Physical Activity and Health Promotion

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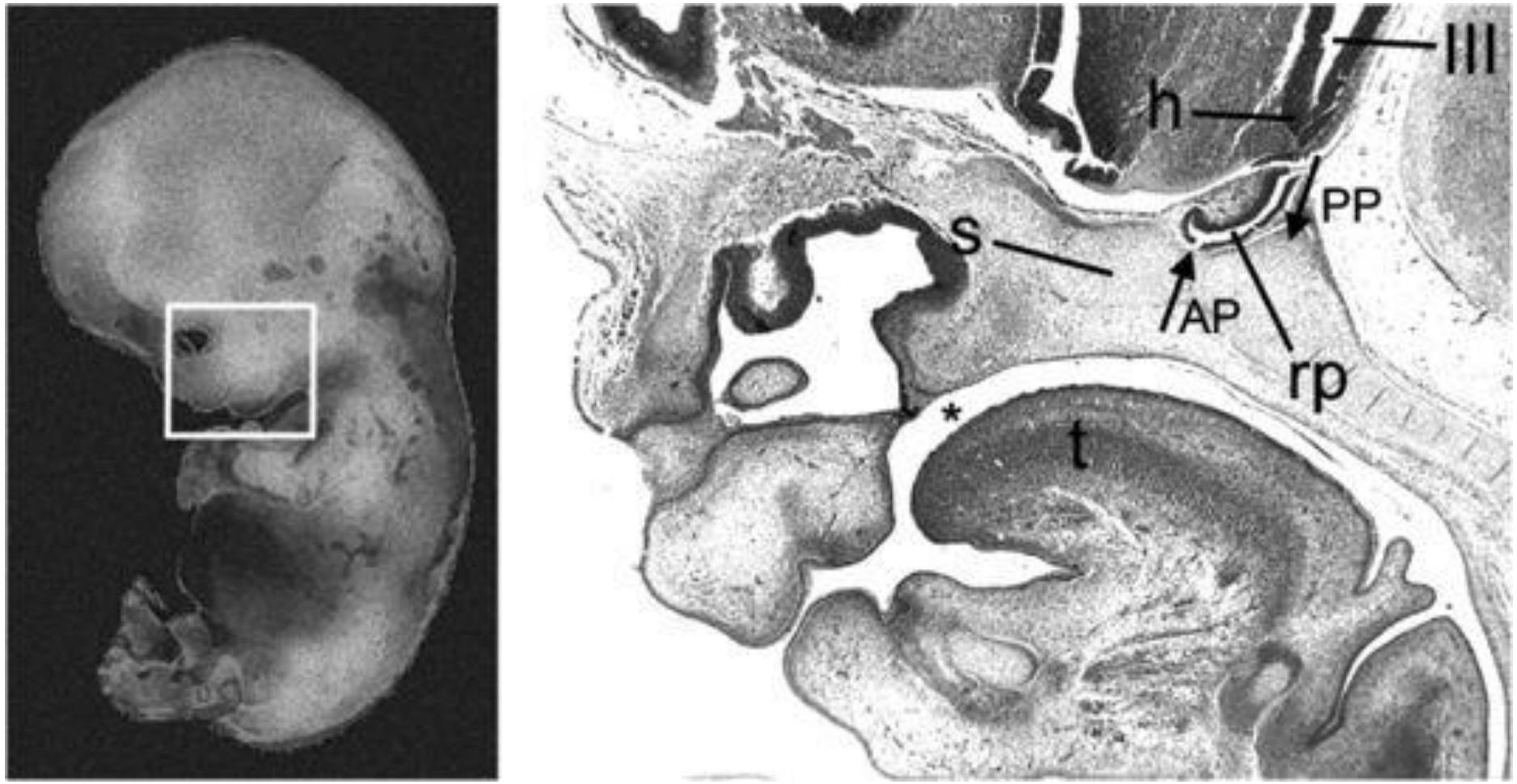
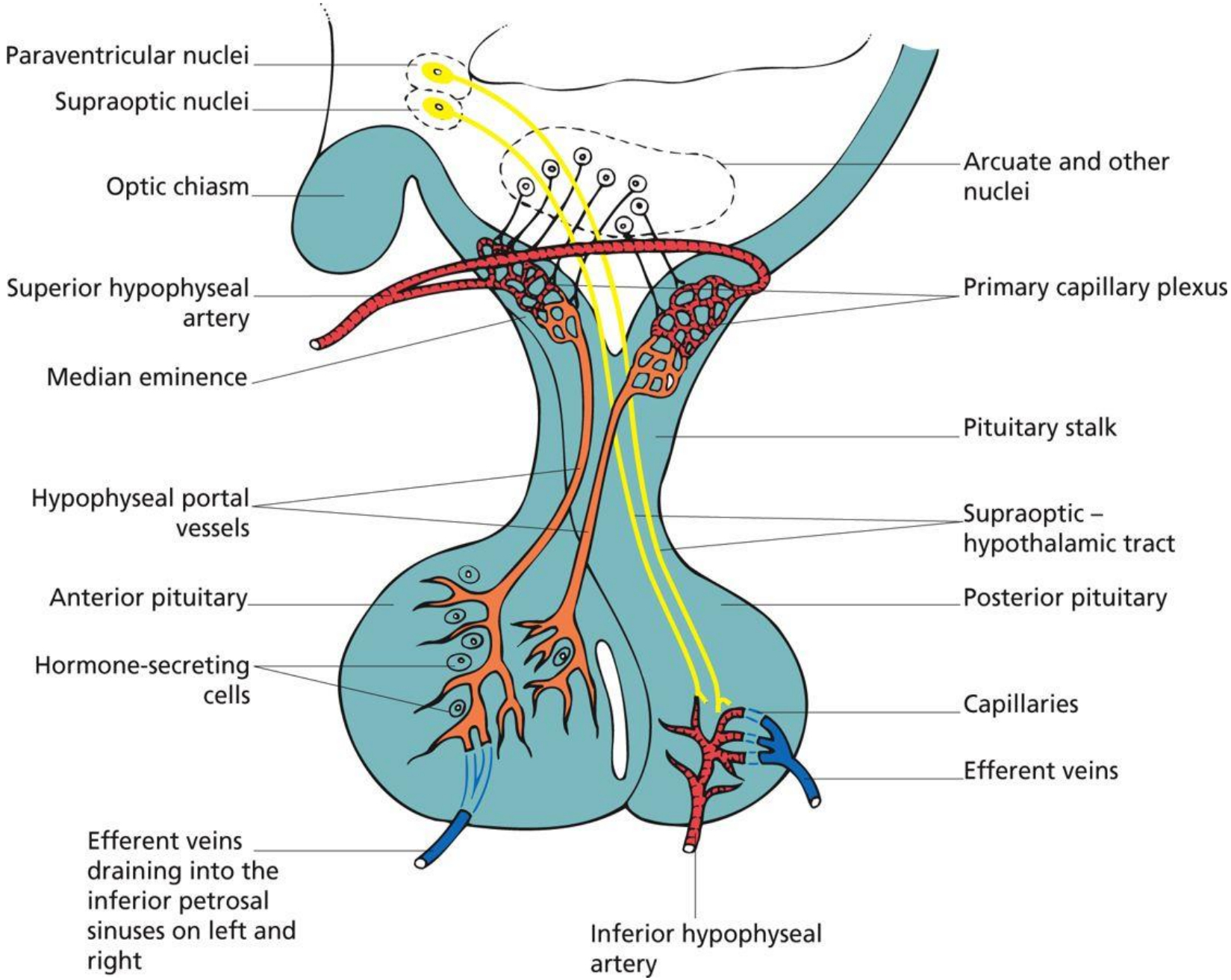
Lesson 2

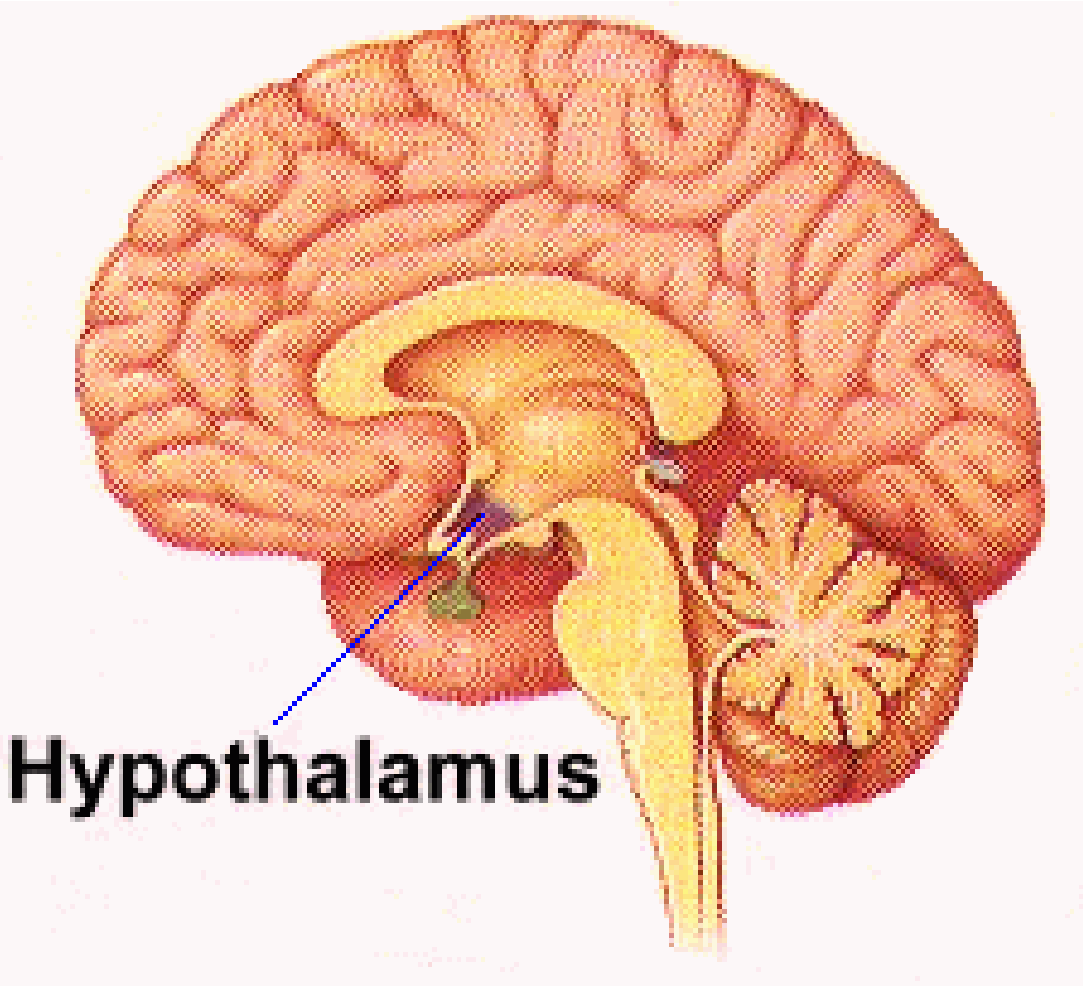
The hypothalamus and pituitary gland

https://www.endocrinologiamoretti.it



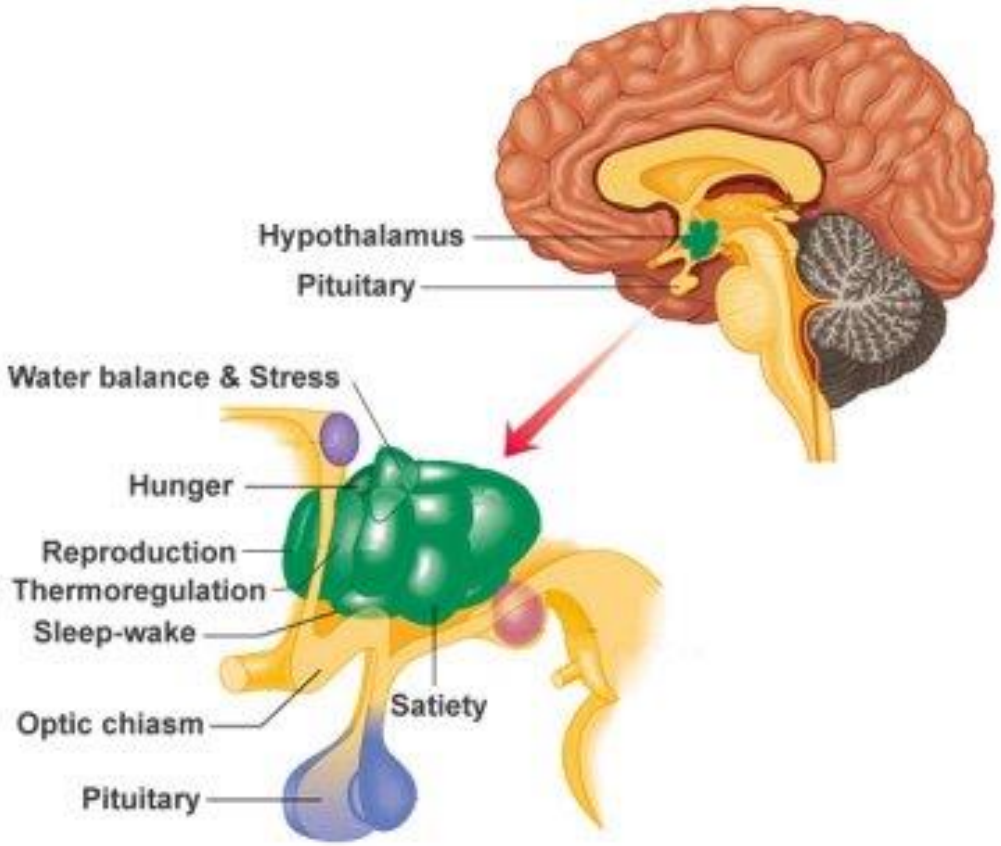
The human pituitary gland forms at ~8 weeks of development. The boxed region is enlarged to the right. The arrows show the respective migration of the cells that form the anterior (AP) and posterior pituitary (PP). III, third ventricle; h, hypothalamus; rp, Rathke's pouch; s, sphenoid bone; t, tongue; *, oral cavity.


Paraventricular nuclei
Supraoptic nuclei
Optic chiasm
Superior hypophyseal artery
Median eminence
Hypophyseal portal vessels
Anterior pituitary
Hormone-secreting cells
Efferent veins draining into the inferior petrosal sinuses on left and right
Arcuate and other nuclei
Primary capillary plexus
Pituitary stalk
Supraoptic – hypothalamic tract
Posterior pituitary
Capillaries
Efferent veins
Inferior hypophyseal artery



Medial Supraoptic Paraventricular (PVN) Secretes vasopressin and oxytocin; large neurones pass through the pituitary stalk as the ‘supraoptic-hypothalamic tract’ to the posterior pituitary where the nerve terminals contain storage granules Secretes corticotrophin-releasing hormone (CRH)
Supraoptic (SON) Vasopressin and oxytocin secretion (like PVN)
Suprachiasmatic (SCN) Biological clock functions (e.g. wake-sleep cycle); receives input from retina Tuberal
Ventromedial (VMN) Satiety; lesions cause overeating (‘hyperphagia’) Mood
Arcuate Secretes multiple releasing hormones, somatostatin and dopamine from nerve terminals in the median eminence into capillary network for delivery to the anterior pituitary; overlapping function with PVN and other nuclei Mammillary
Mammillary No known endocrine function; role in memory
Posterior Thermoregulation Blood pressure

The hypothalamic-anterior pituitary hormone axis

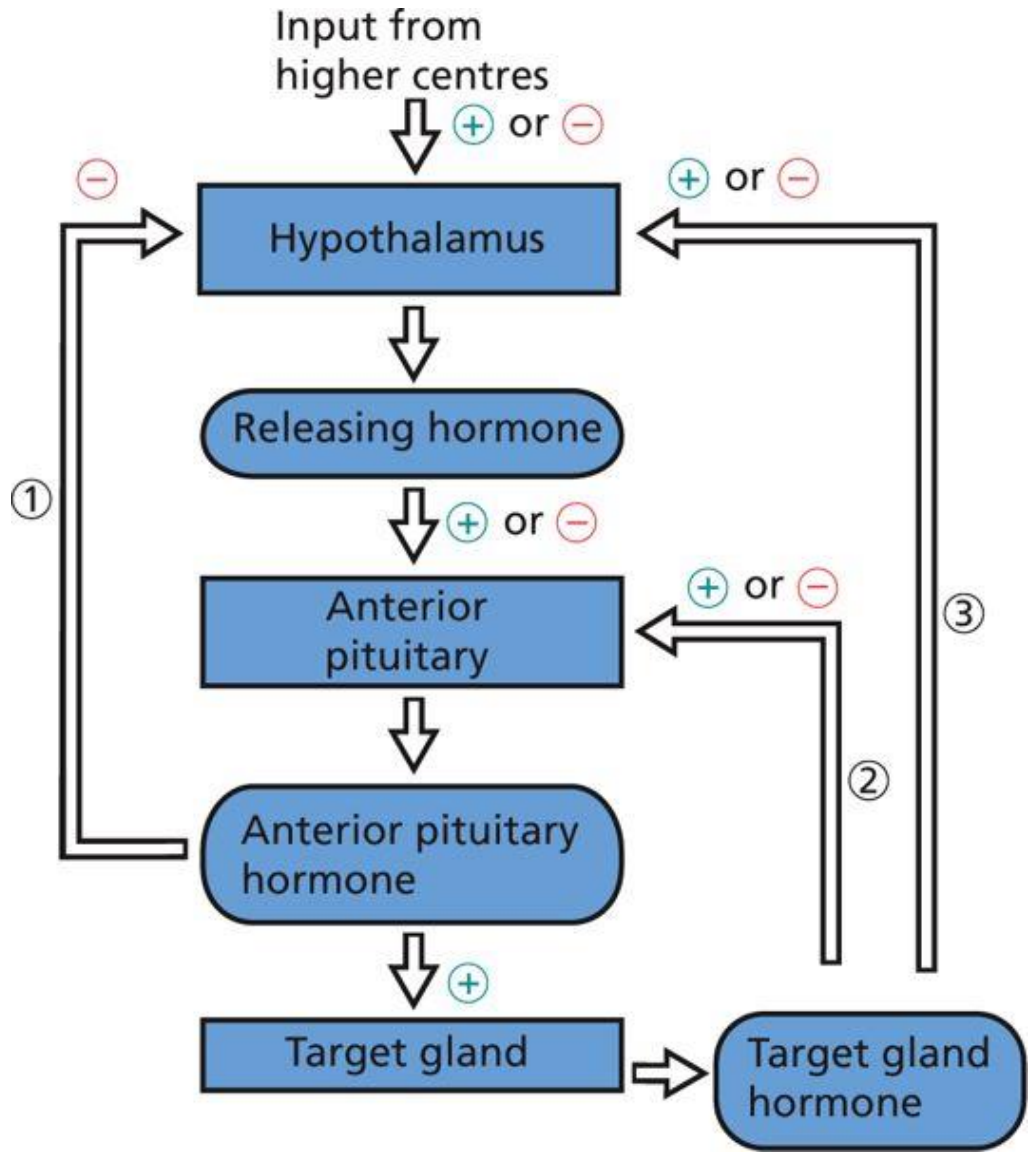


Summary

The hypothalamus is a critical part of the brain linking diverse aspects of the endocrine system to the CNS and vice versa in health and disease. For example, depression is associated with altered function of the hypothalamic—anterior pituitary adrenocortical axis. In many situations it functions as a rheostat (e.g. like the thermostat on a heating system), regulating the stimulation or suppression of a variety of processes such as hunger or thirst. It lies below the thalamus and above the pituitary gland as a series of nuclei categorized anatomically as medial (plus subdivisions) and lateral. Many of the nuclei interact with peripheral endocrine organs either dependent on or independent of the hormone axes of the anterior pituitary. It is also involved in the body's counter-regulatory hormone response to hypoglycaemia. The hypothalamus is responsible for temperature control and the regulation of several circadian rhythms and 'biological clock' functions (e.g. the wake-sleep cycle). Occasionally, despite careful monitoring of radiation dose, some patients consider that these latter functions become disturbed after external beam radiotherapy targeted at the pituitary gland. In regulating thirst, the hypothalamus receives endocrine signals from circulating atrial natriuretic peptide (ANP) and angiotensin amongst other hormones, and has neurones that are receptive to sodium concentration and osmolality. These inputs then regulate vasopressin secretion and the sensation of thirst.

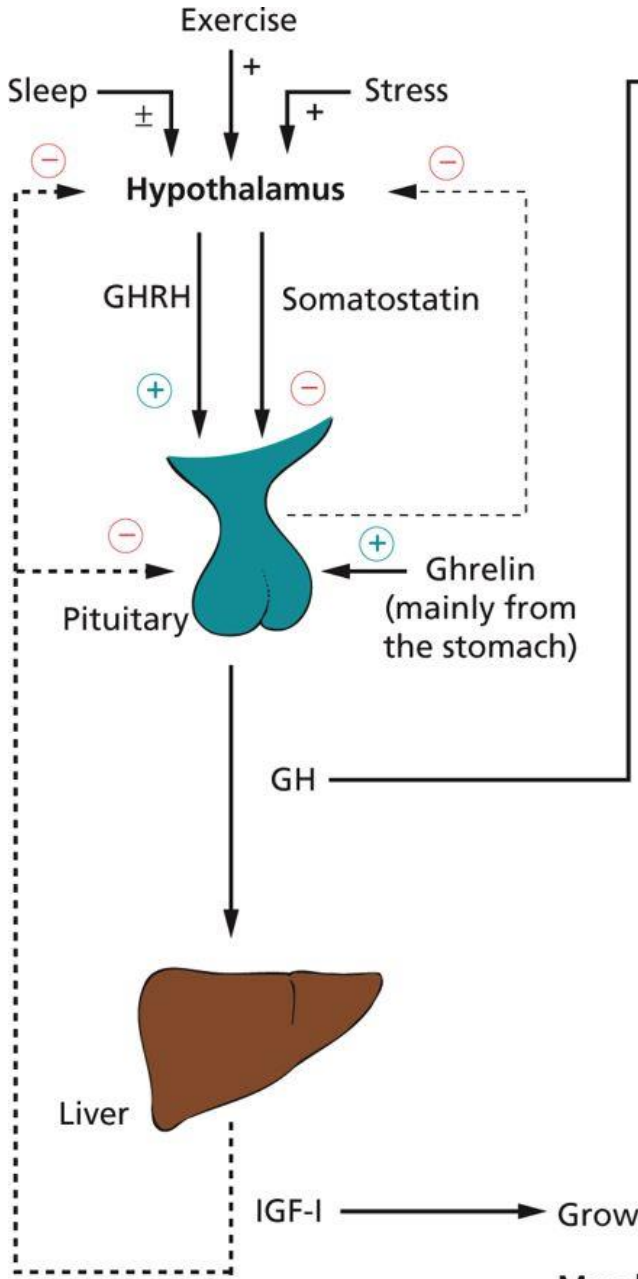
Hormone-secreting cell types of the anterior pituitary

Anterior pituitary cell type	Hormone secreted	Size (number of amino acids)	Target organ	Hypothalamic regulator (+ or – effect)
Somatotroph	Growth hormone (GH)	191	Diverse	GH-releasing hormone (GHRH, +) and Somatostatin (SS, –)
Lactotroph	Prolactin (PRL)	199	Breast	Dopamine (–) and thyrotrophin-releasing hormone (TRH, +)
Corticotroph	Adrenocorticotrophic hormone (ACTH)	39	Adrenal cortex	Corticotrophin-releasing hormone(CRH, +)
Thyrotroph	Thyroid-stimulating hormone (TSH)	204	Thyroid	TRH (+) Somatostatin (SS, -)
Gonadotroph	Follicle-stimulating hormone (FSH) and luteinizing hormone(LH)	Both 204	Ovary or testis	Gonadotrophin-releasing hormone(GnRH, +)


Input from higher centres
+ or −
Hypothalamus
Releasing hormone
+ or −
Anterior pituitary
Anterior pituitary hormone
+
Target gland
Target gland hormone
+ or −
+ or −
+ or −
−
①
②
③

Pulsatility

Pulsatility of hypothalamic hormone release can also affect anterior pituitary responsiveness. Constant gonadotrophin-releasing hormone (GnRH) desensitizes the gonadotroph, leading to loss of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) secretion, and, consequently, testicular or ovarian quiescence. Thus, continuous intravenous GnRH can be used as a contraceptive or as pharmacological castration in hormone-dependent prostrate or breast cancer. In contrast, pulses of GnRH every 90 min can be used to restore fertility in patients with hypothalamic dysfunction.



DIRECT EFFECTS

Liver: gluconeogenesis and glycogenolysis

Adipose: lipolysis

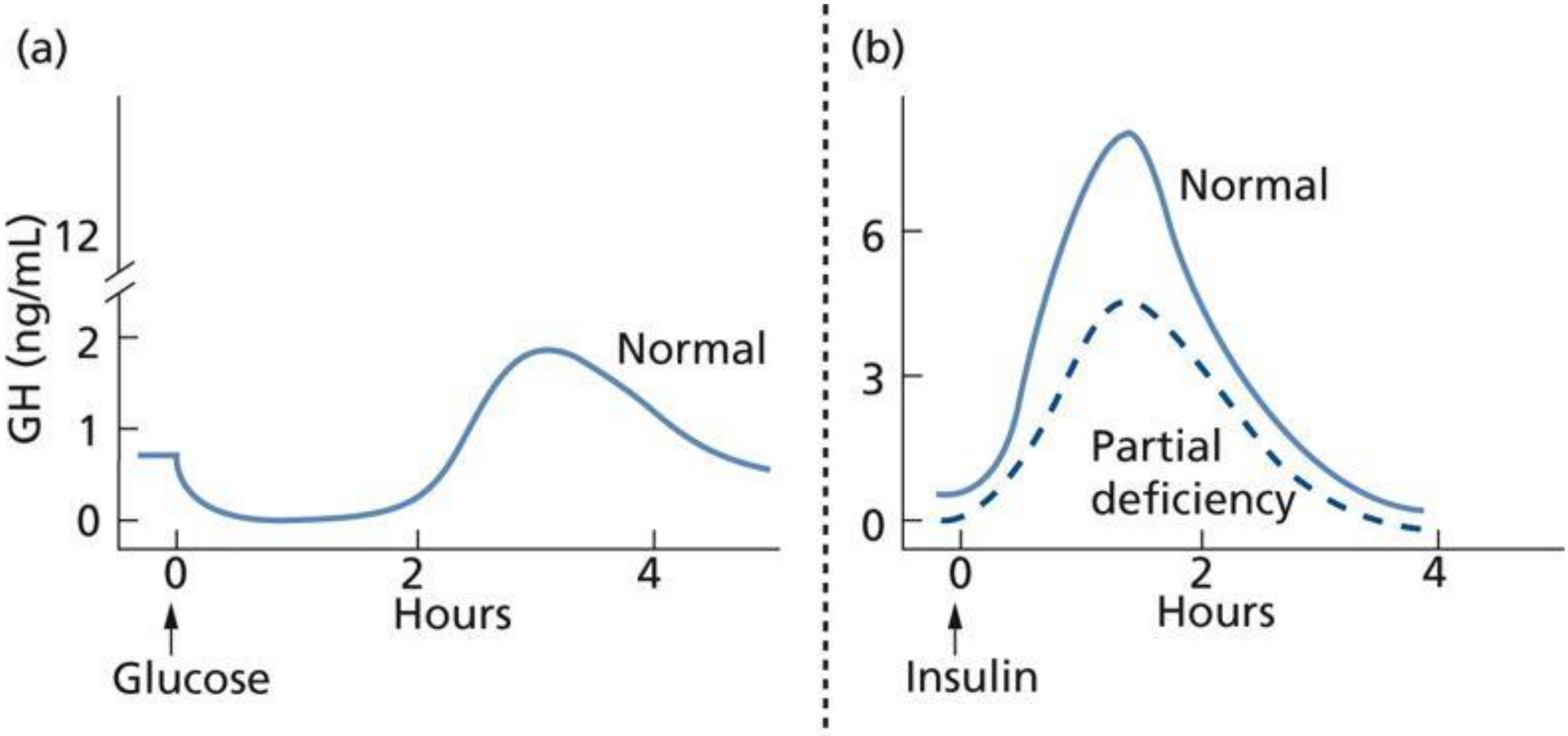
Muscle: glycogenolysis and inhibition of glycogen synthesis

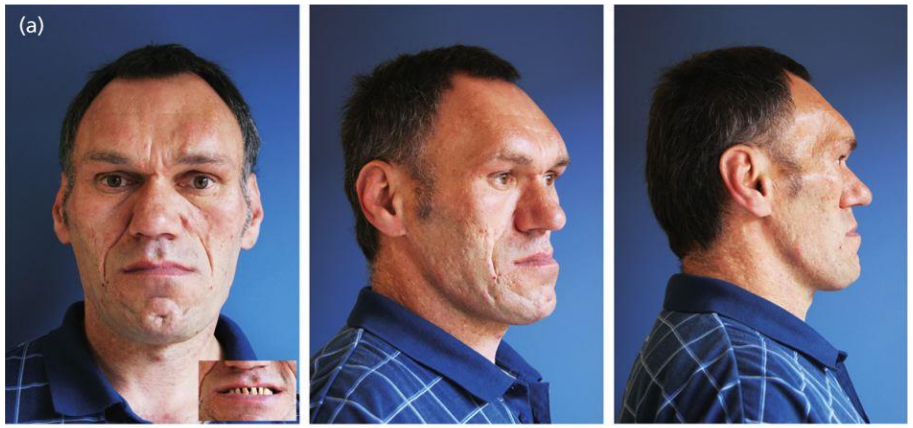
Cartilage / Bone: chondrocyte and osteoblast differentiation

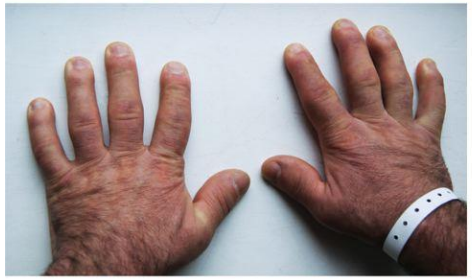
Energy expenditure: increased

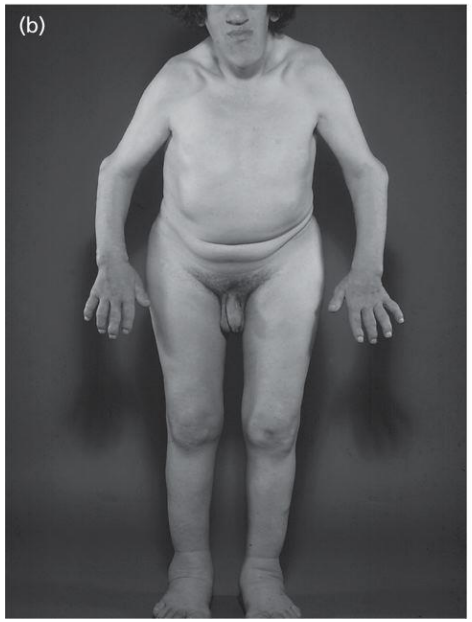
Growth: long bones at epiphyseal plate

Muscle (and periphery): glucose uptake, glycolysis, glycogen synthesis

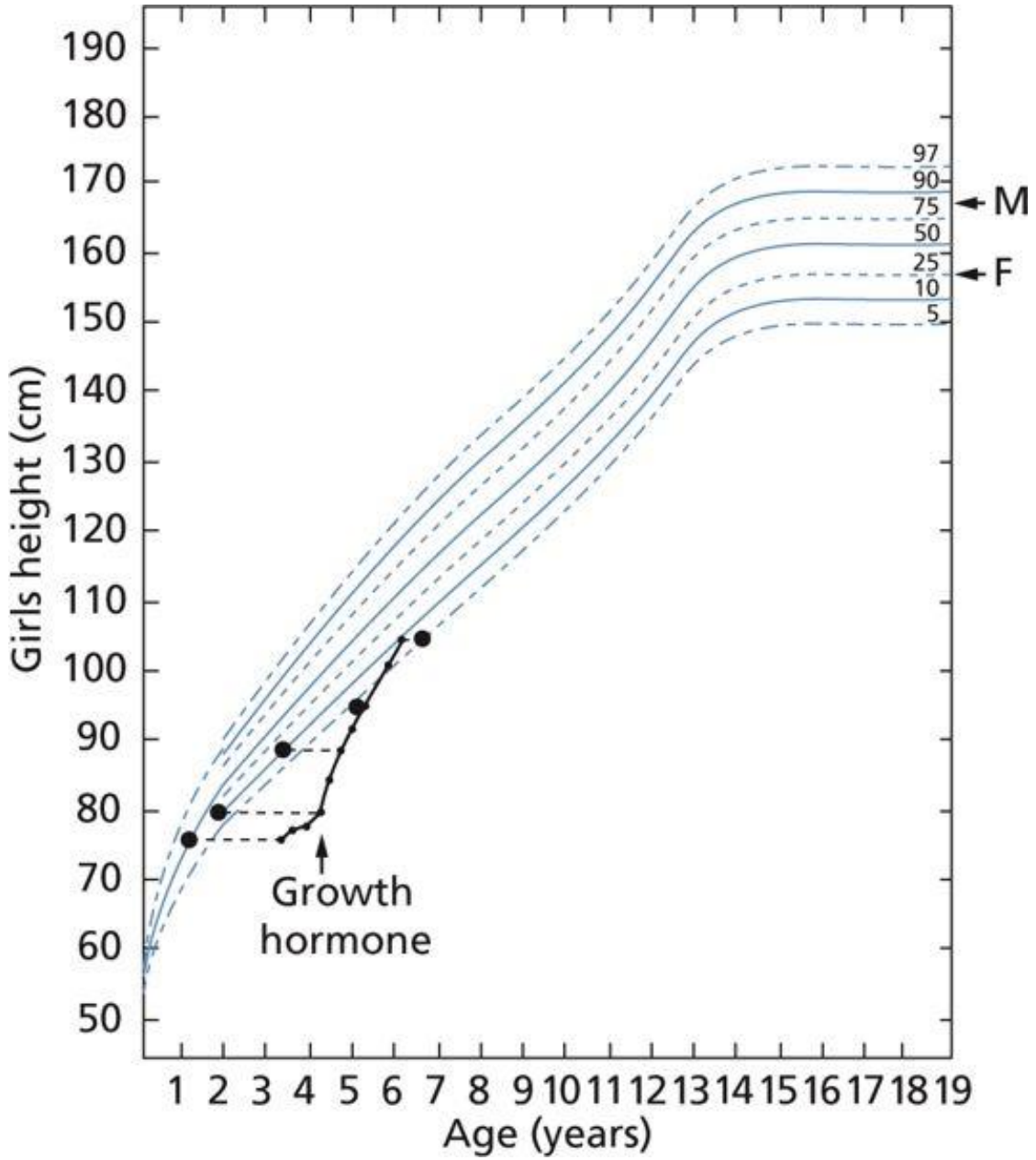

(a)
GH (ng/mL)
12
2
1
0
Normal
0
2
4
Hours
Glucose
(b)
6
3
0
Normal
Partial
deficiency
0
2
4
Hours
Insulin



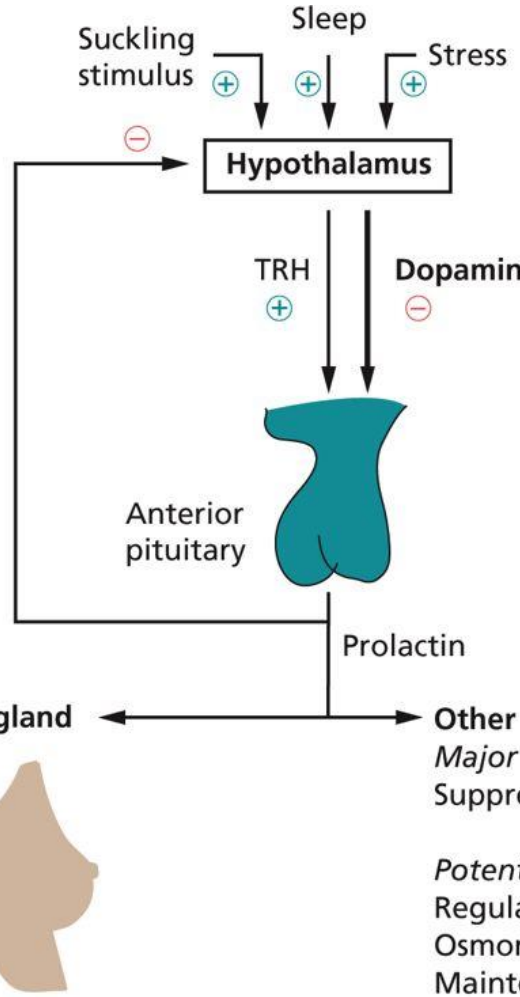


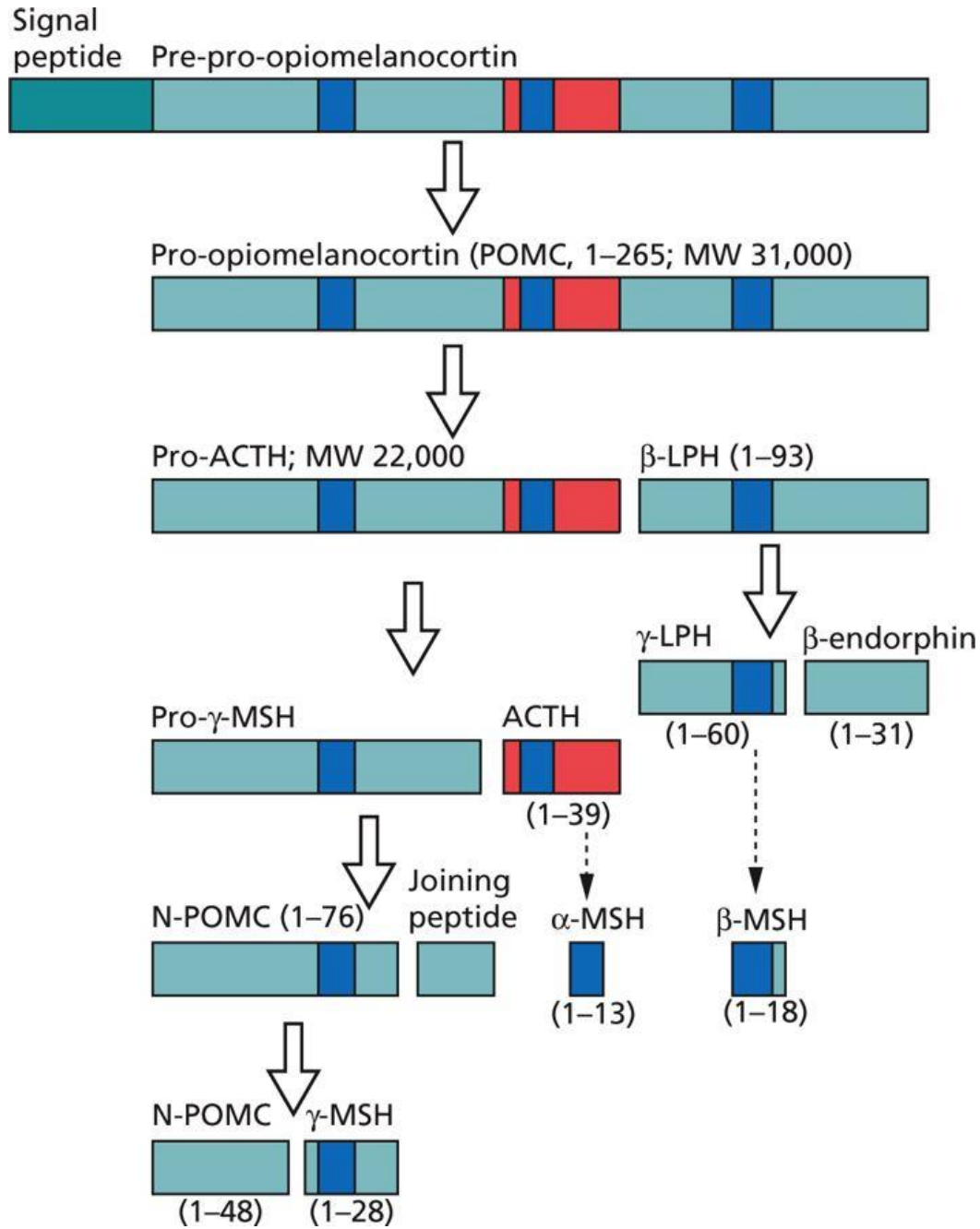


Two patients with acromegaly. (a) Patient 1. Note the large facial features, frontal bossing, prognathia causing under-bite (the lower teeth are further forward than the upper teeth) and dental separation, greasy skin quality, and thickened ’spade-like’ hands. (b) Patient 2. Note enlargement of the hands and feet. The joints are abnormal and there is thickening of soft tissues with fluid retention, manifest here by ankle oedema, although this might also be a consequence of right-sided heart failure.



Short stature due to growth hormone (GH) deficiency and the effect of GH replacement. The height of a girl is shown compared to the reference growth charts, where the population is split into centiles (i.e. 50% of girls' heights lie below the 50th centile line, 5% below the 5th, etc.). Her height for chronological age (•) is greatly reduced, but skeletal maturity (or bone age) is also delayed. As a consequence, height plotted for bone age (•) falls within the centiles of normality. Bone age is determined by radiological examination of the left hand. Comparison is made with standard radiographs to assess skeletal maturity. Serum GH was undetectable in a basal sample and no secretion could be elicited by dynamic testing. Secretion of other anterior pituitary hormones was normal. After GH replacement was initiated, there was rapid catch-up of both height and skeletal maturity. M and F represent maternal and paternal height respectively.


Suckling stimulus
Sleep
Stress
Hypothalamus
TRH
Dopamine
Anterior pituitary
Prolactin
Mammary gland
Other effects
Major
Suppression of LH and FSH production
Potential or minor
Regulation of lymphocytes
Osmoregulation
Maintenance of the corpus luteum in the ovary
Steroidogenesis in testis and ovary
Stimulates development
• Epithelial cell proliferation
Initiates and maintains lactation
• Synthesis of casein and lactalbumin
• Synthesis of lactose
• Synthesis of free fatty acids
• Synergized by glucocorticoids
• Inhibited by oestrogen and progesterone


Signal peptide
Pre-pro-opiomelanocortin
Pro-opiomelanocortin (POMC, 1–265; MW 31,000)
Pro-ACTH; MW 22,000
β-LPH (1–93)
γ-LPH
β-endorphin
(1–60)
(1–31)
Pro-γ-MSH
ACTH
(1–39)
N-POMC (1–76)
Joining peptide
α-MSH
(1–13)
β-MSH
(1–18)
N-POMC
γ-MSH
(1–48)
(1–28)