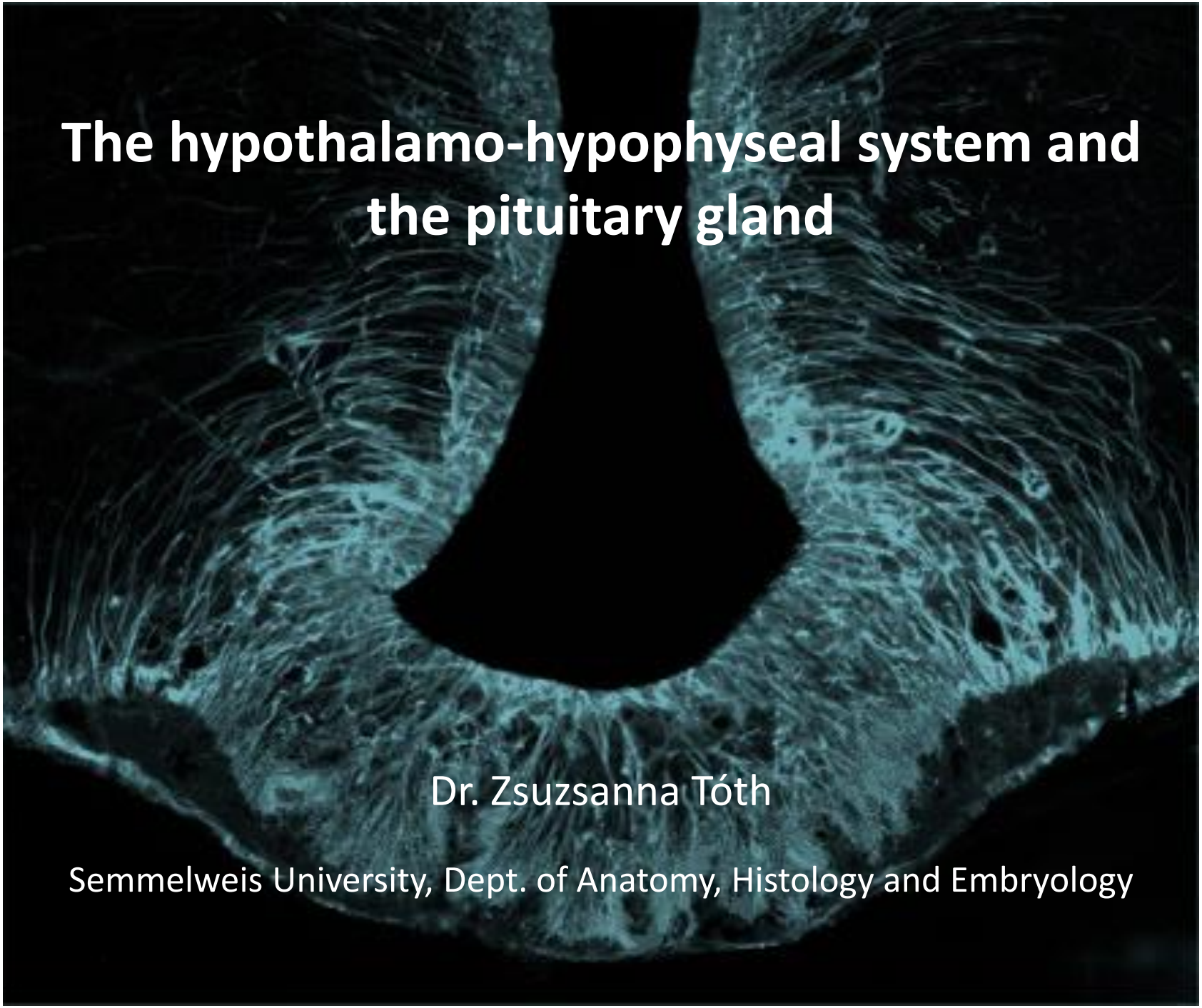
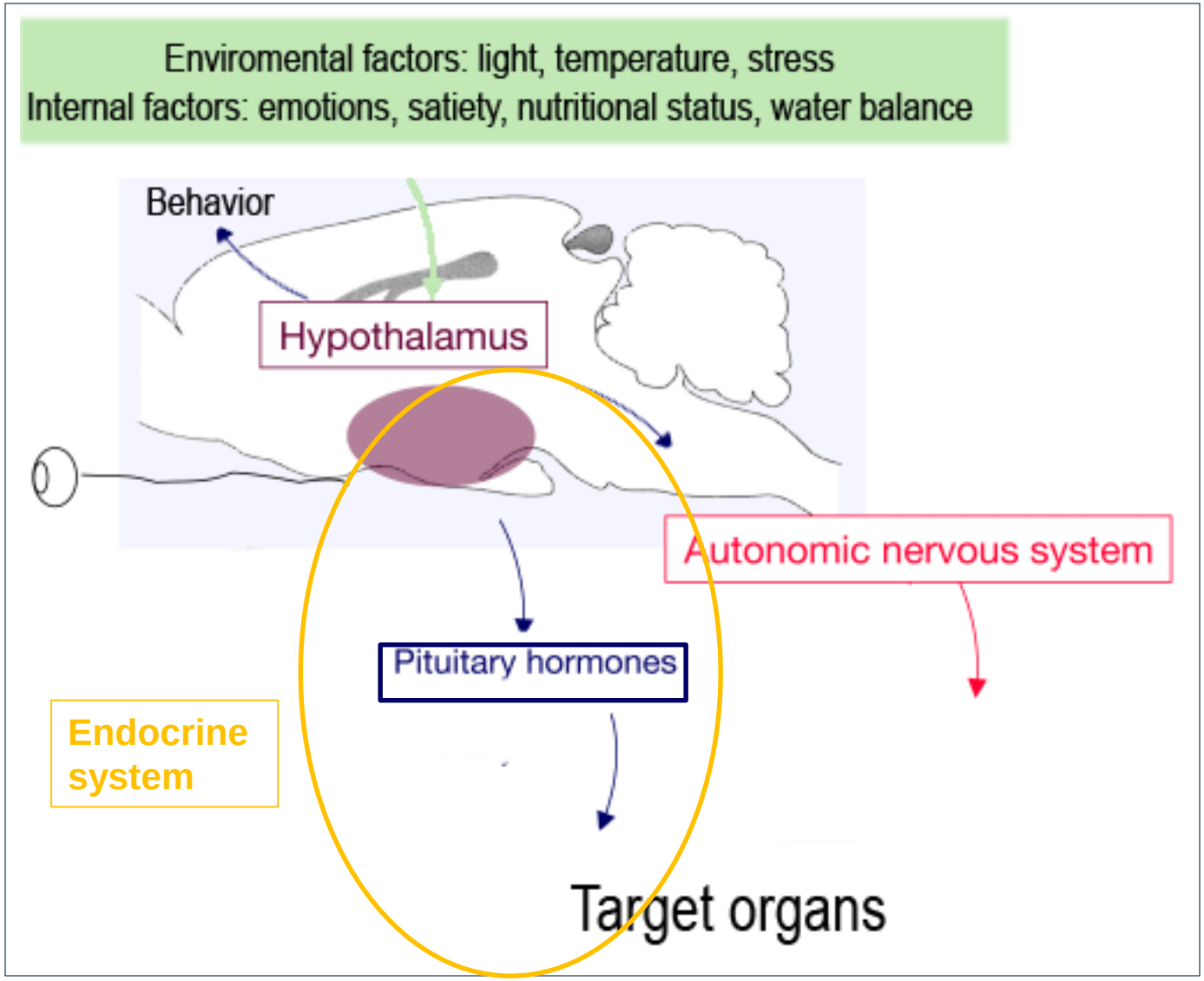


The hypothalamo-hypophyseal system and the pituitary gland

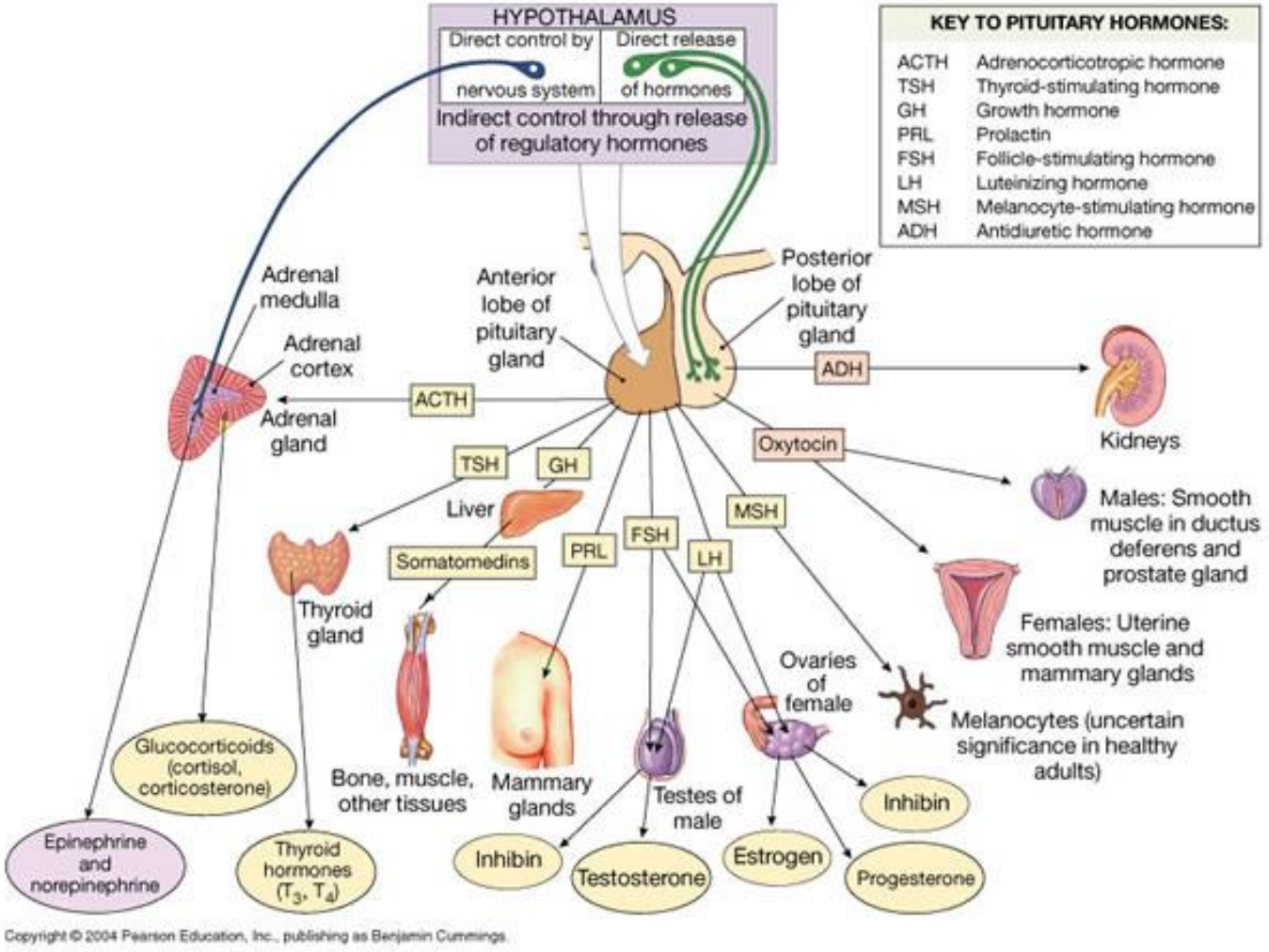
Dr. Zsuzsanna Tóth

Semmelweis University, Dept. of Anatomy, Histology and Embryology

Homeostatic integration within the hypothalamus

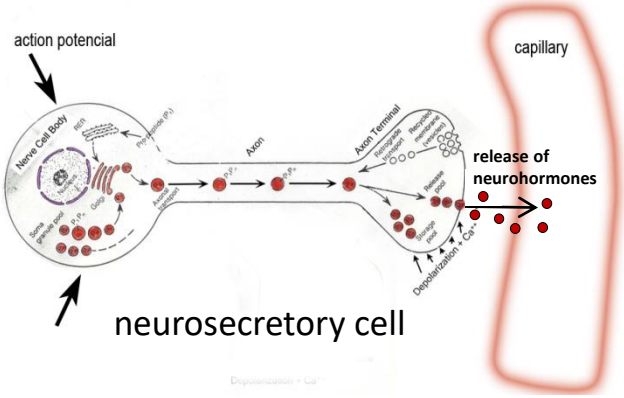


The hypothalamo-hypophyseal system- neuroendocrine system

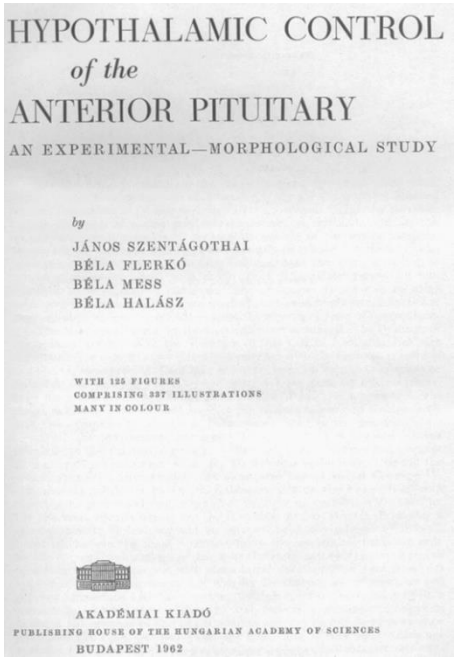


Neurosecretion is a special feature in the hypothalamo-hypophyseal system

Ernst and Berta Scharrer, 1928



Béla Halász


HYPOTHALAMIC CONTROL
of the
ANTERIOR PITUITARY
AN EXPERIMENTAL—MORPHOLOGICAL STUDY

by
JÁNOS SZENTÁGOTHAI
BÉLA FLERKÓ
BÉLA MESS
BÉLA HALÁSZ

WITH 125 FIGURES
COMPRISING 327 ILLUSTRATIONS
MANY IN COLOUR

AKADÉMIAI KIADÓ
PUBLISHING HOUSE OF THE HUNGARIAN ACADEMY OF SCIENCES
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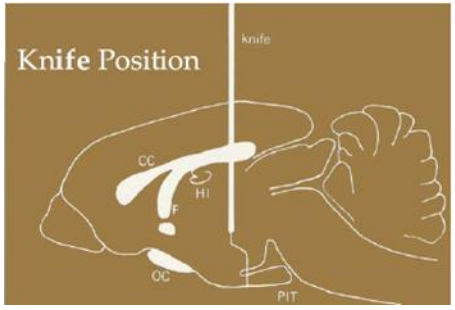
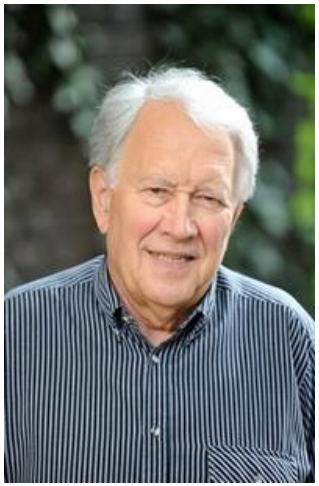
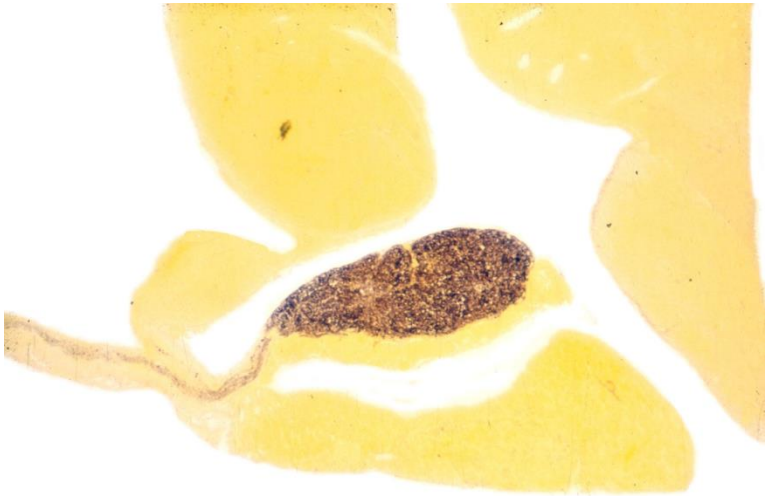


János Szentágothai

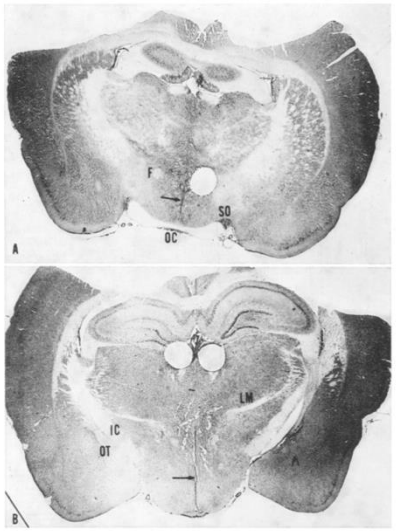
Identification of different neurohormones and the specific nuclei where they are produced



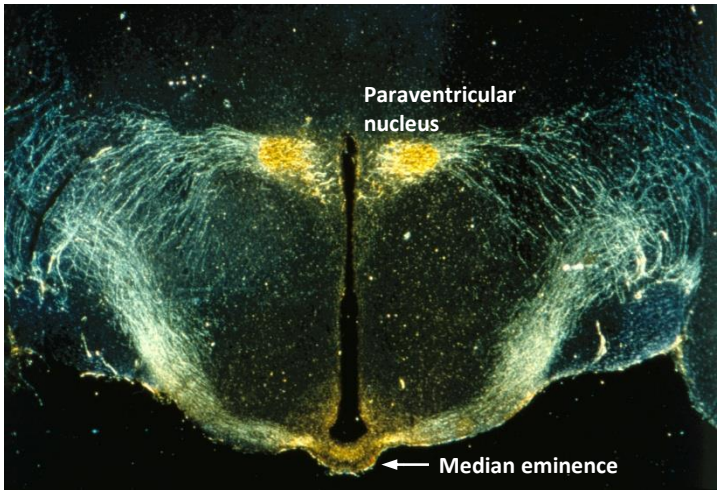
Miklós Palkovits



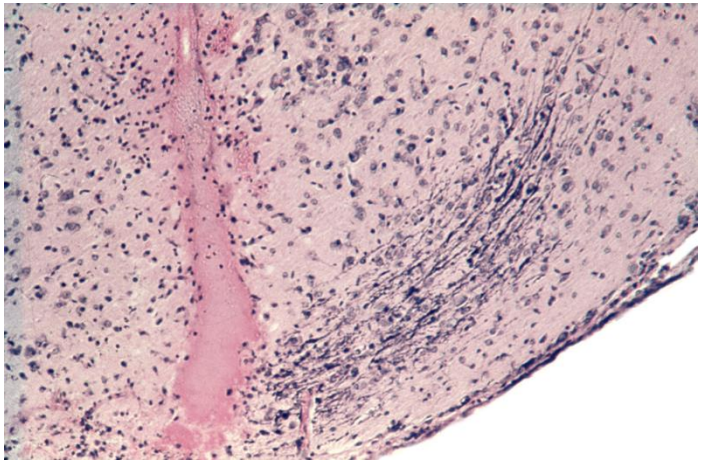
ADH containing fibers and accumulation of ADH in the posterior pituitary, sagittal section



Palkovits M: Isolated removal of hypothalamic or other brain nuclei of the rat. Brain Res 59:449-450 (1973)



ADH immunohistochemistry, rat hypothalamus coronal section



ADH accumulation right to the knife cut demonstrates the direction of the transport

Hypothalamic nuclei and areas

Anterior region

- n. anterior
- n. preopticus med. and lat.
- n. paraventricularis
- n. supraopticus
- n. suprachiasmaticus

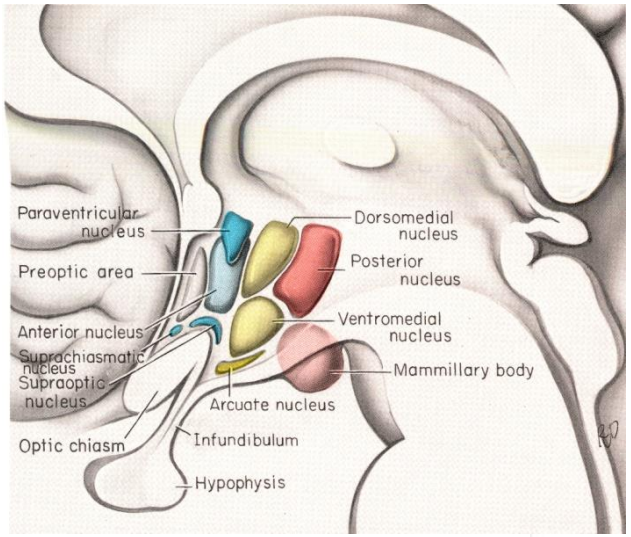
Medial region

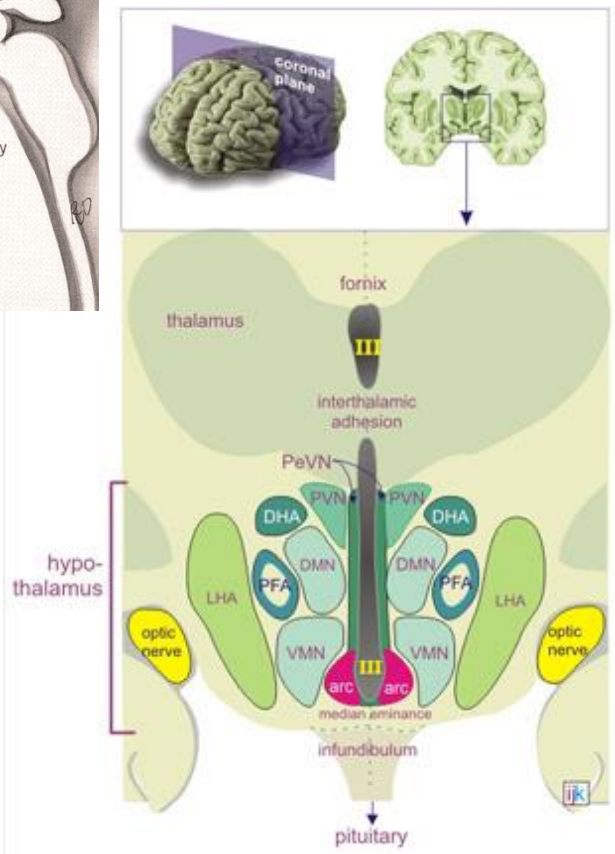
- **Periventricular zone**

  Medial zone
  n. ventro- and dorsomedialis
- n. infundibularis (arcuatus)

  Lateral zone
  dorsolateral hypothalamic area
  medial forebrain bundle

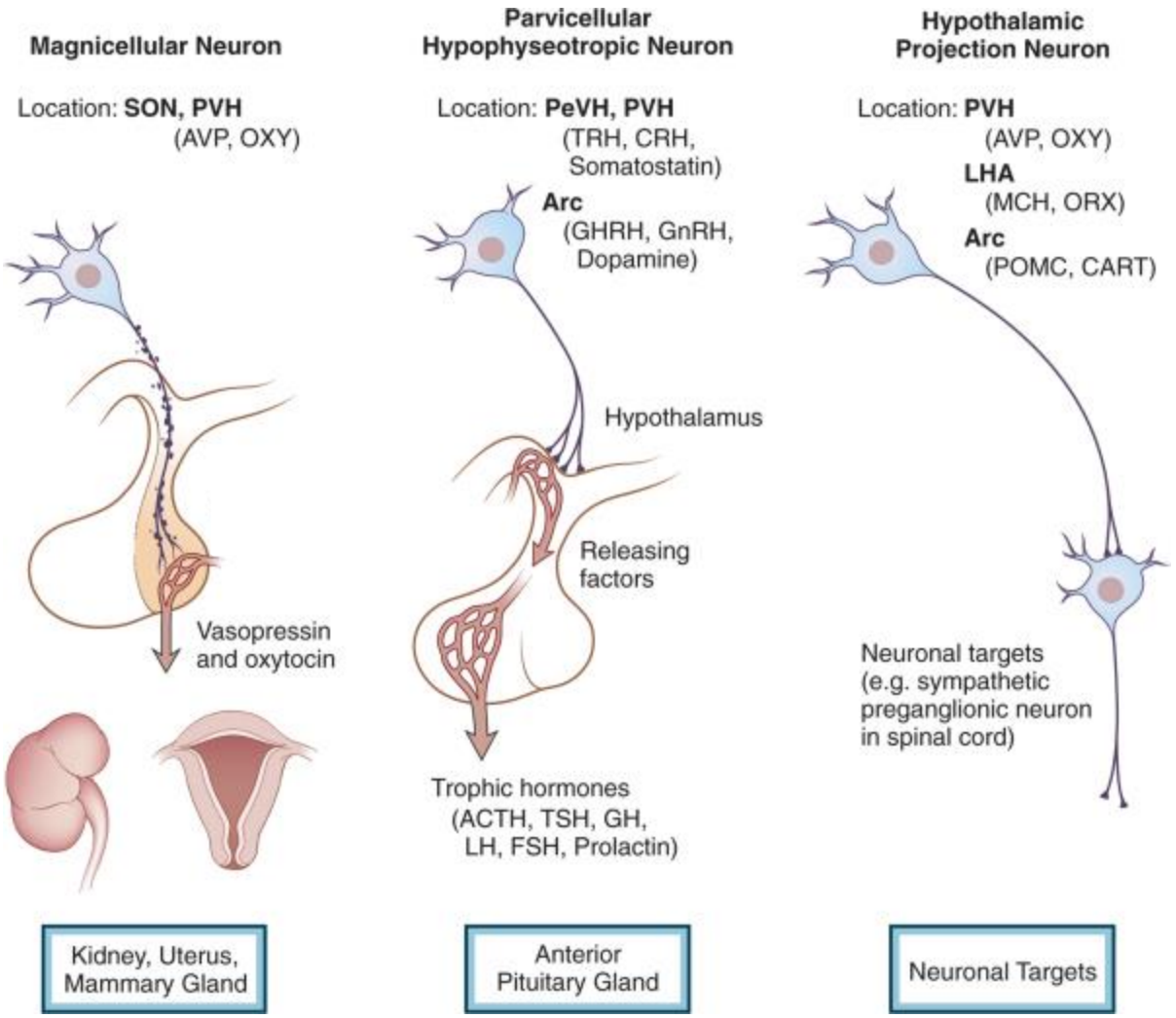
Posterior region
n. hypothalamicus posterior
corpus mamillare



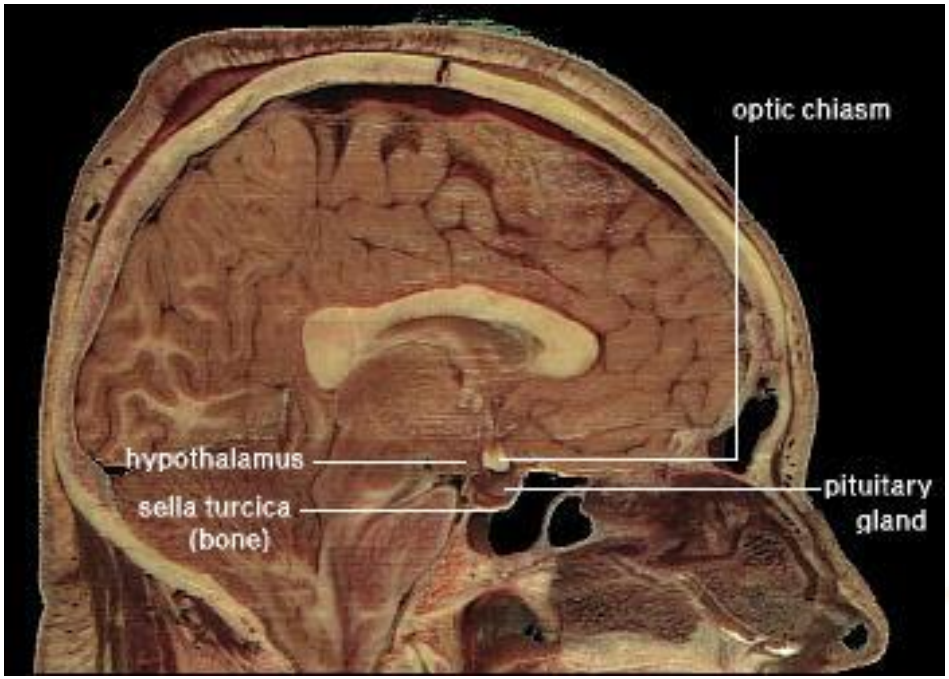


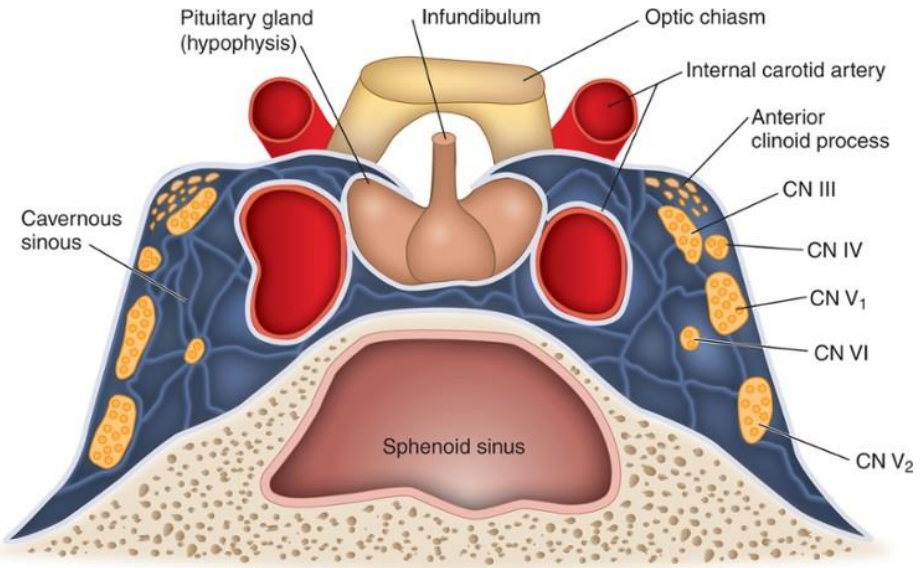
contributes to the HTH system

Neurosecretory cells are the magno- and parvocellular neurons in the hypothalamus



The pituitary is connected with the hypothalamus via the infundibulum





Blood supply:

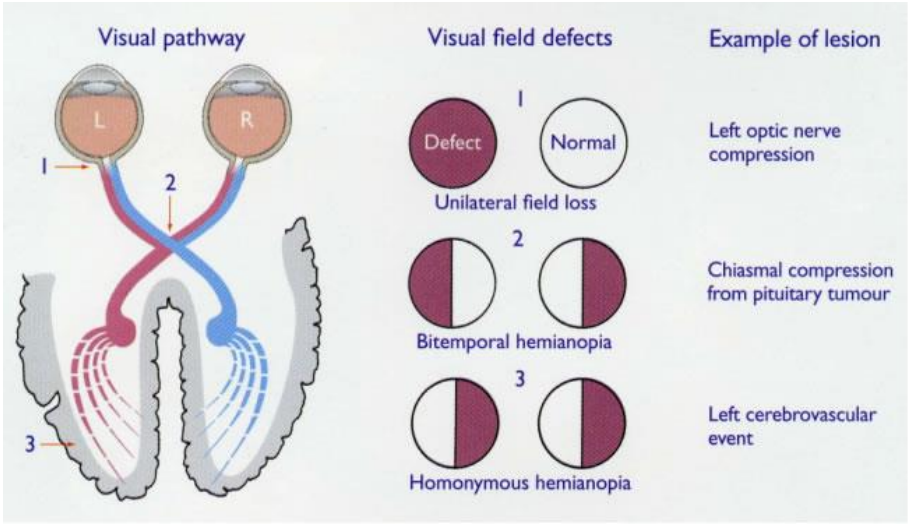
Superior hypophyseal artery – internal carotid artery

Inferior hypophyseal artery - circulus arteriosus

Pituitary tumors may cause visual disturbances

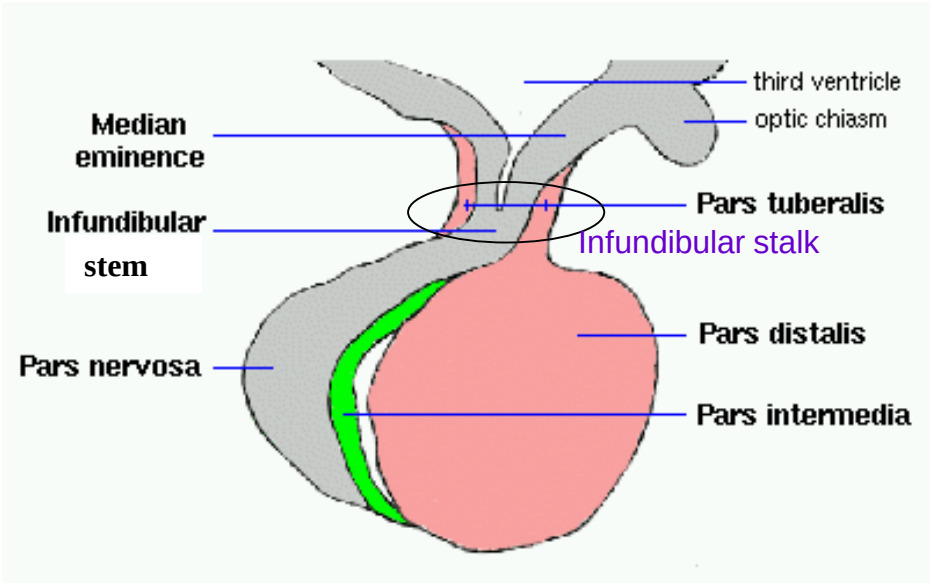
normal:

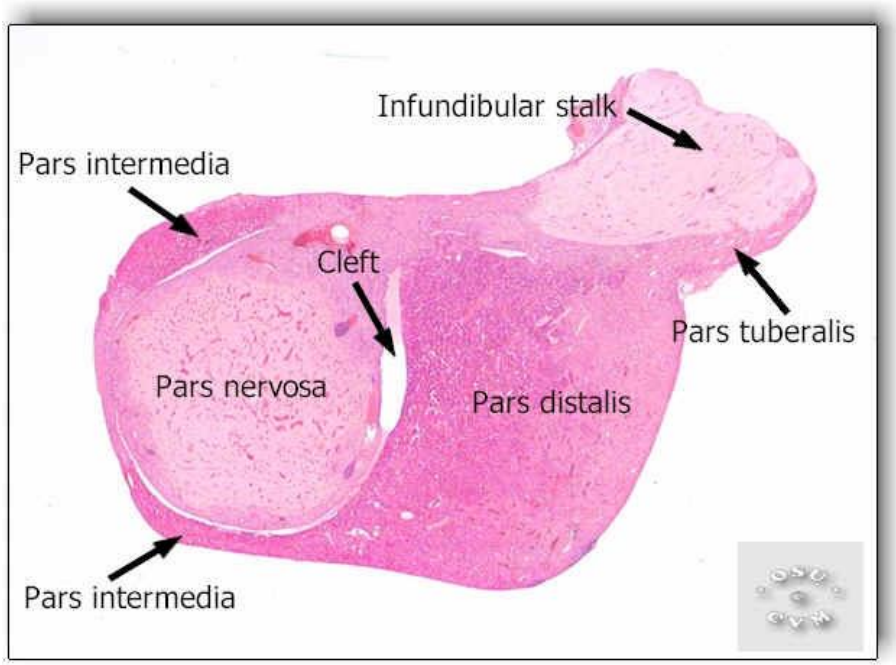
Bitemporal Hemianopia:
chiasma lesion



Adeno- and neurohypophysis are the main parts of the pituitary

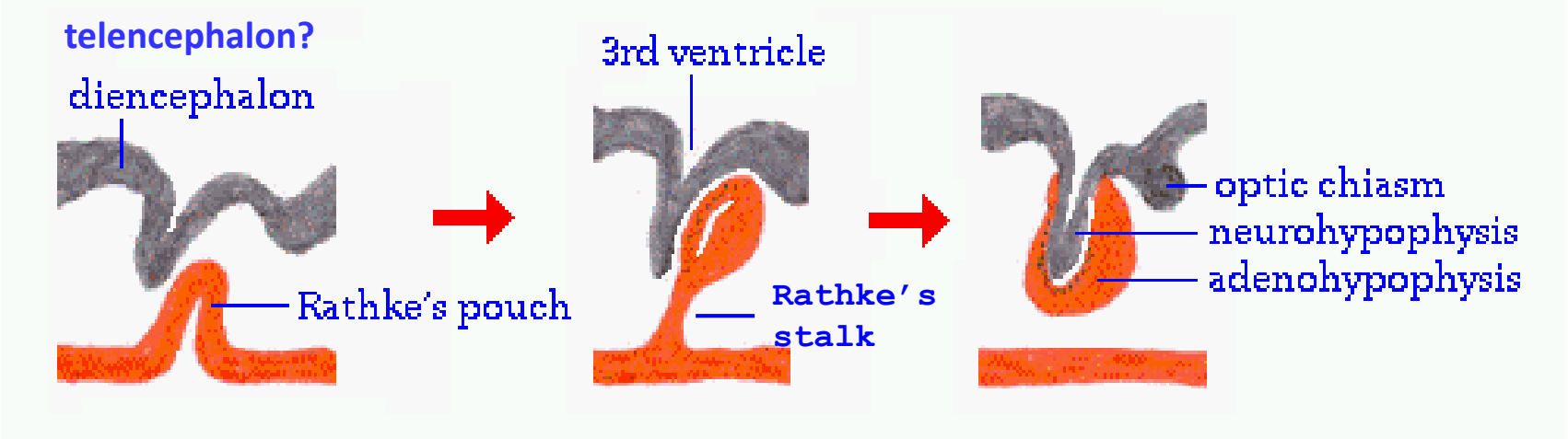
Neurohypophysis: **Adenohypophysis:**





- The adenohypophysis is a glandular, the neurohypophysis is a neuronal tissue.
- Neurohypohysis = posterior pituitary: does not produces hormones
- Adenohypophysis = anterior pituitary: produces its own hormones
- Hypophyseal cleft: between the pars intermedia and pars distalis

The adeno- and neurohypophysis are both ectodermal, but have different embryological origin

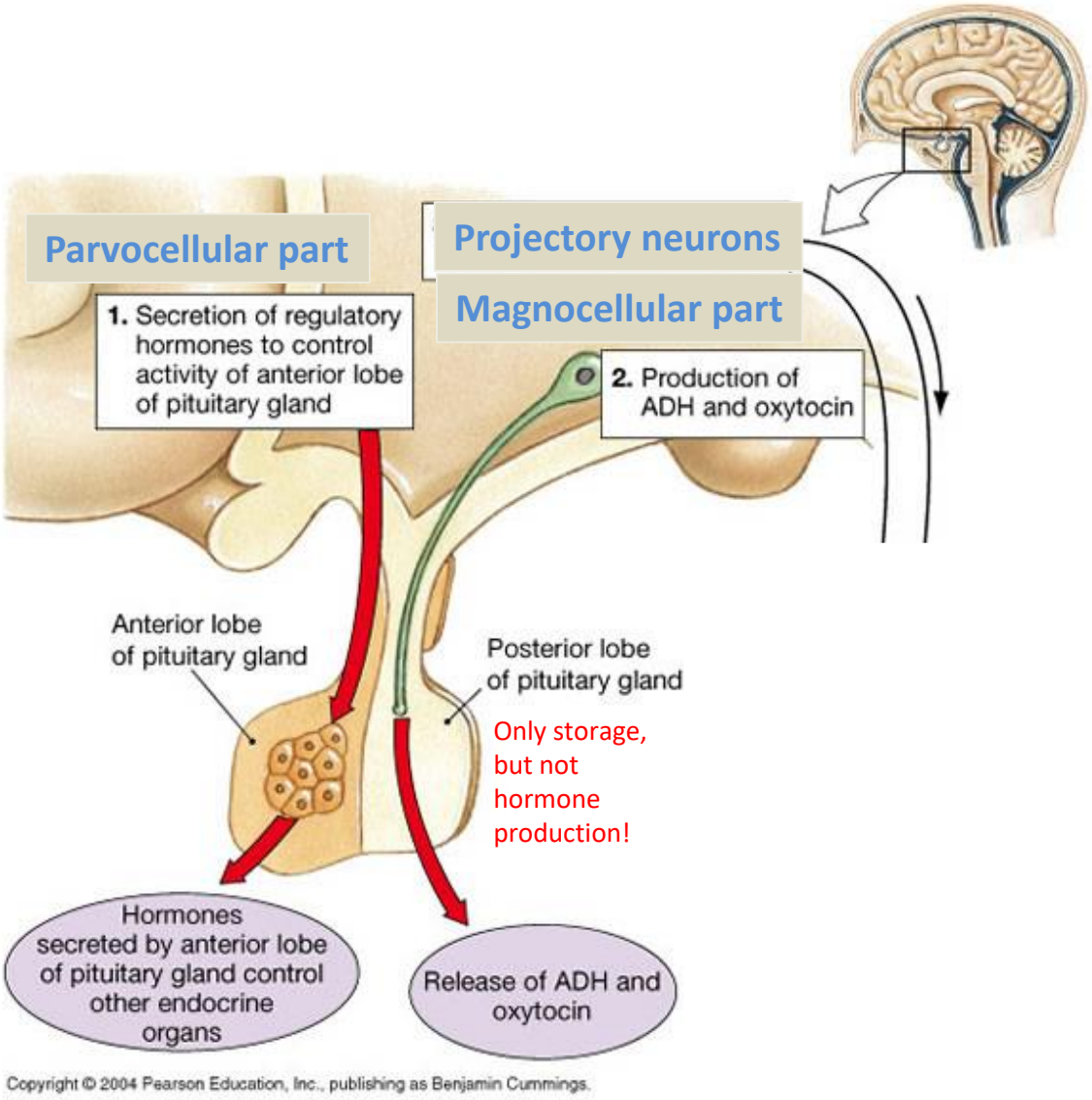


Rathke's pouch is a depression in the roof of the developing mouth (stomodeum) in front of the buccopharyngeal membrane.

- Neurohypophysis: neuroectodermal
- Adenohypophysis: ectodermal

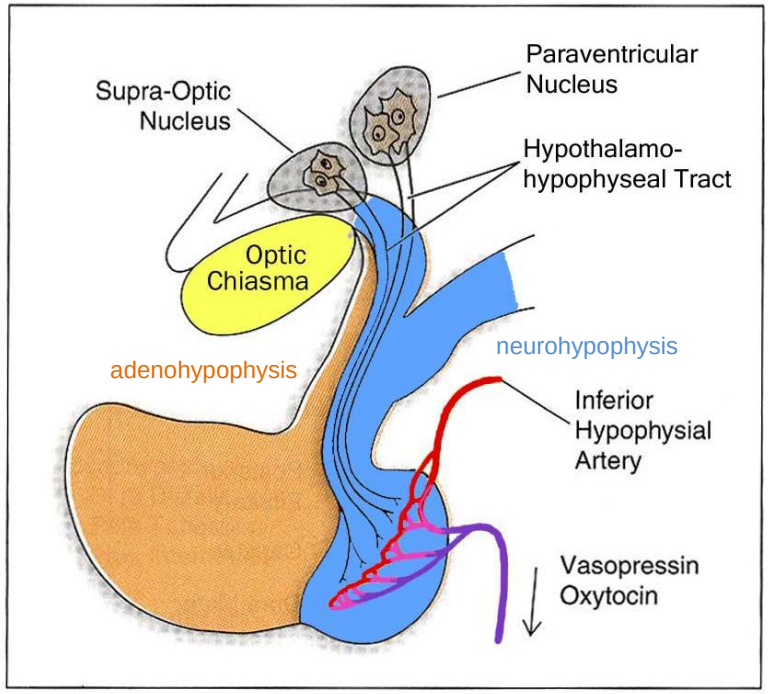
Development of the Hypophysis

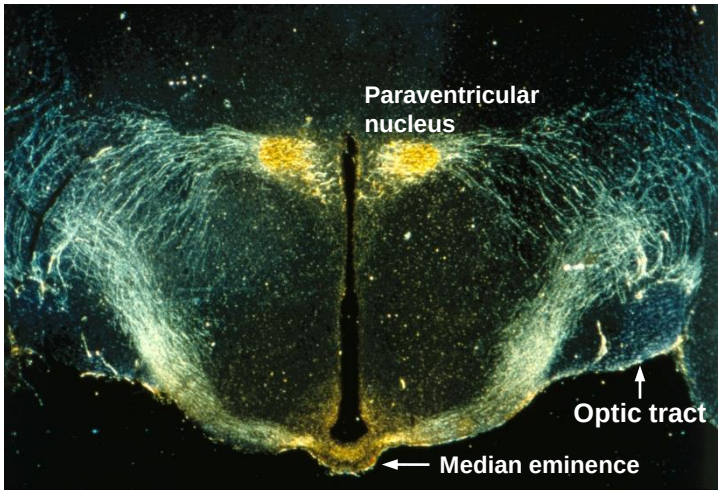
The adeno- and neurohypophysis have different functions



Magnocellular neurons of the supraoptic and the paraventricular nucleus in the hypothalamus project to the neurohypophysis

hypothalamo-neurohypophyseal neurosecretory system

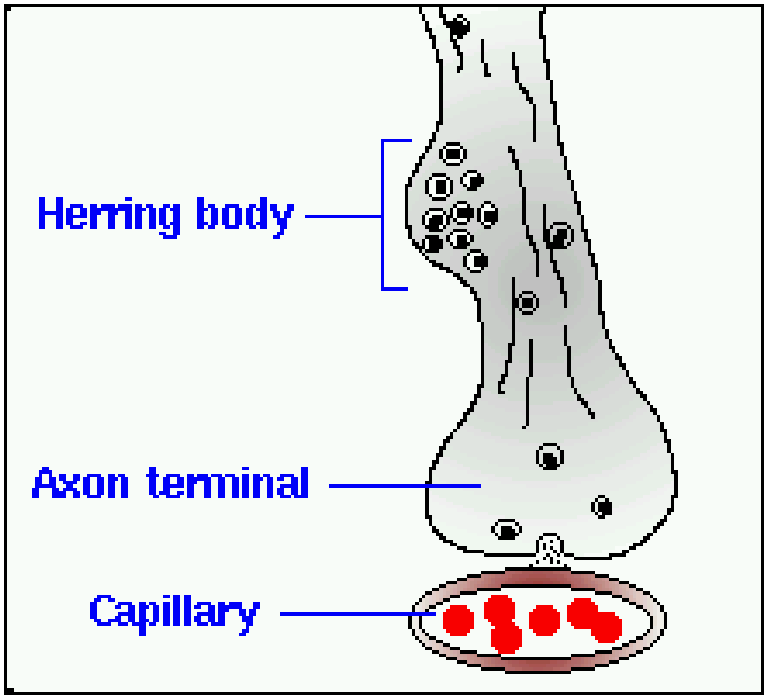




ADH immunohistochemistry, rat hypothalamus coronal section

- Fibers of the magnocellular neurons compose the ***hypothalamo-hypophyseal tract***.
- Magnocellular neurons express vasopressin (ADH) or oxytocin (different cells).
- Oxytocin stimulates uterus contraction, milk ejection, social bonding.
- ADH increases water absorption in the collecting ducts of the kidney nephron.
- central diabetes insipidus (polyuria, polydipsia)

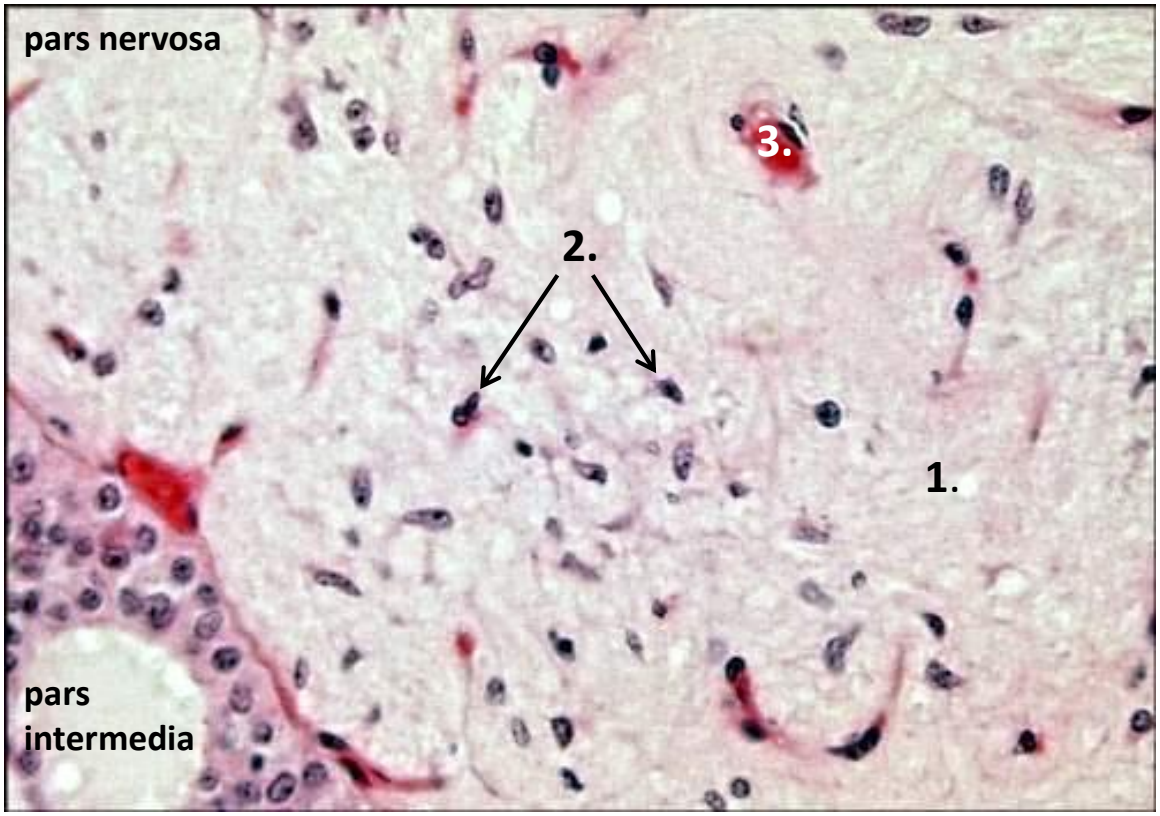
Oxytocin and vasopressin are transported via the axons connected to carrier molecules called neurophysins

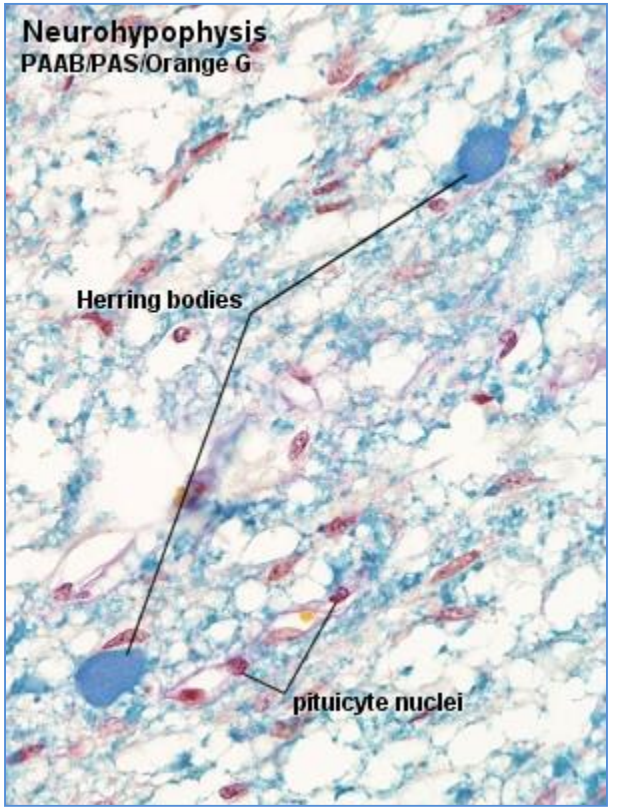


Herring bodies:

- large clusters of neurosecretory granules at the terminal portion of the axons
- oxytocin+neurophysin1 or ADH+neurophysin2 is stored in different terminals
- they can be seen at light microscopic level

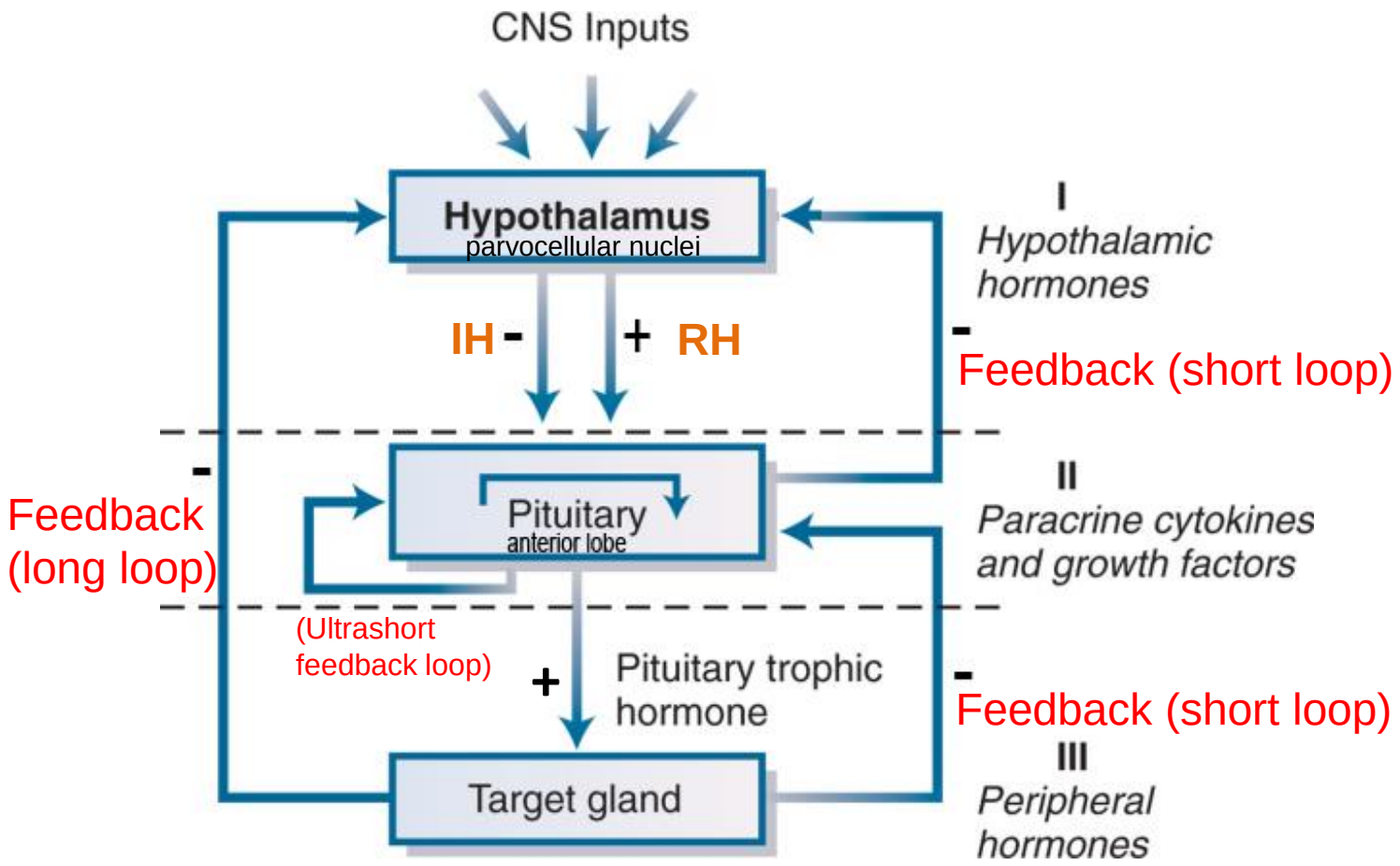
Histology of the pars nervosa



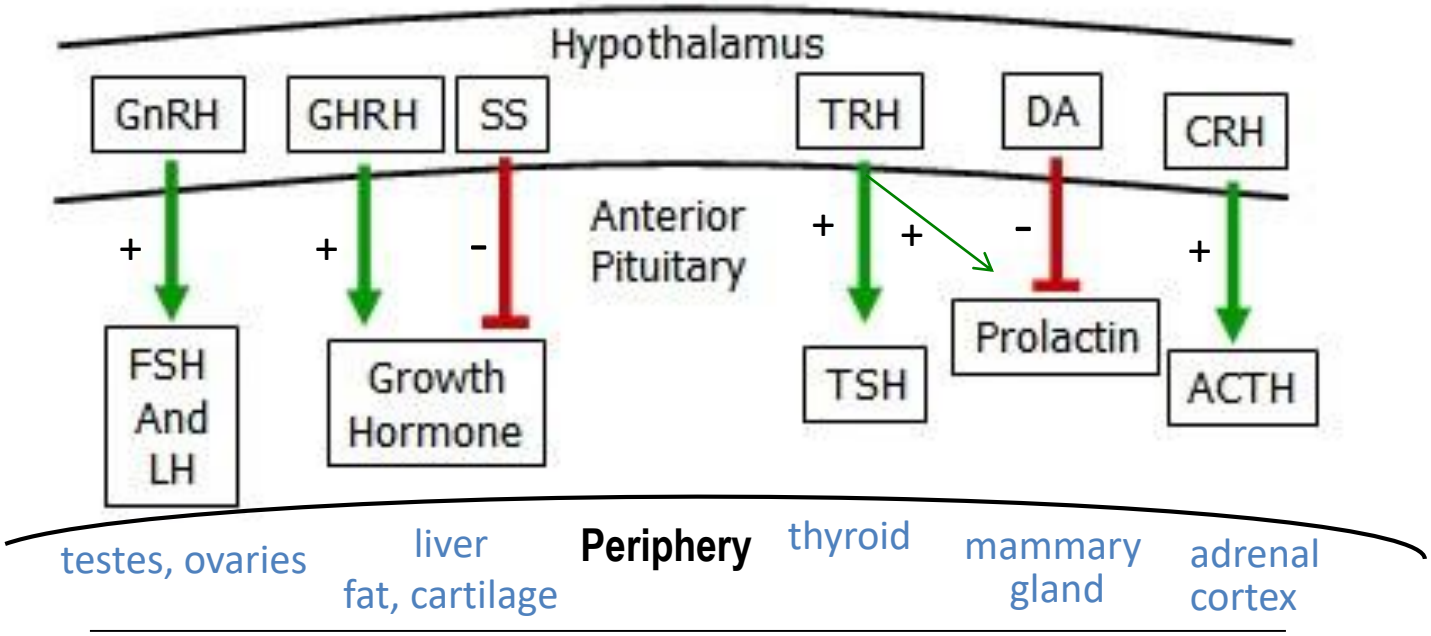


1. unmyelinited axons
2. special glial cells - pituicytes, oval nucleus
3. fenestrated capillaries

Parvocellular neurons of the hypothalamus regulate hormone production of the adenohypophysis: tuberoinfundibular neurosecretory system



Releasing and inhibiting hormones and their target in the anterior pituitary



GnRH: gonadotropin releasing hormone or luteinizing-hormone-releasing hormone (LHRH)

GHRH: growth hormone releasing hormone

SS: somatostatin

TRH: thyrotropin-releasing hormone

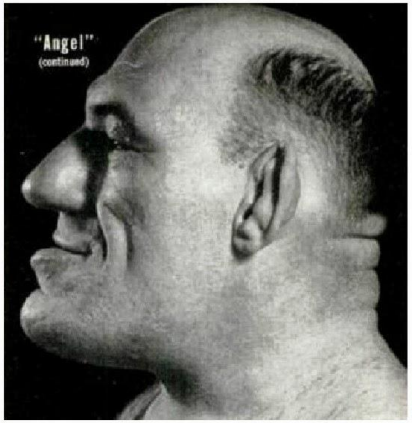
DA: dopamine

CRH: corticotropin-releasing hormone or factor (CRF)

Growth hormone overproduction

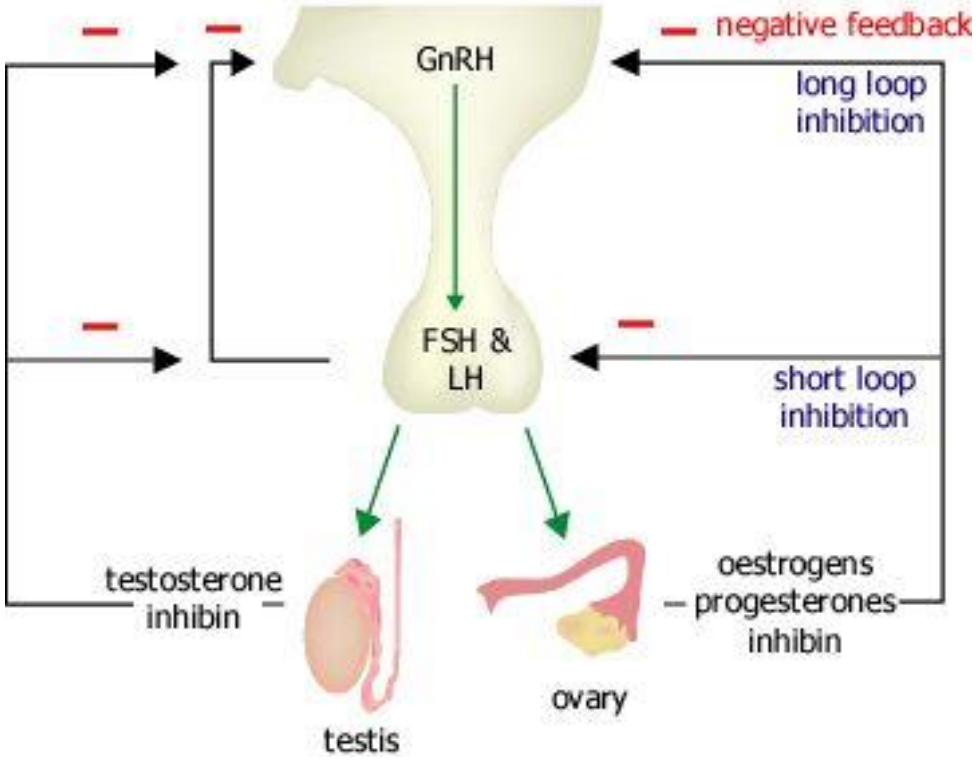
Gigantism

Acromegaly

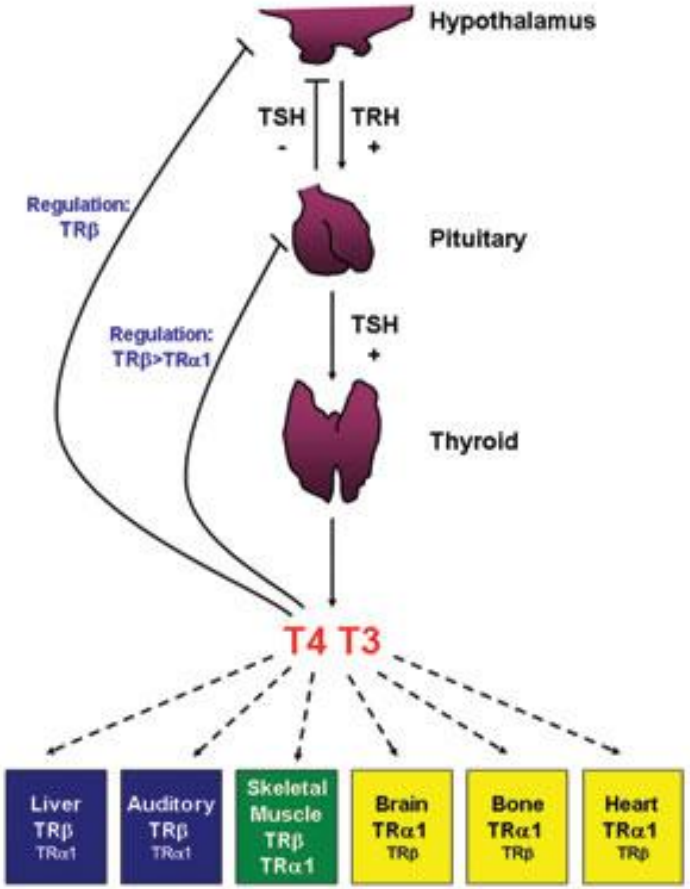


Maurice Tillet, the „French Angel” 1940.

Hypotalamic-pituitary-gonadal (HPG) and -thyroid (HPT) axes

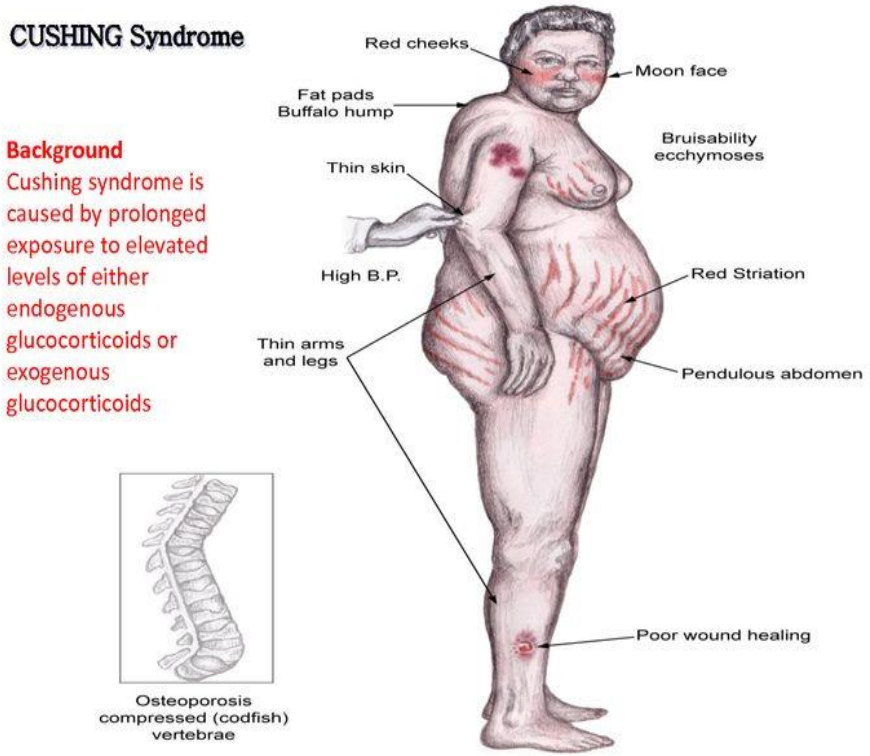


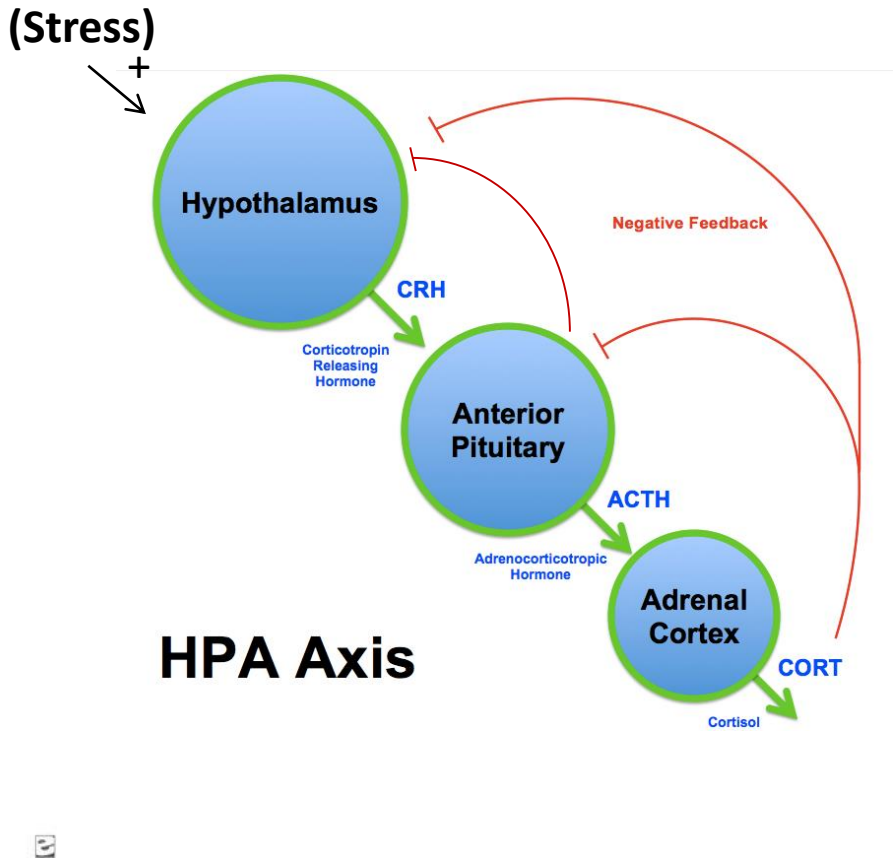
HPG axis



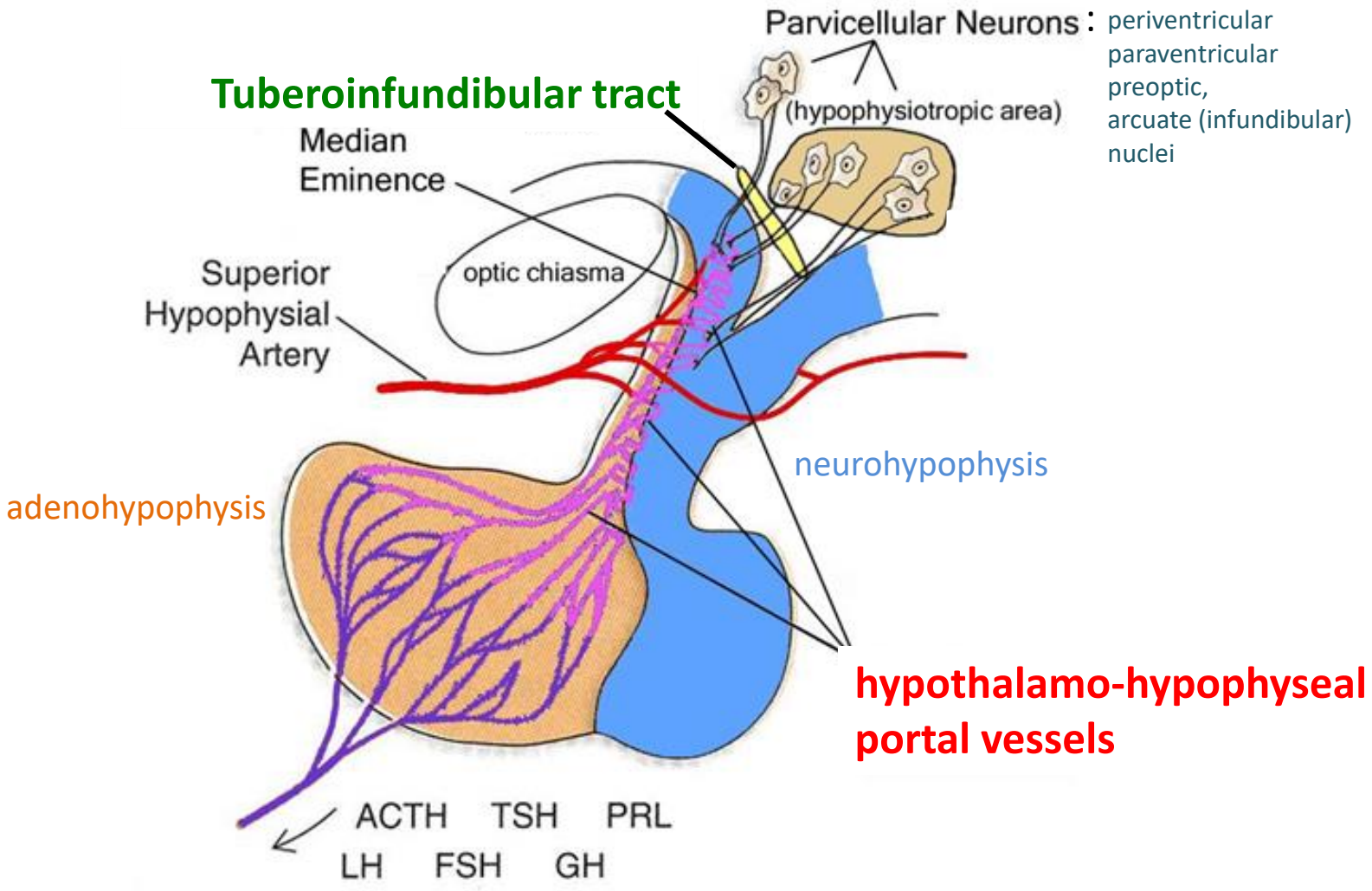
HPT axis

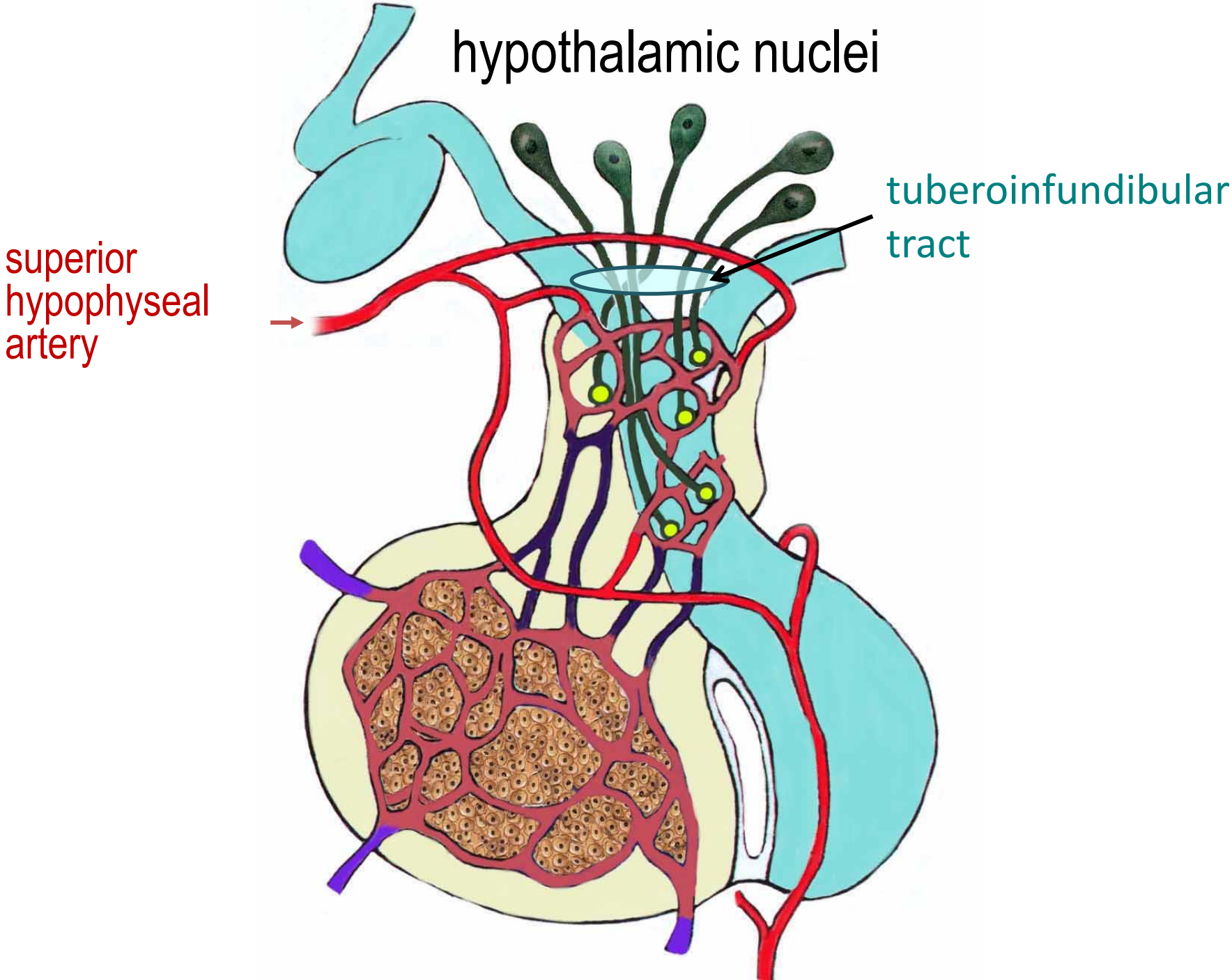
Hypotalamic-pituitary-adrenal (HPA) axis

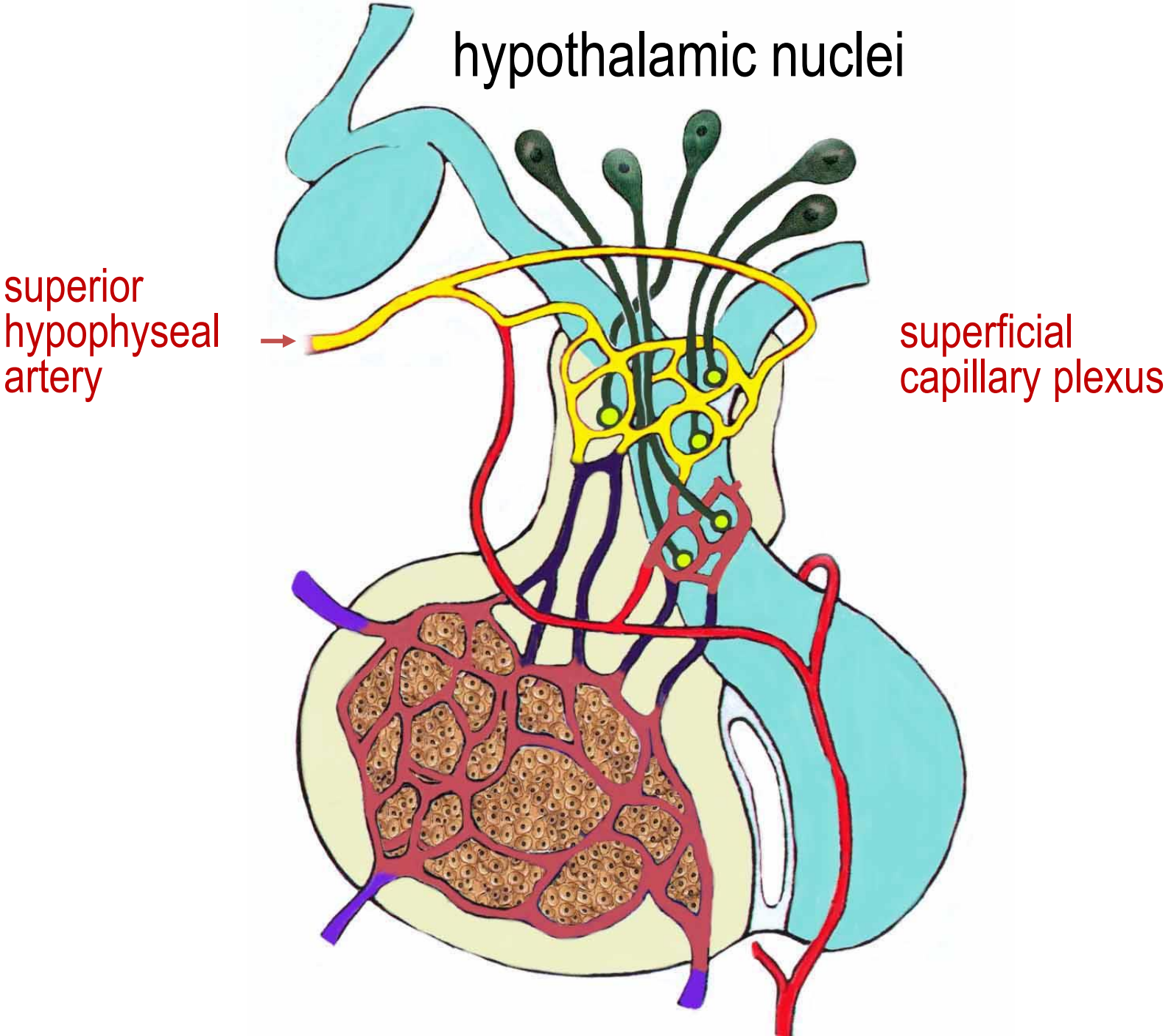


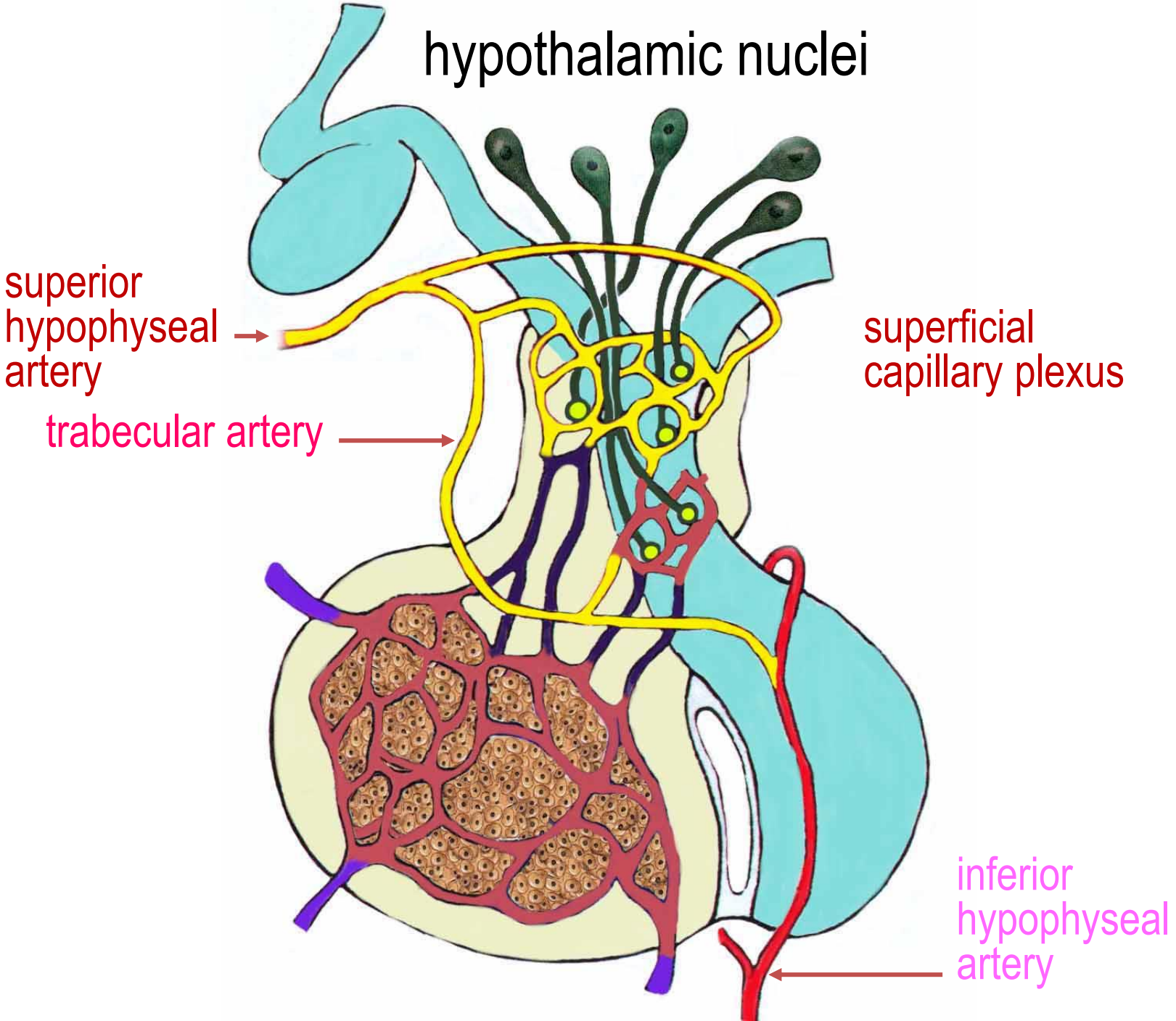


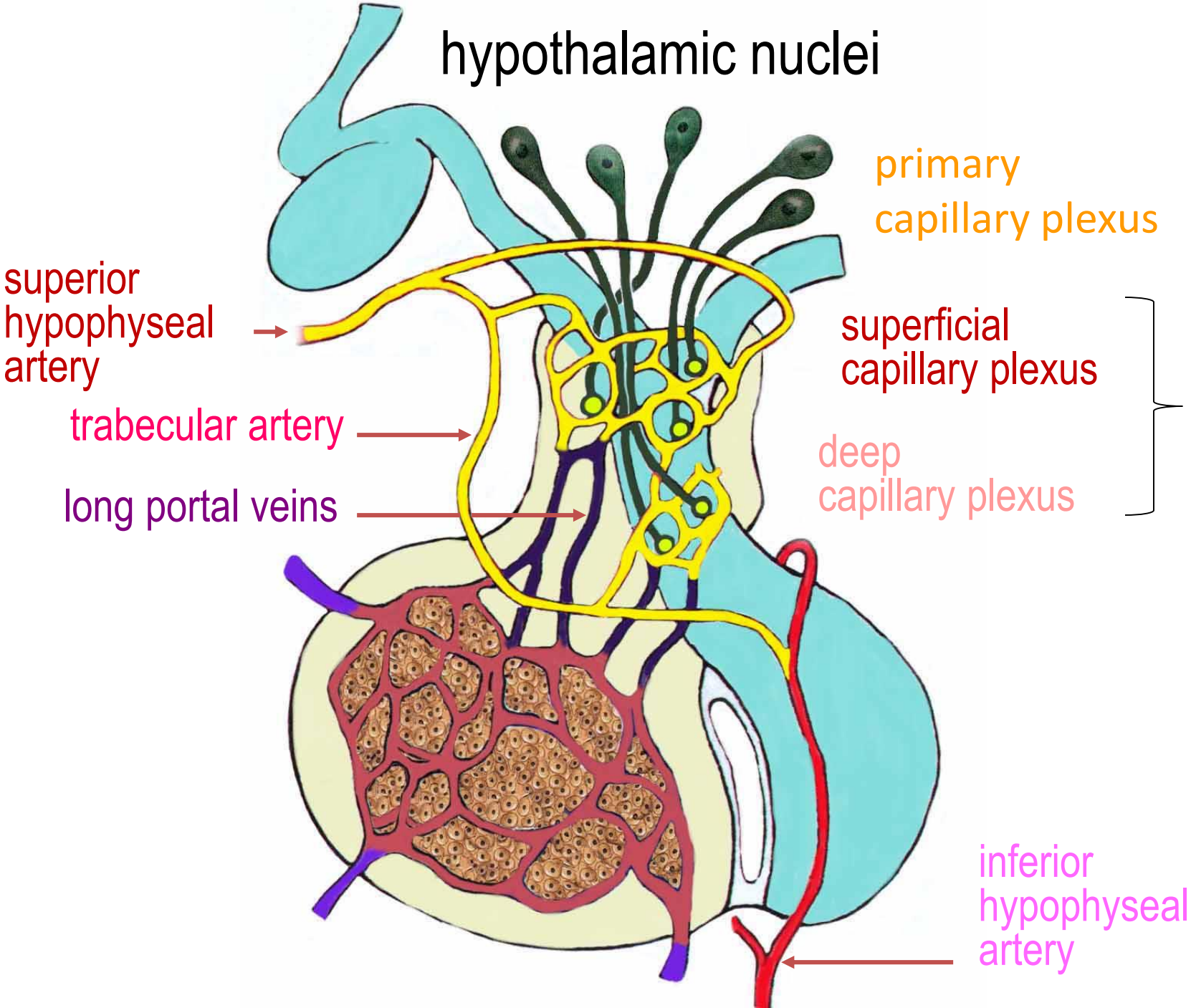
Parvocellular neurons project to the median eminence and release hormones into the portal circulation

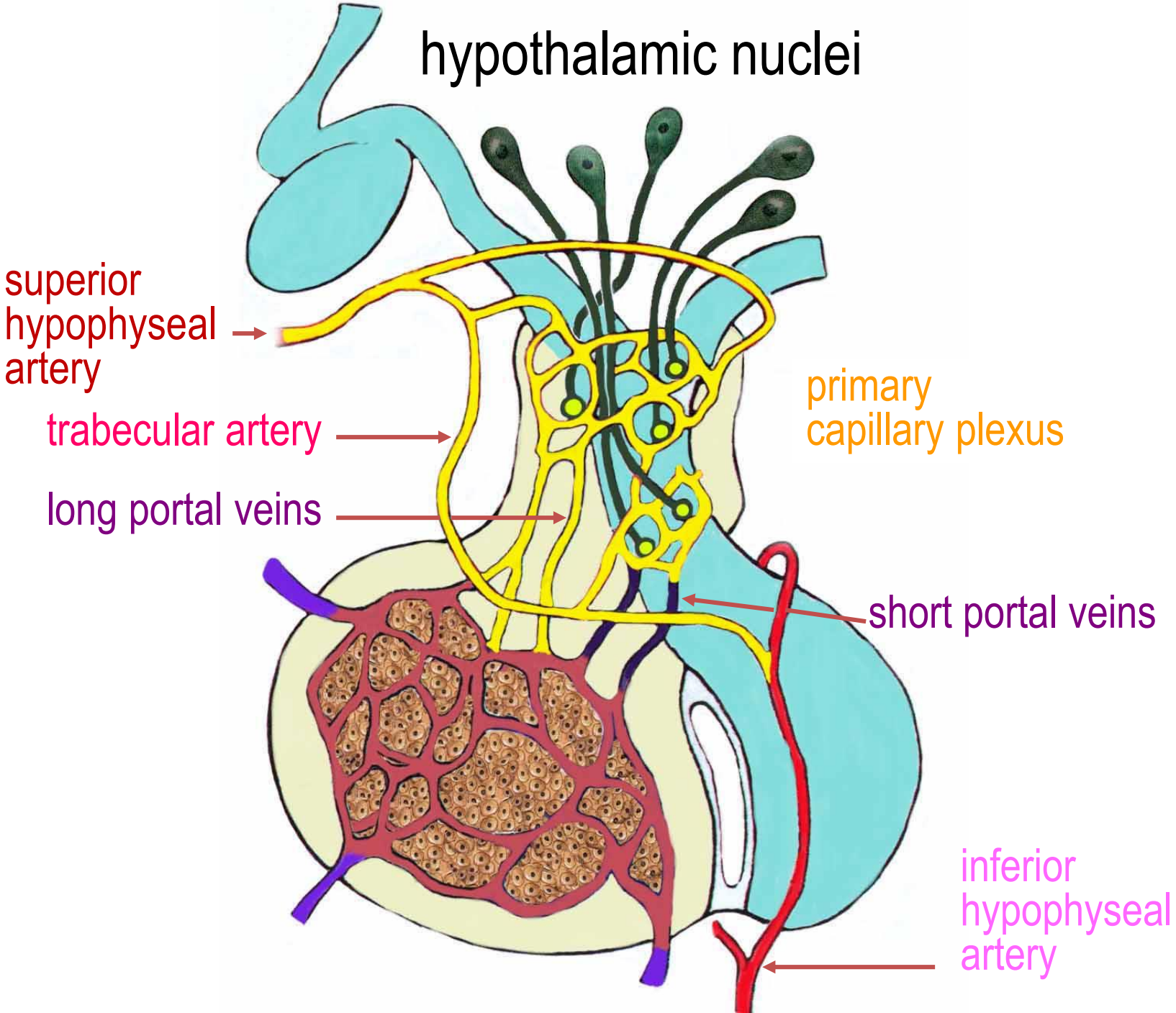


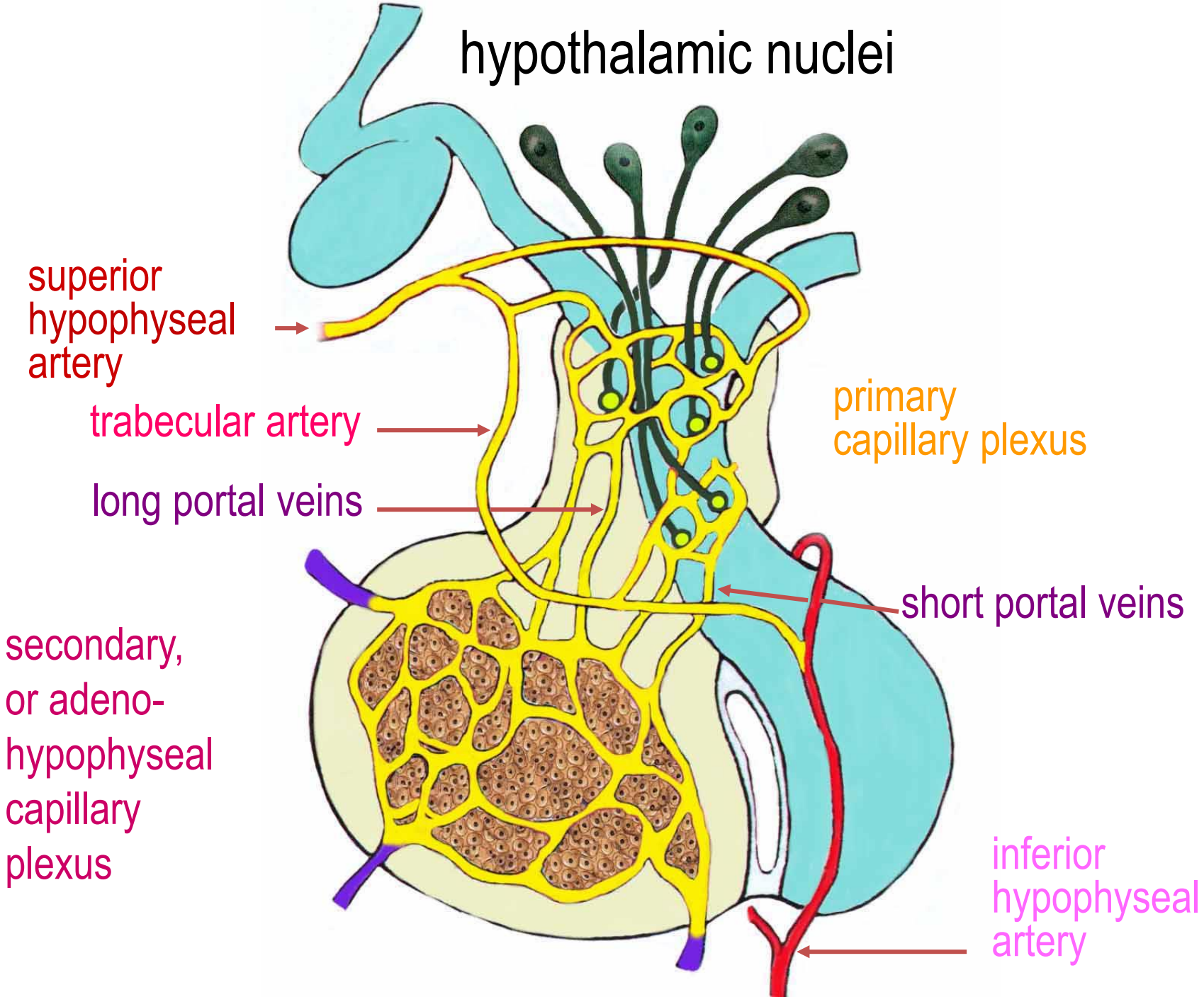

hypothalamic nuclei
tuberoinfundibular tract
superior hypophyseal artery

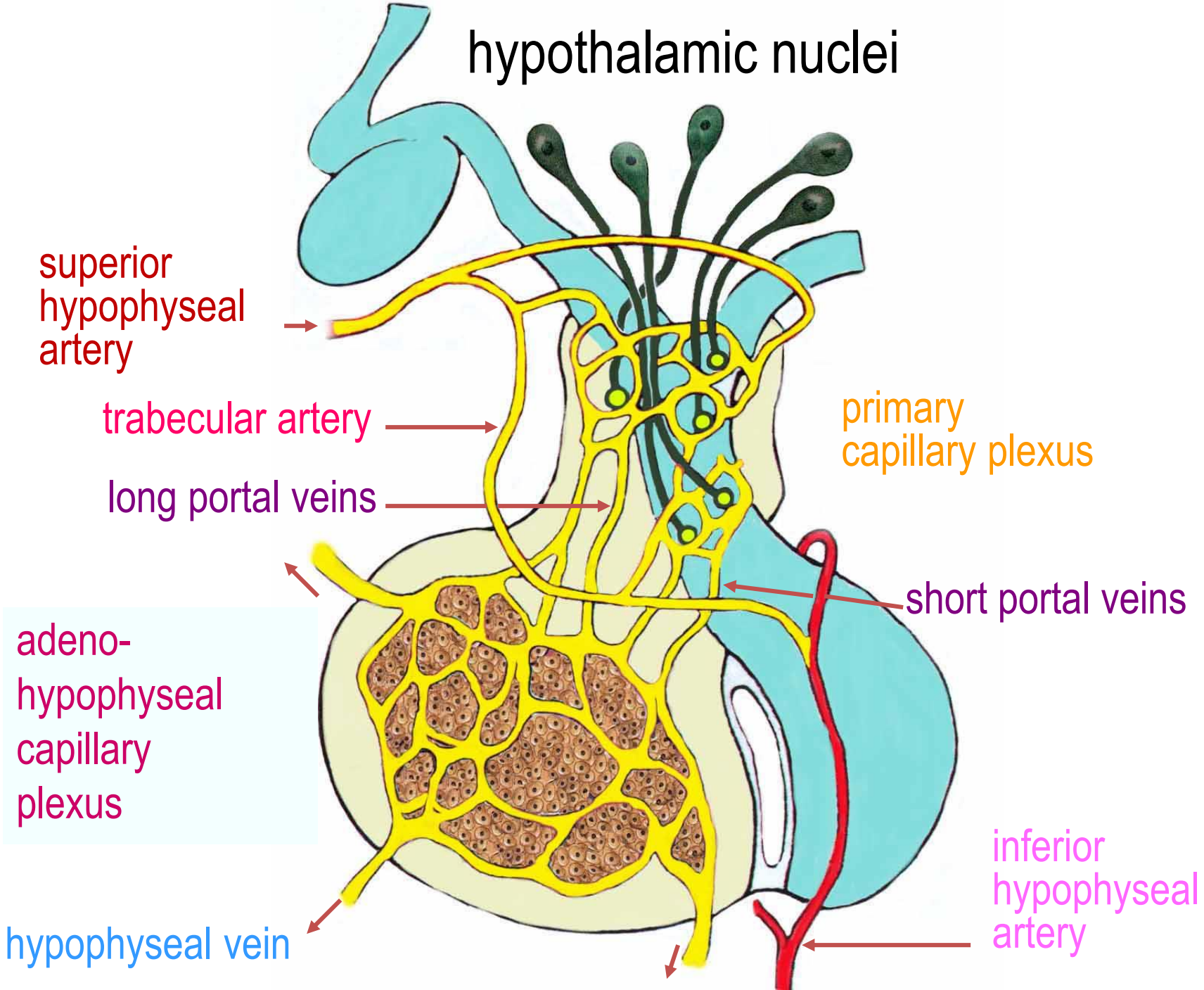

hypothalamic nuclei
superior hypophyseal artery
superficial capillary plexus


hypothalamic nuclei
superior hypophyseal artery
trabecular artery
superficial capillary plexus
inferior hypophyseal artery

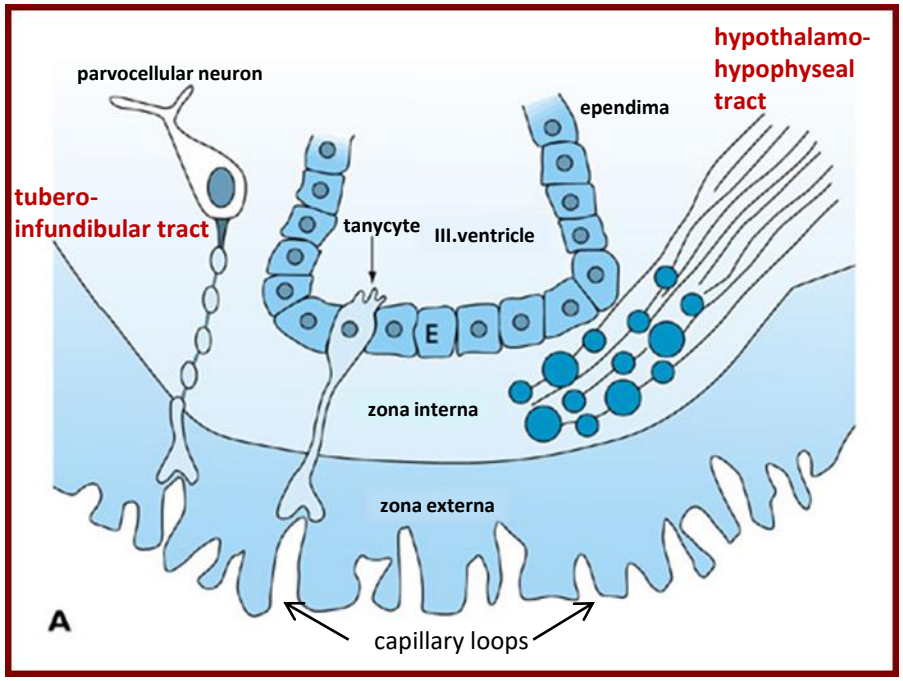

hypothalamic nuclei
primary
capillary plexus
superior
hypophyseal
artery
superficial
capillary plexus
trabecular artery
deep
capillary plexus
long portal veins
inferior
hypophyseal
artery

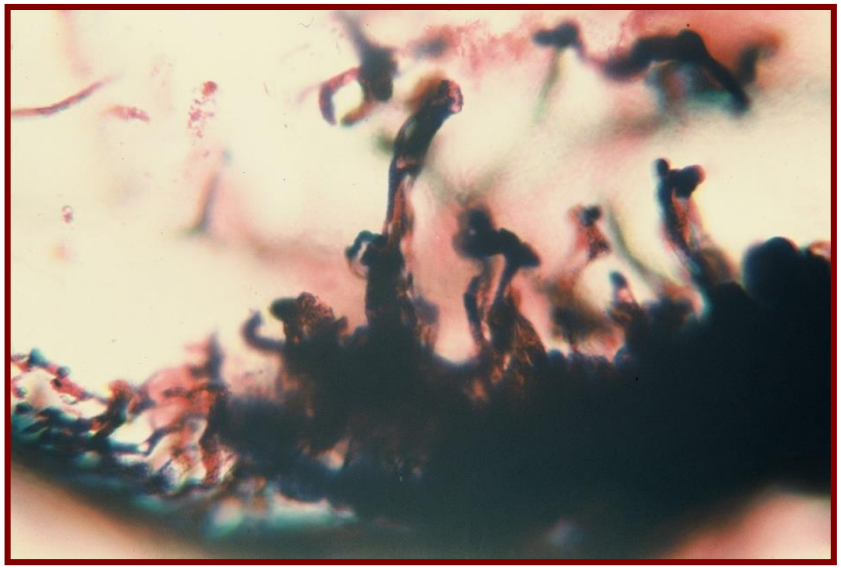

hypothalamic nuclei
superior hypophyseal artery
trabecular artery
long portal veins
primary capillary plexus
short portal veins
inferior hypophyseal artery


hypothalamic nuclei
superior hypophyseal artery
trabecular artery
long portal veins
primary capillary plexus
short portal veins
secondary, or adeno-hypophyseal capillary plexus
inferior hypophyseal artery


hypothalamic nuclei
superior hypophyseal artery
trabecular artery
long portal veins
primary capillary plexus
short portal veins
adeno-hypophyseal capillary plexus
hypophyseal vein
inferior hypophyseal artery

The hypothalamo-hypophyseal and the tuberoinfundibular tracts are separated in the median eminence



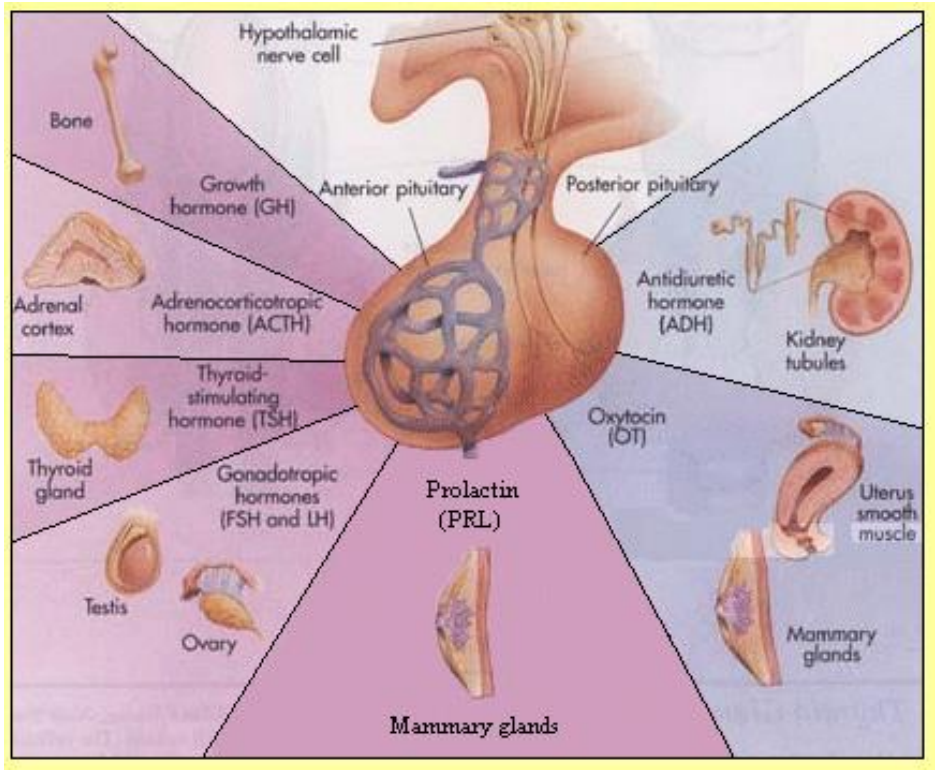


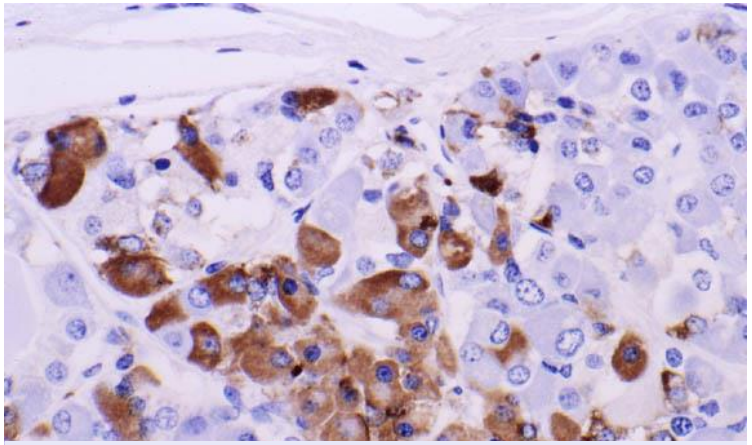
Capillary loops in the external zone of the median eminence, blood-brain barrier is missing here

Tanycites:

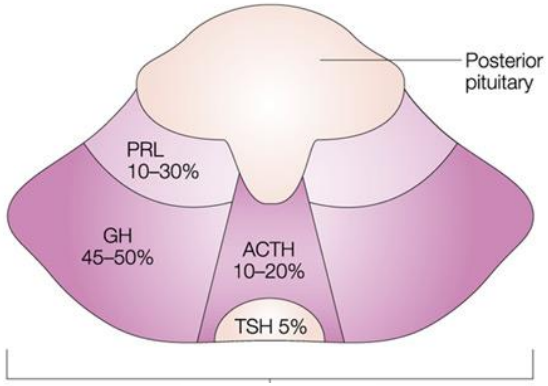
- are radial glial – like cells, some of them are stem cells,
- are in contact with the cerebrospinal fluid and/or with hypothalamic neurons and also with the median eminence,
- are able to regulate hormone release into the perivascular space,
- are glucose sensitive.

Hormone producing cells of the anterior pituitary can be identified by immunohistochemistry





Lactotroph cells (brown)-prolactin immunostaining



Pars distalis

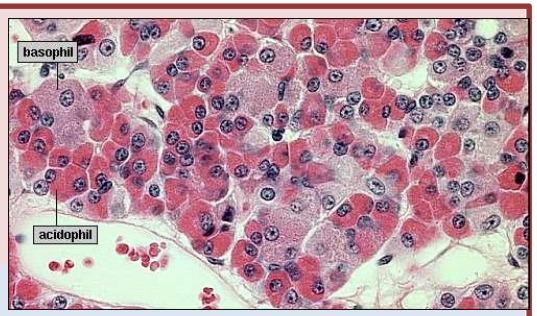
Gonadotropes (LH and FSH coexpressing cells):

- comprise 10–15% of anterior pituitary cells and are scattered throughout the anterior pituitary.

Pituitary cell types in hematoxylin-eosin stained section

Acidophils

- **Somatotrophes** produce growth hormone
- **Lactotrophes** produce prolactin



chromophil

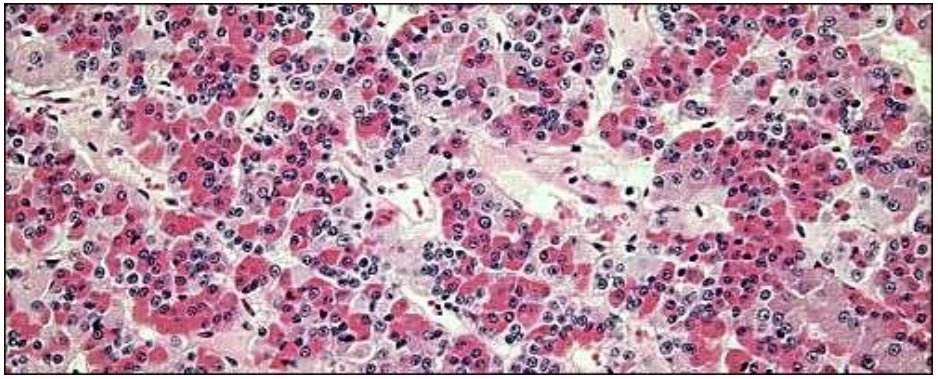
Basophils

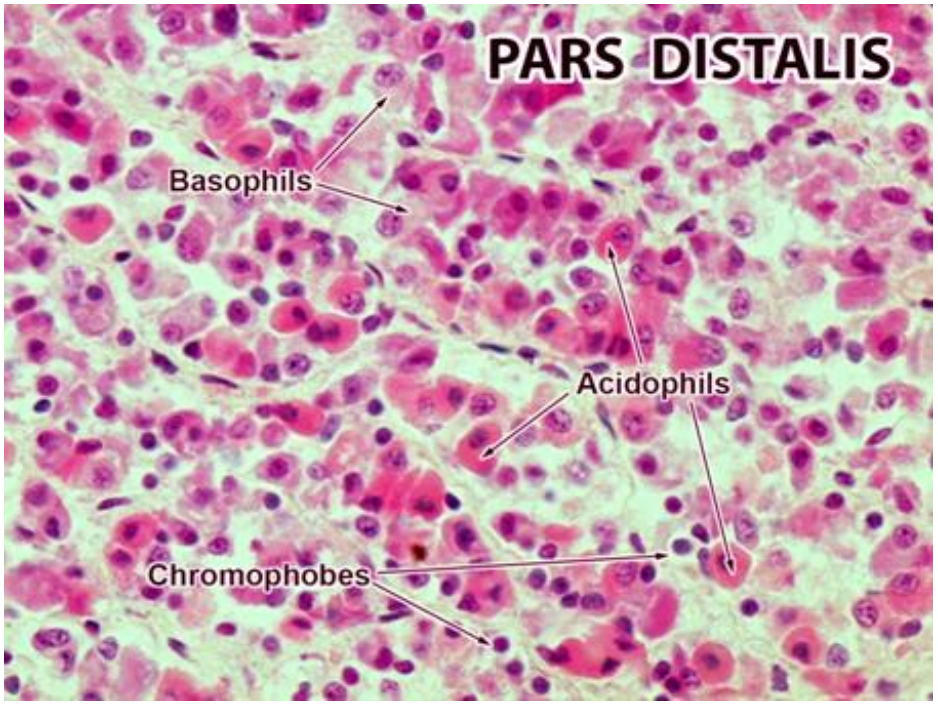
- **Thyrotrophes** produce thyroid stimulating hormone
- **Gonadotrophes** produce luteinizing hormone or follicle-stimulating hormone
- **Corticotrophes** produce adrenocorticotrophic hormone

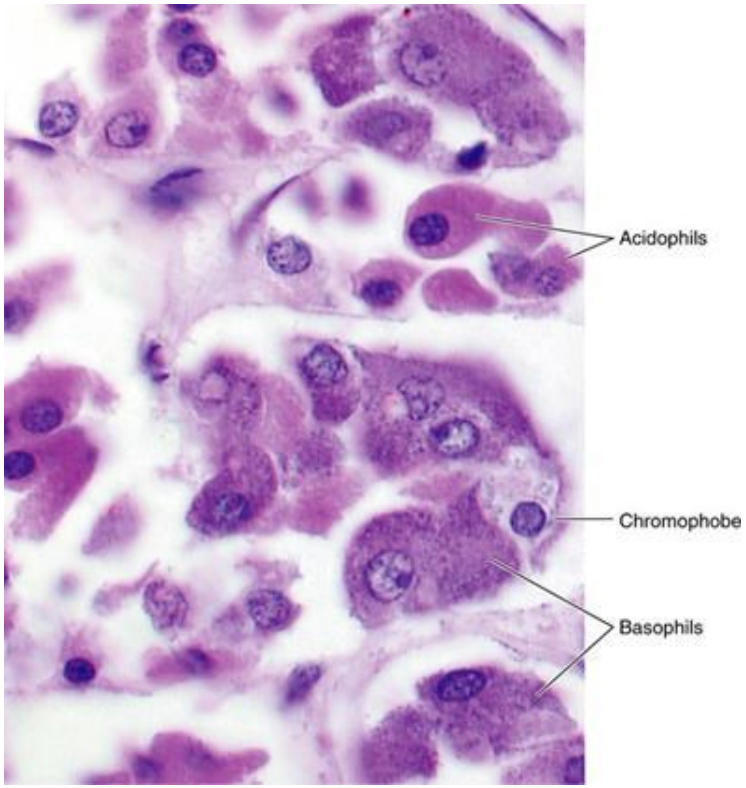
Chromophobes

These are cells that have minimal or no hormonal content. Many of the chromophobes may be acidophils or basophils that have degranulated and thereby are depleted of hormone. Some chromophobes may also represent stem cells that have not yet differentiated into hormone-producing cells.

Acidophil, basophil and chromophobe cells at light microscopic level

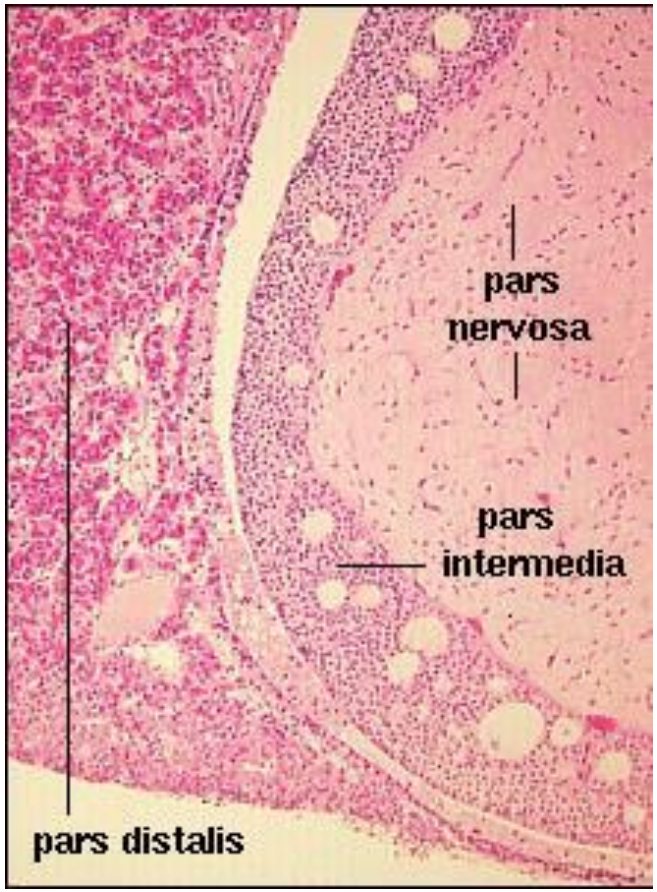


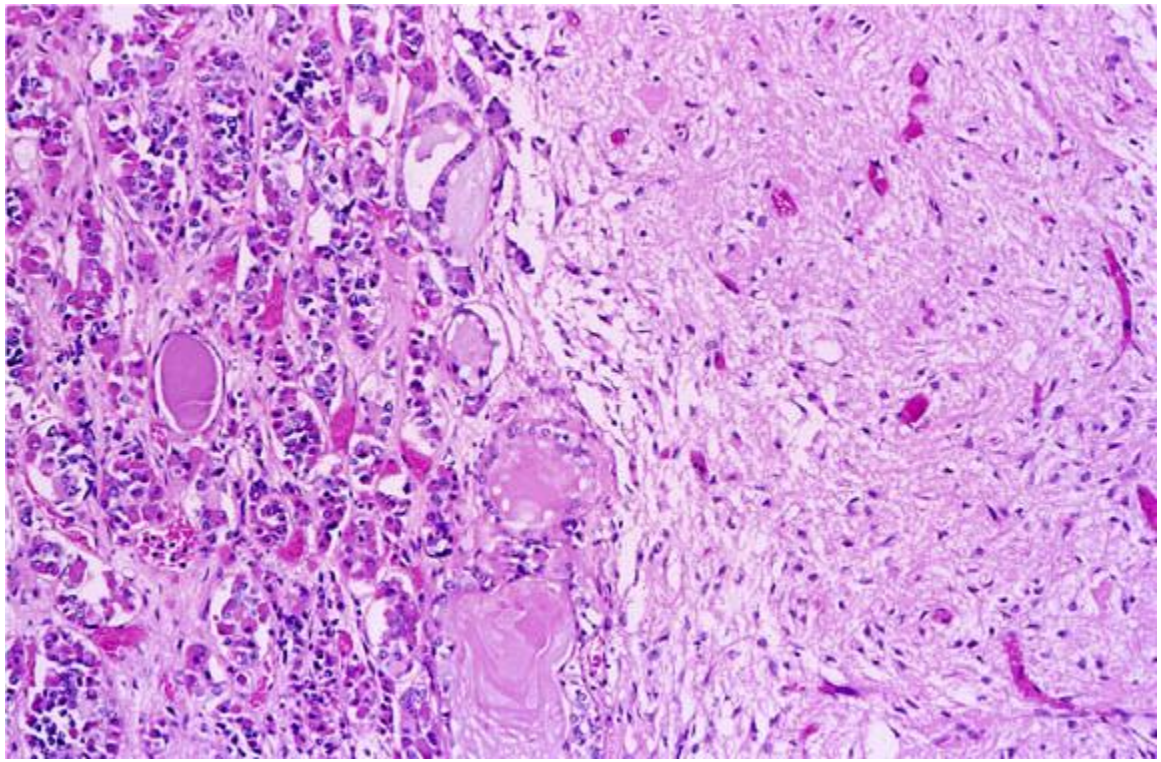




- cells arranged in cords
- pars distalis: all type of cells
- pars tuberalis: basophil cells

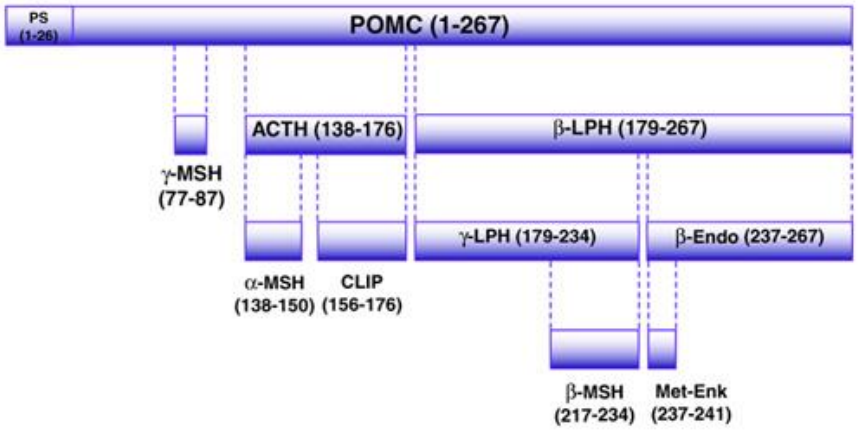
The pars intermedia is very small in adults and may contain colloid-filled cysts





- Cysts filled with colloid, lined with cuboidal cells, remainders of the Rathke's pouch
- Small basophils-hormone production (MSH), more active during fetal life
- Chromophobes

Proopiomelanocortin (POMC)



- Common precursor of ACTH and MSH.
- POMC cells: pars distalis and intermedia of pituitary, arcuate nucleus of the hypothalamus, epidermis.
- MSH stimulates melanin production of the skin (suntan).

John F. Kennedy

Hyperpigmentation (high MSH):

- Addison disease – adrenal cortex insufficiency: low cortisol , lack of feedback.
- Cushing disease - high ACTH and cortisol levels - pituitary adenoma.
- Pregnancy – melasma.

SUMMARY TABLE 18–2 The Pituitary Hormones

Region/Area	Hormone(s)	Target(s)	Hormonal Effect(s)	Hypothalamic Regulatory Hormone
ANTERIOR LOBE (ADENOHYPOPHYSIS)				
Pars distalis	Thyroid-stimulating hormone (TSH)	Thyroid gland	Secretion of thyroid hormones (T_3, T_4)	Thyrotropin-releasing hormone (TRH)
	Adrenocorticotropic hormone (ACTH)	Adrenal cortex (zona fasciculata)	Secretion of glucocorticoids (cortisol, corticosterone)	Corticotropin-releasing hormone (CRH)
	Gonadotropins:			
	Follicle-stimulating hormone (FSH)	Follicle cells of ovaries Sustentacular cells of testes	Secretion of estrogen, follicle development Stimulation of sperm maturation	Gonadotropin-releasing hormone (GnRH) As above
	Luteinizing hormone (LH)	Follicle cells of ovaries	Ovulation, formation of corpus luteum, secretion of progesterone	As above
		Interstitial cells of testes	Secretion of testosterone	As above
	Prolactin (PRL)	Mammary glands	Production of milk	Prolactin-releasing factor (PRF) Prolactin-inhibiting hormone (PIH)
	Growth hormone (GH)	All cells	Growth, protein synthesis, lipid mobilization and catabolism	Growth-hormone-releasing hormone (GH–RH) Growth hormone-inhibiting hormone (GH–IH)
Pars intermedia (not active in normal adults)	Melanocyte-stimulating hormone (MSH)	Melanocytes	Increased melanin synthesis in epidermis	Melanocyte-stimulating hormone–inhibiting hormone (MSH–IH)
POSTERIOR LOBE (NEUROHYPOPHYSIS OR PARS NERVOSA)				
	Antidiuretic hormone (ADH)	Kidneys	Reabsorption of water, elevation of blood volume and pressure	None: Transported along axons from supraoptic nucleus to posterior lobe of the pituitary gland
	Oxytocin (OT)	Uterus, mammary glands (females) Ductus deferens and prostate gland (males)	Labor contractions, milk ejection Contractions of ductus deferens and prostate gland	None: Transported along axons from paraventricular nucleus to posterior lobe of the pituitary gland

Take home message

Hypothalamus	Transport to the pituitary	Target within the pituitary	Action in the pituitary
Magnocellular nuclei (supraoptic, paraventricular)	axonal projection	neurohypophysis	storage and release into the systematic circulation
Parvocellular nuclei, regulatory hormones	portal circulation	adenohypophysis	regulation of anterior pituitary's hormone secretion