarian follicle development Males: spermatogenesis
LH	Females: ovarian follicle development Males: testicular hormone secretion
ACTH	Secretion of hormones of the adrenal cortex
TSH	Secretion of thyroid hormone

\* Ridiculously Oversimplified Summary



Acidophils

GH

PL

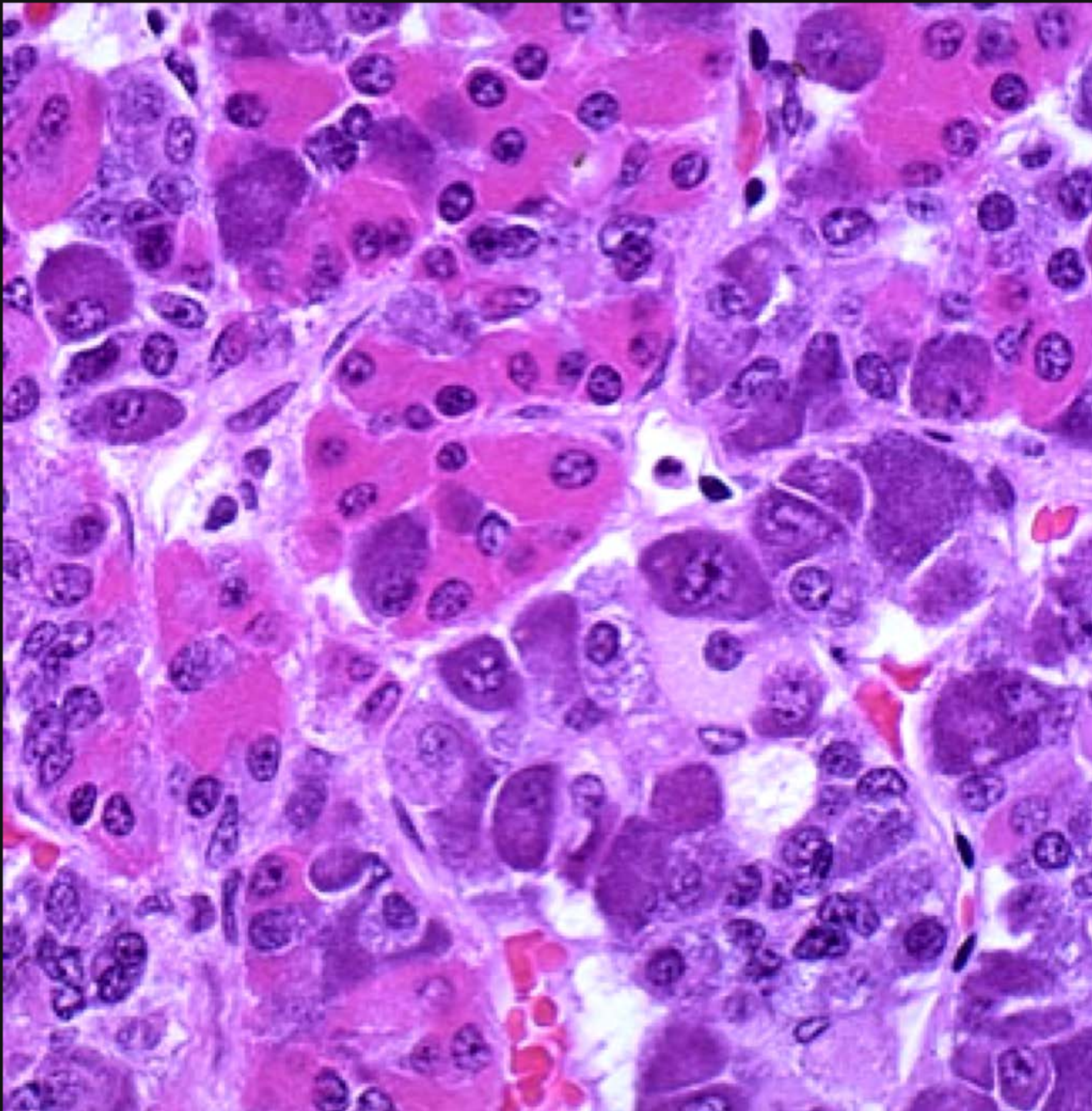
Basophils

FSH

LH

ACTH

TSH



Acidophils

GH

PL

Basophils

FSH

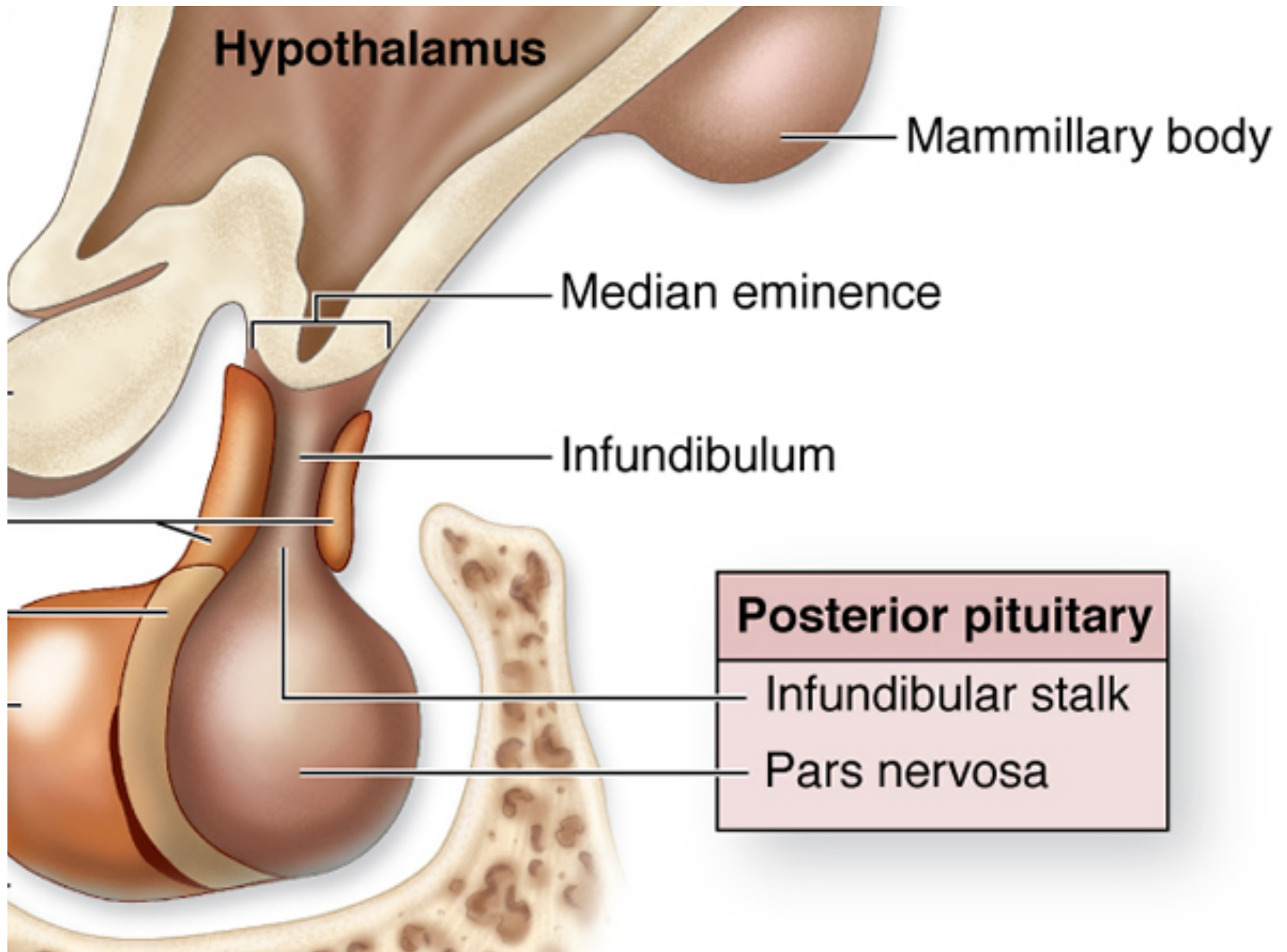
LH

ACTH

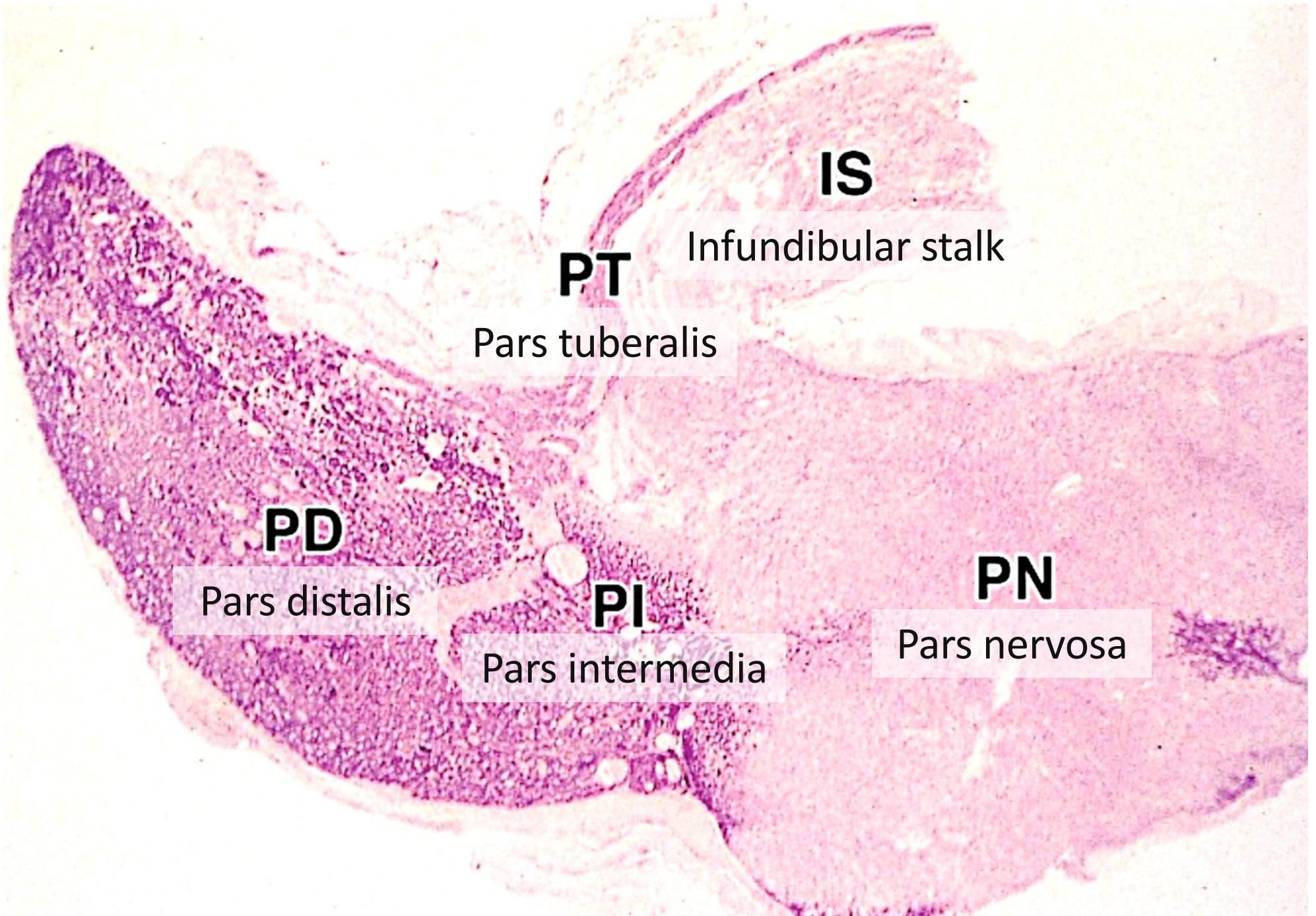
TSH

# Posterior Pituitary (Neurohypophysis)

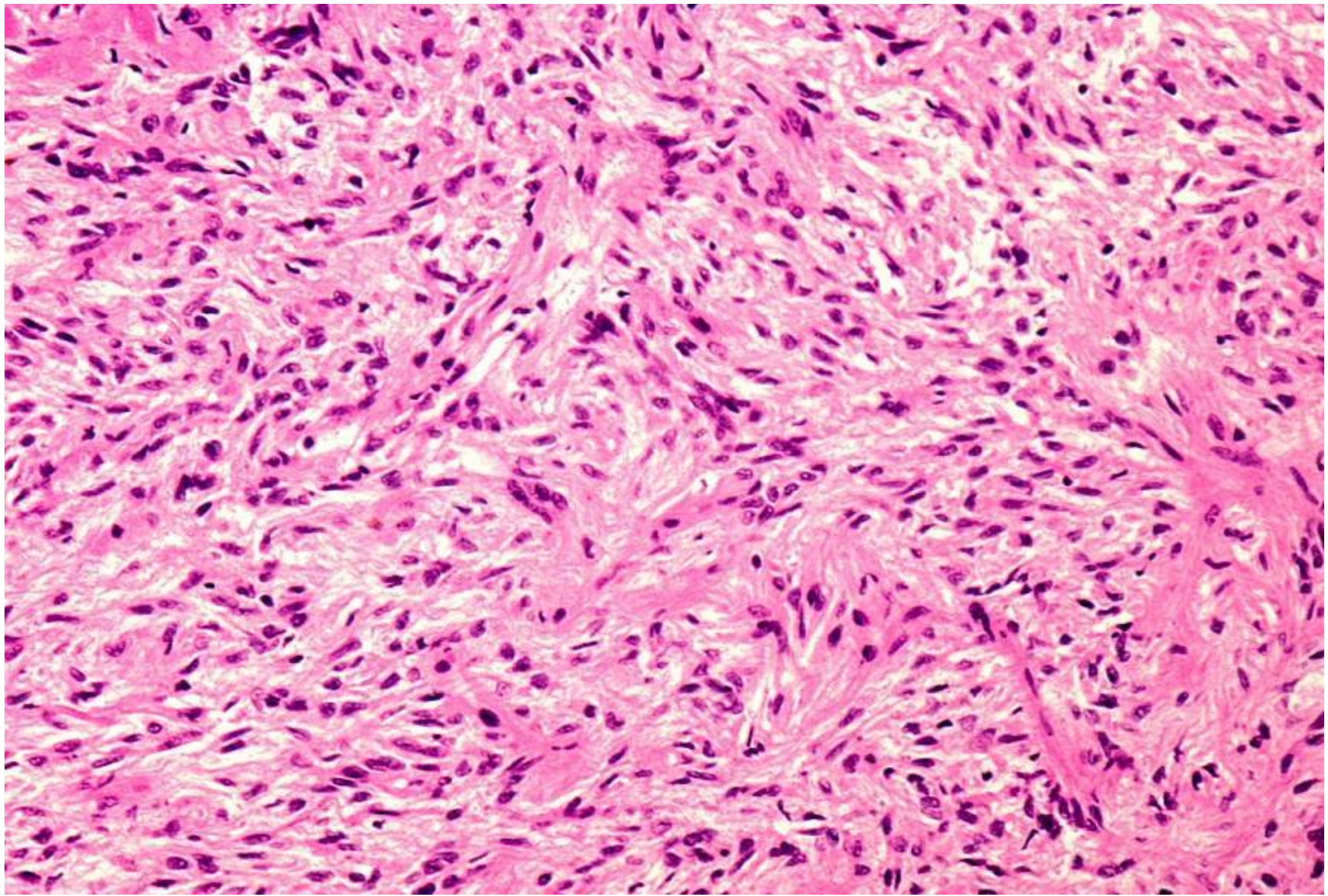
- Composed of neural tissue (mostly axons).
- Subdivisions
  - Pars nervosa (biggest and most important part)
  - Median eminence (floor of the hypothalamus)
  - Infundibulum and infundibular stalk (axons traveling from hypothalamus to pars nervosa)



Posterior pituitary

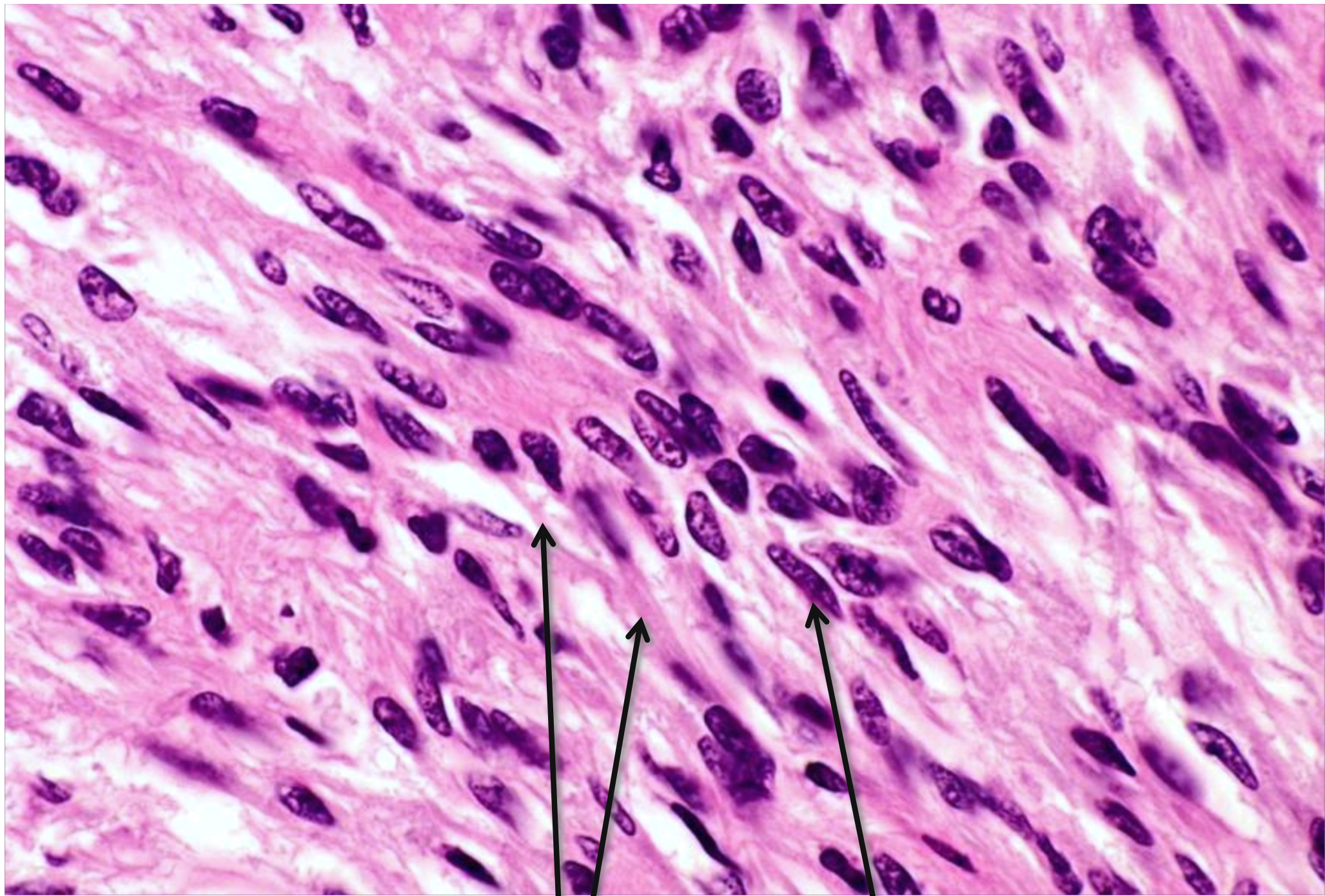


Pituitary: super low-power view



Posterior pituitary

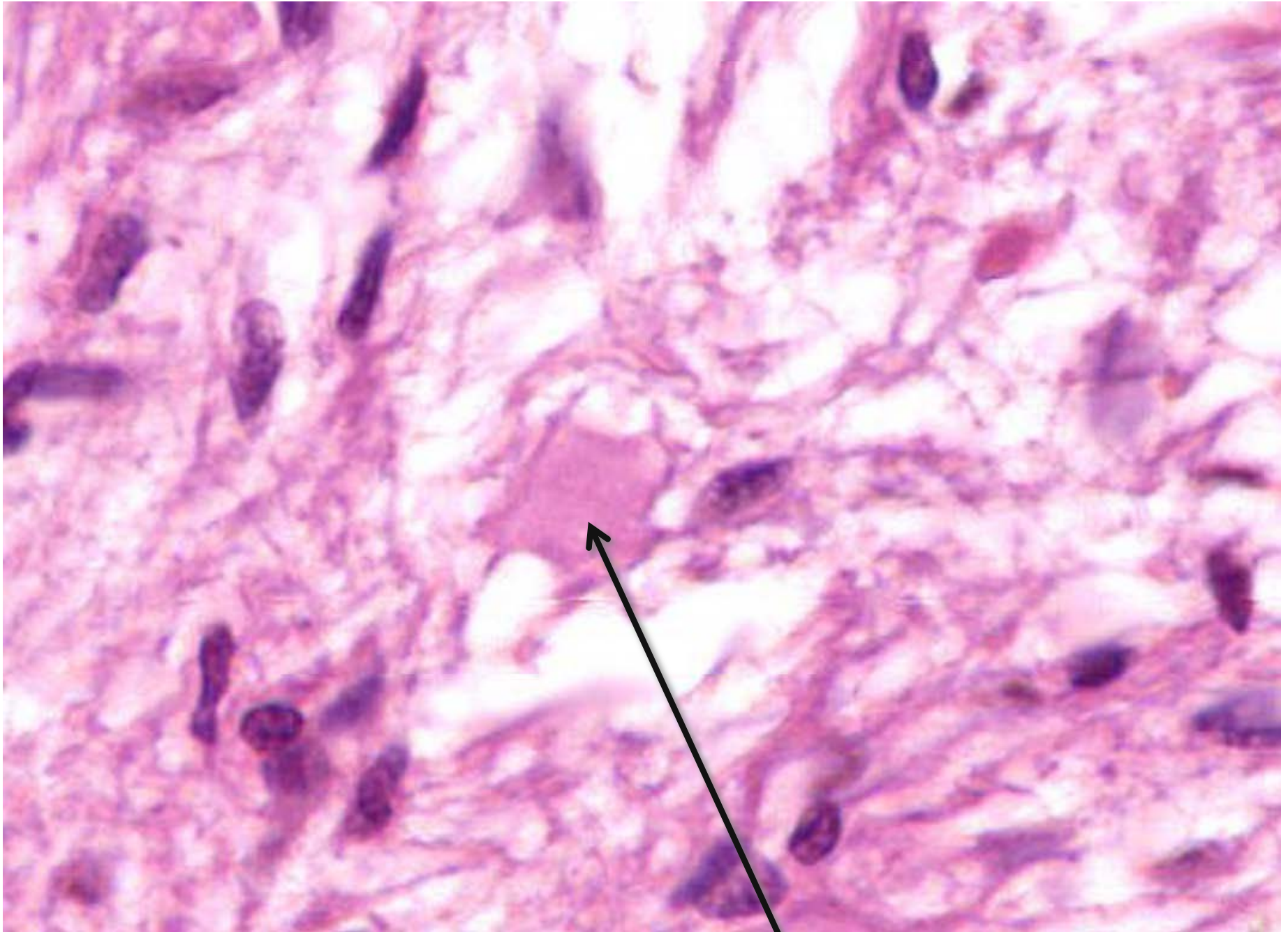




Posterior pituitary: axons and pituicytes (glial cells)

# Hormones of the Posterior Pituitary

- Posterior pituitary doesn't make hormones! It secretes hormones made by the hypothalamus.
- Herring bodies are dilated portions of axons containing with hormone-filled vesicles.
- Hormones:
  - Antidiuretic hormone (ADH)  
(also called vasopressin)
  - Oxytocin



Posterior pituitary: Herring body

# BAHS\* of Posterior Pituitary Hormones

Hormone	Stimulates
Antidiuretic hormone	Water reabsorption in the kidney
Oxytocin	Contraction of uterine smooth muscle in labor. Contraction of breast cells to allow milk let down.

\* Boring as heck summary

# VIS\* of Oxytocin

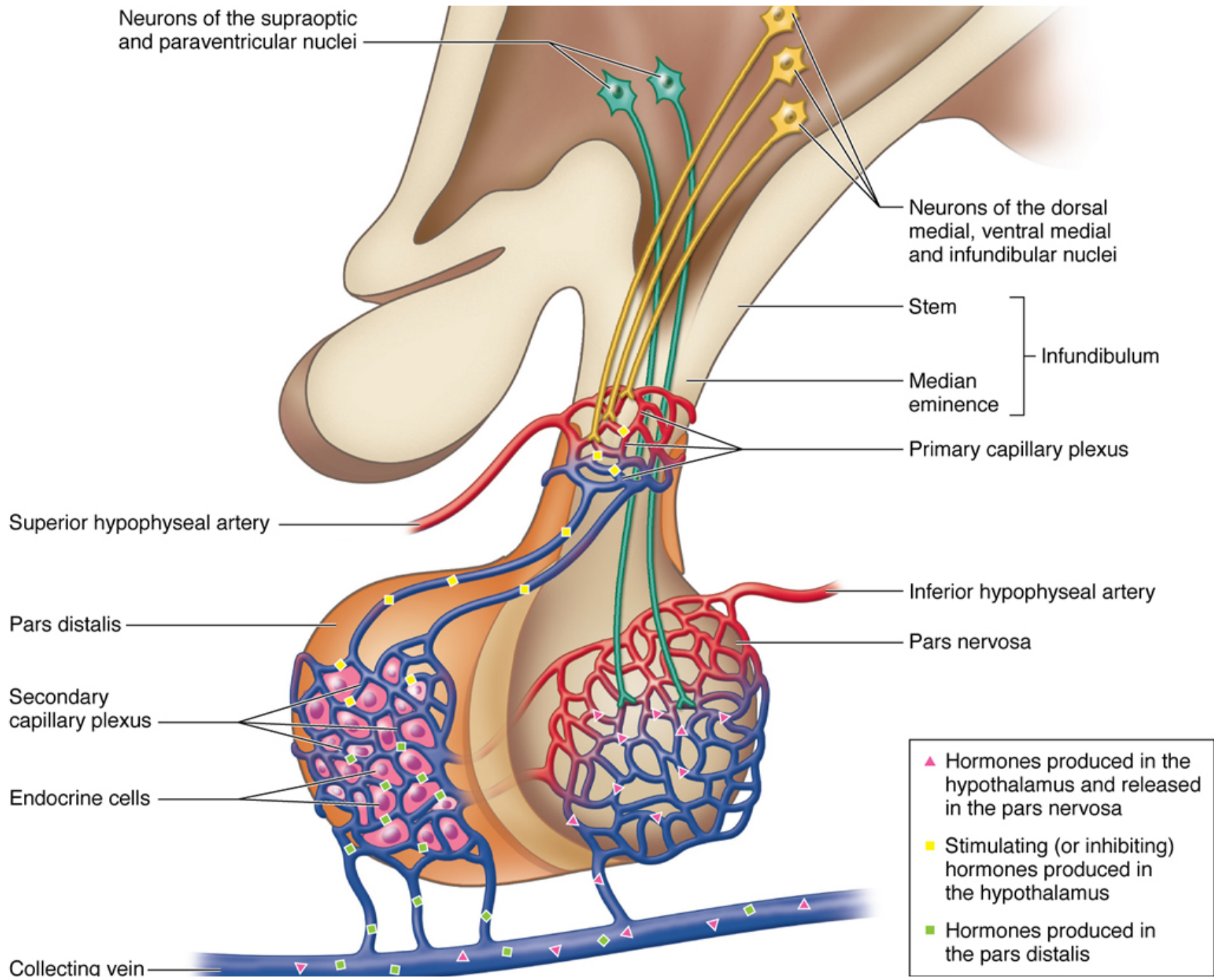
Situation	Stimulates
Interpersonal connection	Trust
Orgasm	Pleasure AND connection with that particular person
Intimate relationship	Monogamy
Sports teams	Better performance

\* Very interesting summary



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# Hypothalamo-hypophyseal portal system

# Control of the Anterior Pituitary

## Hypothalamus

The hypothalamus produces and releases hormones that stimulate or (less commonly) inhibit hormone secretion from the anterior pituitary.

## Target organs

Hormones produced by target organs exert negative feedback on both the hypothalamus and the anterior pituitary. Too much hormone turns off production/secretion for a while. Nice!

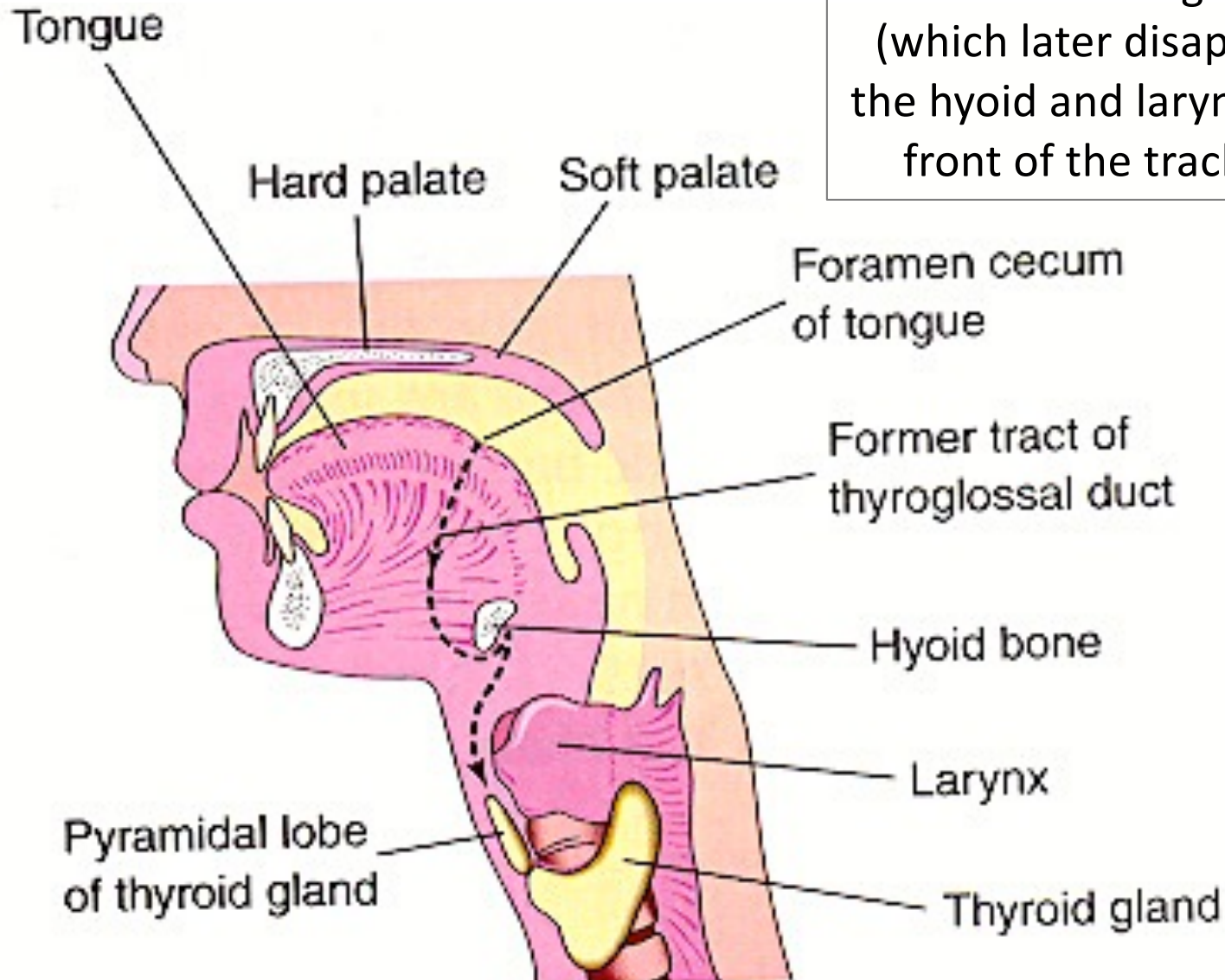


# Endocrine System Lecture Outline

- Introduction
- Pituitary
- Thyroid

# Development of the Thyroid Gland

Originates from foramen cecum; descends along thyroglossal duct (which later disappears), in front of the hyoid and larynx, to its position in front of the trachea (by week 7).



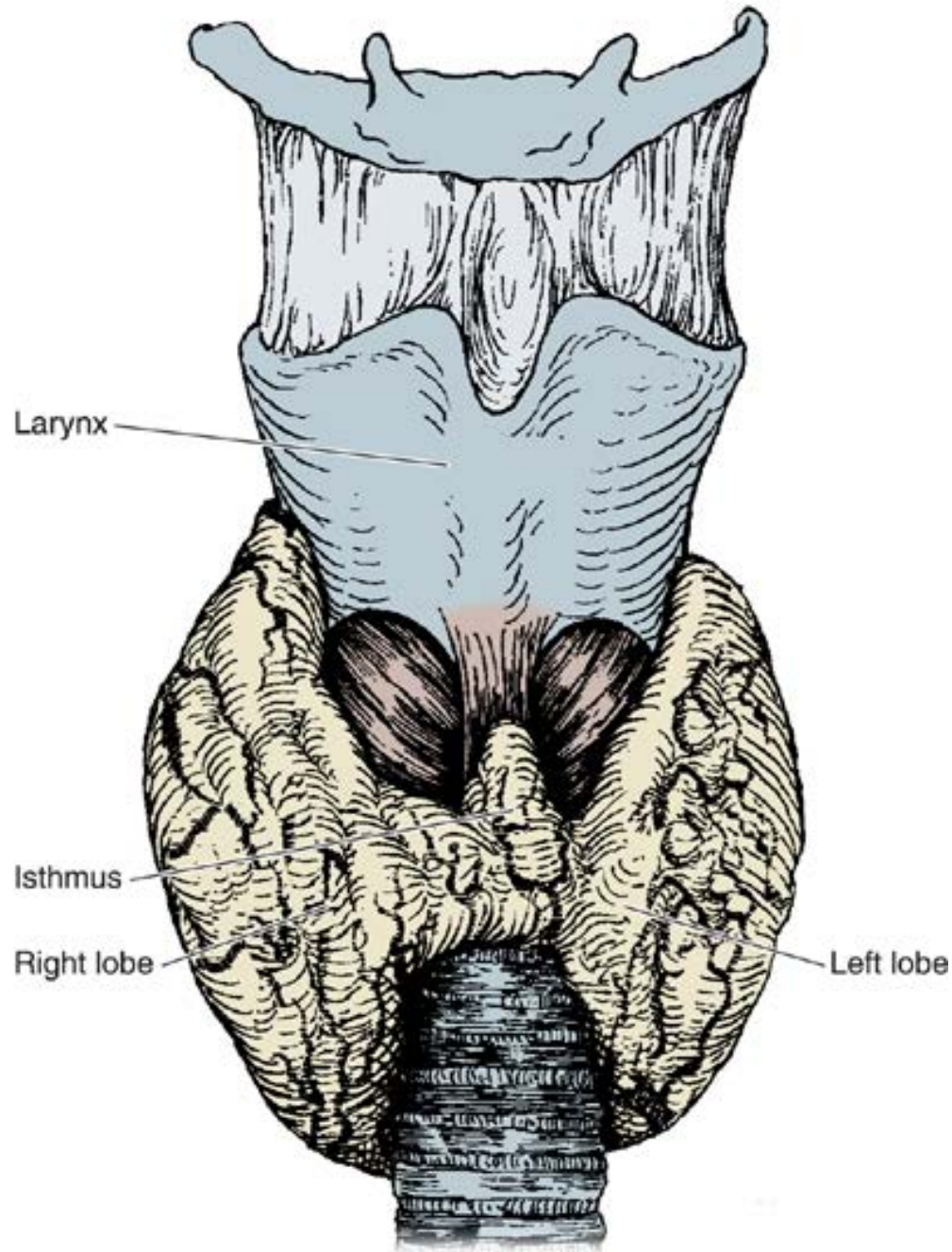


Thyroglossal duct cyst

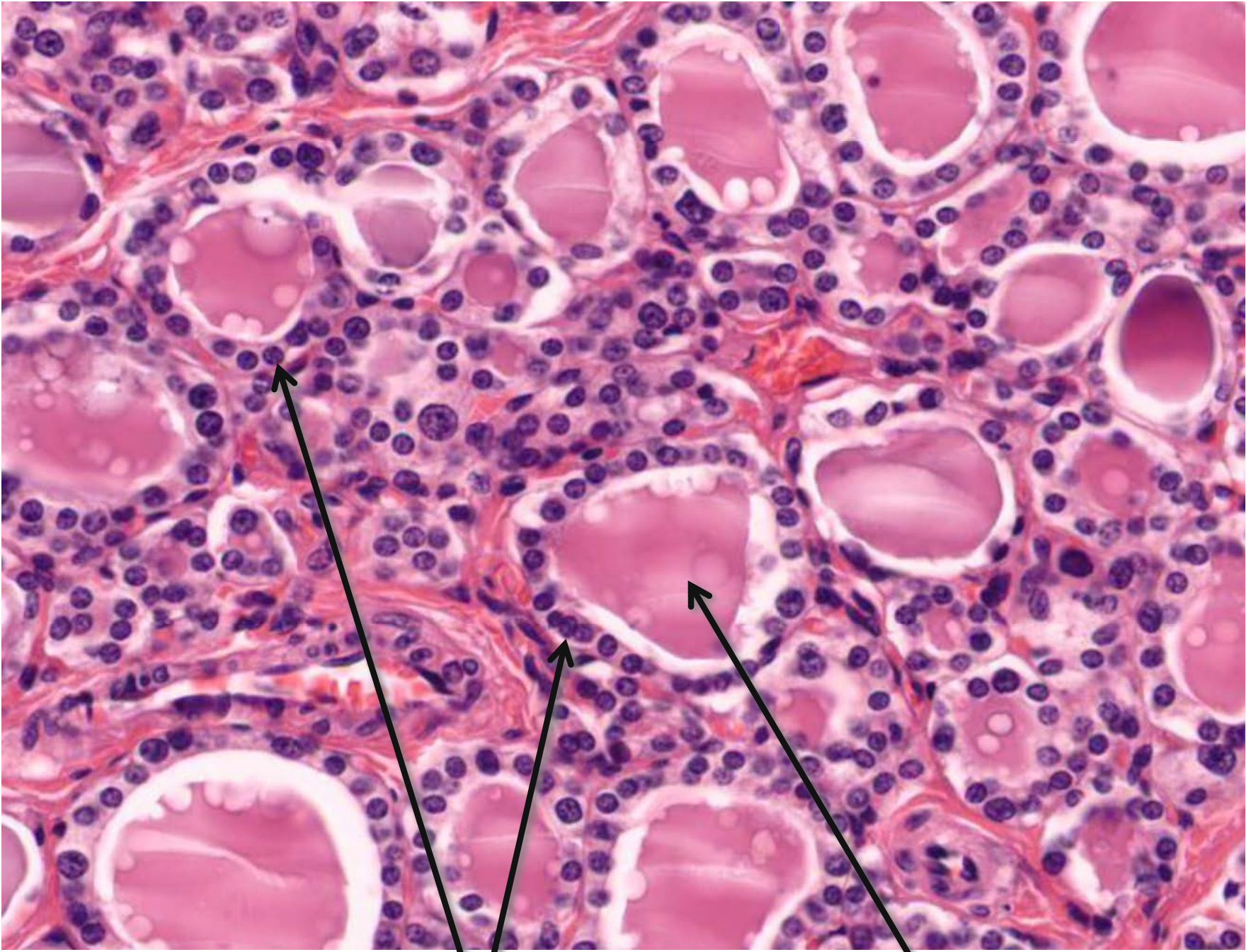


Lingual thyroid

## Developmental abnormalities of the thyroid



Thyroid gland gross anatomy

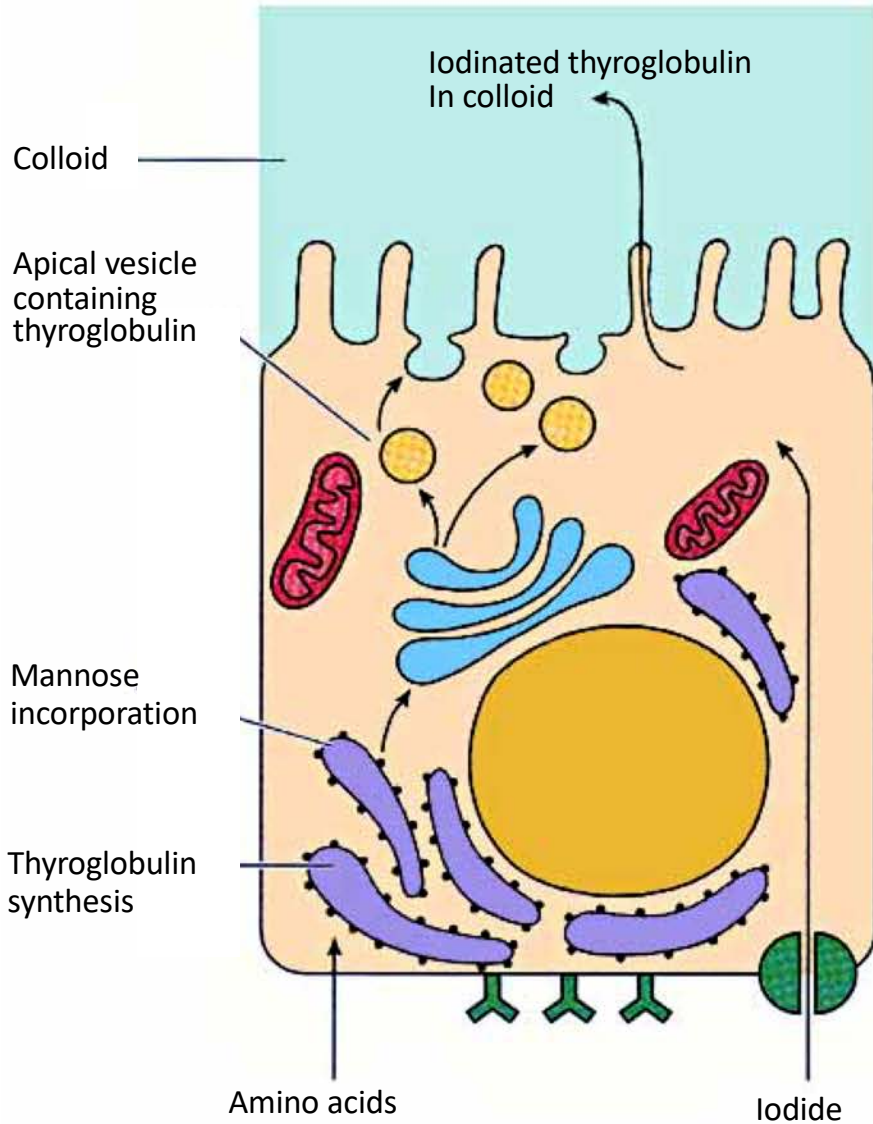


Thyroid follicles containing colloid

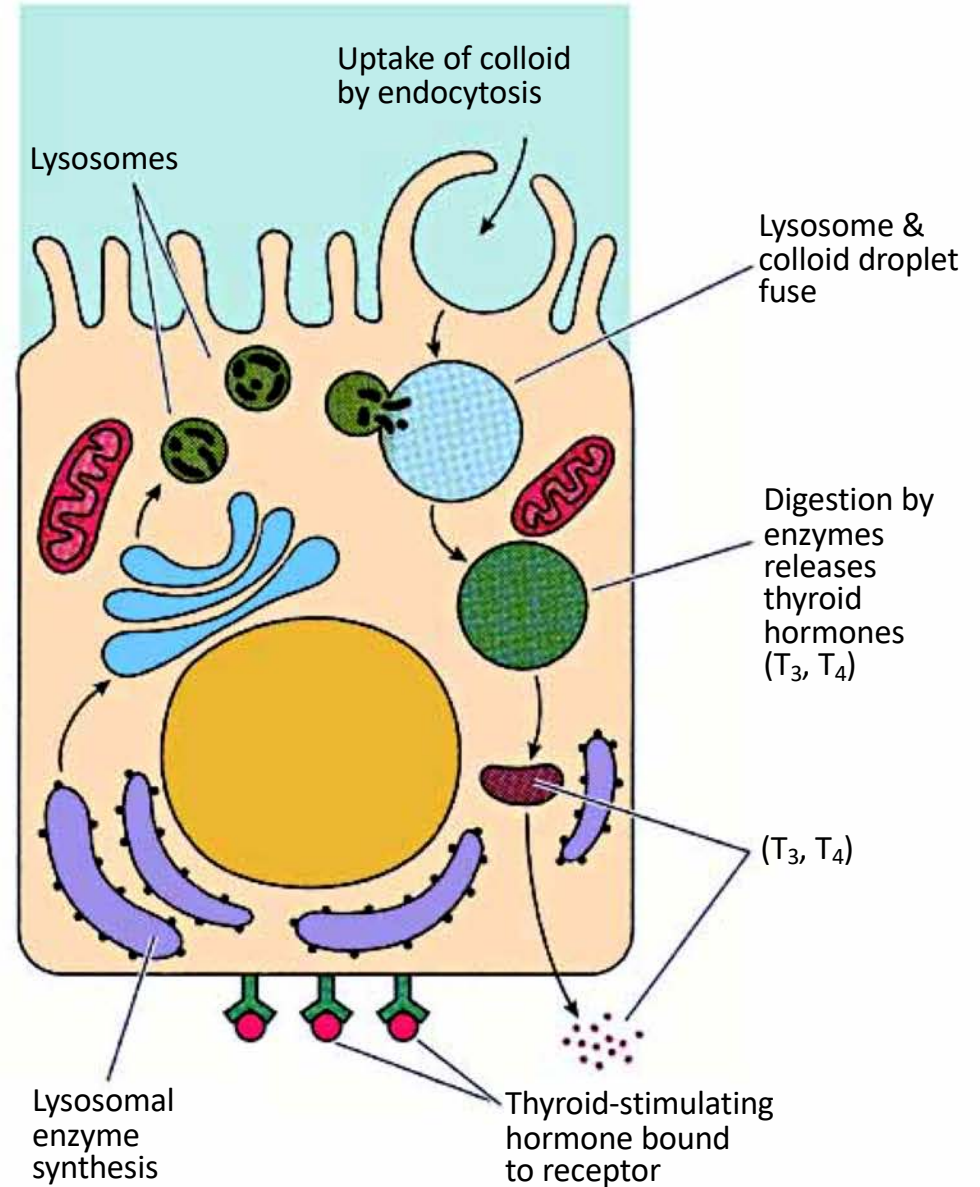
# Thyroid Gland

- Composed of round follicles lined by simple squamous to cuboidal epithelium and filled with colloid.
- Follicular cells synthesize thyroid hormones (T3 and T4) and secrete them into the blood.
- Hypothalamus releases TRH (thyrotropin releasing hormone), which makes pituitary release TSH (thyroid stimulating hormone), which makes thyroid release thyroid hormone.

## Synthesis and Iodination of Thyroglobulin



## Release of Thyroid Hormone



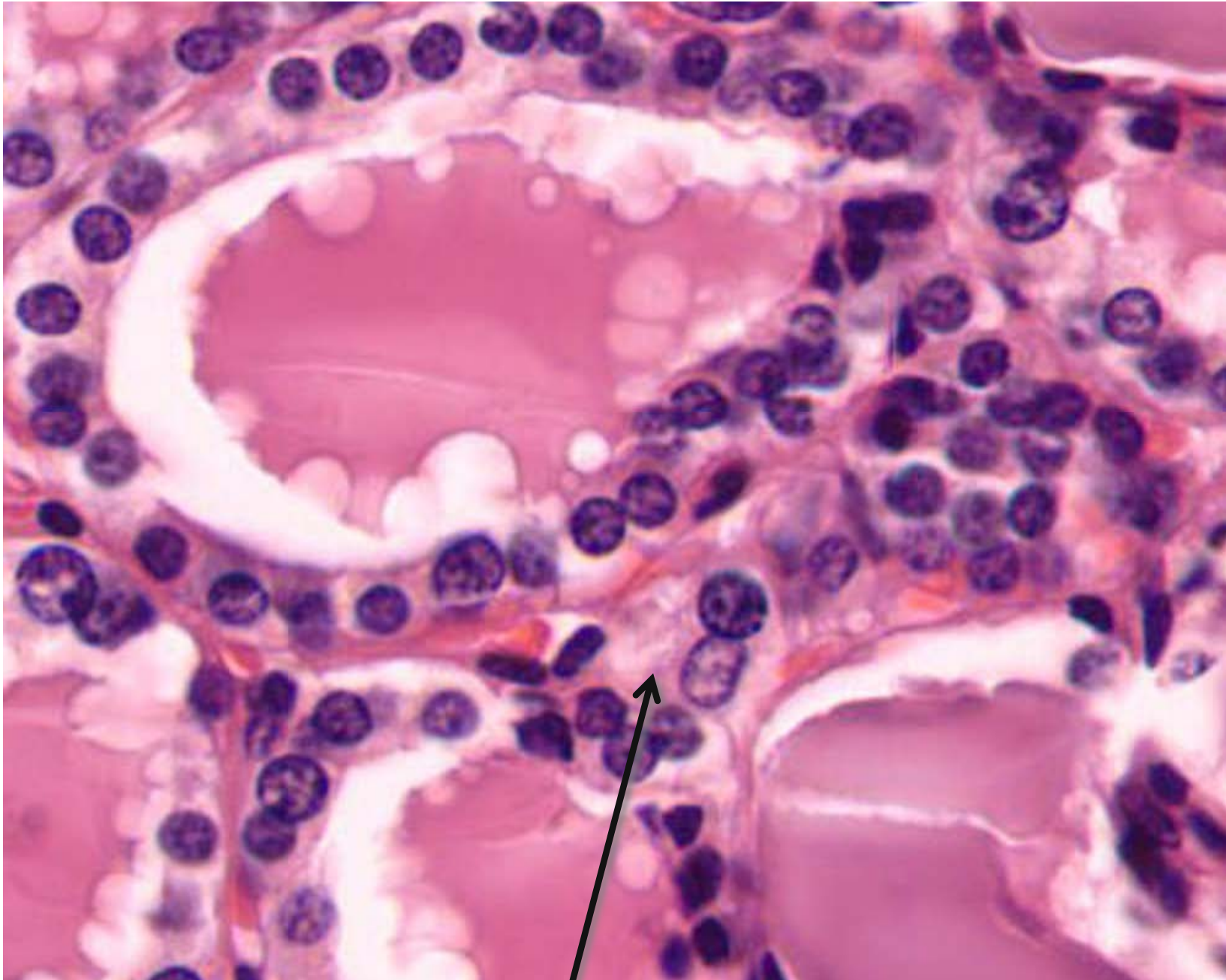
# What Does Thyroid Hormone Do?

- Quick answer: increase growth and metabolism.
- More detailed answer: stimulate mitochondrial protein synthesis, increase absorption of carbohydrates, regulate fat metabolism, promote cell growth.
- Bottom line: it increases basal metabolic rate and revs up most bodily functions (increases heart rate, raises body temperature, increases nervous reactivity, increases GI motility...the list goes on).



## Parafollicular Cells (C Cells)

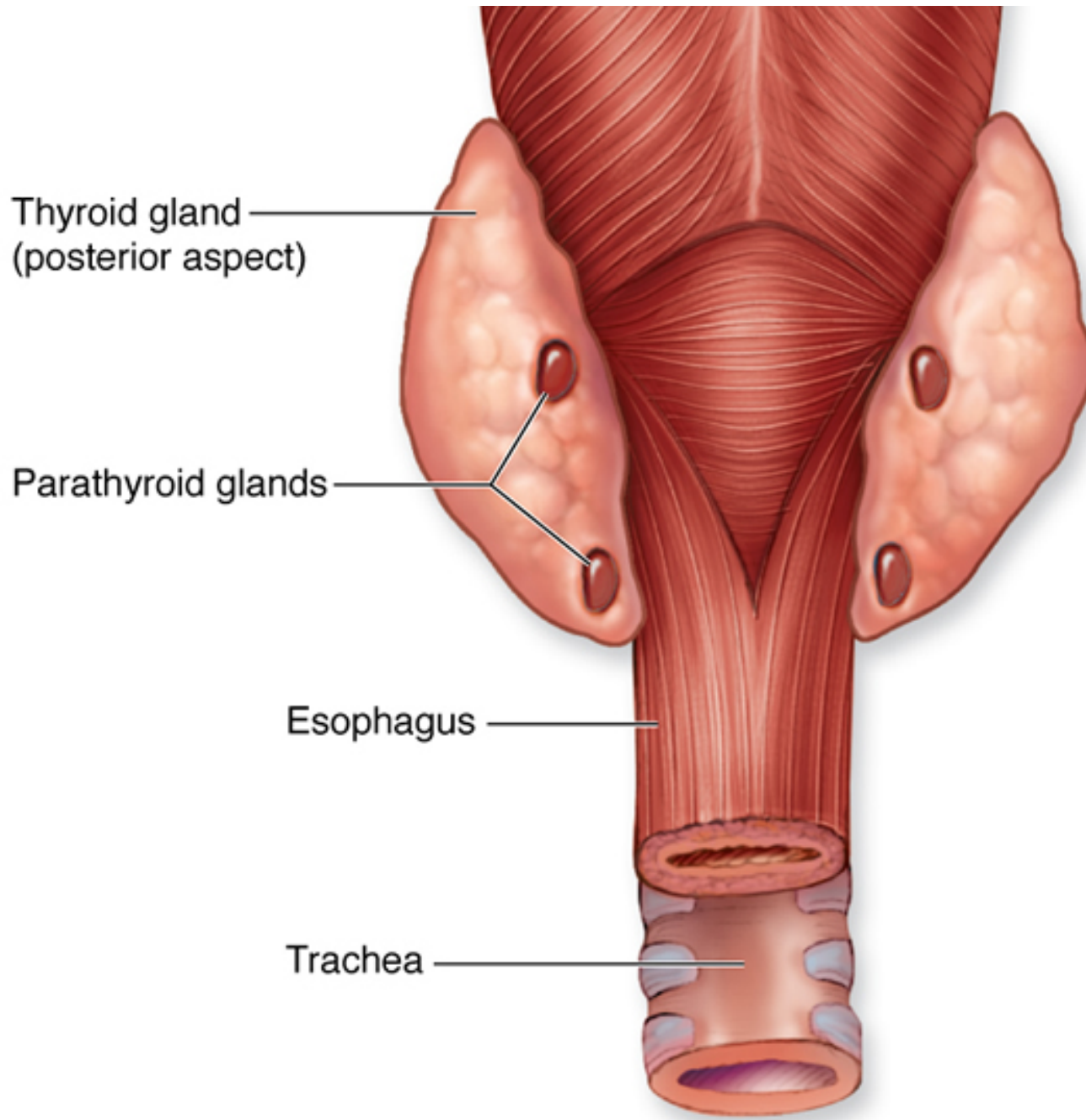
- Derived from neural crest ectoderm.
- Located between follicular cells and between follicles.
- Parafollicular cells are larger cells with clear cytoplasm and small secretory granules containing calcitonin.
- Calcitonin is made in response to high blood calcium (it's not regulated by the pituitary!).
- Calcitonin lowers blood calcium levels by inhibiting osteoclastic resorption.



Parafollicular (C) cell

# Endocrine System Lecture Outline

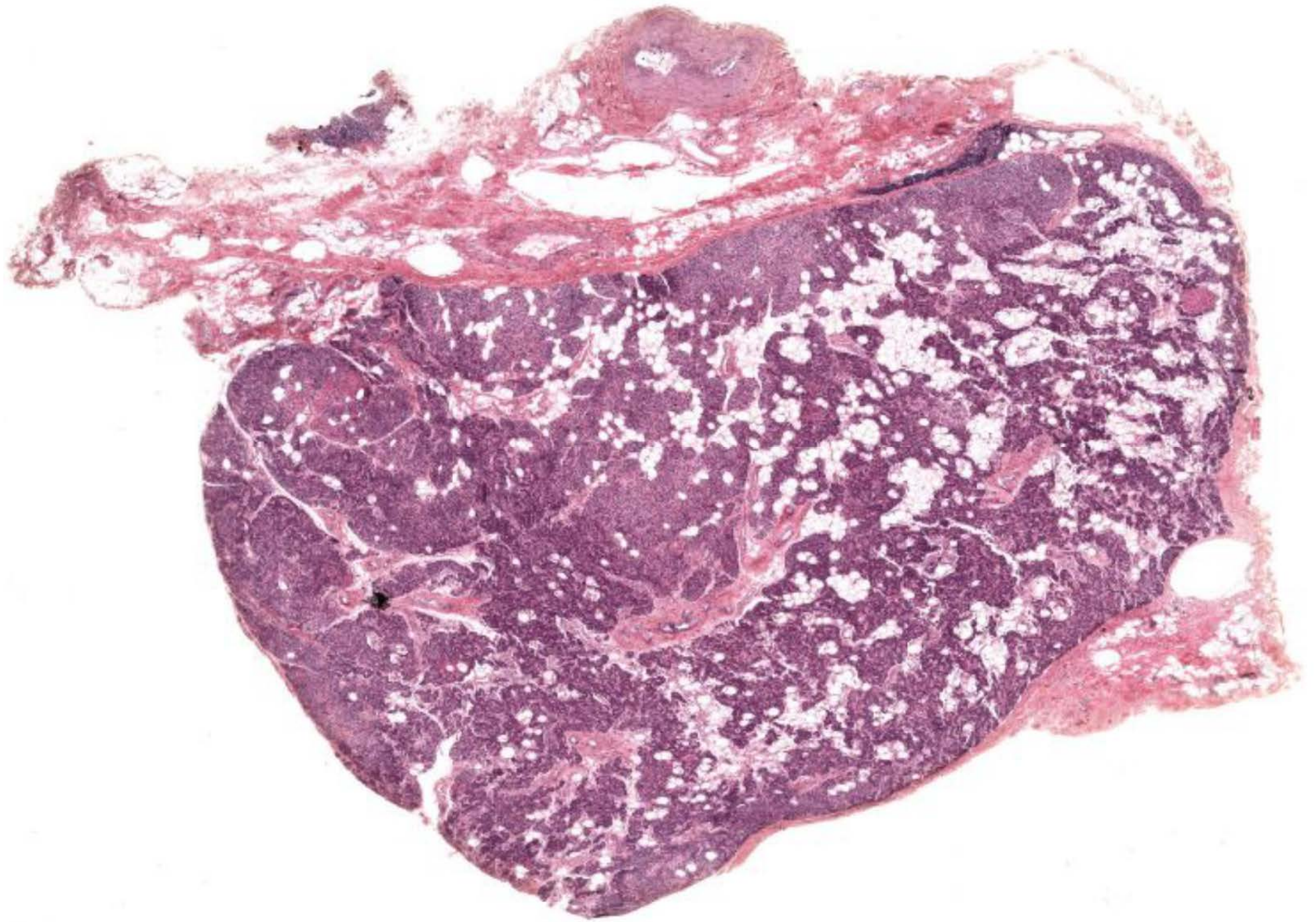
- Introduction
- Pituitary
- Thyroid
- Parathyroid



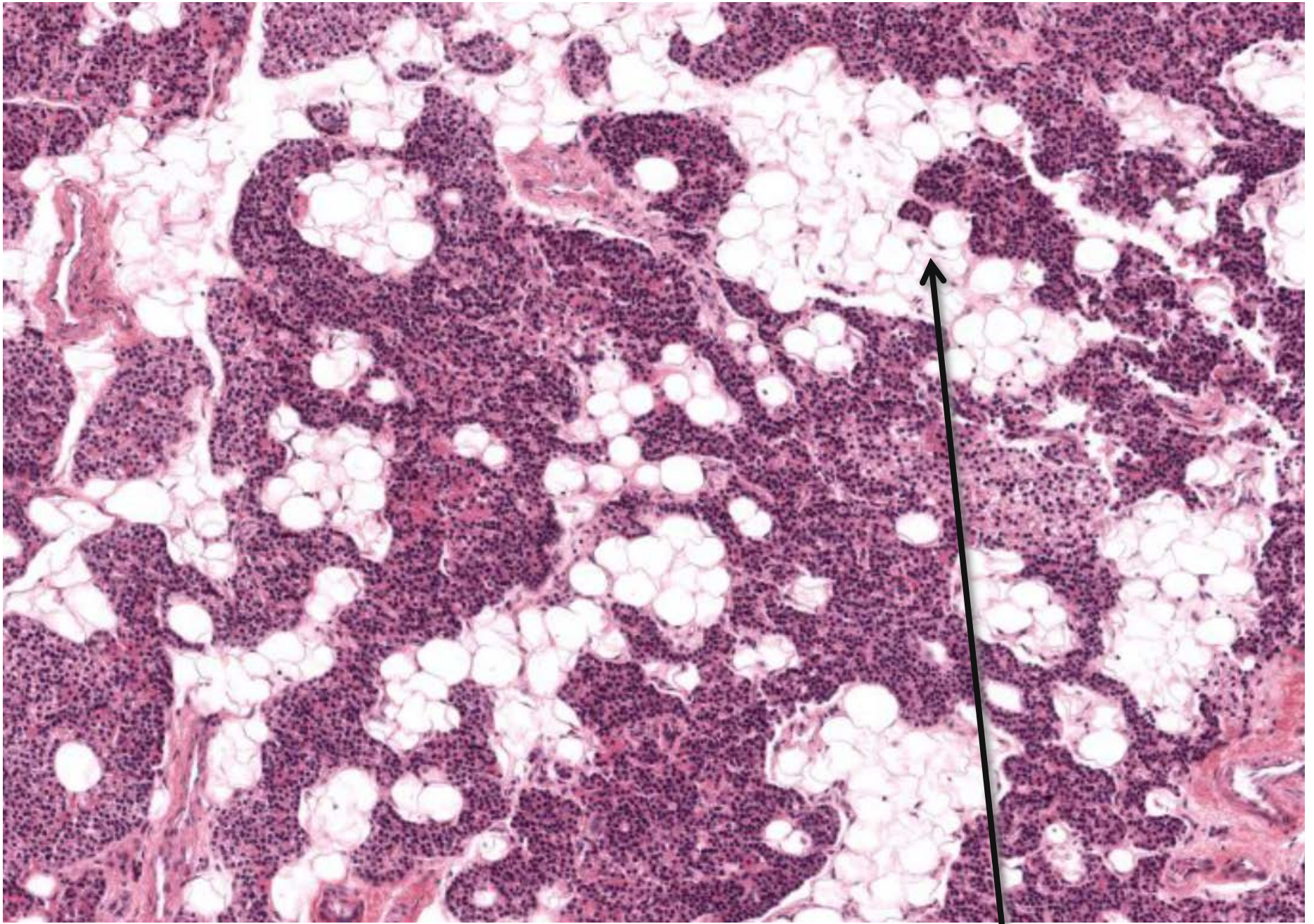
Parathyroid glands gross anatomy

# Parathyroid Glands

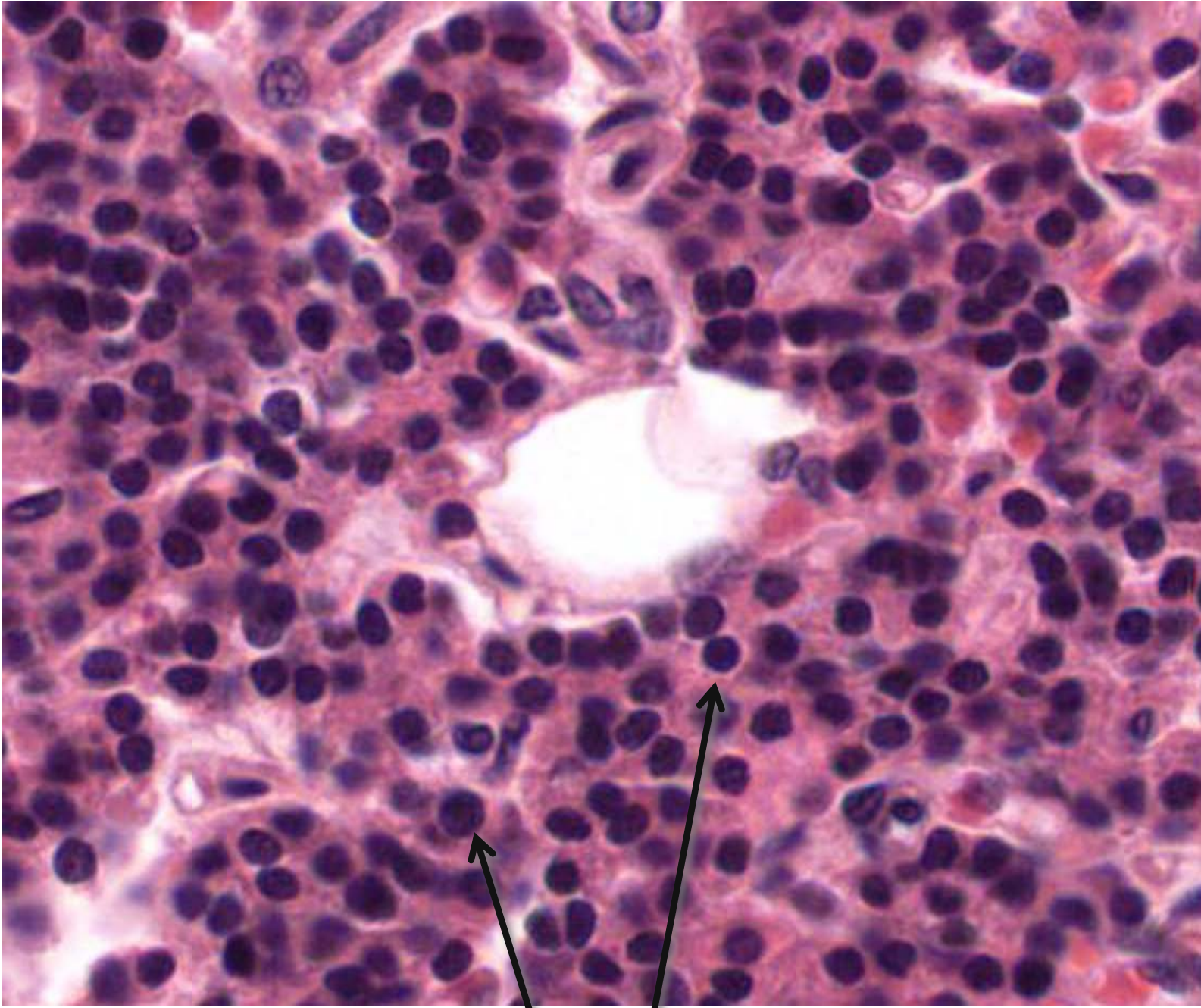
- Four glands on posterior surface of thyroid.
- Main function: secrete parathyroid hormone (PTH) to regulate calcium levels.
- PTH raises calcium levels in response to low serum calcium (it's not regulated by the pituitary!).
- Two main cell types: chief cells (secrete PTH) and oxyphils (function unknown).



Parathyroid gland: super low-power view

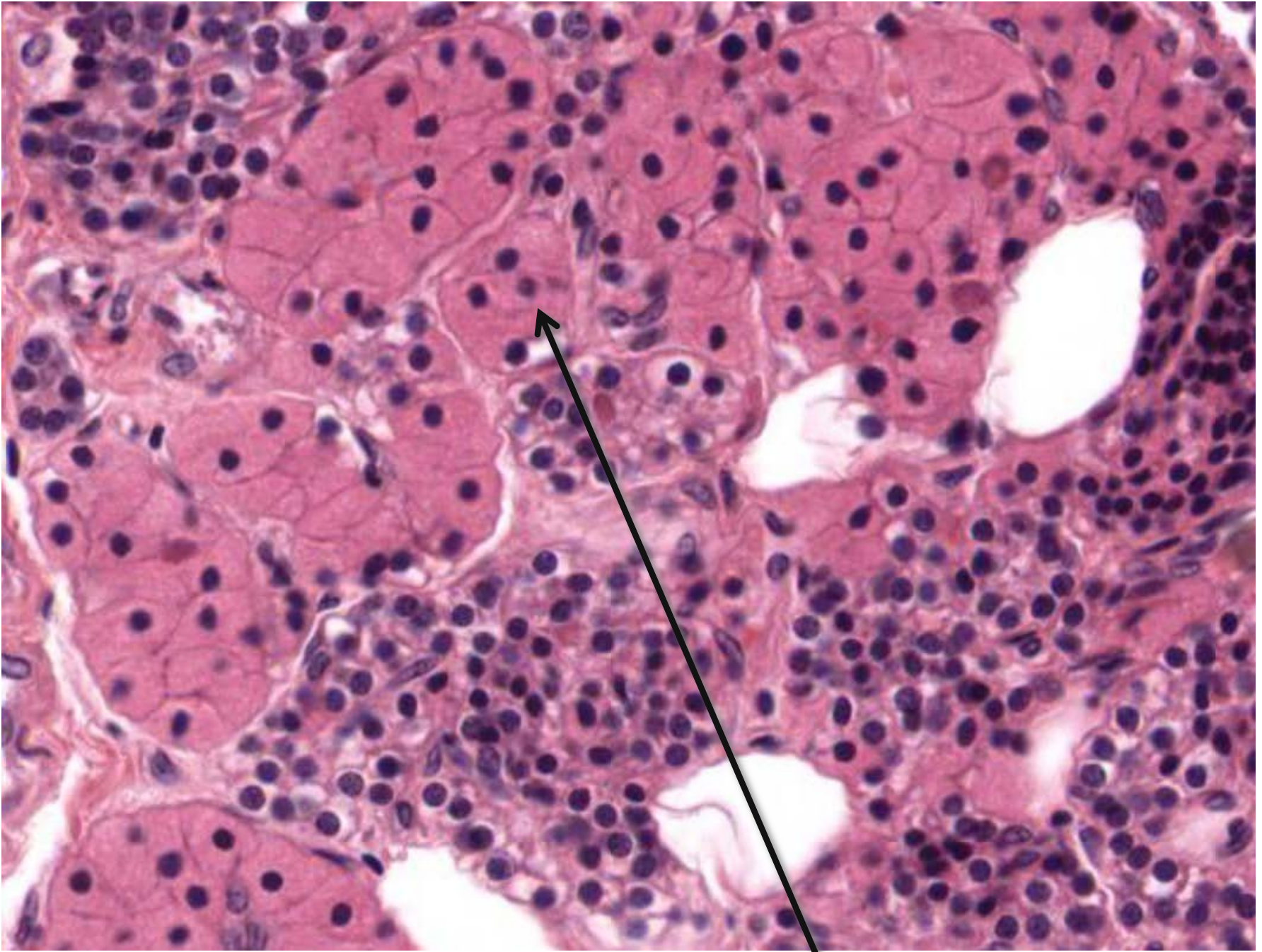


Parathyroid gland: adipose tissue



Parathyroid gland: chief cells

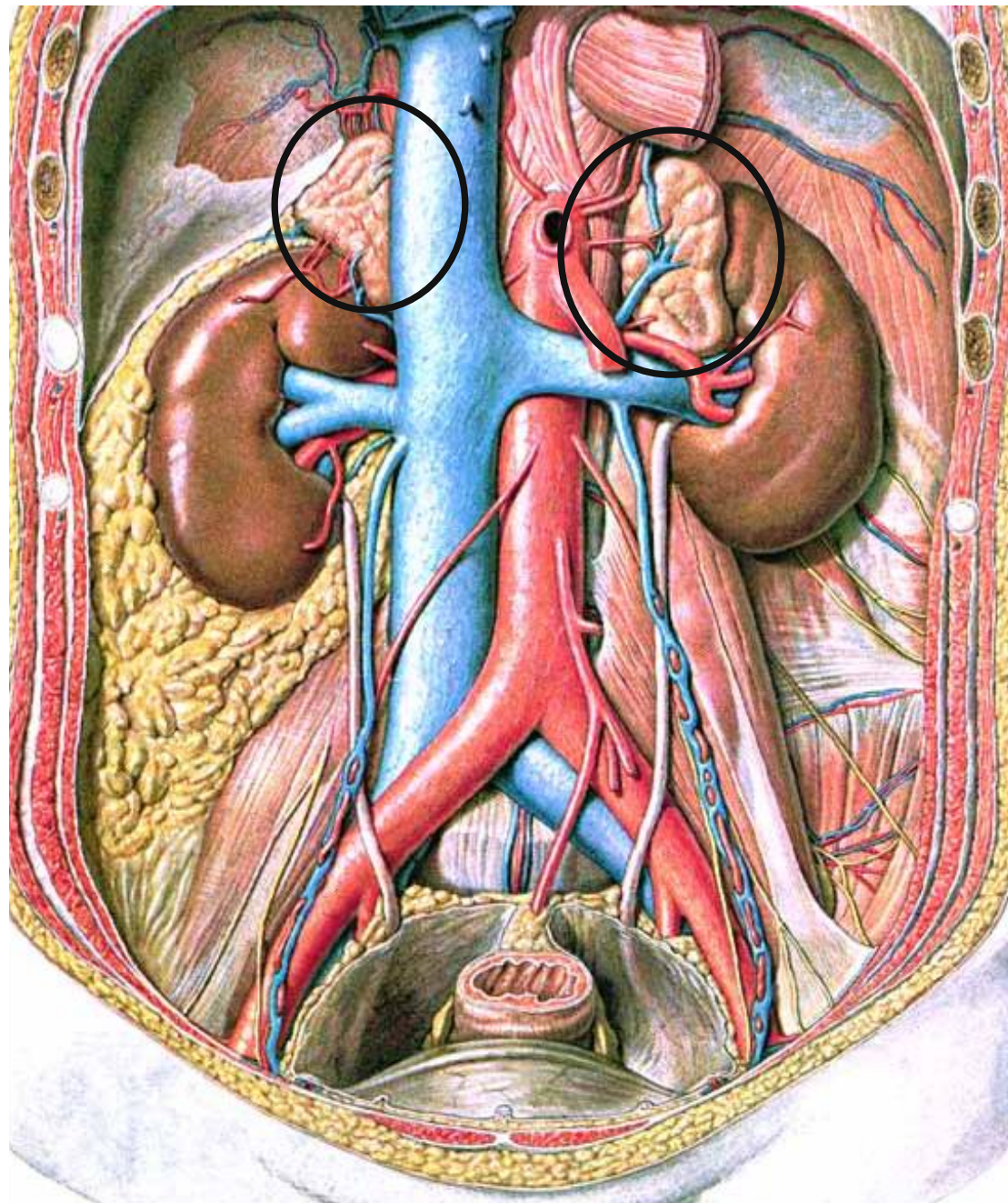




Parathyroid gland: oxyphil cells

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- Adrenal



Adrenal gland gross anatomy

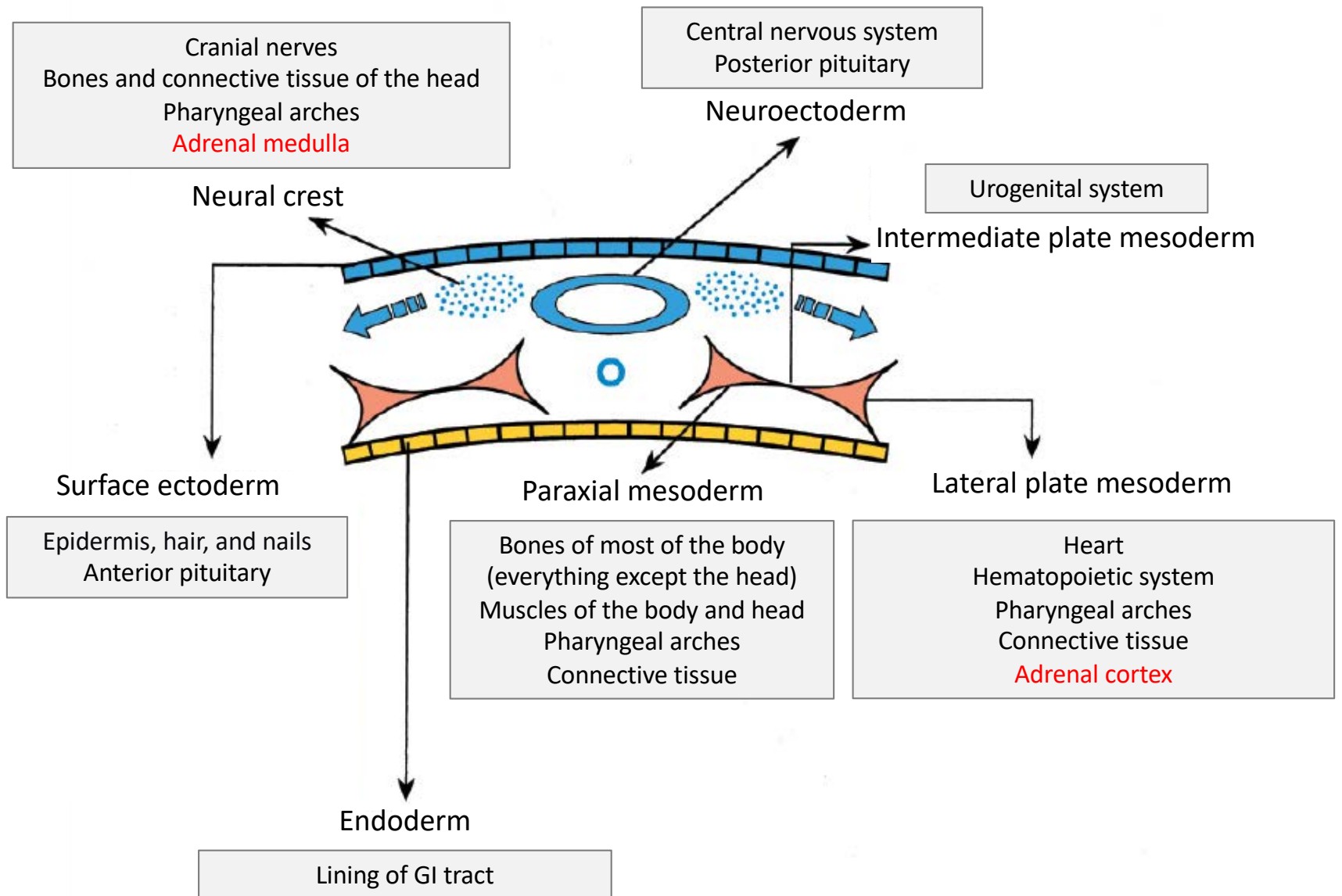
# The Adrenal Cortex and Medulla

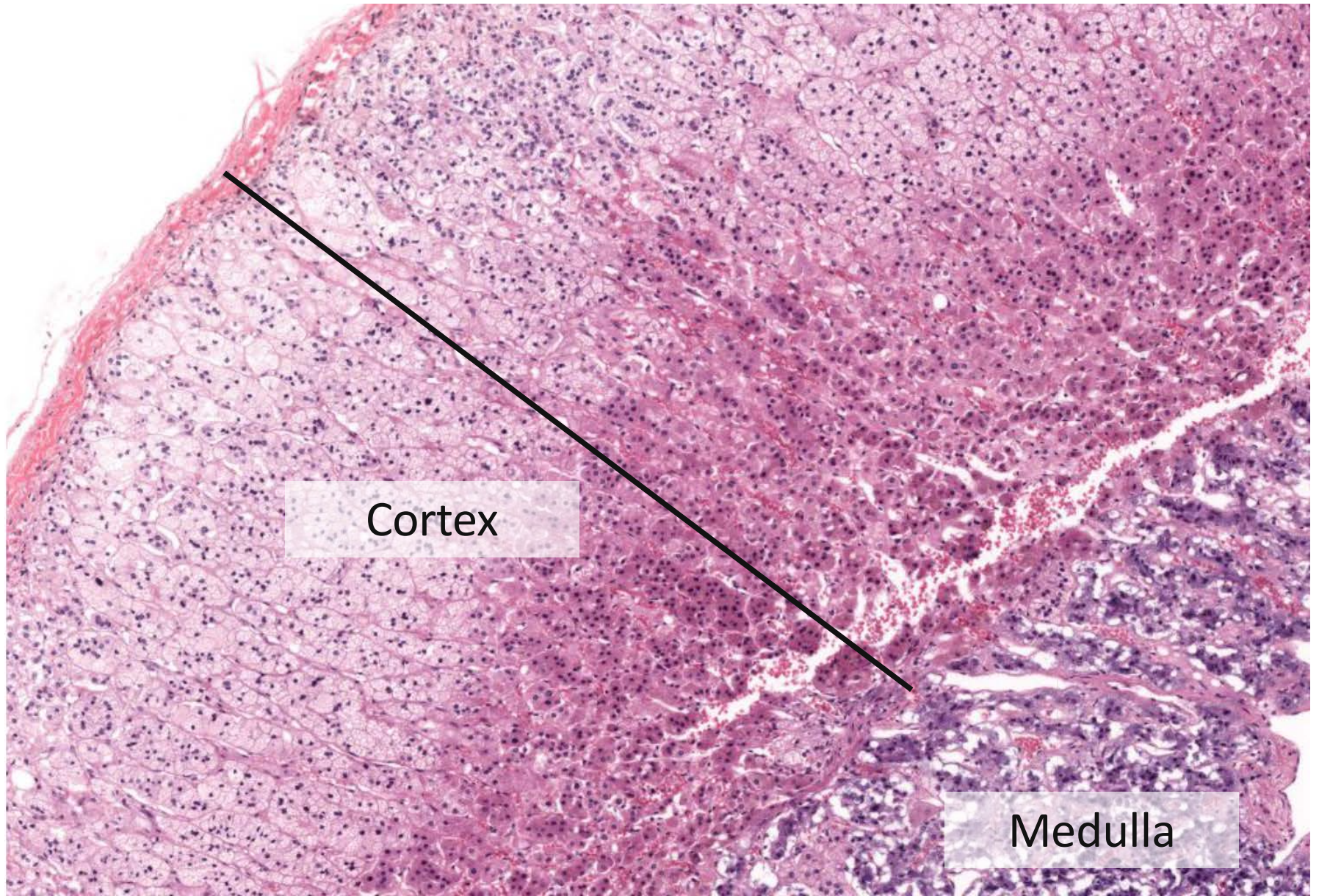
**Adrenal cortex** is on the outside

- Originates from mesoderm
- Produces steroids (mineralocorticoids, glucocorticoids, and sex steroids)

**Adrenal medulla** is on inside

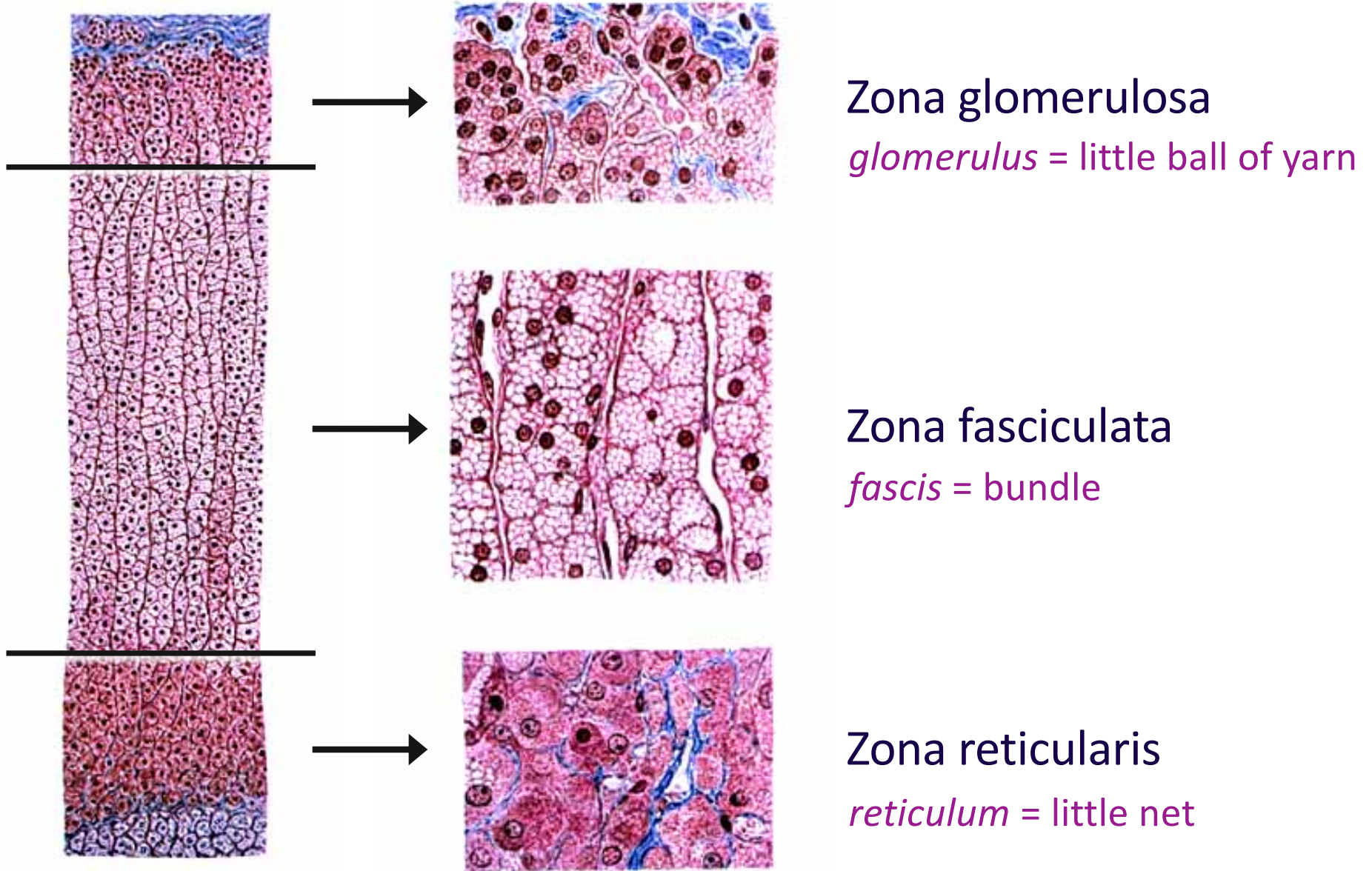
- Originates from neural crest
- Produces epinephrine and norepinephrine





Adrenal gland histology

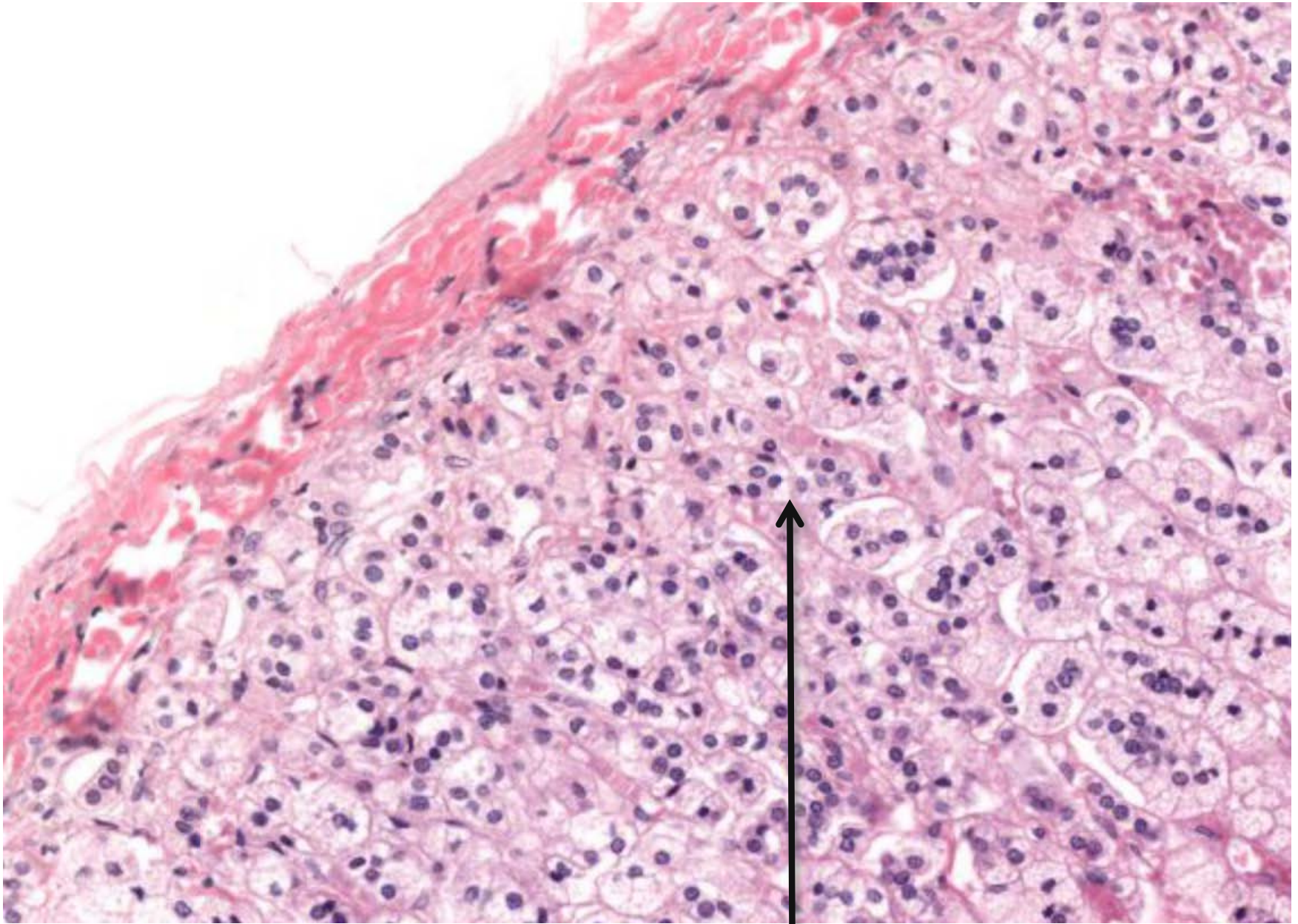
# Zones of the Adrenal Cortex



# Zona Glomerulosa

- Outermost zone. Cells arranged in little clusters.
- Cells produce mineralocorticoids (mostly aldosterone).
- Aldosterone stimulates sodium reabsorption by the kidney (leading to an increase in blood pressure).
- Aldosterone release is stimulated *mostly* by angiotensin II (only *slightly* by ACTH).





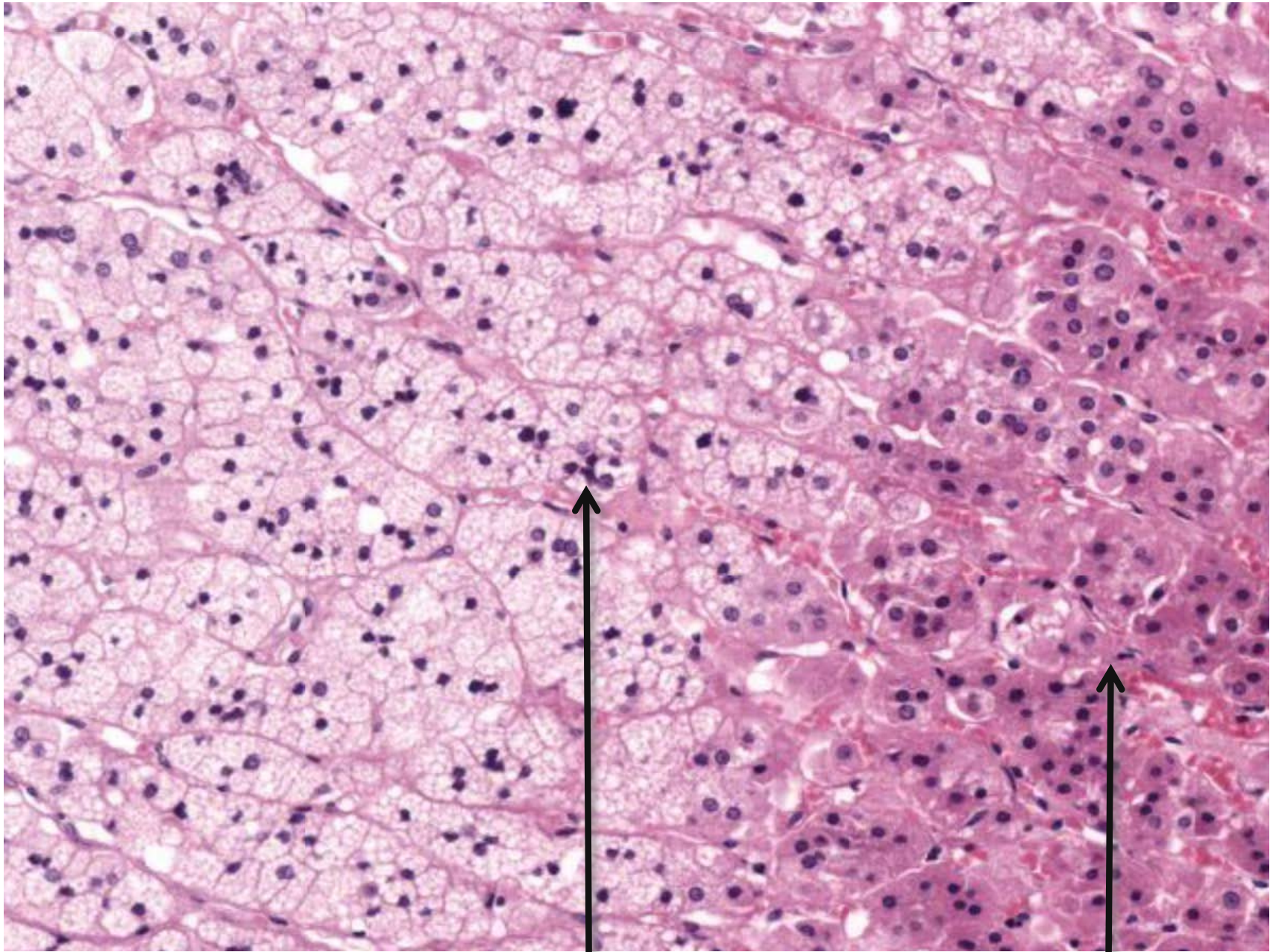
Adrenal cortex: glomerulosa

## Zona Fasciculata

- Middle zone. Cells arranged in straight bundles.
- Cells make glucocorticoids (mostly cortisol), and a small amount of androgens.
- Cortisol is a long-term “stress” hormone
  - Mobilizes resources (increases blood glucose)
  - Shuts down stuff you don't need (digestion, growth, immune response, reproduction)
- Cortisol release is stimulated by ACTH.

# Zona Reticularis

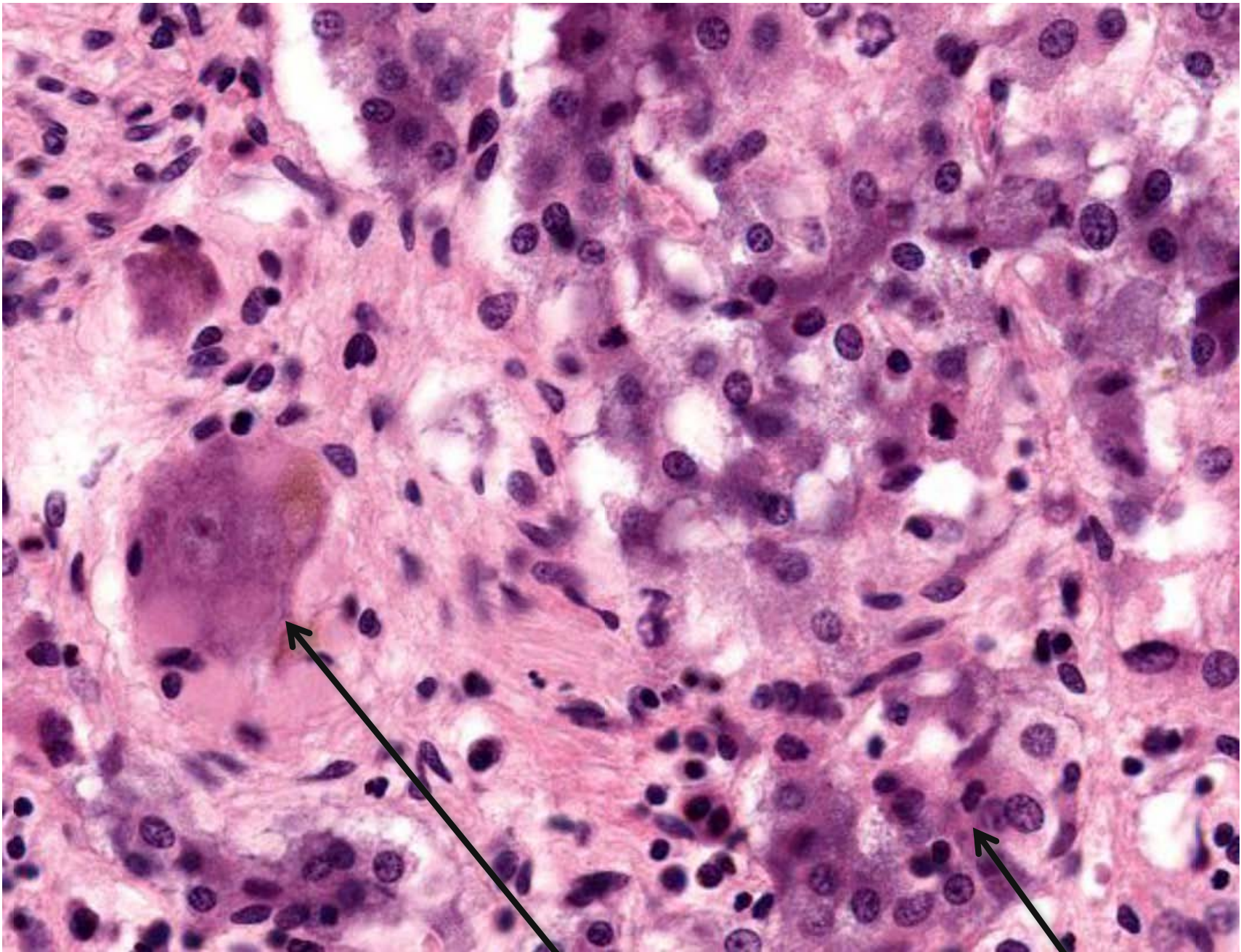
- Innermost zone. Cells form an irregular network.
- Cells make sex steroids (androgens).
- Androgens have weak masculinizing characteristics.
- Androgen release is stimulated by ACTH.



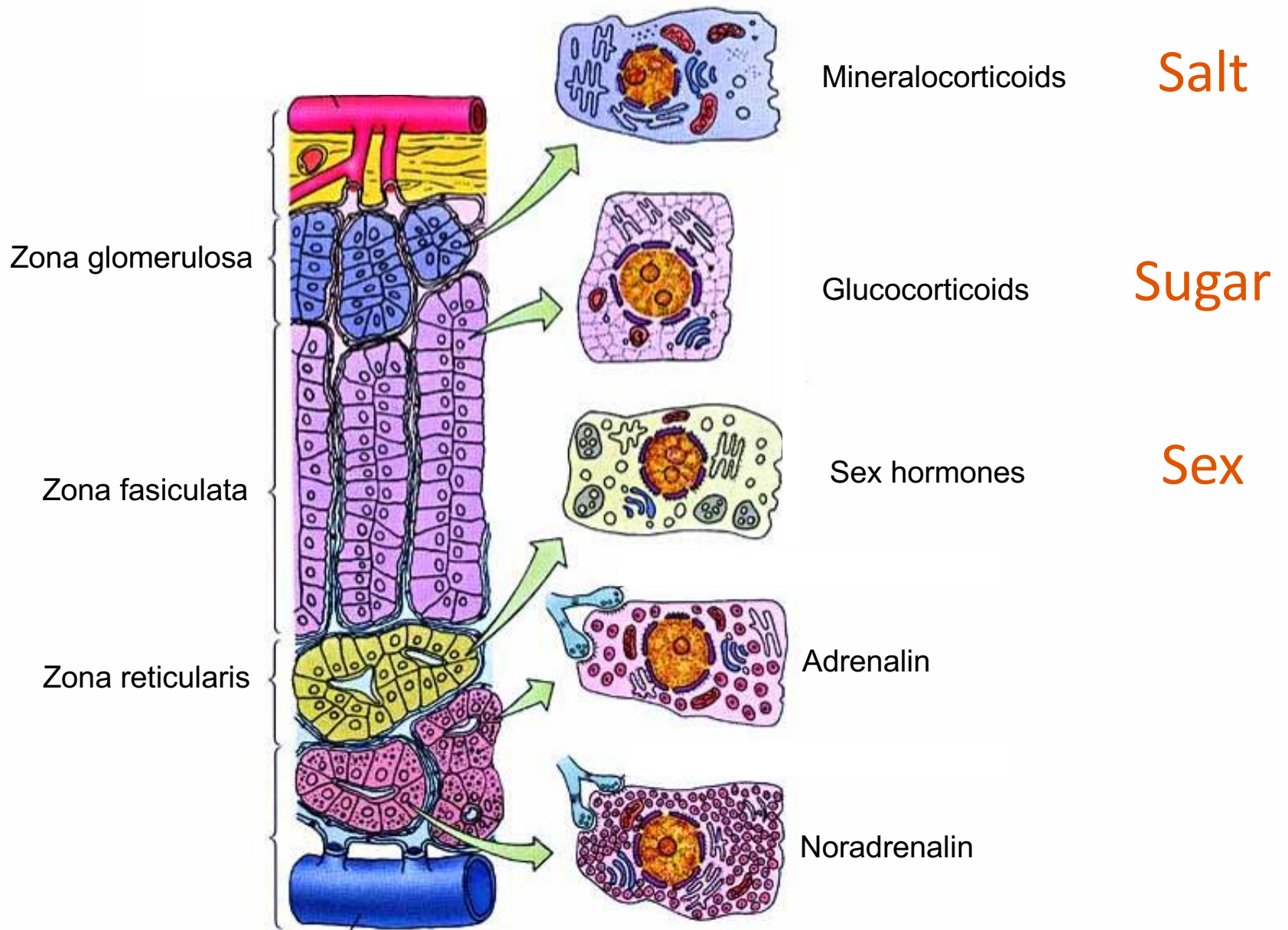
Adrenal cortex: fasciculata and reticularis

# Adrenal medulla

- Contains chromaffin cells (modified sympathetic neurons lacking axons and dendrites) and a few sympathetic ganglion cells.
- Chromaffin cells produce catecholamines (mostly epinephrine and a little norepinephrine) when stimulated by preganglionic sympathetic neurons.
- Catecholamines are the “fight or flight” hormones. They increase blood glucose, increase heart rate, increase blood flow to heart and skeletal muscle, and decrease blood to non-essential organs.



Adrenal medulla: ganglion cell and chromaffin cells



Adrenal gland hormones

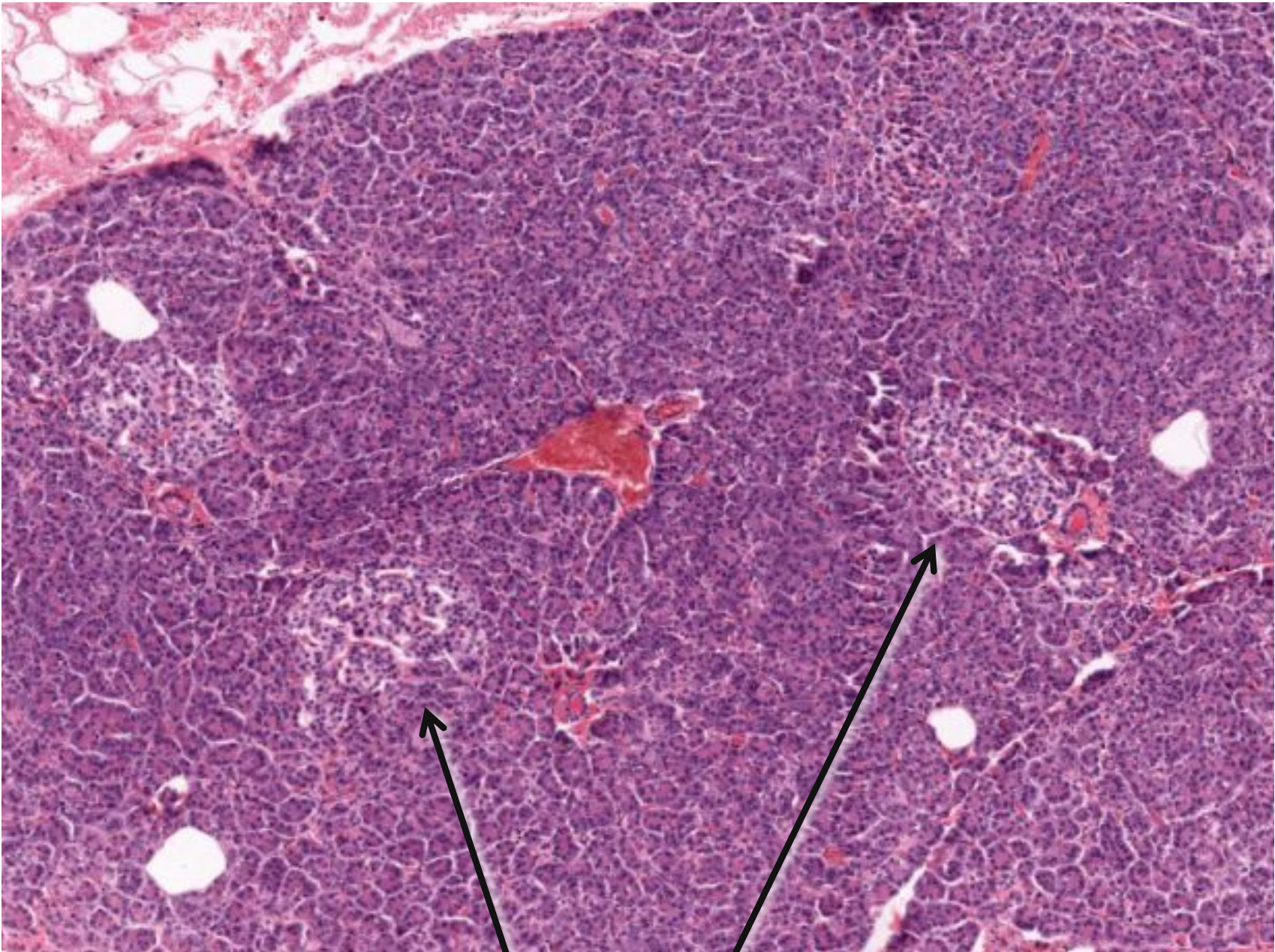
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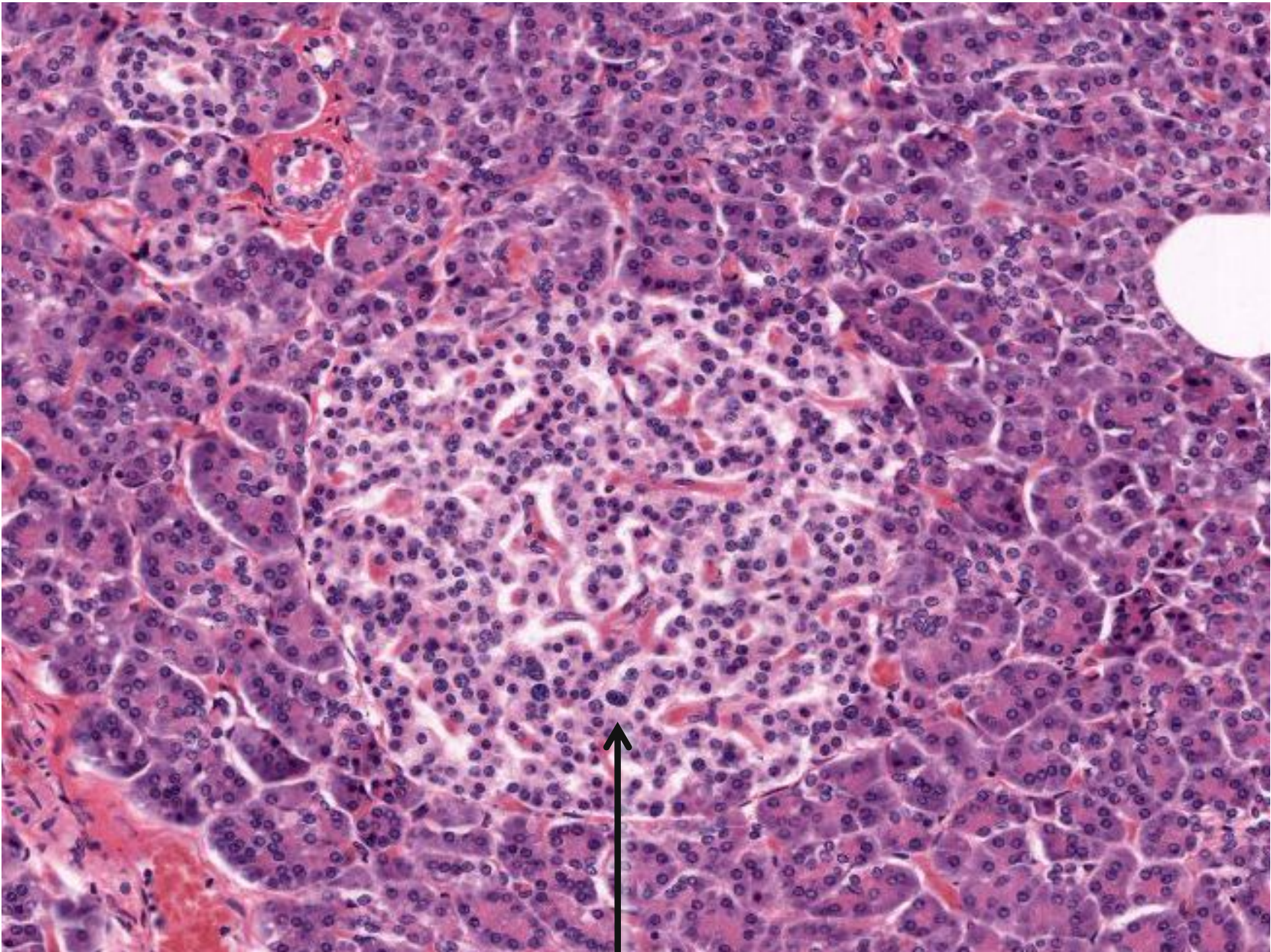


# Pancreas

- The pancreas has both exocrine (ducts) glands and endocrine (ductless) glands.
- The exocrine glands produce digestive enzymes; we'll discuss these in the Pancreas, Liver and Gallbladder lecture.
- The endocrine glands produce hormones that regulate blood glucose: glucagon, insulin, and somatostatin. They also produce pancreatic polypeptide, which helps regulate the digestive system.



Pancreatic islets (of Langerhans)



Pancreatic islet (of Langerhans)

# Main Islet Cells and Hormones

## A (alpha) cells

- Secrete glucagon when blood glucose is low
- Glucagon raises blood glucose

## B (beta) cells

- Secrete insulin when blood glucose is high
- Insulin decreases blood glucose by making cells take up glucose and making the liver synthesize glycogen

# Other Islet Cells and Hormones

## D (delta) cells

- Secrete somatostatin
- Somatostatin inhibits release of insulin and glucagon

## F cells

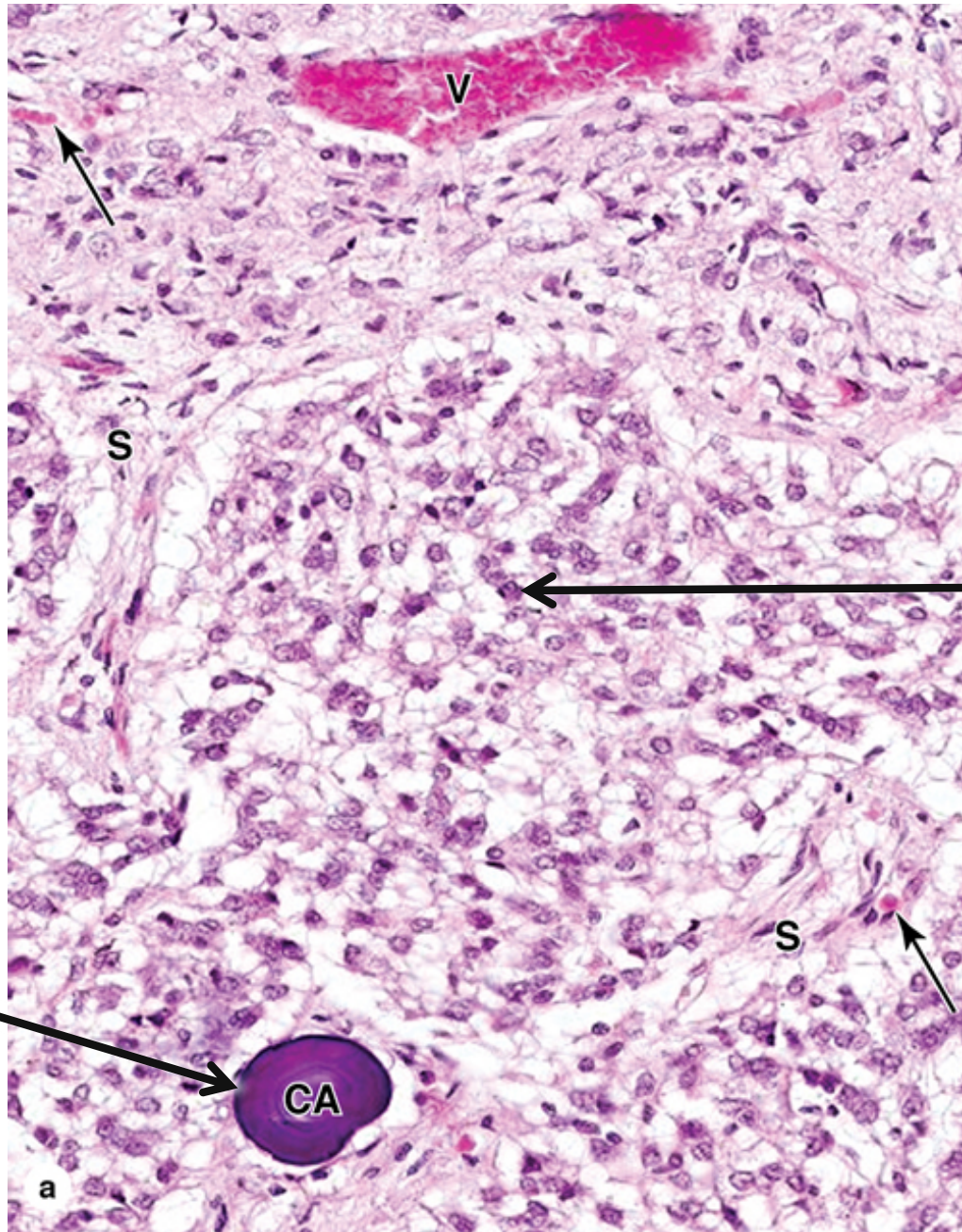
- Secrete pancreatic polypeptide
- Pancreatic polypeptide inhibits release of digestive enzymes
- Also causes relaxation of gallbladder and decreases secretion of bile

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- Pancreas
- Pineal

# Pineal Gland

- Located in brain near posterior third ventricle
- Two main cell types: pinealocytes and glial cells
- Pinealocytes occur in clusters and produce melatonin (which helps induce sleep) in response to light.
- “Brain sand” (corpora arenacea) are globules of basophilic calcified material that can be seen radiologically.



pinealocytes

corpus arenaceum

Pineal gland



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