The Pituitary Gland

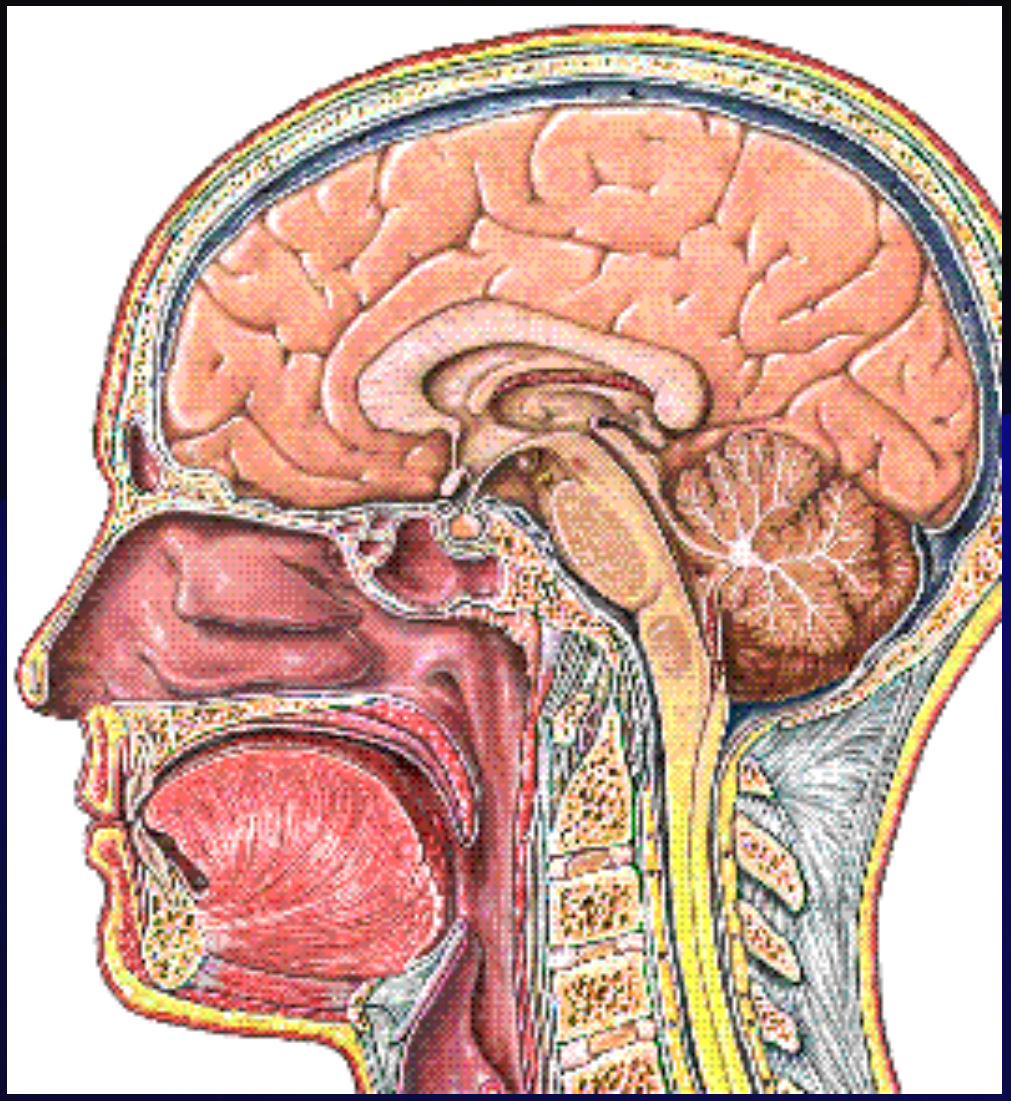
MENU

This tutorial is designed as a single presentation, but if you wish to review a particular section, click one of the links below...

Location of the Pituitary Gland

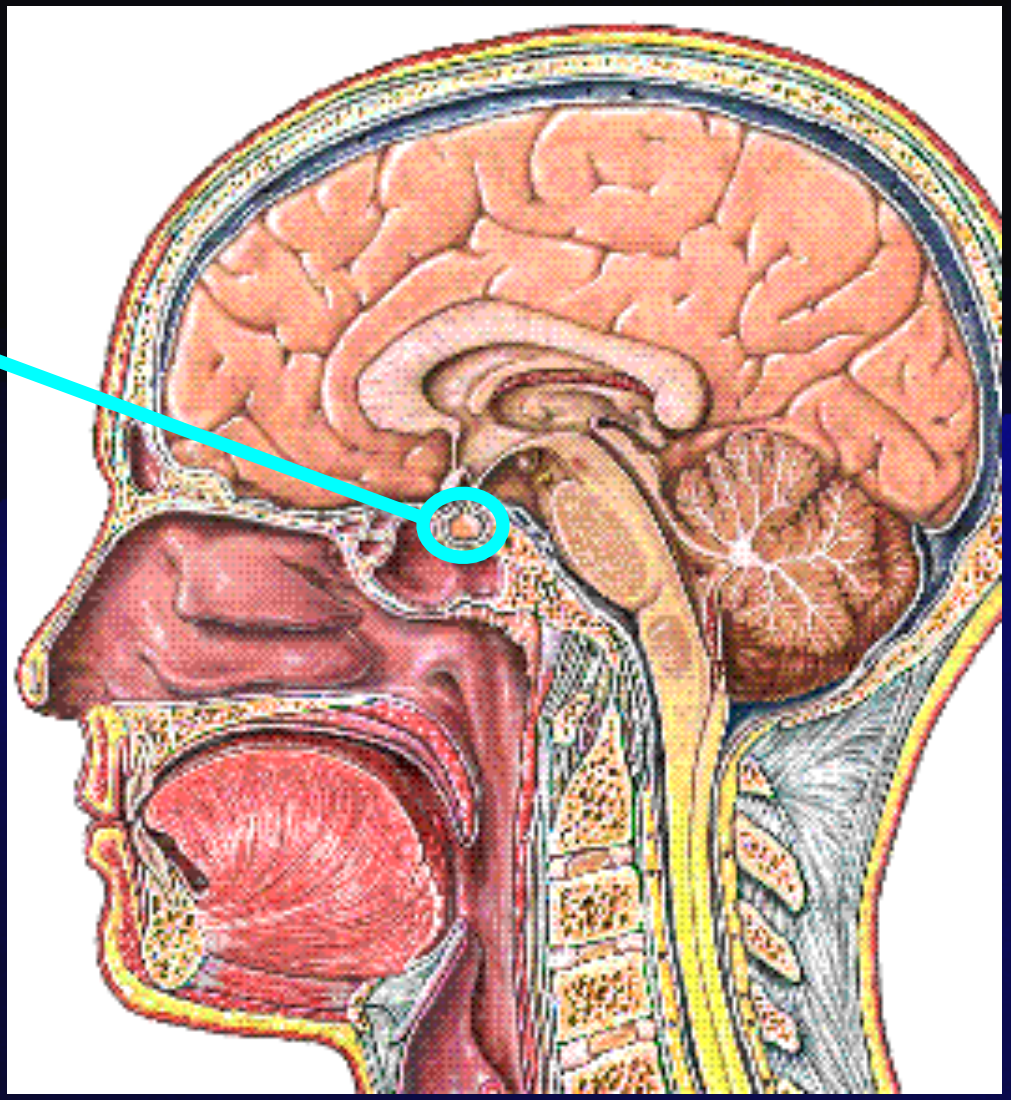
The pituitary gland controls the functions of many of the other endocrine glands.

It is about the size of a pea !.



Location of the Pituitary Gland

This is the pituitary gland!

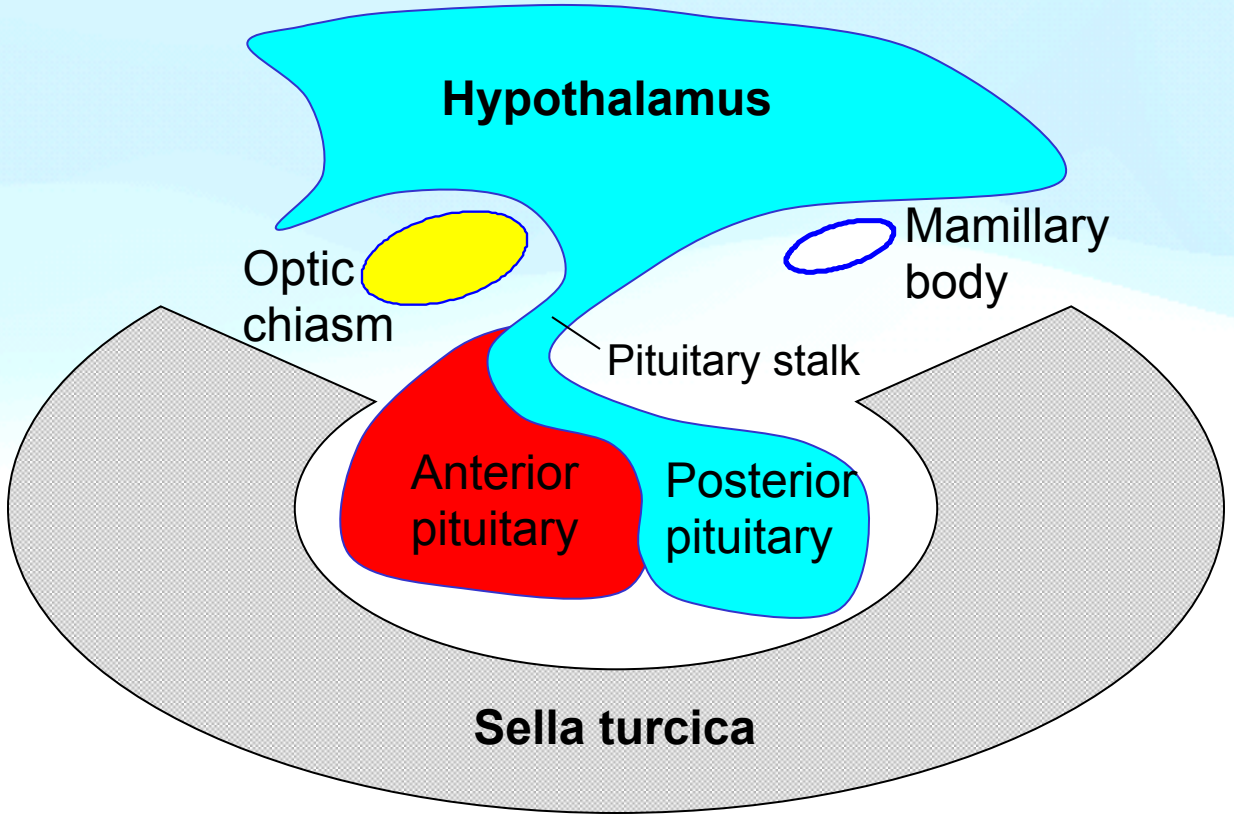


Let's now look at the anatomy of the pituitary gland and its relationship to the hypothalamus and surrounding tissues

Location of the pituitary and hypothalamus

The **hypothalamus** is located at the base of the brain in the posterior part of the forebrain *(diencephalon)*.

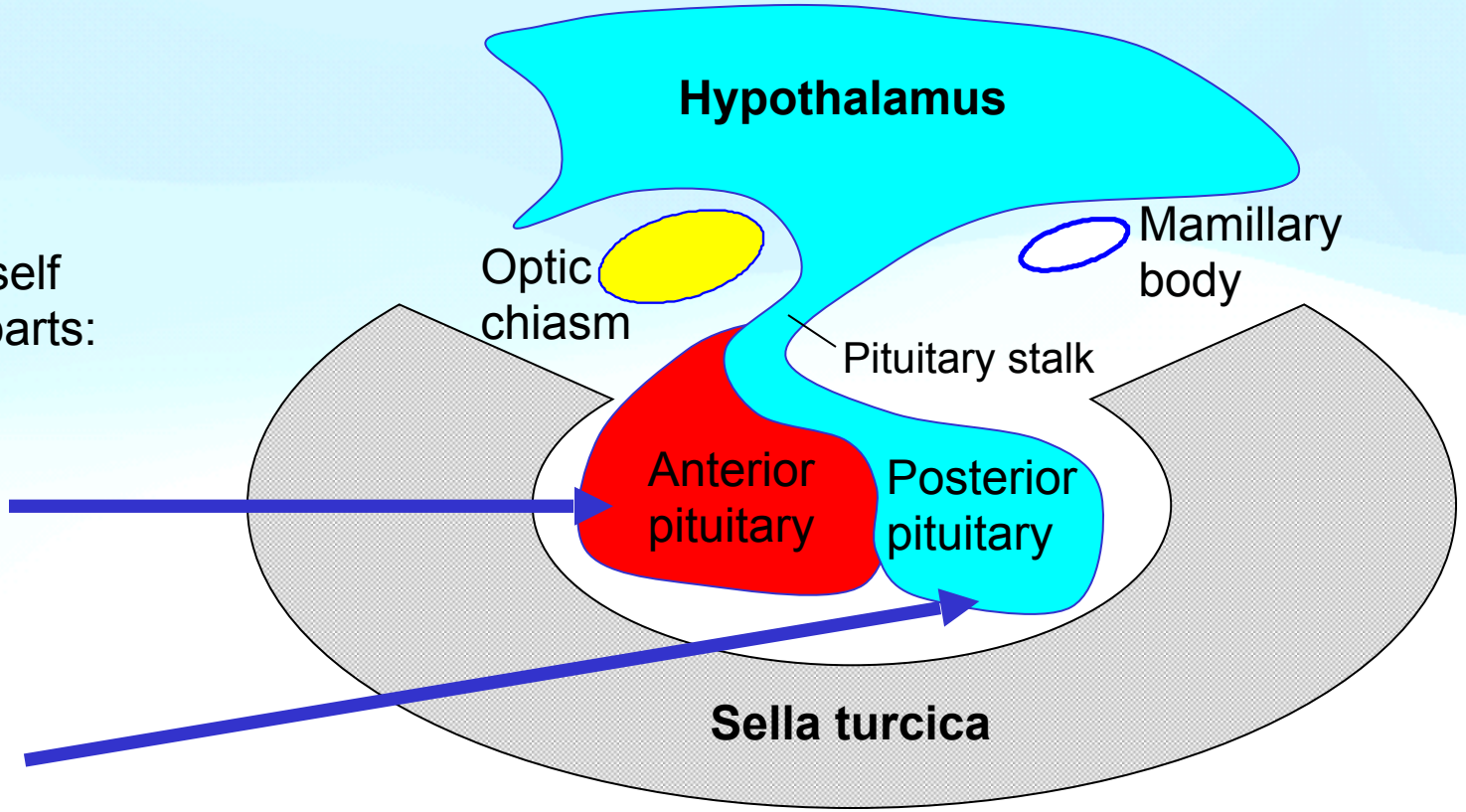
The pituitary is located at the base of the brain within a bony cavity called the *sella turcica*.



Location of the pituitary and hypothalamus

The **pituitary** gland itself consists of two main parts:

- the anterior lobe (*adenohypophysis)*
- the posterior lobe *(neurohypophysis)*

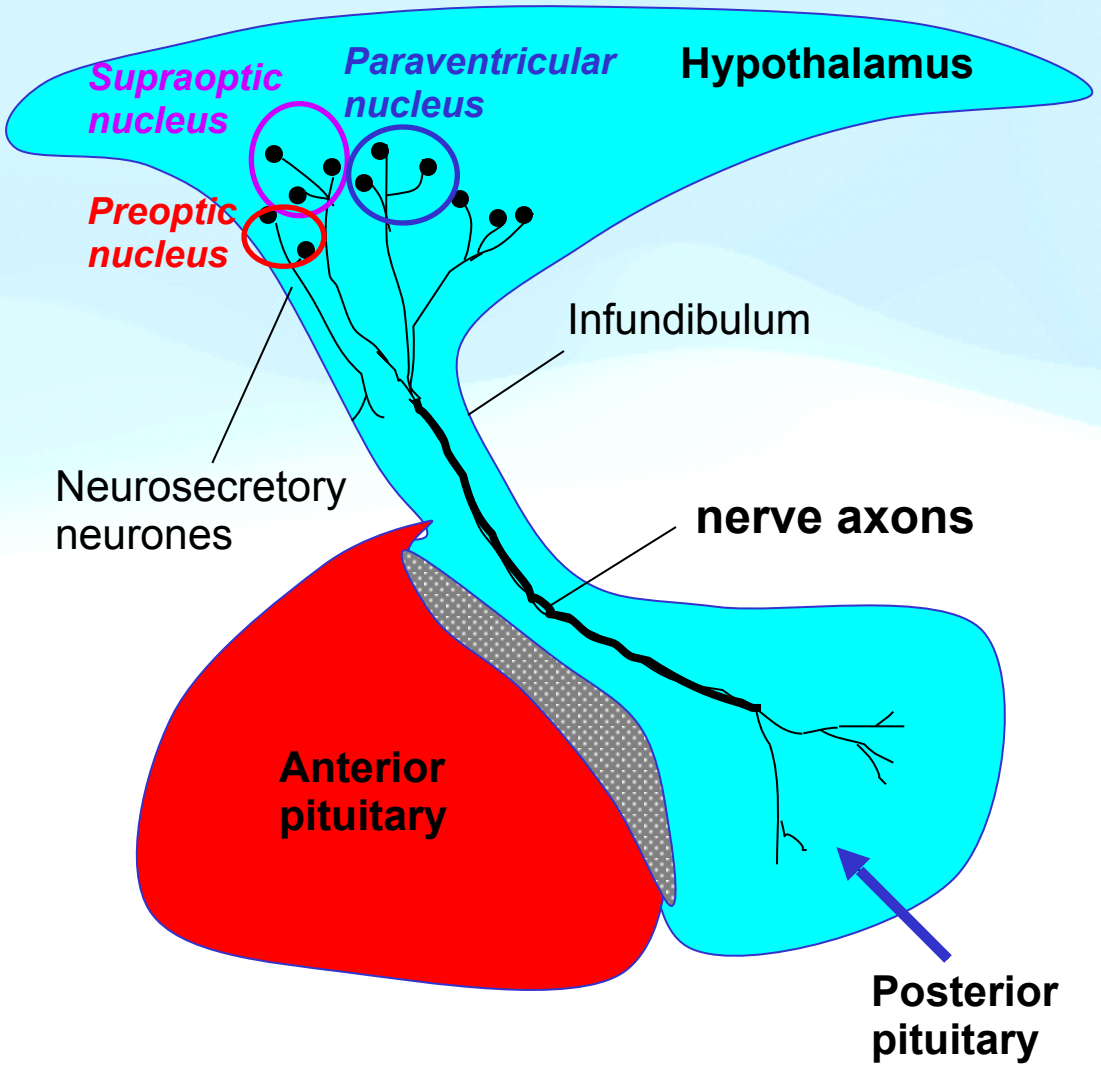


Anatomy of the hypothalamus and pituitary gland

The **hypothalamus** is the "integration centre" for many physiological processes in the body

It is made up of nervous tissue and contains specialised neurones arranged in groups called nuclei. These include the *preoptic*, the *supraoptic* and the *paraventricular* nuclei.

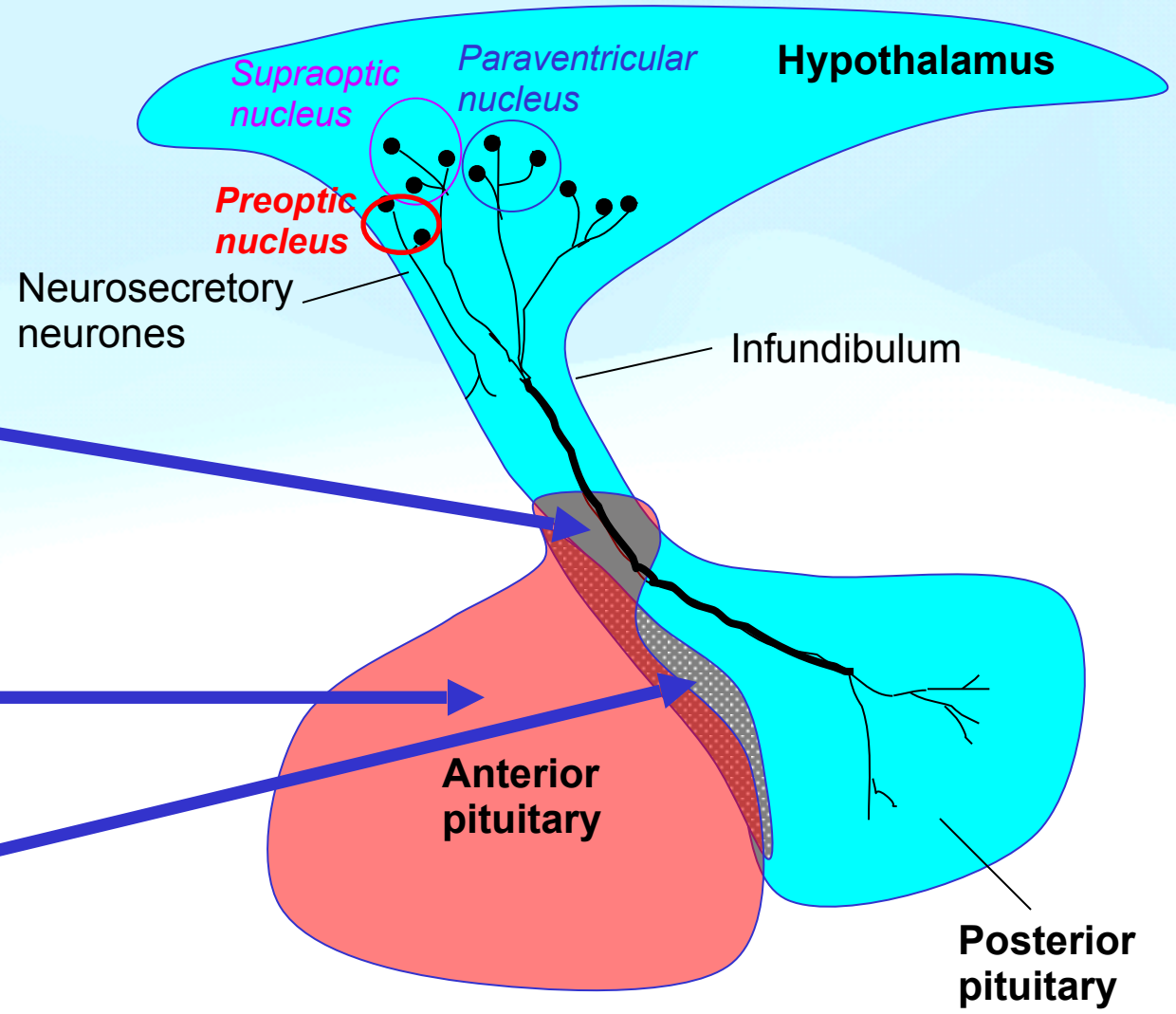
These nuclei have axons, which terminate in the <u>posterior lobe</u> of the pituitary.



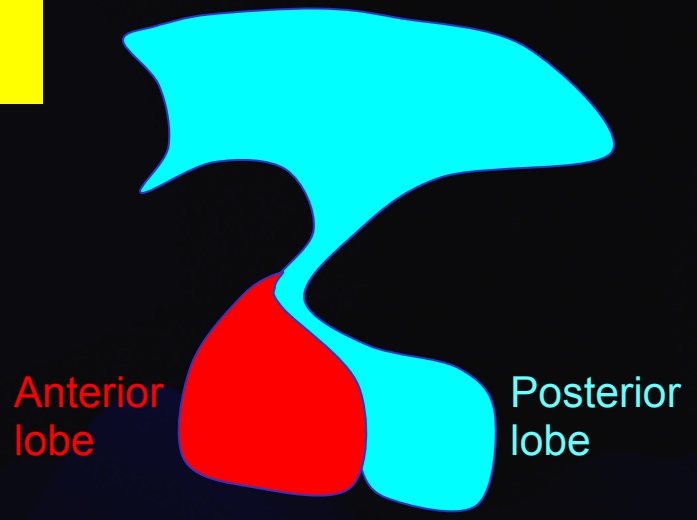
Anatomy of the hypothalamus and pituitary gland

The **anterior lobe** is larger than the posterior lobe and has three parts:

- the pars tuberalis, which forms a sleeve round the pituitary stalk
- the pars distalis (the major part)
- the pars intermedia, which adjoins the posterior lobe



Development of the pituitary gland



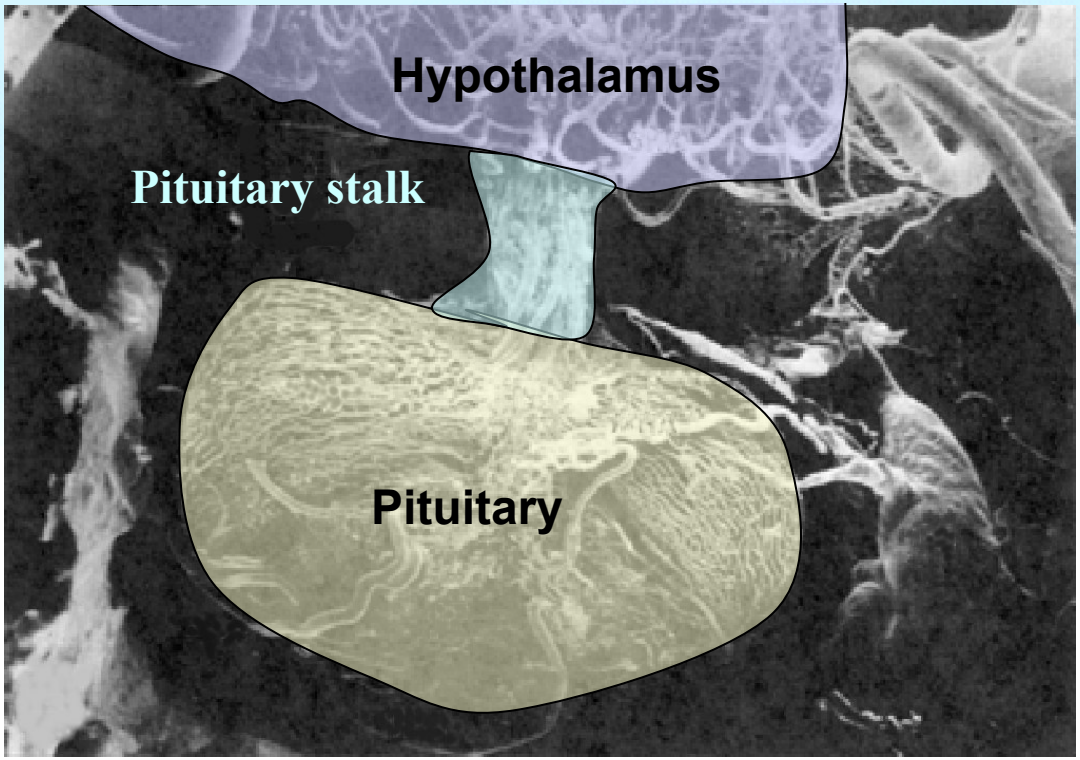
• The two lobes of the pituitary develop from different embryological tissues.

•The POSTERIOR pituitary is *neural tissue* derived from primitive ectoderm. It develops as a downgrowth from the hypothalamus.

•The ANTERIOR pituitary consists of *epithelial tissue* and develops upwards as an outgrowth from the roof of the mouth.

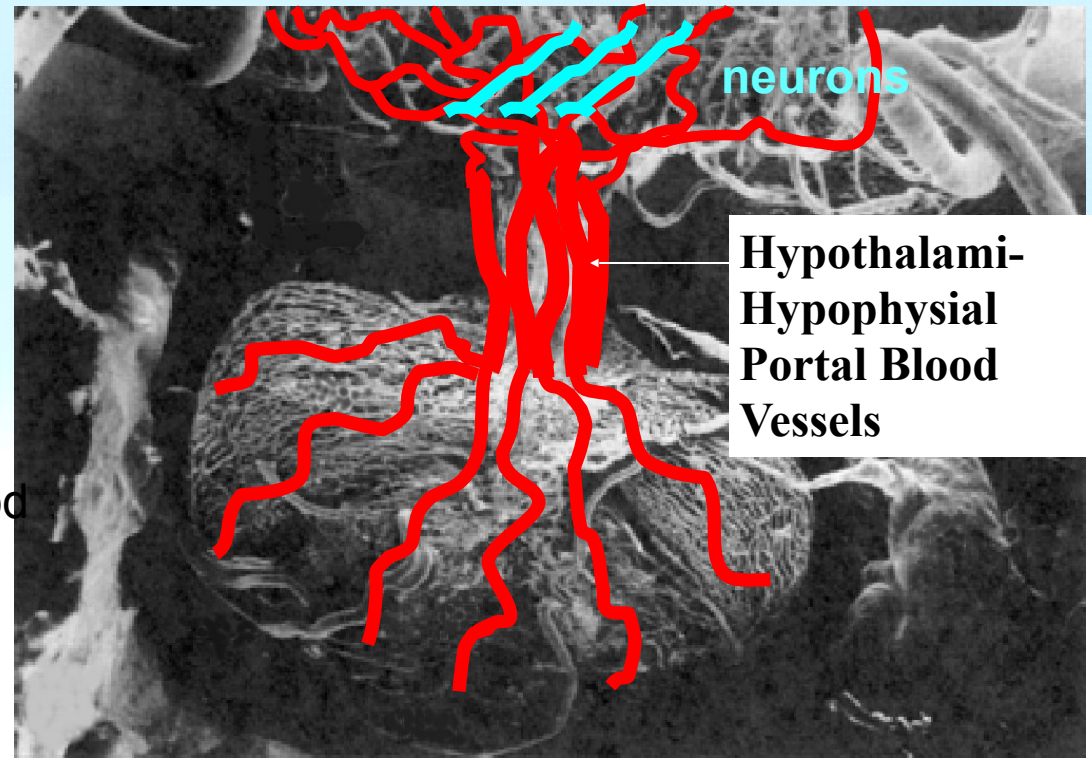
Connections between the hypothalamus and the anterior pituitary gland

In this photograph you can see the lower part of the hypothalamus connected to the pituitary gland by the pituitary stalk or infundibulum.



Connections between the hypothalamus and the anterior pituitary gland

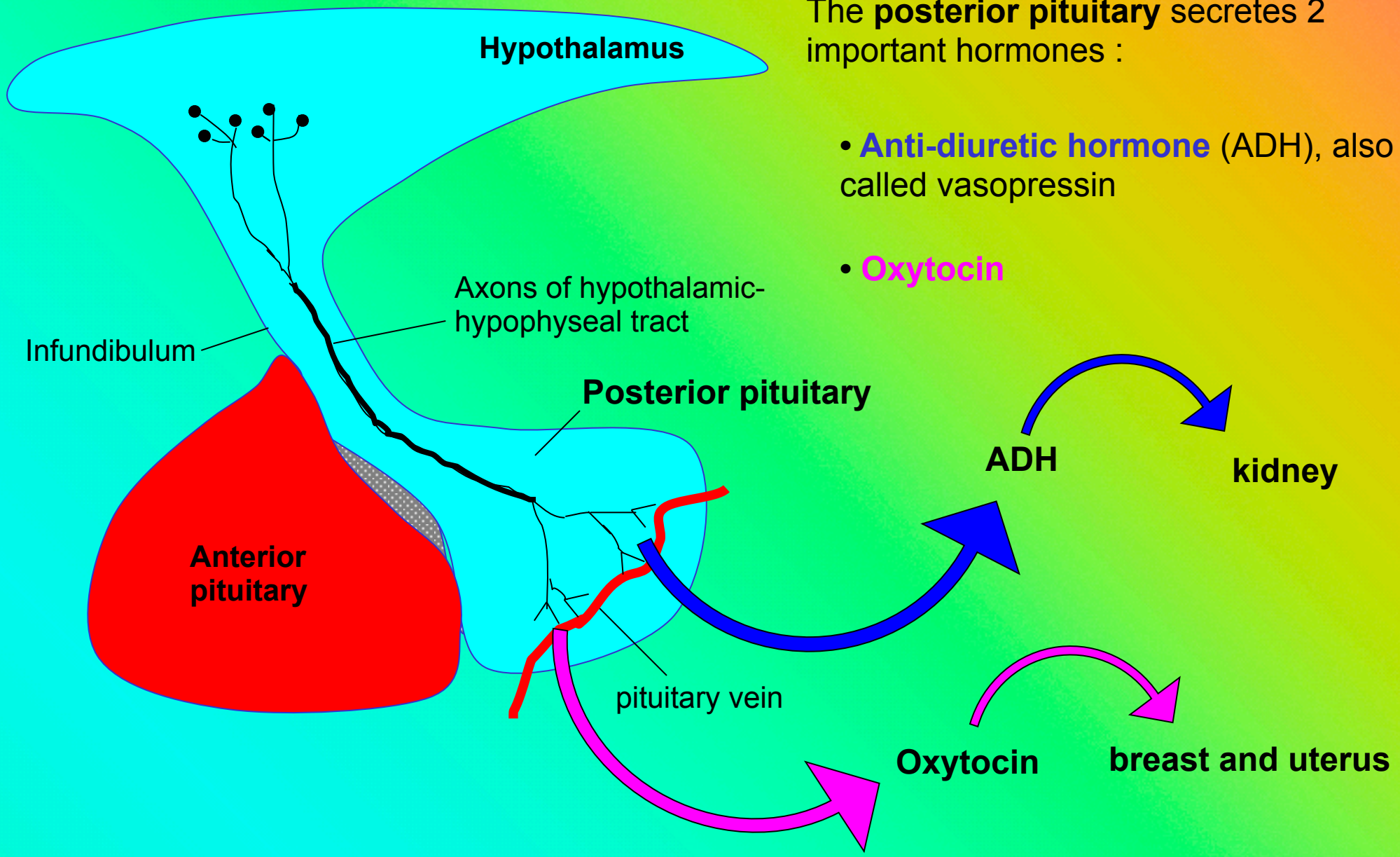
A network of blood capillaries in the hypothalamus drain into larger portal blood vessels, which link the hypothalamus to the anterior pituitary.



Some of the neurones in the hypothalamus terminate close to the blood capillaries in the hypothalamus, but there is **NO** direct neural connection between the hypothalamus and the anterior pituitary gland.

Posterior Pituitary Hormones

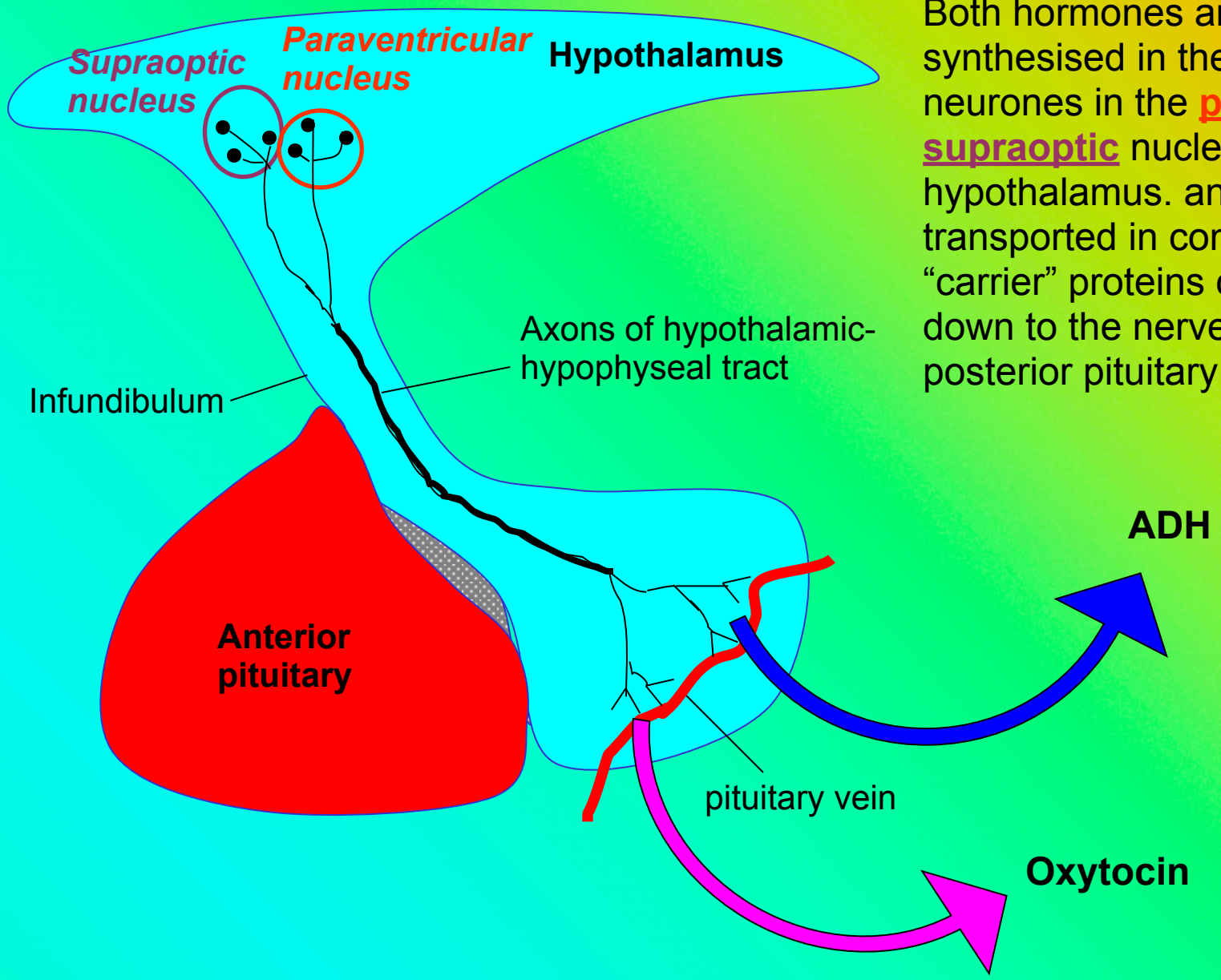
Control of the posterior pituitary gland



The **posterior pituitary** secretes 2 important hormones :

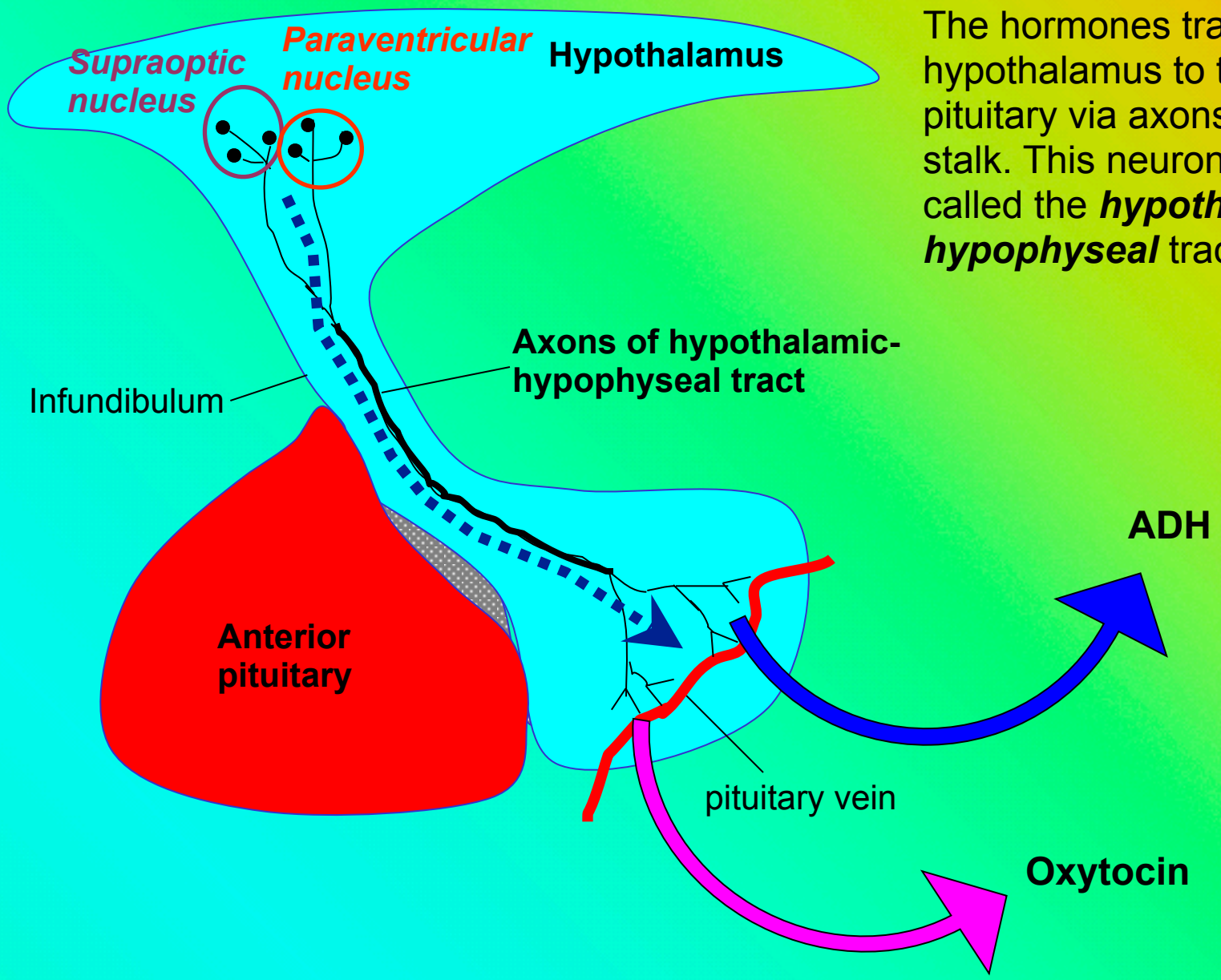
- **Anti-diuretic hormone** (ADH), also called vasopressin
- **Oxytocin**

Control of the posterior pituitary gland



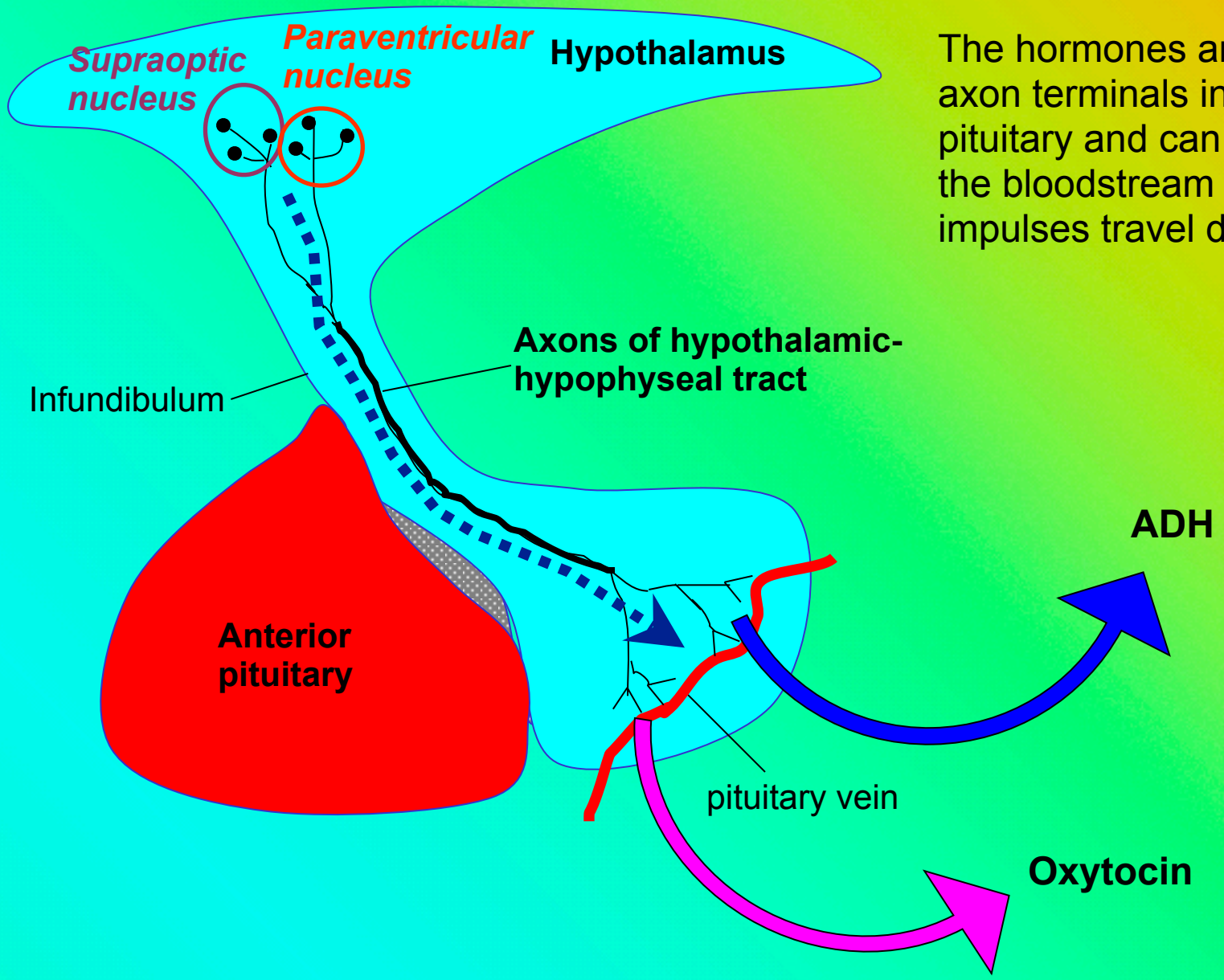
Both hormones are peptides, which are synthesised in the cell bodies of neurones in the **paraventricular** and **supraoptic** nuclei of the hypothalamus. and are then transported in combination with "carrier" proteins called neurophysins down to the nerve endings in the posterior pituitary gland.

Control of the posterior pituitary gland



The hormones travel from the hypothalamus to the posterior pituitary via axons in the pituitary stalk. This neuronal connection is called the ***hypothalamic-hypophyseal*** tract.

Control of the posterior pituitary gland

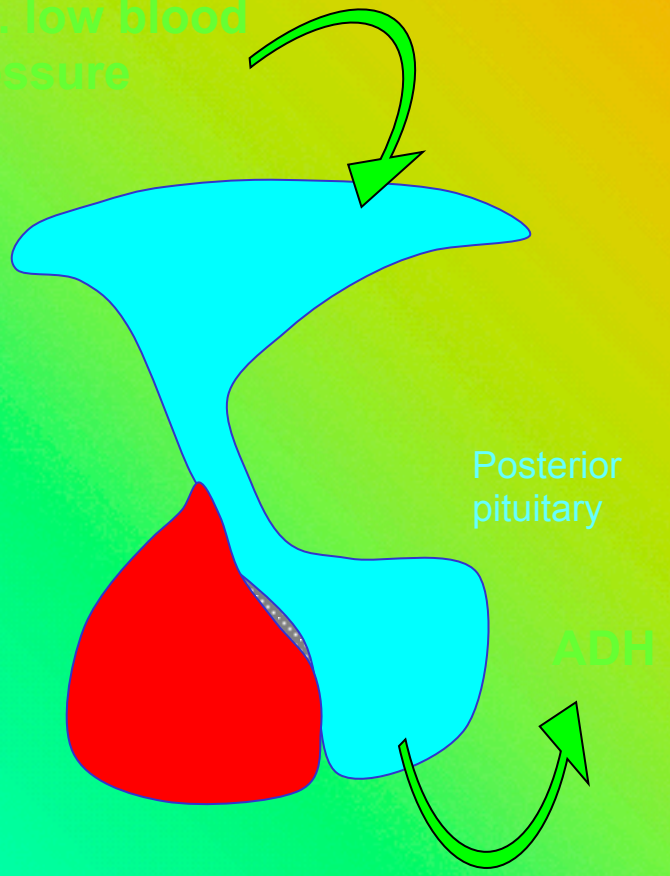


The hormones are stored in the axon terminals in the posterior pituitary and can be secreted into the bloodstream when nerve impulses travel down the neurons

What are the actions of the posterior pituitary hormones?

Anti-diuretic hormone (ADH) (vasopressin)

- ADH secretion is stimulated by low blood pressure
- ADH increases water reabsorption in the kidney and so modulates blood pressure
- A deficiency in ADH causes diabetes insipidus (polyuria, hypotension)

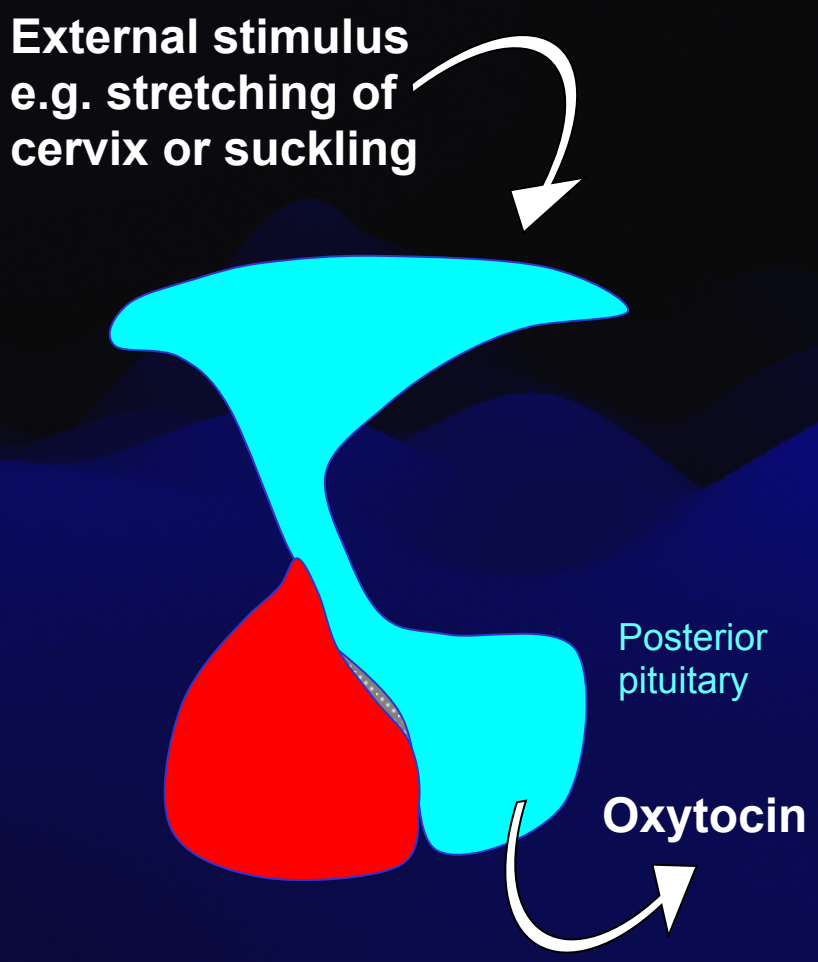


Oxytocin

- Oxytocin secretion is stimulated by stretching of the cervix during birth and suckling of the baby at the breast

- Oxytocin stimulates uterine contractions during labour and the milk ejection reflex after birth

- A deficiency of oxytocin causes a failure to progress in labour and difficulty with breast feeding



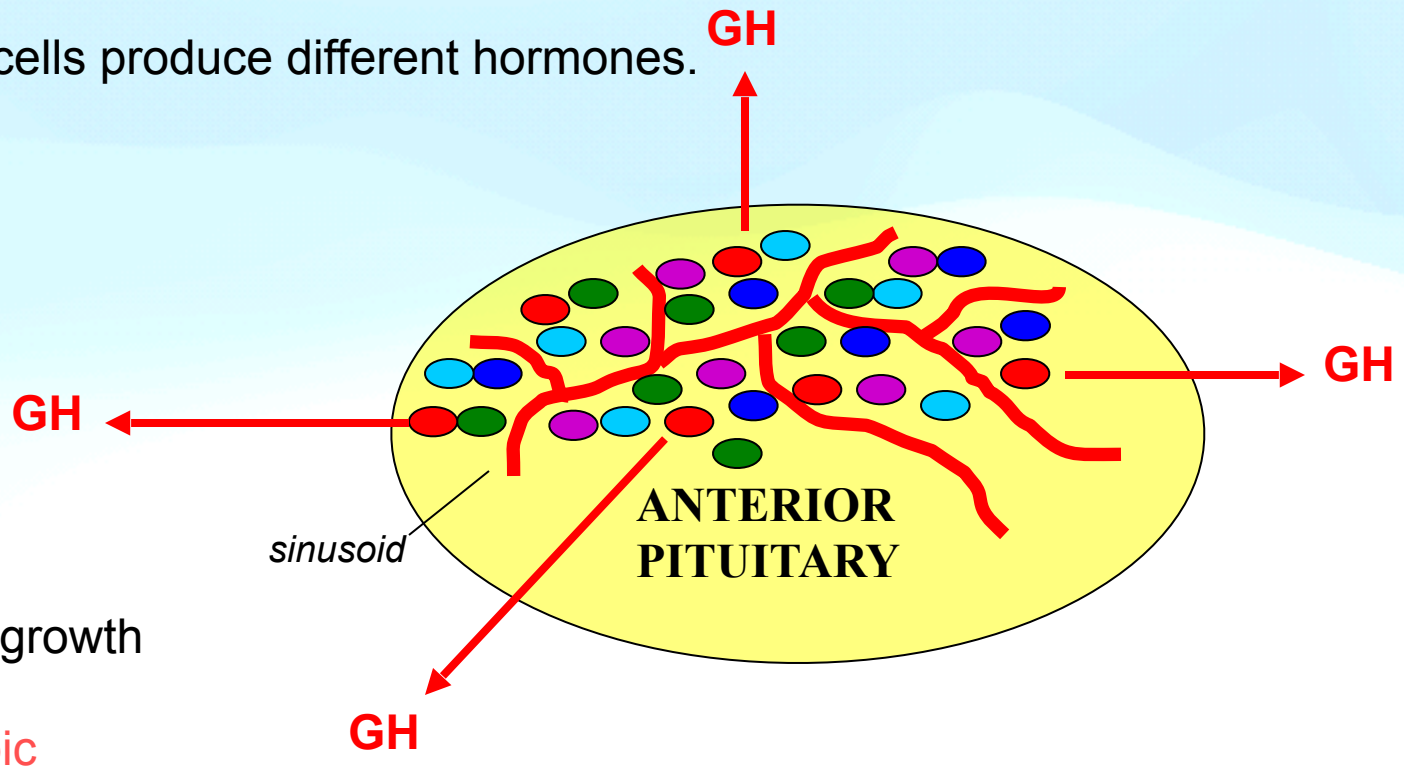
Anterior Pituitary Hormones

Cellular structure of the anterior pituitary gland

The anterior pituitary is composed of groups of epithelial cells surrounded by wide capillaries called *sinusoids*.

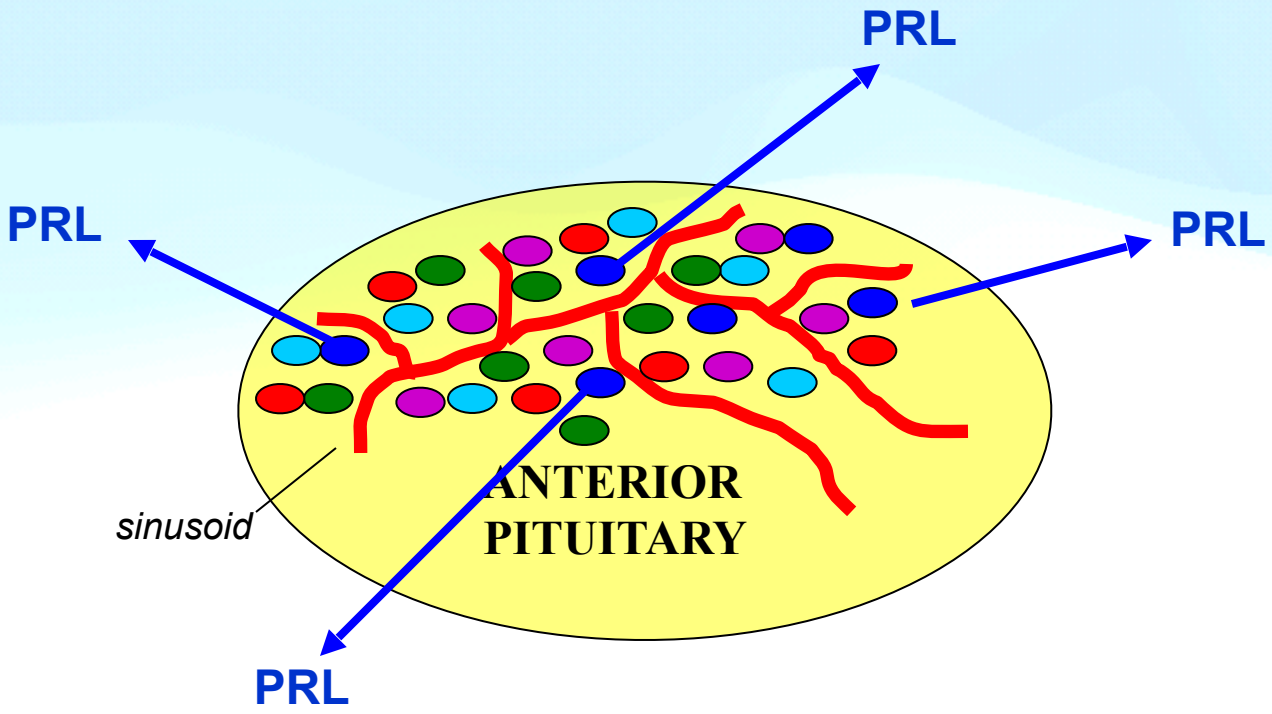
Different populations of cells produce different hormones.

For example:



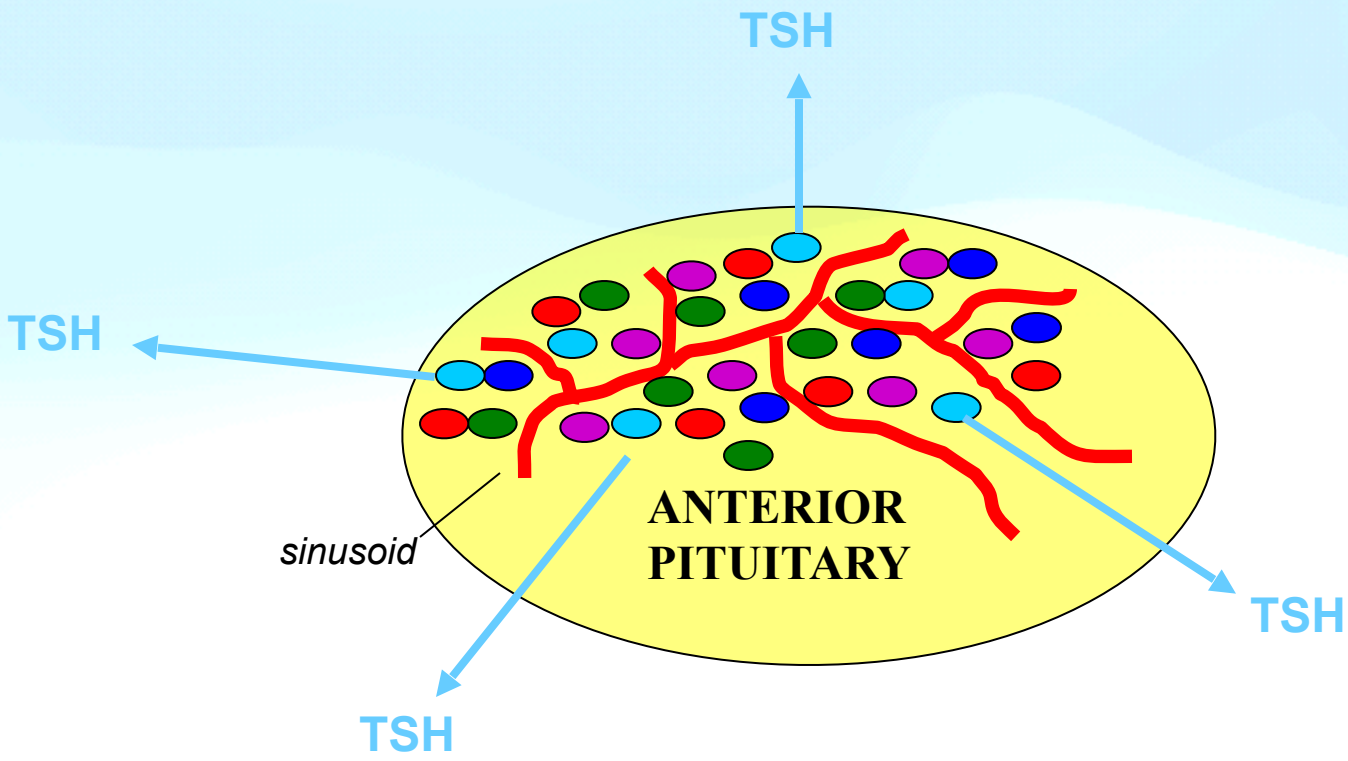
Somatotropes produce growth hormone (**GH**)
Also called (somatotropic hormone) or (somatotropin),

Lactotropes produce prolactin (**PRL**)

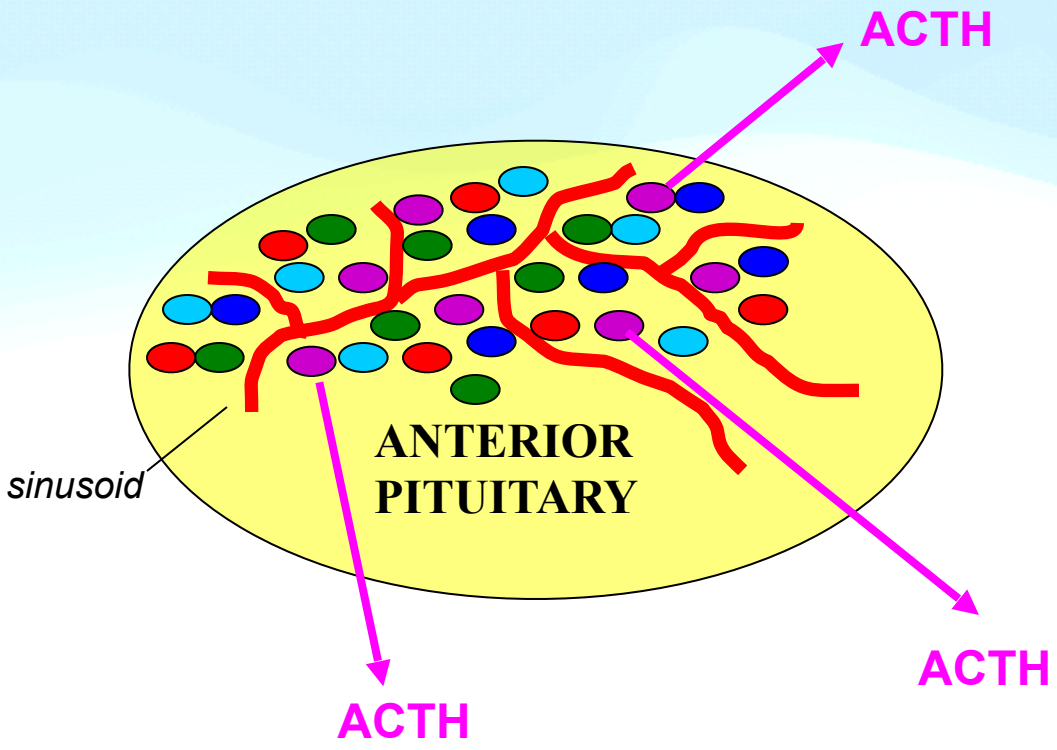


Thyrotropes produce thyroid-stimulating hormone (TSH)

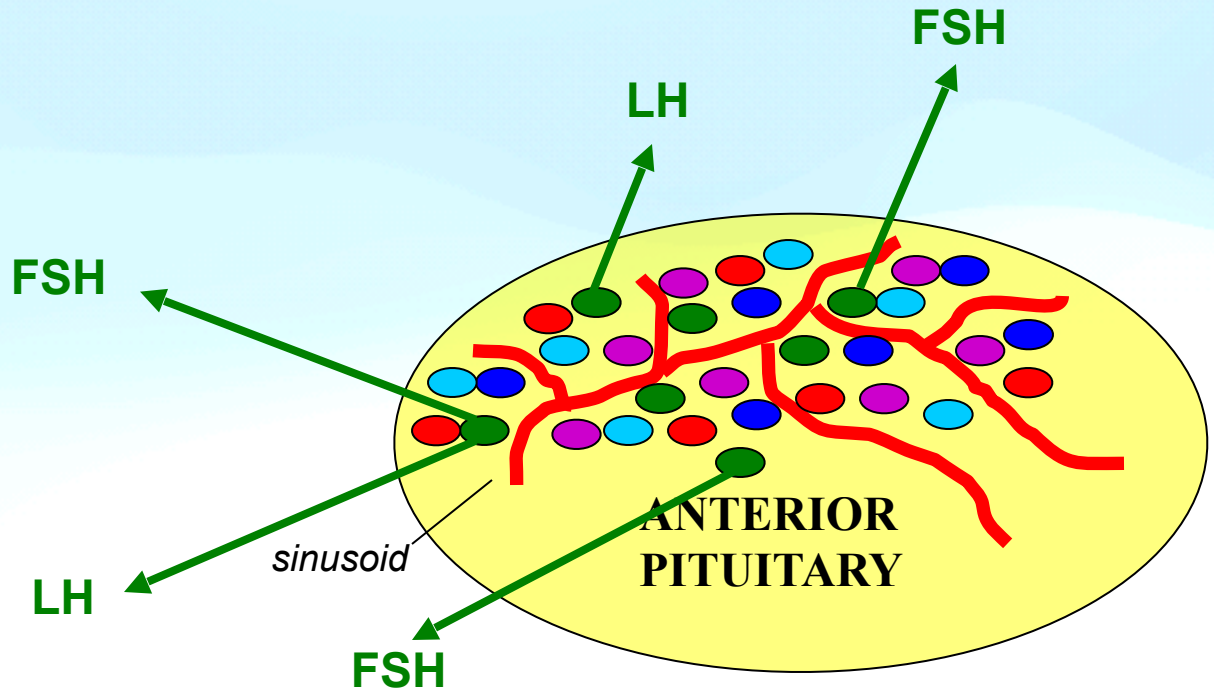
Also called Thyrotropin



Corticotropes produce adrenocorticotrophic hormone (**ACTH**) also called **(Corticotropin)**



Gonadotropes produce luteinizing hormone (**LH**) and follicle-stimulating hormone (**FSH**)

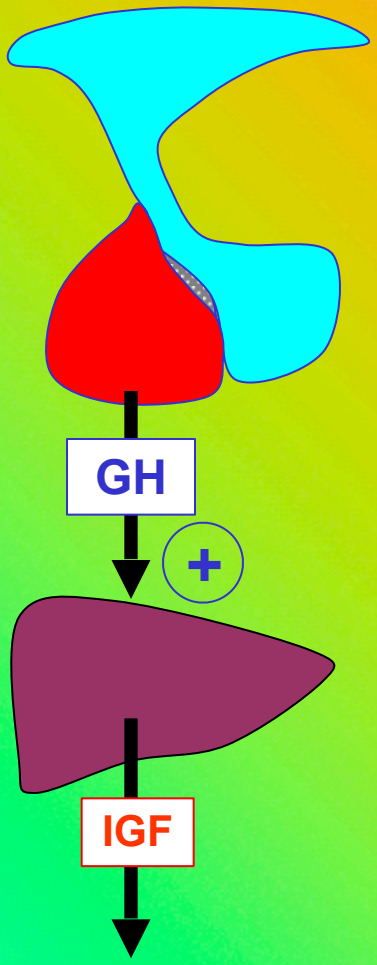


Anterior pituitary hormones - Growth Hormone

1. **Growth Hormone (GH)** regulates growth in the muscles and bones and opposes the action of insulin

Many body cells (chondrocytes, fat cells, muscle, but mainly the liver) respond to GH by secreting insulin-like growth factor (IGF)

Therefore, GH acts <u>indirectly</u> via IGF to regulate body growth



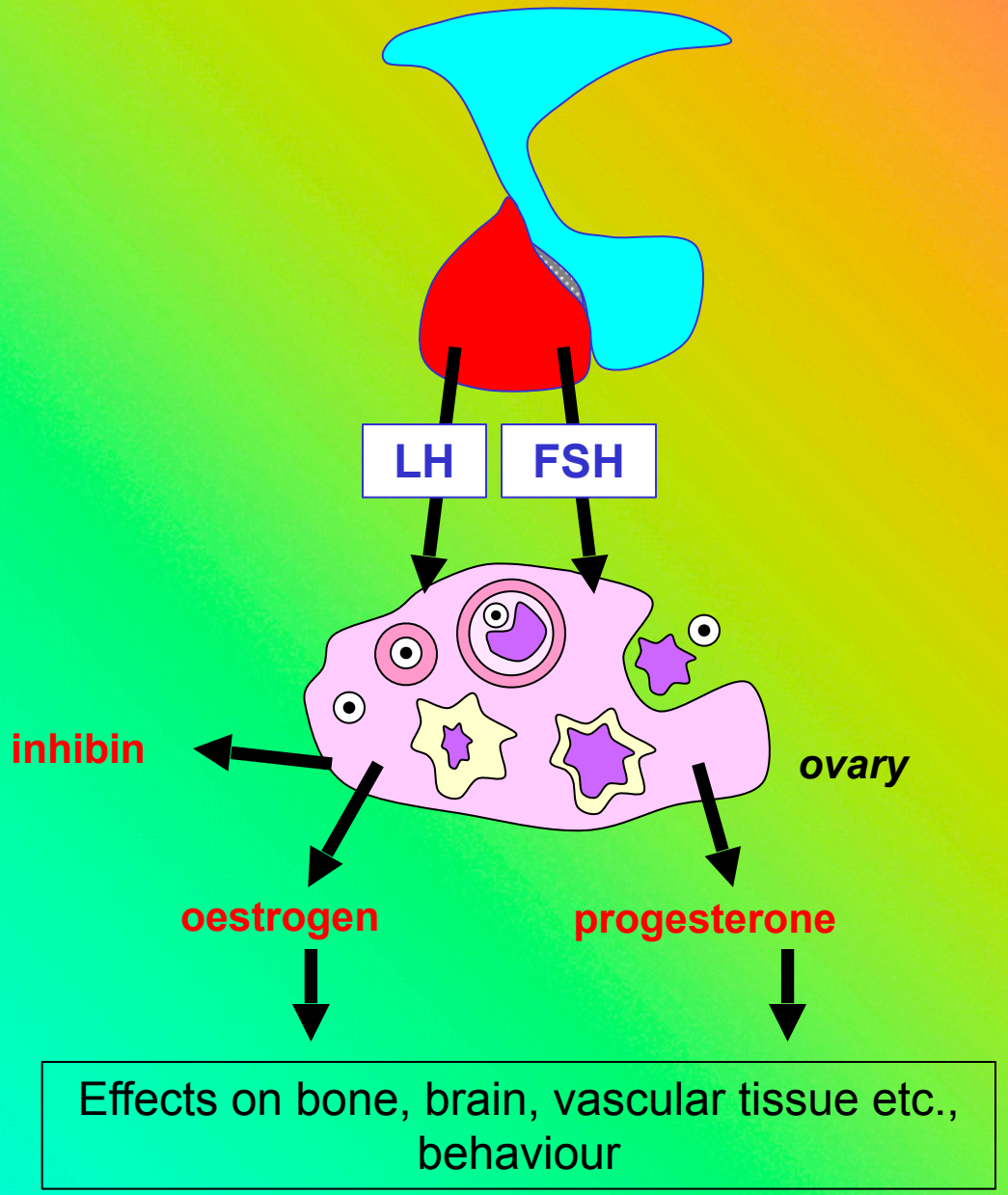
Growth and cellular differentiation in bone, muscle and adipose cells

Anterior pituitary hormones - LH and FSH

2. **Luteinising Hormone (LH)** and **Follicle Stimulating Hormone (FSH)** control both the ovaries and testes

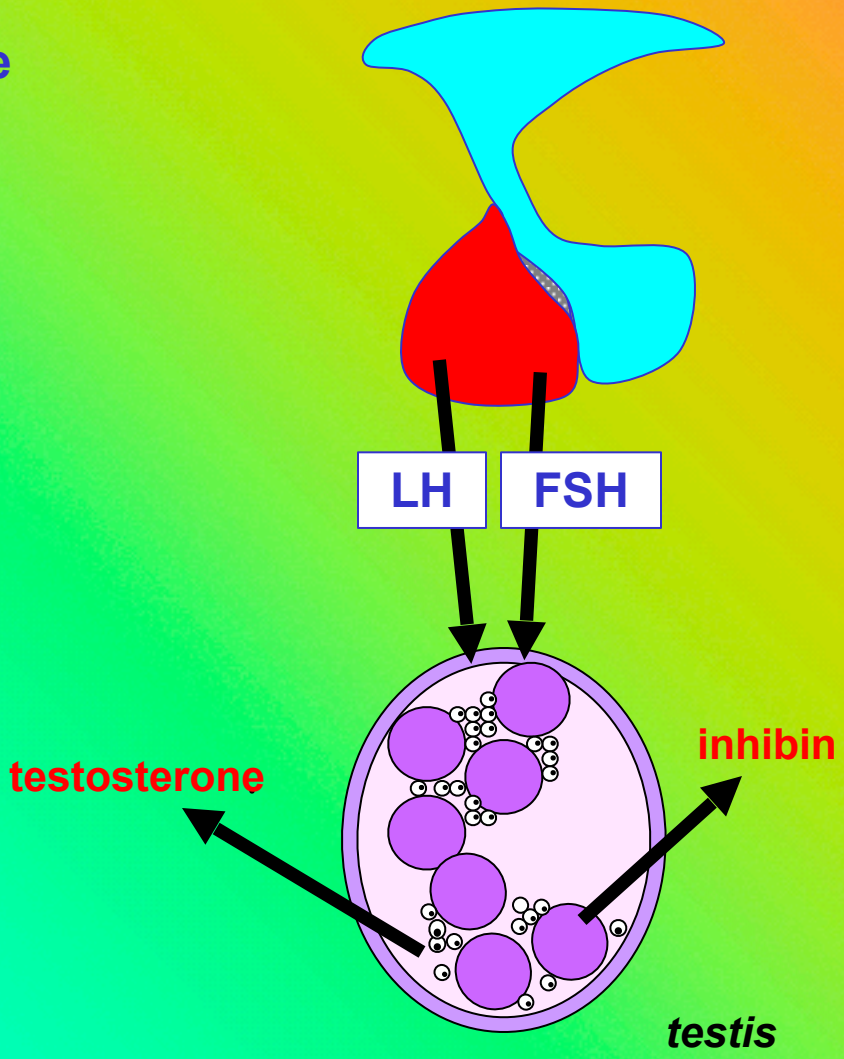
In the female, **LH** and **FSH** stimulate the ovary.

The ovarian steroid hormones (oestradiol and progesterone) have effects on many other parts of the body (bone, brain, vascular tissue etc.), secondary sexual characteristics and behaviour.



2. **Luteinising Hormone (LH)** and **Follicle Stimulating Hormone (FSH)** control both the ovaries and testes

In the male, **LH** and **FSH** stimulate the Leydig cells and the Sertoli cells in the testis, respectively, to secrete testosterone and inhibin



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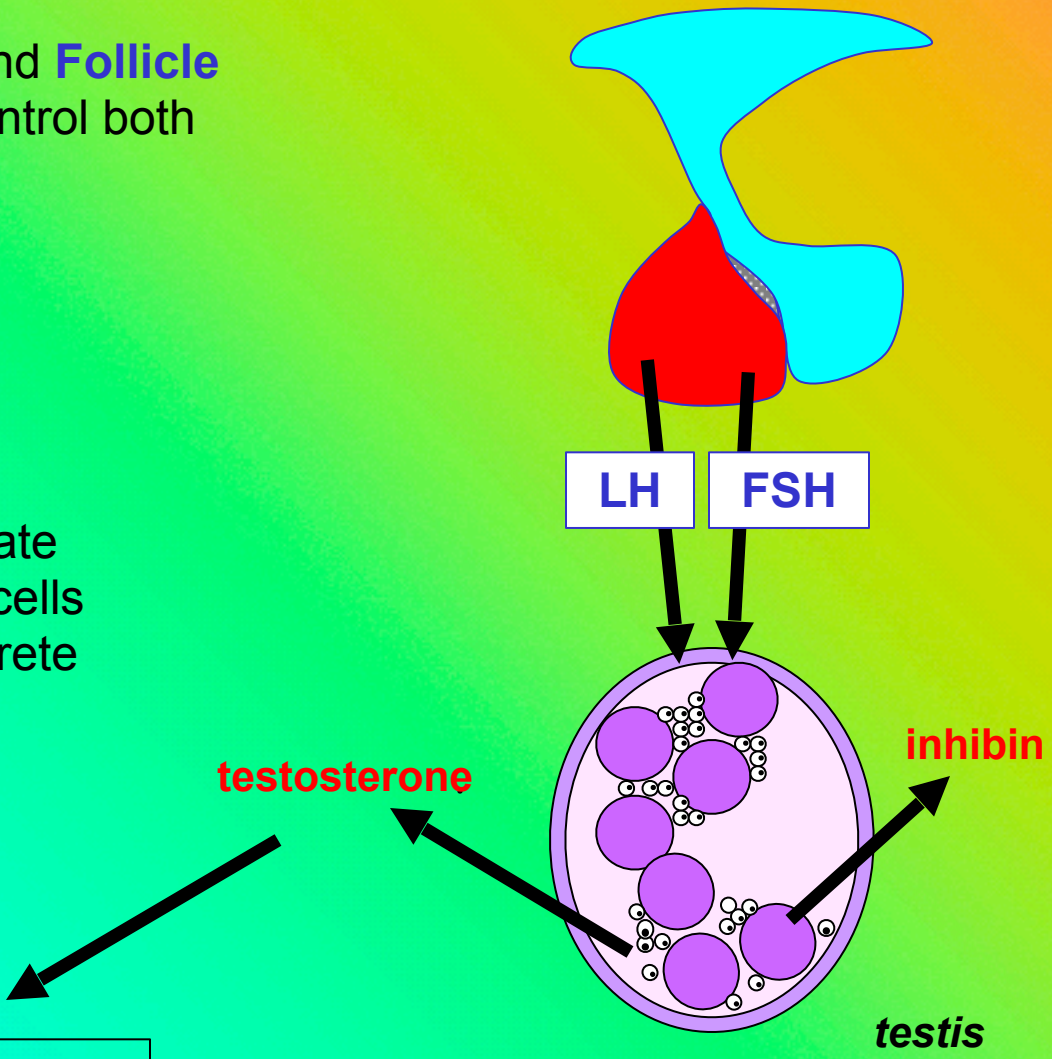
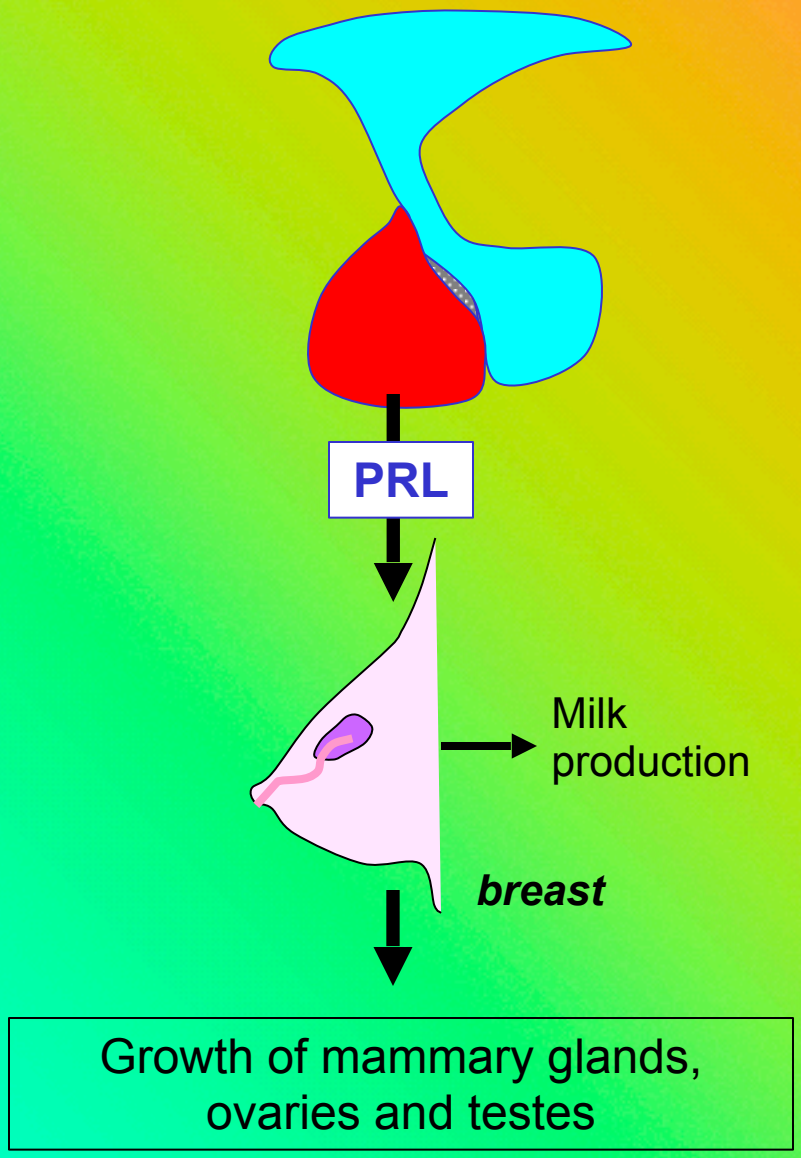


Spermatogenesis, secondary sexual characteristics and behaviour

Anterior pituitary hormones - Prolactin

3. **Prolactin (PRL)** initiates lactation and promotes the growth of the mammary glands, ovaries and testes

Prolactin acts directly on the breast to stimulate milk production.

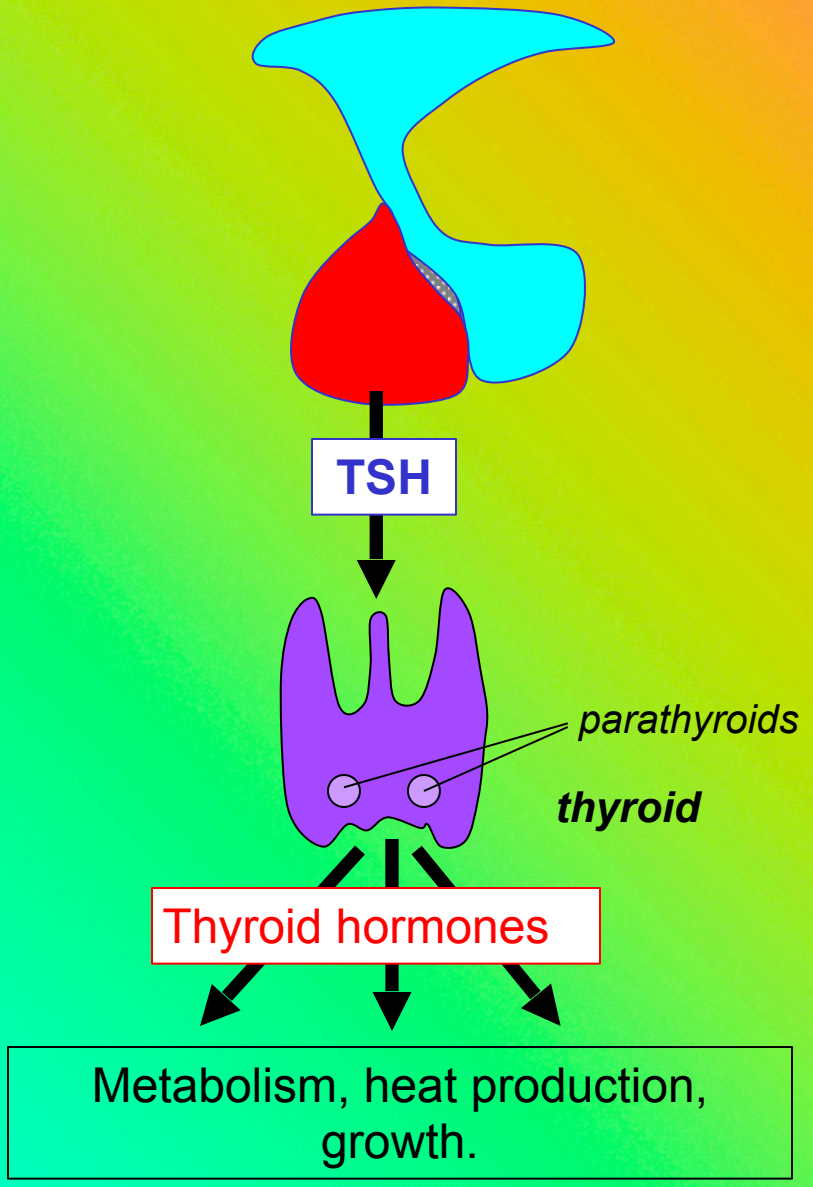


Anterior pituitary hormones - Thyroid-stimulating hormone

4. **Thyroid-stimulating hormone (TSH)** regulates the thyroid gland

TSH acts on the thyroid gland to stimulate the release of thyroid hormones (Thyroxine, T_4, Tri-iodothyronine, T_3, and Calcitonin) as well as changes to the thyroid gland

The thyroid hormones play an important role in controlling control carbohydrate and fat metabolism, and basal metabolic rate.

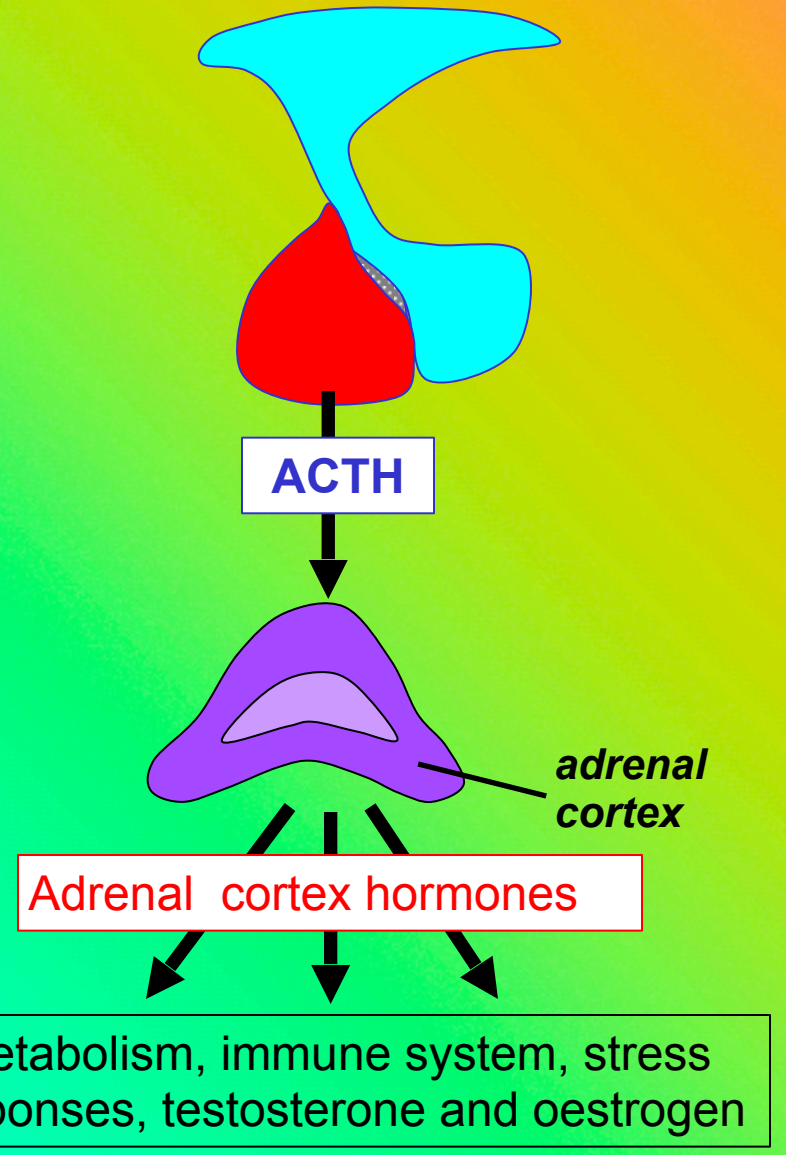


Anterior pituitary hormones - Adrenocorticotrophic hormone

5. **Adrenocorticotrophic hormone (ACTH)** controls hormone secretion from the adrenal cortex

ACTH acts on the adrenal cortex to stimulate the release of glucocorticoids (mainly cortisol) and adrenal androgens (mainly androstenedione and dehydroepiandrosterone (DHEA))

Cortisol controls the metabolism of carbohydrates, fats and proteins, inflammatory and immune responses, and responses to stress



Summary of hormones secreted by the anterior pituitary gland

So the anterior pituitary secretes at least 7 important hormones:

Growth Hormone (GH) regulates growth in muscles and bones and opposes the action of insulin

Prolactin initiates lactation and promotes the growth of the mammary glands, ovaries and testes

Luteinising Hormone (LH) and
Follicle Stimulating Hormone (FSH) control both the ovaries and the testes

Thyroid Stimulating Hormone (TSH) regulates the thyroid gland

Adrenocorticotrophic Hormone (ACTH) controls hormone secretion from the adrenal cortex

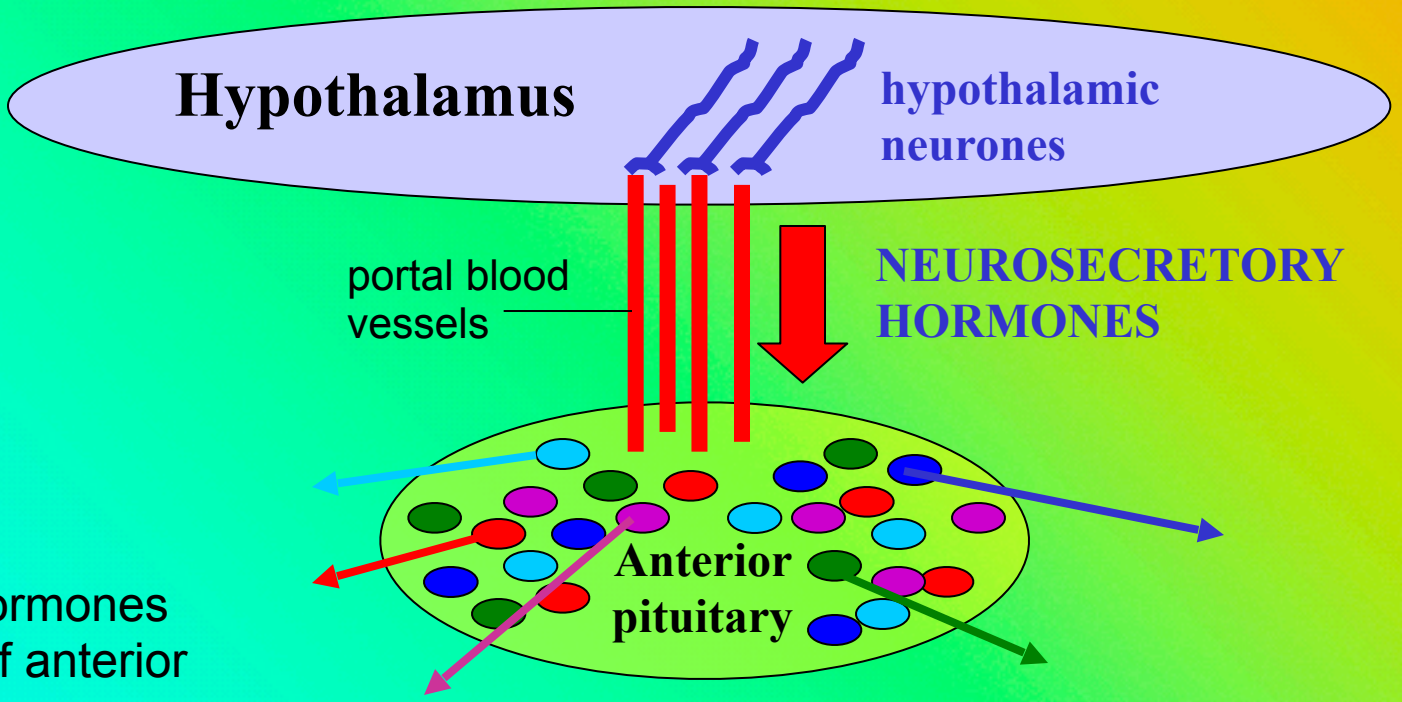
Control of the Anterior Pituitary

Hypothalamic control of the anterior pituitary hormones

We have already seen that many neurones terminate in the base of the hypothalamus in close association with the portal blood vessels.

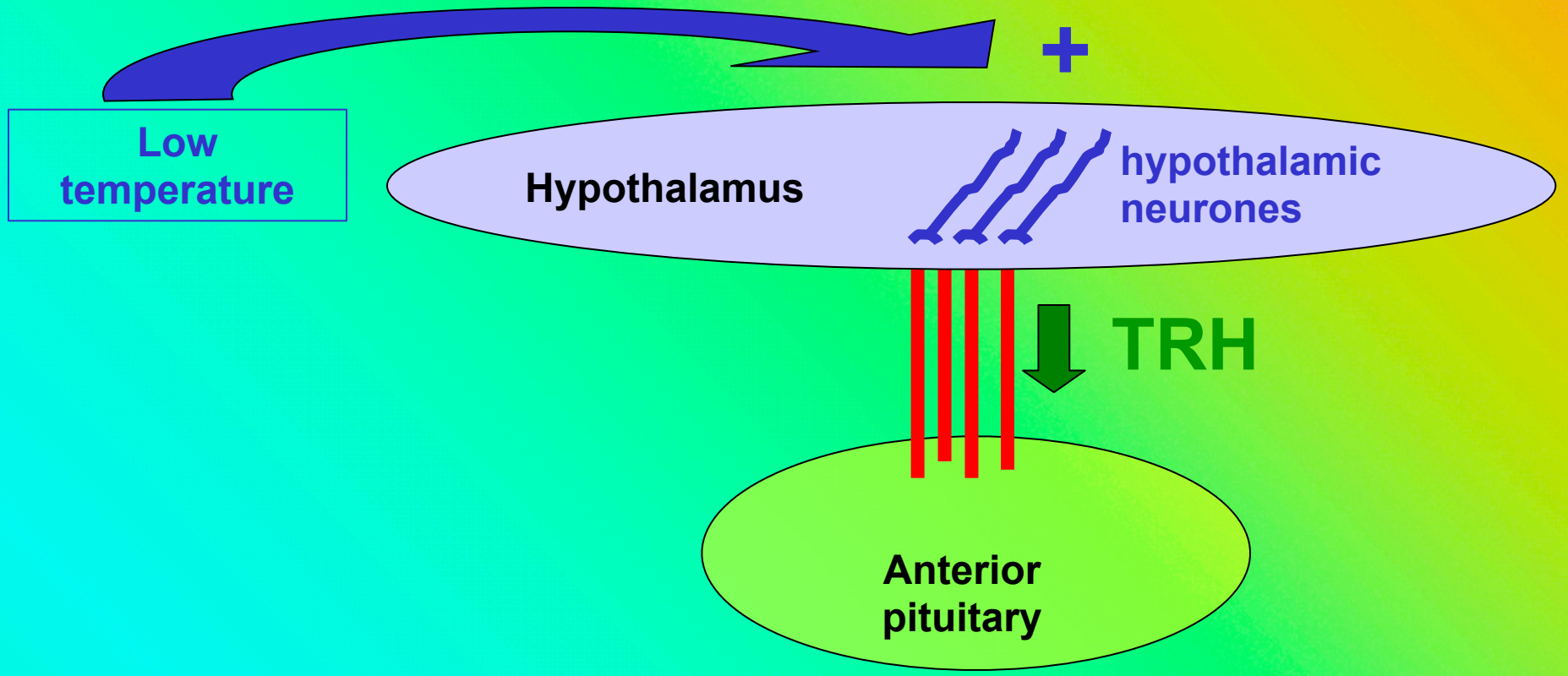
These hypothalamic neurones release neurosecretory hormones into the portal blood vessels

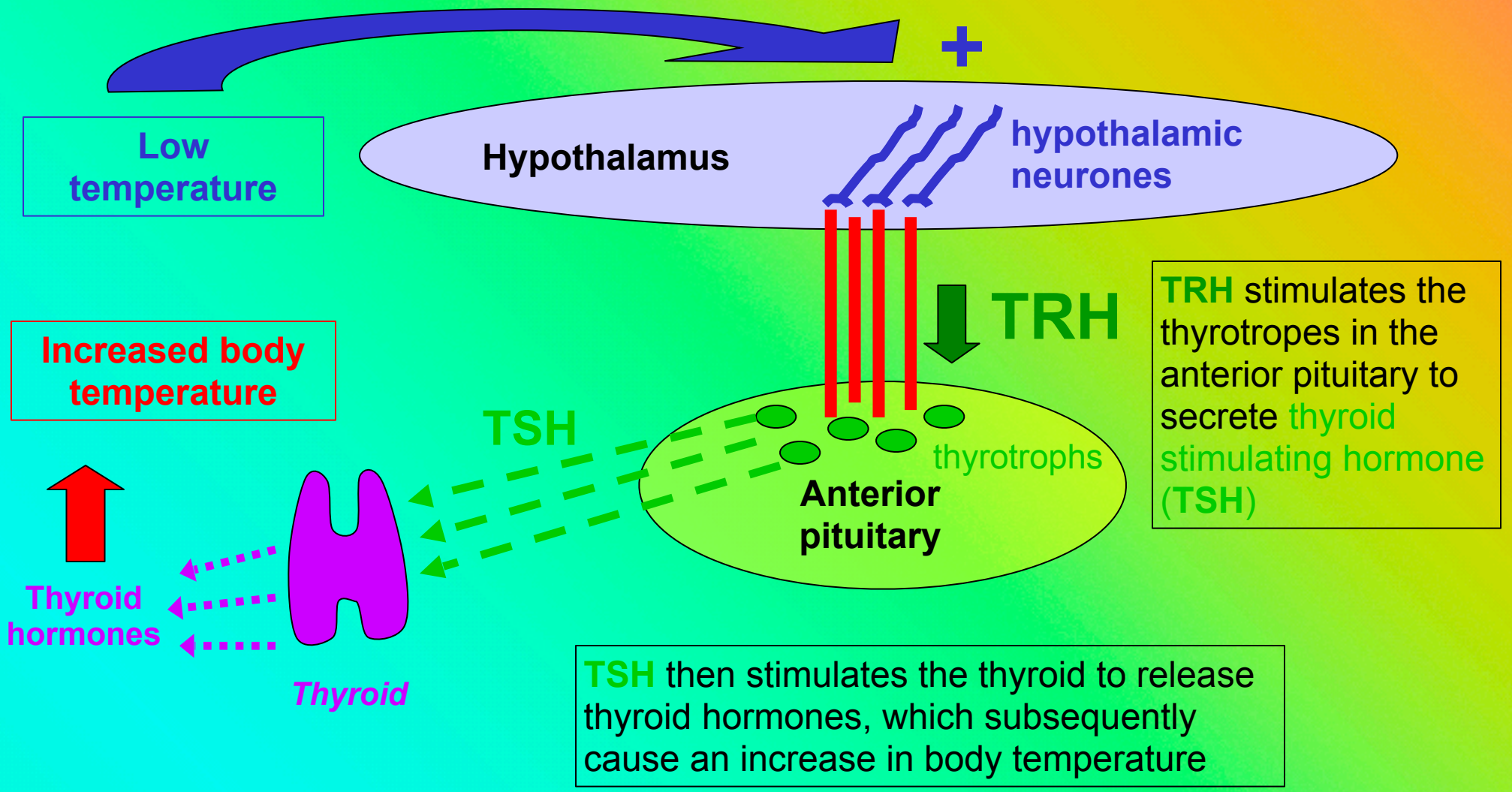
The hypothalamic hormones control the release of anterior pituitary hormones



In the cold, *specific* neurones in the hypothalamus secrete the neurosecretory hormone **Thyrotrophin Releasing Hormone (TRH)**

Only certain neurones in the hypothalamus can secrete **TRH**. Other hypothalamic neurones secrete different neurosecretory hormones under different conditions.



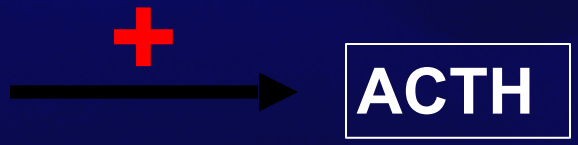

Low temperature
Hypothalamus
+
hypothalamic neurones
TRH
TRH stimulates the thyrotropes in the anterior pituitary to secrete thyroid stimulating hormone (TSH)
Increased body temperature
TSH
thyrotrophs
Anterior pituitary
Thyroid hormones
Thyroid
TSH then stimulates the thyroid to release thyroid hormones, which subsequently cause an increase in body temperature

Hypothalamic hormones that control the anterior pituitary

The hypothalamus secretes several hormones that control the secretion of anterior pituitary hormones:

- **Growth Hormone Releasing Hormone (GHRH)**
- **Growth Hormone inhibiting Hormone (GHIH)**
- **(Somatostatin)**

- **Corticotrophin Releasing Hormone (CRH)**



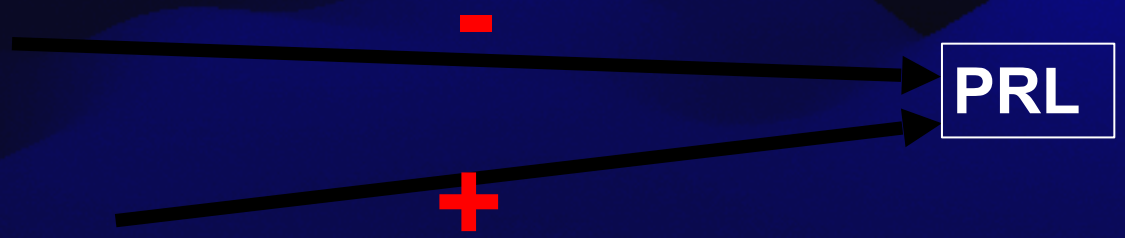
- **Gonadotrophin Releasing Hormone (GnRH)**

Hypothalamic hormones that control the anterior pituitary

The hypothalamus secretes several hormones that control the secretion of anterior pituitary hormones:

- **Thyrotrophin Releasing Hormone (TRH)**

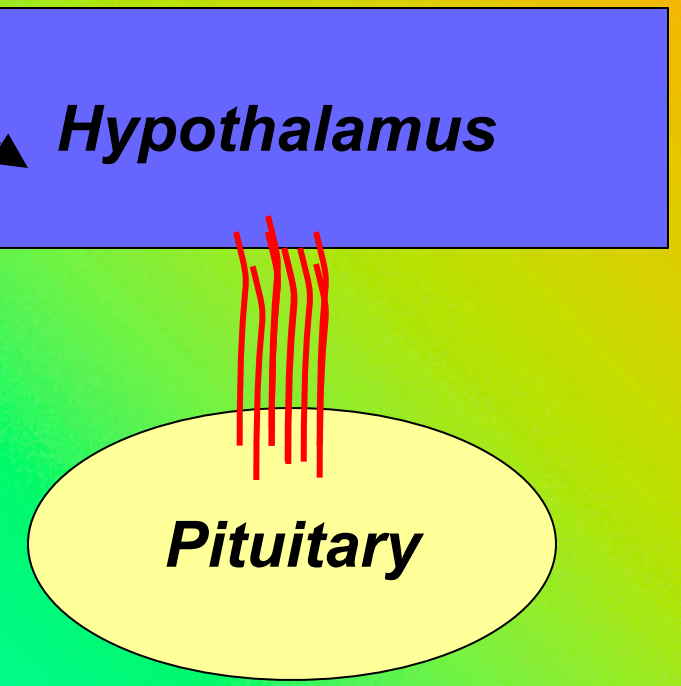
- **Prolactin Inhibiting Factors (PIF), (Dopamine)**



- **Prolactin Releasing Factors (PRF)**, one of which is TRH

Specific stimuli

We have already seen that specific stimuli (e.g. cold in the case of TSH) feed into the hypothalamic control system…



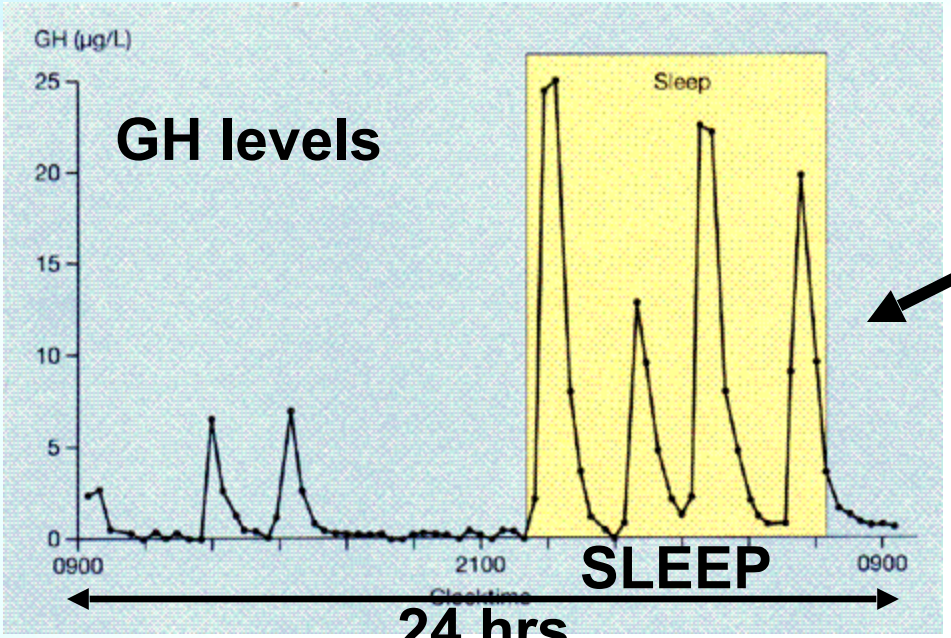
Circadian changes

Specific stimuli

In addition, many hormones show daily rhythms….

Hypothalamus

Pituitary



Note that GH is released in pulses during the hours of sleep.

Circadian changes

Specific stimuli

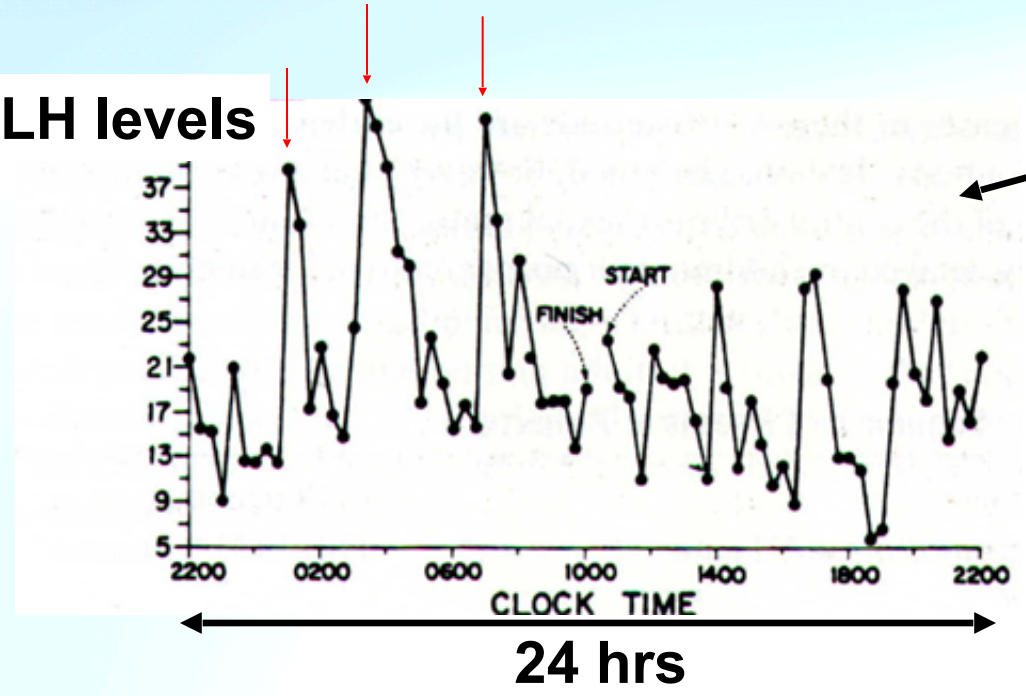
The secretion of GnRH seems to be governed by a hypothalamic “pulse generator”.

“Pulse generator”

Pulses of GnRH

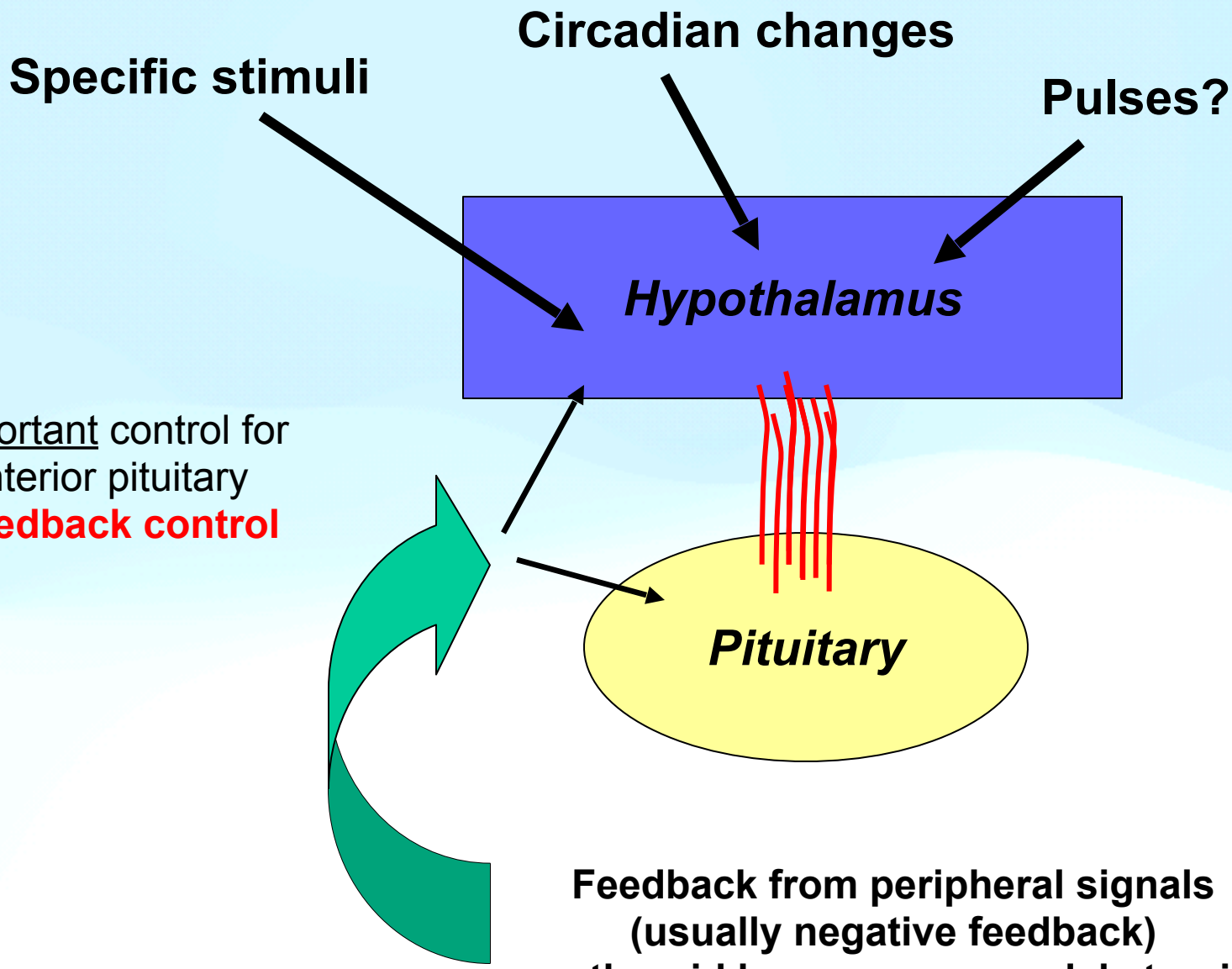
Pituitary

LH levels



24 hour profile of LH levels in a young adult.

Note the pulses of LH marked by arrows.



And a very important control for most the the anterior pituitary hormones is **feedback control** ….

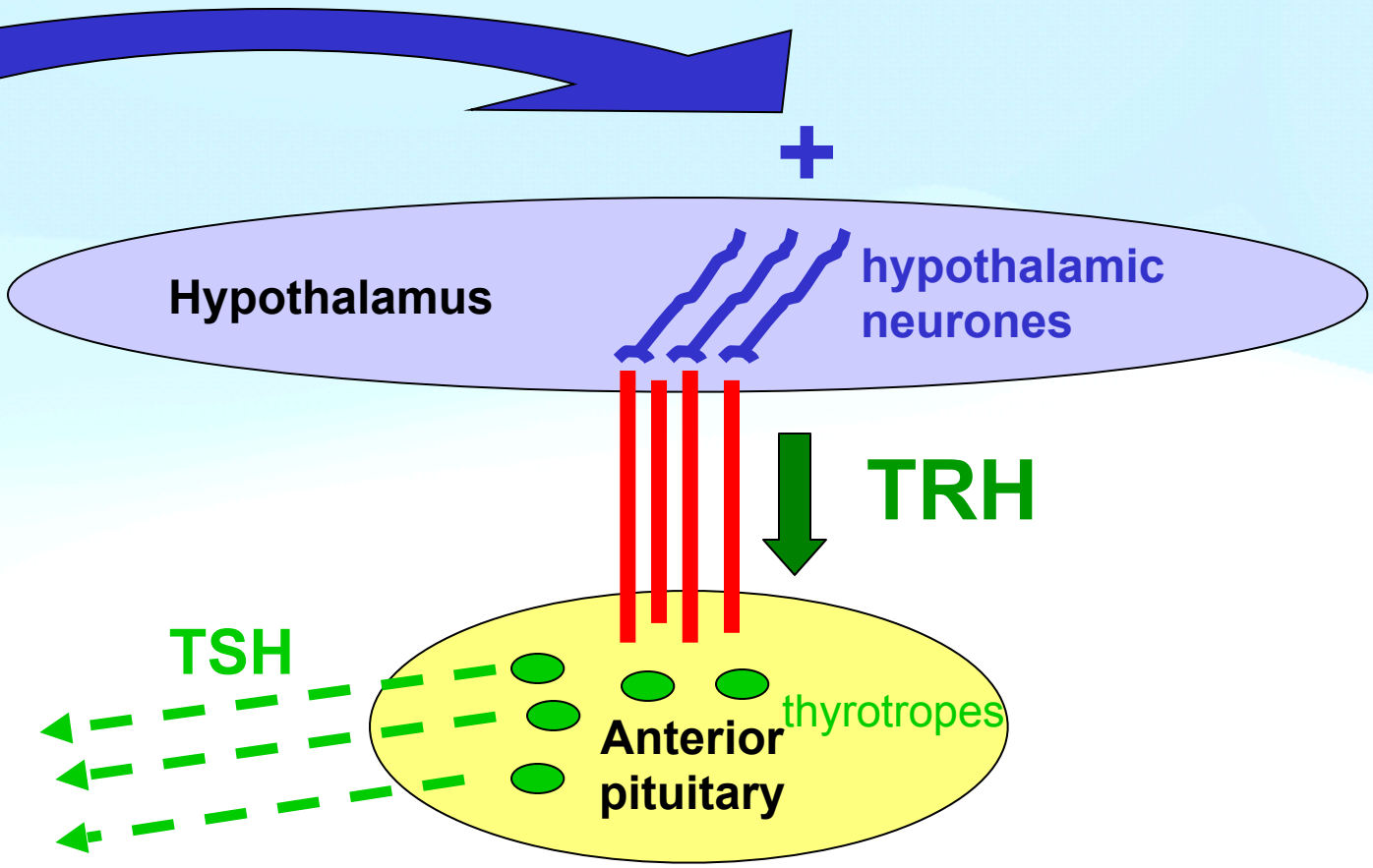
Feedback from peripheral signals (usually negative feedback) e.g. thyroid hormones, gonadal steroids

Negative feedback controls of the hypothalamic-pituitary axis

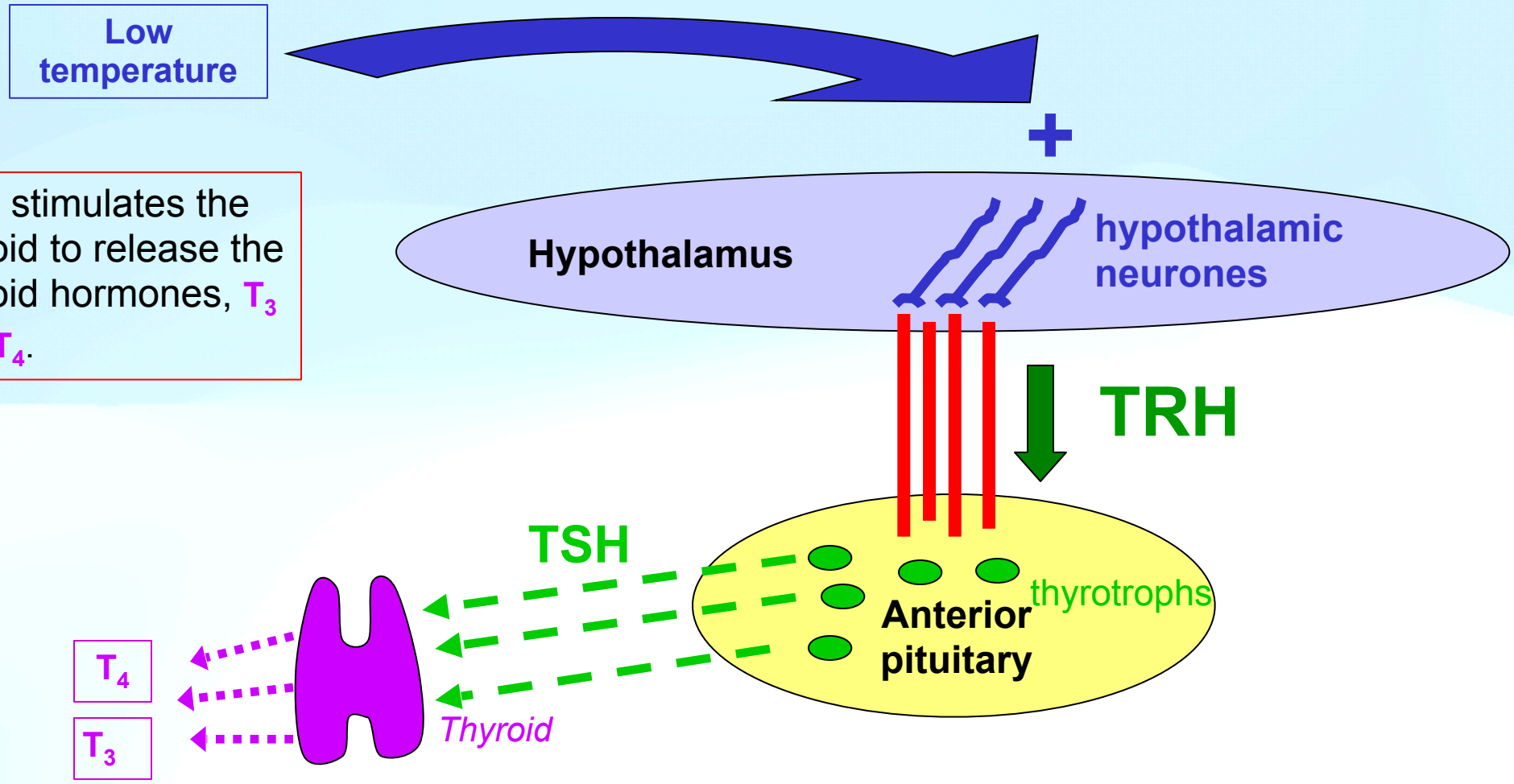
Low temperature

Specific external signals, e.g. low temperature, stimulate the secretion of **TRH** by the hypothalamus.

TRH stimulates the secretion of **TSH** by the anterior pituitary.

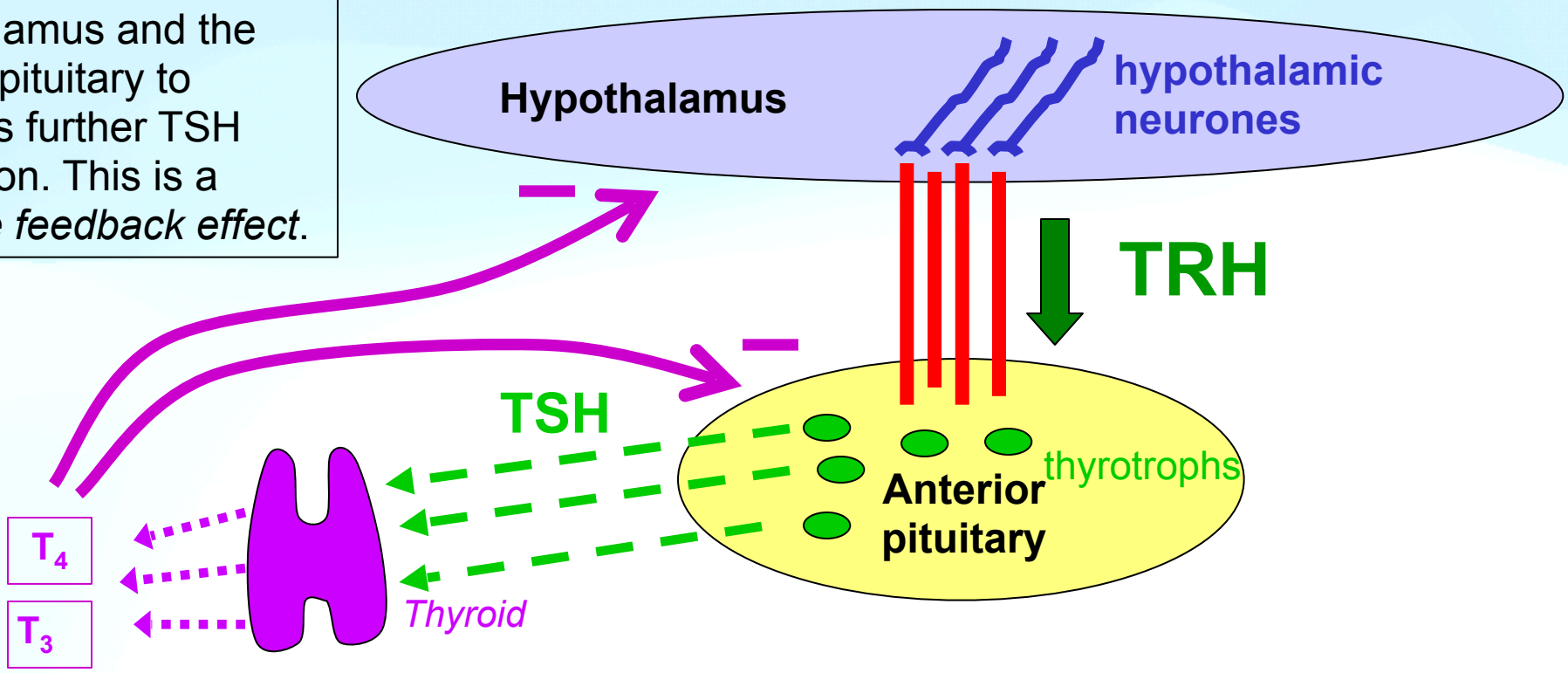


Negative feedback controls of the hypothalamic-pituitary axis



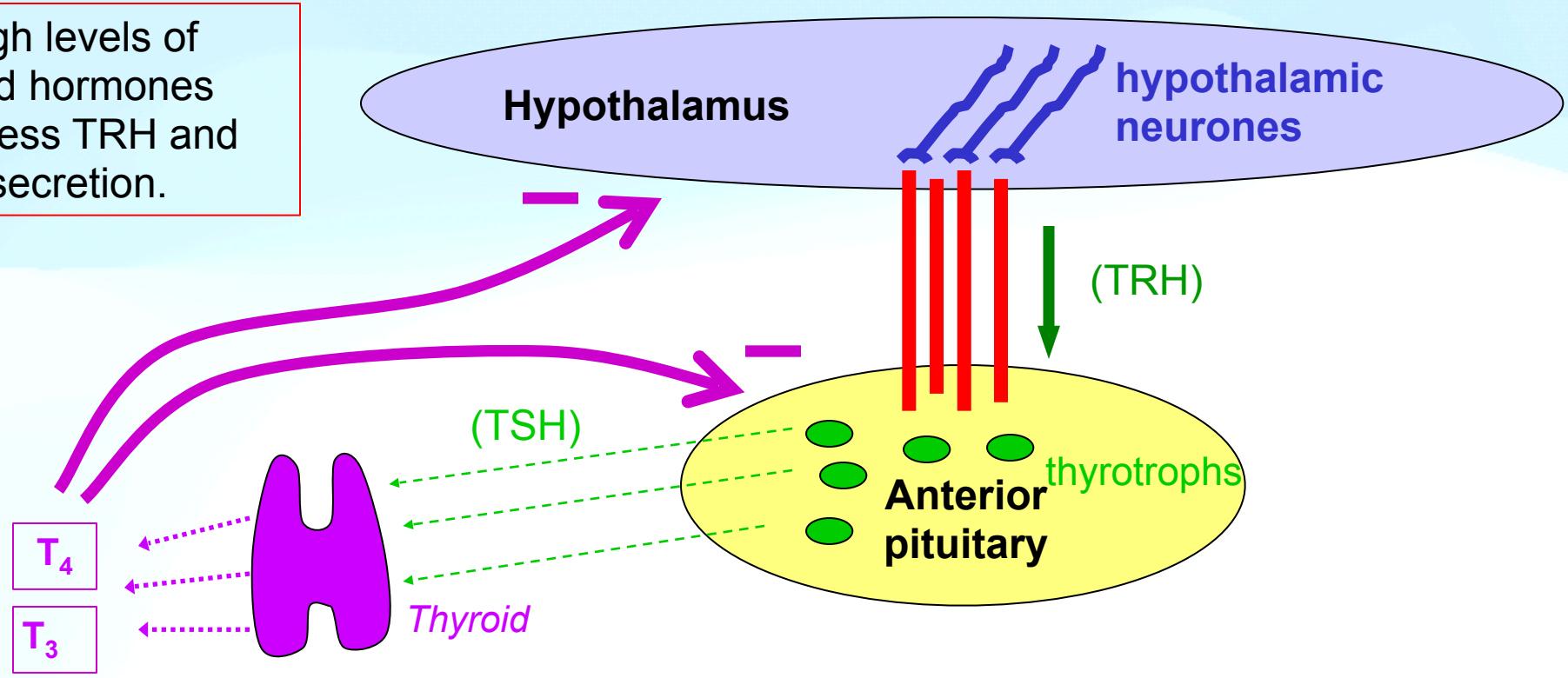
Negative feedback controls of the hypothalamic-pituitary axis

The thyroid hormones feedback onto the hypothalamus and the anterior pituitary to suppress further TSH production. This is a *negative feedback effect*.



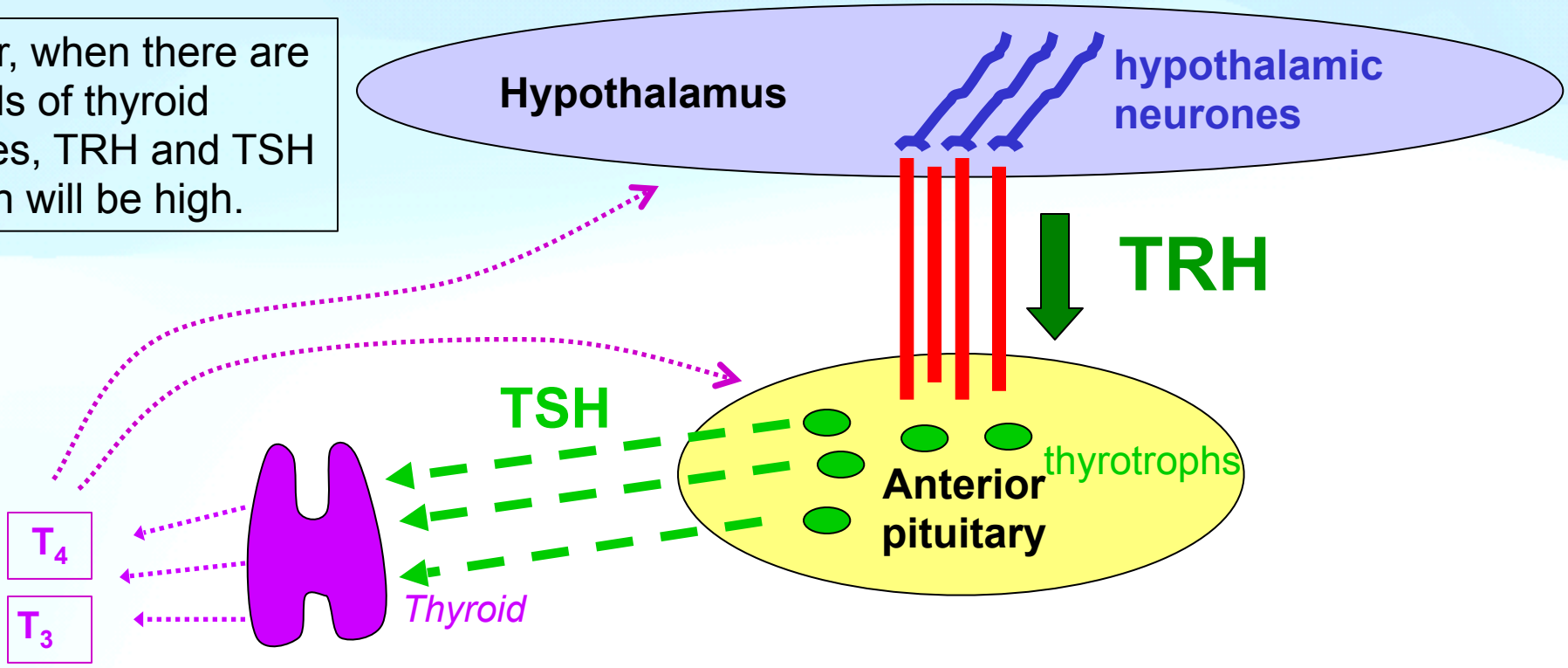
Negative feedback controls of the hypothalamic-pituitary axis

So high levels of thyroid hormones suppress TRH and TSH secretion.



Negative feedback controls of the hypothalamic-pituitary axis

However, when there are low levels of thyroid hormones, TRH and TSH secretion will be high.



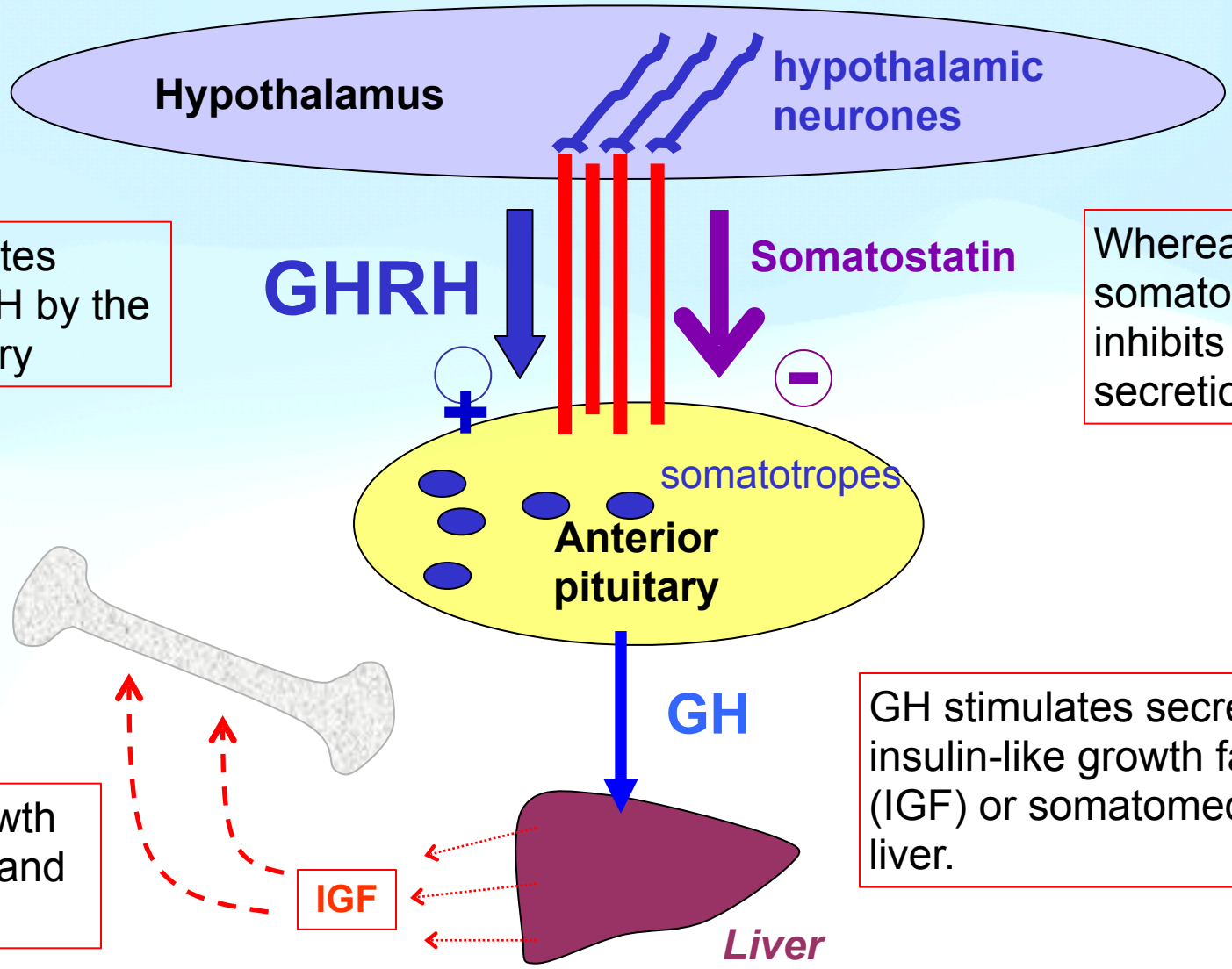
Clinical significance

Because the control of the hypothalamic-pituitary axis involves a number of steps, problems of under-secretion or over-secretion of hormones can arise from different physiological defects in the control pathway.

Using growth hormone (GH) as an example, we will now look now how problems might arise….

But first a reminder of the controls of GH……...

Control of Growth Hormone



GHRH stimulates secretion of GH by the anterior pituitary

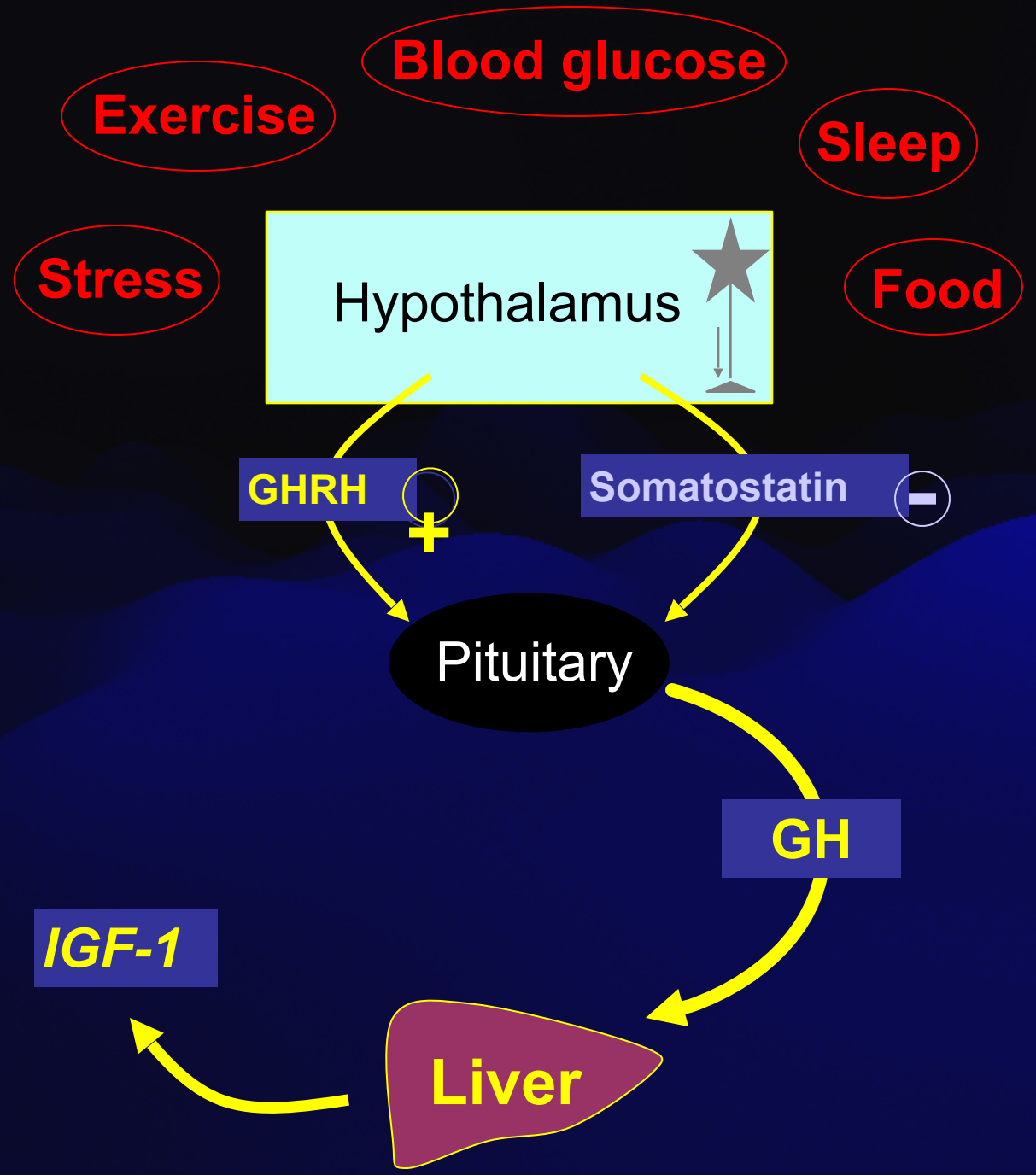
Whereas somatostatin inhibits GH secretion

IGFs stimulate growth in bones, muscles and fat

GH stimulates secretion of insulin-like growth factors (IGF) or somatomedin by the liver.

Control of GH secretion

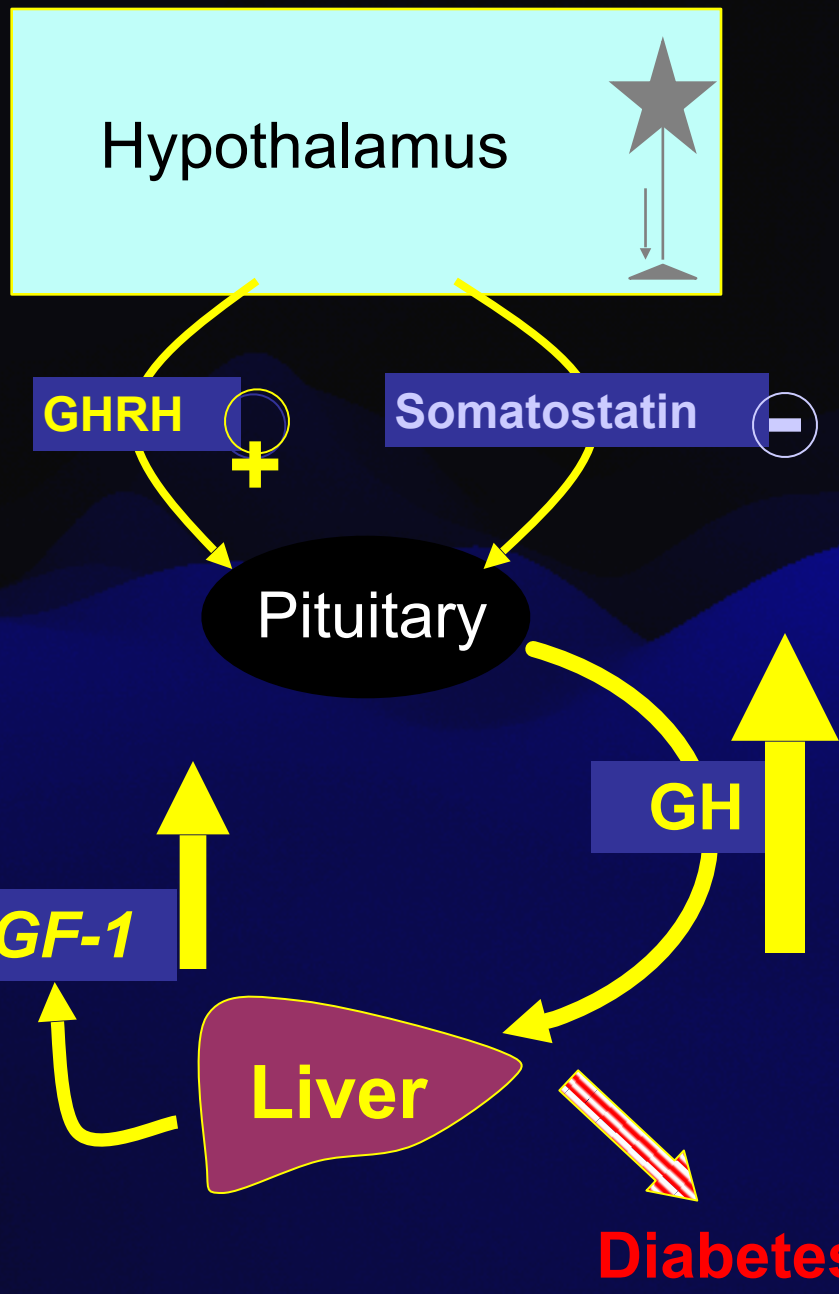
But other factors such as sleep, exercise, stress, food intake and blood sugar levels also influence the release of these hormones



Hypersecretion of GH

In a few people, the pituitary continues to secrete GH independently of the normal regulatory mechanisms.

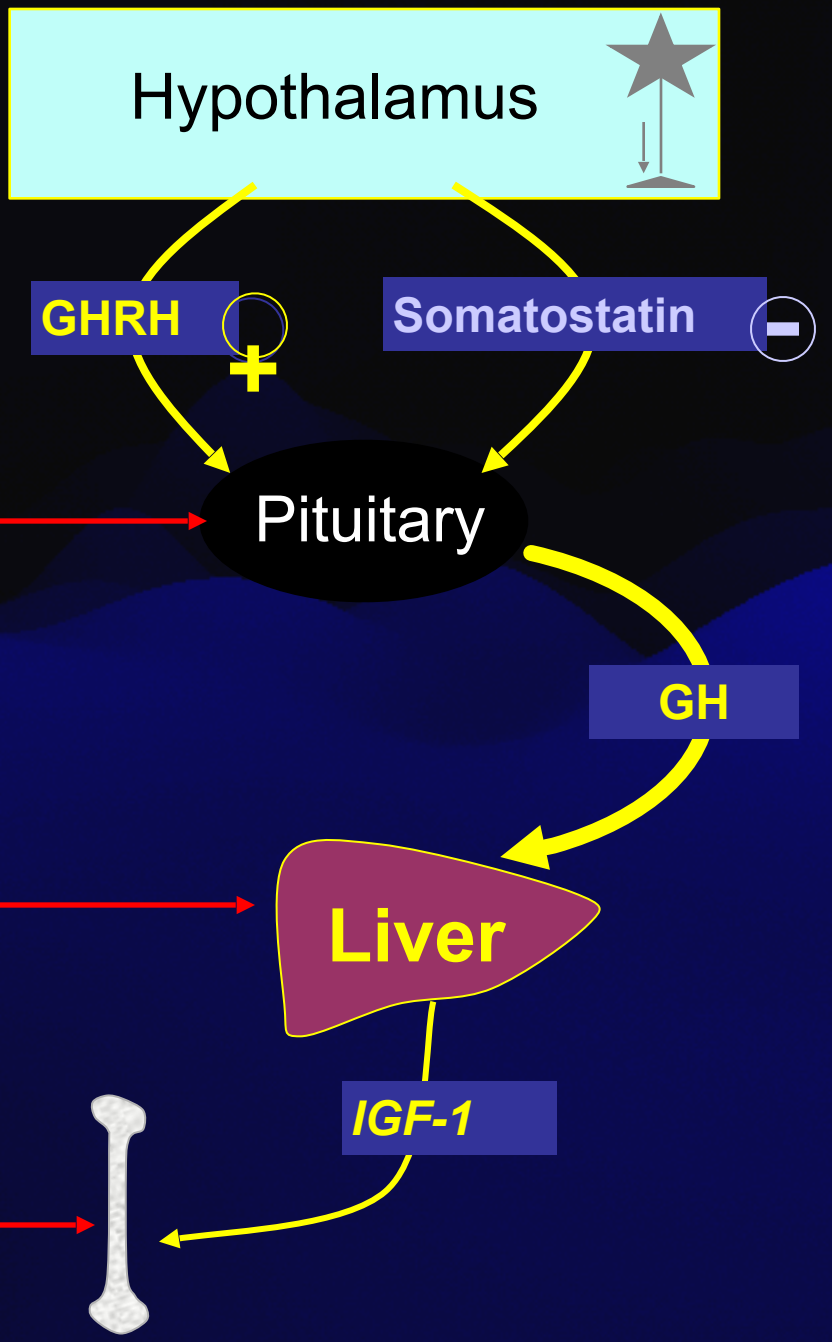
The levels of GH increase above normal, leading to excess bone growth and organ enlargement.



The hypersecretion of GH also causes changes in sugar and lipid metabolism and can cause diabetes.

What could cause short stature?

Problems can occur in the hypothalamus *e.g.* *defects in GHRH production*



Problems can occur in the pituitary *e.g.* *defects in GH secretion or bioactivity*

Problems can occur in the ability of cells to produce *IGF.*

Problems can occur in the target organs *e.g.* *defects in growth response*

Factors That Stimulate or Inhibit Secretion of Growth Hormone

Stimulate Growth Hormone Secretion	Inhibit Growth Hormone Secretion
Decreased blood glucose	Increased blood glucose
Decreased blood free fatty acids	Increased blood free fatty acids
Starvation or fasting, protein deficiency	Aging
Trauma, stress, excitement	Obesity
Exercise	Growth hormone inhibitory hormone (somatostatin)
Testosterone, estrogen	Growth hormone (exogenous)
Deep sleep (stages II and IV)	Somatomedins (insulin-like growth factors)
Growth hormone–releasing hormone	

Abnormalities of Growth Hormone Secretion

Panhypopituitarism. This term means decreased secretion of all the anterior pituitary hormones. The decrease in secretion may be congenital (present from birth), or it may occur suddenly or slowly at any time during life, most often resulting from a pituitary tumor that destroys the pituitary gland.

Dwarfism. Most instances of dwarfism result from generalized deficiency of anterior pituitary secretion (panhypopituitarism) during childhood. In general, all the physical parts of the body develop in appropriate proportion to one another, but the rate of development is greatly decreased. A child who has reached the age of 10 years may have the bodily development of a child aged 4 to 5 years, and the same person at age 20 years may have the bodily development of a child aged 7 to 10 years.

Abnormalities of Growth Hormone Secretion

Panhypopituitarism in the Adult. The general effects of adult panhypopituitarism are (1) hypothyroidism, (2) depressed production of glucocorticoids by the adrenal glands, and (3) suppressed secretion of the gonadotropic hormones so that sexual functions are lost. Thus, the picture is that of a lethargic person (from lack of thyroid hormones) who is gaining weight (because of lack of fat mobilization by growth, adrenocorticotropic, adrenocortical, and thyroid hormones) and has lost all sexual functions.

Gigantism. The somatotropes become excessively active. As a result, large quantities of growth hormone are produced. All body tissues grow rapidly, including the bones. If the condition occurs before adolescence, before the epiphyses of the long bones have become fused with the shafts, height increases so that the person becomes a giant— up to 8 feet tall.

Abnormalities of Growth Hormone Secretion

Acromegaly: Enlargement is especially marked in the bones of the hands and feet and in the membranous bones, including the cranium, nose, bosses on the forehead, supraorbital ridges, lower jawbone, and portions of the vertebrae, because their growth does not cease at adolescence.