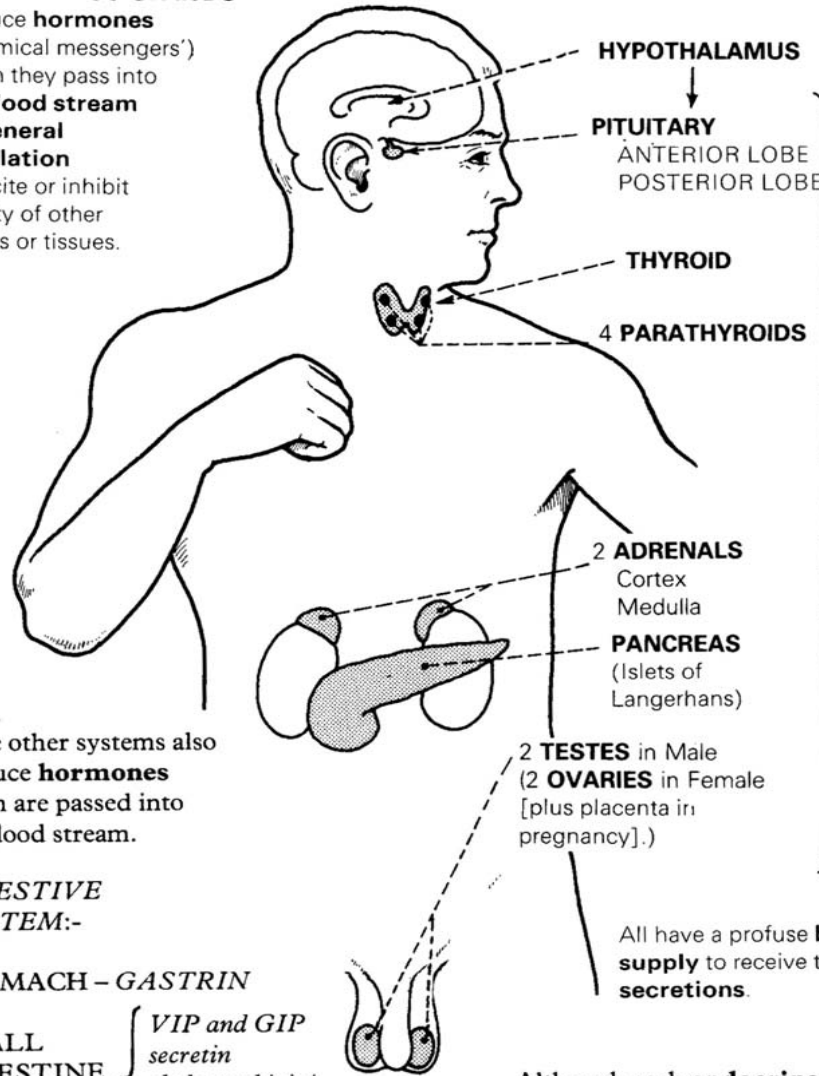


ENDOCRINE SYSTEM

The **DUCTLESS GLANDS** produce **hormones** ('chemical messengers') which they pass into the **blood stream** for **general circulation** to excite or inhibit activity of other organs or tissues.



The glands of internal secretion are concerned with the **control** and **coordination** of processes which are widespread in the body – such as:

Metabolism

Growth

Maintenance of stability of **internal environment**

Resistance to stress

and with

Reproduction.

Some other systems also produce **hormones** which are passed into the blood stream.

DIGESTIVE SYSTEM:-

STOMACH – **GASTRIN**

SMALL INTESTINE { *VIP and GIP secretin cholecystokinin/pancreozymin*

KIDNEY { *erythropoietin renin 1,25 DHCC*

All have a profuse **blood supply** to receive their **secretions**.

Although each **endocrine gland** has specific functions all are interdependent. Overactivity or underactivity of one tends to affect the whole system.

表 11.1 內分泌腺的部份列表

內分泌腺體	主要激素	主要標的器官	主要的效果
脂肪組織	瘦體素 (Leptin)	下視丘	抑制食慾
腎上腺皮質 (Adrenal Cortex)	糖皮質激素 (Glucocorticoids) 醛固酮 (Aldosterone)	肝臟、肌肉(muscles)、腎臟	糖皮質激素影響糖類的代謝；醛固酮促進鈉離子保留、鉀離子排出
腎上腺髓質 (Adrenal medulla)	腎上腺素 (Epinephrine)	心臟、支氣管(bronchioles)、血管(blood vessels)	造成腎上腺素性的刺激
心臟 (Heart)	心房利尿納素 (Atrial natriuretic hormone)	腎臟 (Kidneys)	促進鈉離子在尿液中排出
下視丘 (Hypothalamus)	釋放和抑制激素 (Releasing and inhibiting hormone)	腦下腺前葉	調節腦下腺前葉激素的分泌
小腸 (Small Intestine)	胰泌素(Secretin)和膽囊收縮素 (Cholecystokinin)	胃、肝臟和胰臟(Pancreas)	抑制胃蠕動，刺激膽汁和胰液的分泌
蘭氏小島 (Islets of Langerhans)	胰島素 (Insulin) 昇糖素 (Glucagon)	許多器官肝臟和脂肪組織 (Adipose tissue)	胰島素促進細胞吸收葡萄糖，及形成肝醣和脂肪；昇糖素刺激肝醣和脂肪的水解
腎臟 (Kidneys)	促進紅血球生成激素 (Erythropoietin)	骨髓 (Bone marrow)	刺激紅血球細胞的產生
肝臟 (Liver)	體制素 (Somatomedins)	軟骨 (Cartilage)	刺激細胞分裂和生長
卵巢 (Ovaries)	雌二醇 (estradiol-17 β) 和 黃體激素 (progesterone)	雌性的生殖管道和乳腺 (Mammary gland)	維持生殖管道的結構和促進第二性徵的表現
副甲狀腺 (Parathyroid gland)	副甲狀腺素 (Parathyroid hormone)	骨骼 (Bone)、小腸 (Small intestine) 和腎臟	增加血液中鈣離子的濃度
松果腺 (Pineal gland)	褪黑激素 (Melatonin)	下視丘和腦下腺前葉	影響性腺激素的分泌
腦下腺前葉 (Anterior pituitary)	刺激激素 (Trophic hormone)	內分泌腺和其它的器官	刺激標的器官的成長和發育；刺激其它激素的分泌
腦下腺後葉 (Posterior pituitary)	抗利尿激素 (Antidiuretic hormones) 催產素 (Oxytocin)	腎臟血管 子宮(Uterus)、乳腺	抗利尿激素促進水份的保留和血管收縮 催產素促進子宮和乳腺分泌單位的收縮
皮膚 (Skin)	二羥維生素 D ₃ (1,25-Dihydroxy vitamin D ₃)	小腸	刺激鈣離子的吸收
胃 (Stomach)	胃泌素 (Gastrin)	胃	刺激酸的分泌
睪丸 (Testes)	睪固酮 (Testosterone)	攝護腺(Prostate)、儲精囊 (Seminal vesicles)和其它的器官	刺激第二性徵的發育
胸腺 (Thymus)	胸腺素(Thymosin)	淋巴結(Lymph nodes)	刺激白血球的產生
甲狀腺 (Thyroid gland)	甲狀腺素(Thyroxine, T ₄)和三碘 甲狀腺素(Triiodothyronine, T ₃)	大多數的器官	刺激生長和發育，刺激細胞的呼吸基本速率 (基礎代謝率或 BMR)

TABLE 18.11 Summary of Hormones Produced by Other Organs and Tissues that Contain Endocrine Cells

Hormone	Principal Actions
Gastrointestinal Tract	
Gastrin	Promotes secretion of gastric juice and increases movements of the stomach.
Glucose-dependent insulinotropic peptide (GIP)	Stimulates release of insulin by pancreatic beta cells.
Secretin	Stimulates secretion of pancreatic juice and bile.
Cholecystikinin (CCK)	Stimulates secretion of pancreatic juice, regulates release of bile from the gall-bladder, and brings about a feeling of fullness after eating.
Placenta	
Human chorionic gonadotropin (hCG)	Stimulates the corpus luteum in the ovary to continue the production of estrogens and progesterone to maintain pregnancy.
Estrogens and progesterone	Maintain pregnancy and help prepare mammary glands to secrete milk.
Human chorionic somatomammotropin (hCS)	Stimulates the development of the mammary glands for lactation.

TABLE 18.11 Summary of Hormones Produced by Other Organs and Tissues that Contain Endocrine Cells

Hormone	Principal Actions
Kidneys	
Renin	Part of a sequence of reactions that raises blood pressure by bringing about vasoconstriction and secretion of aldosterone.
Erythropoietin (EPO) Calcitriol* (active form of vitamin D)	Increases rate of red blood cell formation. Aids in the absorption of dietary calcium and phosphorus.
Heart	
Atrial natriuretic peptide (ANP)	Decreases blood pressure.
Adipose Tissue	
Leptin	Suppresses appetite and may increase the activity of FSH and LH.

*Synthesis begins in the skin, continues in the liver, and ends in the kidneys.

Nervous & Endocrine Systems

TABLE 18.1 Comparison of Control by the Nervous and Endocrine Systems

Characteristic	Nervous System	Endocrine System
Mediator molecules	Neurotransmitters released locally in response to nerve impulses.	Hormones delivered to tissues throughout the body by the blood.
Site of mediator action	Close to site of release, at a synapse; binds to receptors in postsynaptic membrane.	Far from site of release (usually); binds to receptors on or in target cells.
Types of target cells	Muscle (smooth, cardiac, and skeletal) cells, gland cells, other neurons.	Cells throughout the body.
Time to onset of action	Typically within milliseconds (thousandths of a second).	Seconds to hours or days.
Duration of action	Generally briefer (milliseconds).	Generally longer (seconds to days).

Table 18-1 Principles of Anatomy and Physiology, 11/e
 © 2006 John Wiley & Sons

Physiological Properties of Hormones

- Small amounts (**pg~ μ g**)
- The secretion rate is determined by the **need**
- No effect on the **source**
- Act on **soma** or **target organs**
- As **trigger** substances
- May have **many effects** e.g. oxytocin

Circulating & Local Hormones

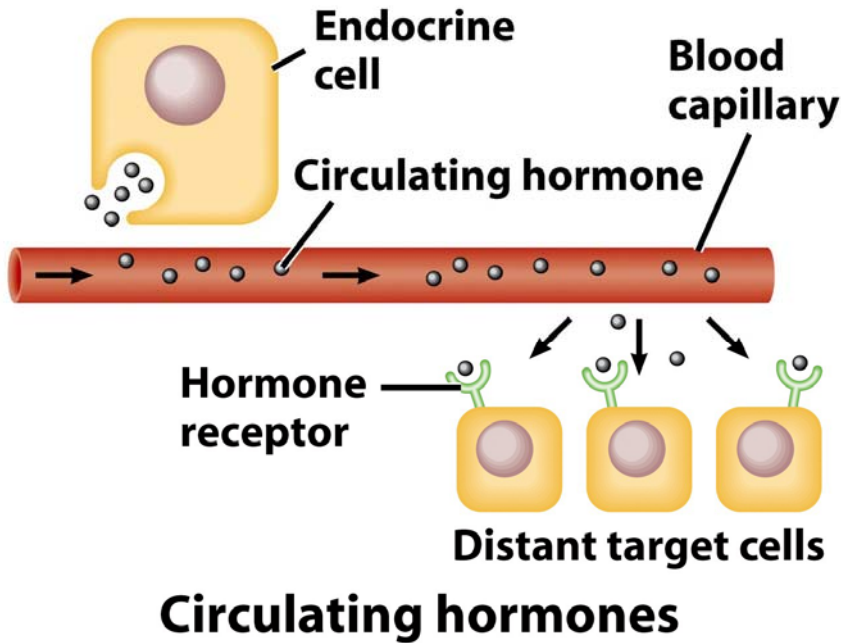


Figure 18-2a Principles of Anatomy and Physiology, 11/e
© 2006 John Wiley & Sons

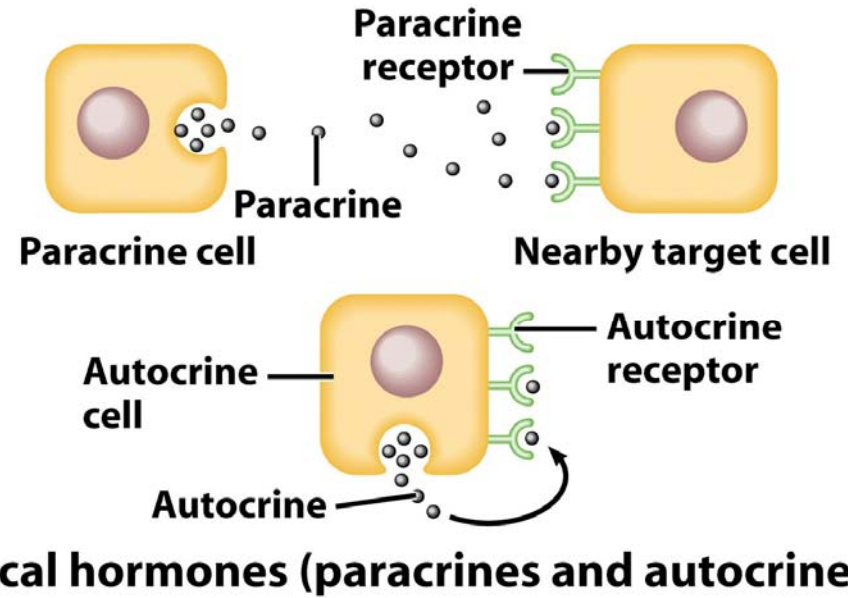


Figure 18-2b Principles of Anatomy and Physiology, 11/e
© 2006 John Wiley & Sons

Categories of Hormones

TABLE 18.2 Summary of Hormones by Chemical Class

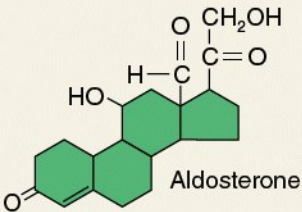
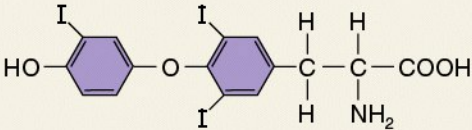
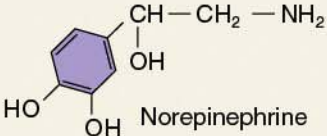
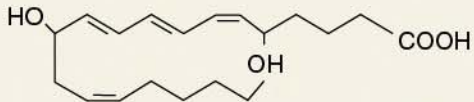
Chemical Class	Hormones	Site of Secretion
Lipid-soluble		
Steroid hormones  <p>Aldosterone</p>	Aldosterone, cortisol, and androgens. Calcitriol. Testosterone. Estrogens and progesterone.	Adrenal cortex. Kidneys. Testes. Ovaries.
Thyroid hormones  <p>Triiodothyronine (T₃)</p>	T ₃ (triiodothyronine) and T ₄ (thyroxine).	Thyroid gland (follicular cells).
Gas	Nitric oxide (NO).	Endothelial cells lining blood vessels.

TABLE 18.2 Summary of Hormones by Chemical Class

Chemical Class	Hormones	Site of Secretion
Water-soluble		
<p>Amines</p>  <p>Norepinephrine</p>	<p>Epinephrine and norepinephrine (catecholamines).</p> <p>Melatonin.</p> <p>Histamine.</p> <p>Serotonin.</p>	<p>Adrenal medulla.</p> <p>Pineal gland.</p> <p>Mast cells in connective tissues.</p> <p>Platelets in blood.</p>
<p>Peptides and proteins</p> <pre> Glutamine ————— Isoleucine Asparagine ————— Tyrosine Cysteine — S — S — Cysteine Proline Leucine Glycine ————— Oxytocin NH₂ </pre>	<p>All hypothalamic releasing and inhibiting hormones.</p> <p>Oxytocin, antidiuretic hormone.</p> <p>Human growth hormone, thyroid-stimulating hormone, adrenocorticotrophic hormone, follicle-stimulating hormone, luteinizing hormone, prolactin, melanocyte-stimulating hormone.</p> <p>Insulin, glucagon, somatostatin, pancreatic polypeptide.</p> <p>Parathyroid hormone.</p> <p>Calcitonin.</p> <p>Gastrin, secretin, cholecystokinin, GIP (glucose-dependent insulinotropic peptide).</p> <p>Erythropoietin.</p> <p>Leptin.</p> <p>Prostaglandins, leukotrienes.</p>	<p>Hypothalamus.</p> <p>Posterior pituitary.</p> <p>Anterior pituitary.</p> <p>Pancreas.</p> <p>Parathyroid glands.</p> <p>Thyroid gland (parafollicular cells).</p> <p>Stomach and small intestine (enteroendocrine cells).</p> <p>Kidneys.</p> <p>Adipose tissue.</p> <p>All cells except red blood cells.</p>
<p>Eicosanoids</p>  <p>A leukotriene (LTB₄)</p>		

Categories of Hormones

依化學組成:

1. Amine Hormones:

Adrenal medulla -NE 、 EP (CAs)

Thyroid gland -Thyroxine (T_4)

2. Peptide hormones -Prolactin 、 Growth hormone....

3. Steroid hormones:

Adrenal cortex -Cortisol 、 Aldosterone

Sex hormones -Estrogens 、 Progesterone

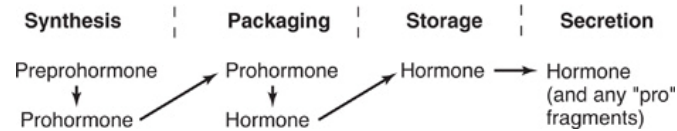
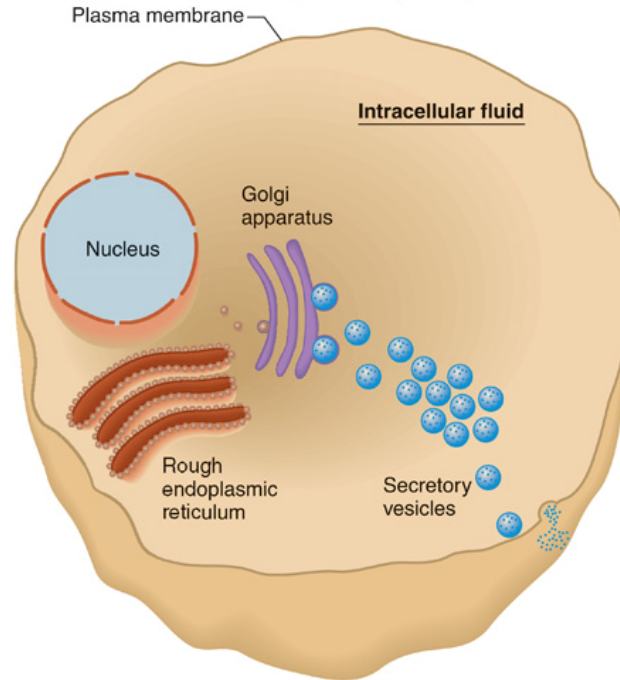
Androgens

Polypeptide & Glycoproteins Hormones

激素	結構	腺體	主要的效果
抗利尿激素 (Antidiuretic hormone)	8個胺基酸	腦下腺後葉	水份保留和血管收縮
催產素(Oxytocin)	8個胺基酸	腦下腺後葉	子宮和乳腺的收縮
胰島素(Insulin)	21和30個胺基酸(雙鍵)	蘭氏小島的β細胞	細胞的葡萄糖吸收、脂肪合成作用和肝糖合成作用
昇糖激素 (Glucagon)	29個胺基酸	蘭氏小島的α細胞	水解所儲存的肝糖和脂肪
腎上腺皮促素 (ACTH)	39個胺基酸	腦下腺前葉	刺激腎上腺皮質
副甲狀腺素 (Parathyroid hormone)	84個胺基酸	副甲狀腺	增加血鈣的濃度
濾泡刺激素 (FSH)、黃體刺激素(LH)、甲狀腺刺激素(TSH)	醣蛋白	腦下腺前葉	刺激目標腺體的成長發育和分泌

Biosynthesis and Secretion of Peptide Hormones

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



pre-pro-insulin → **pro-insulin** → **insulin**

Preprohormones & Prohormones

活化型激素的先趨物—稱為**前激素**(prohormones)

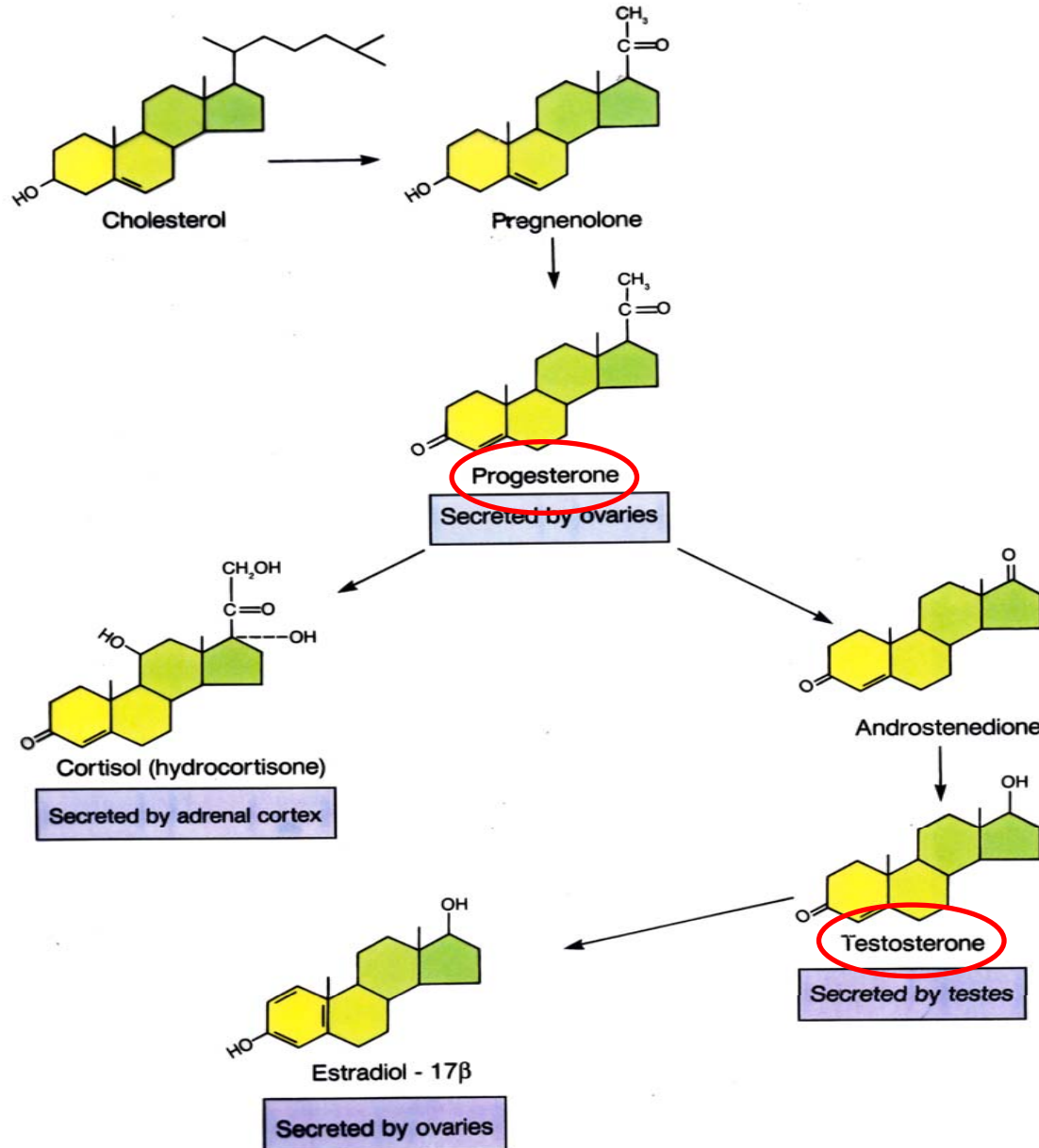
前原激素(preprohormones)

- 前激素在內分泌細胞中是不活化的先趨分子
- 前原激素是內分泌腺體平常分泌的分子，為了使其成為活化態，必須在標的細胞中轉換成其它的衍生物

表 11.3 轉換前原激素成為具生物活性的衍生物

內分泌腺體	前原激素	活性產物	註解
皮膚	維生素 D ₃ (Vitamin D ₃)	1,25 - 二羥維生素 D ₃	水解反應發生在肝臟和腎臟
睪丸	睪固酮	二氫睪固酮 (Dihydrotestosterone, DHT)	DHT 和其它的 5 α - 還原態的 雄性素在大多數的雄性 素依賴的組織被形成
		雌二醇 (Estradiol-17 β , E ₂)	E ₂ 在腦中是從睪固酮所形成， 它被認為同時影響內分泌的功能和行 為睪丸亦可製造少量
甲狀腺	甲狀腺素 (T ₄)	三碘甲狀腺素 (T ₃)	幾乎所有的組織均可將 T ₄ 轉換成 T ₃

Biosynthesis of Steroid Hormones



Biosynthesis of Steroid Hormones

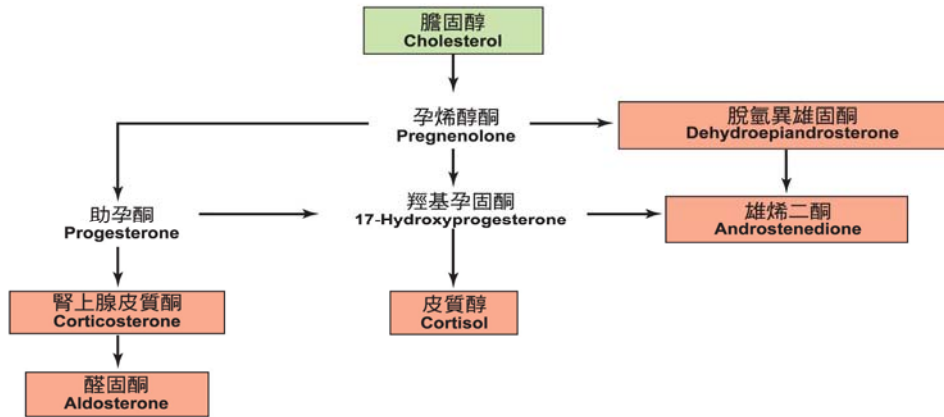


圖 8-4

腎上腺皮質生成類固醇荷爾蒙的簡化途徑；有些中間步驟被省略。每一步驟都是由特定的酵素所執行。方框中的荷爾蒙為五種主要分泌的荷爾蒙。脫氫異雄固酮（dehydroepiandrosterone；DHEA）和雄烯二酮（androstenedione）屬於雄激素（androgens），即為類睪固酮荷爾蒙（testosterone-like hormone）。皮質醇（cortisol）和腎上腺皮質酮（corticosterone）屬於糖類皮質素（glucocorticoids）。醛固酮（aldosterone）屬於礦物皮質素（mineralocorticoid），只由腎上腺皮質的單一部位所產生。

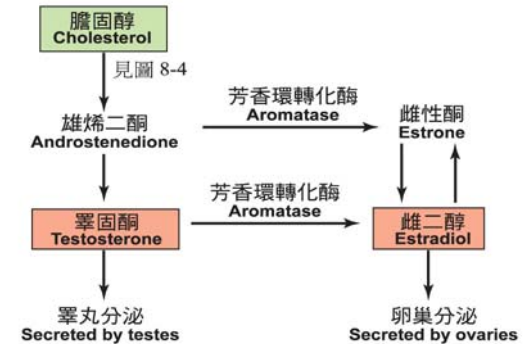


圖 8-6

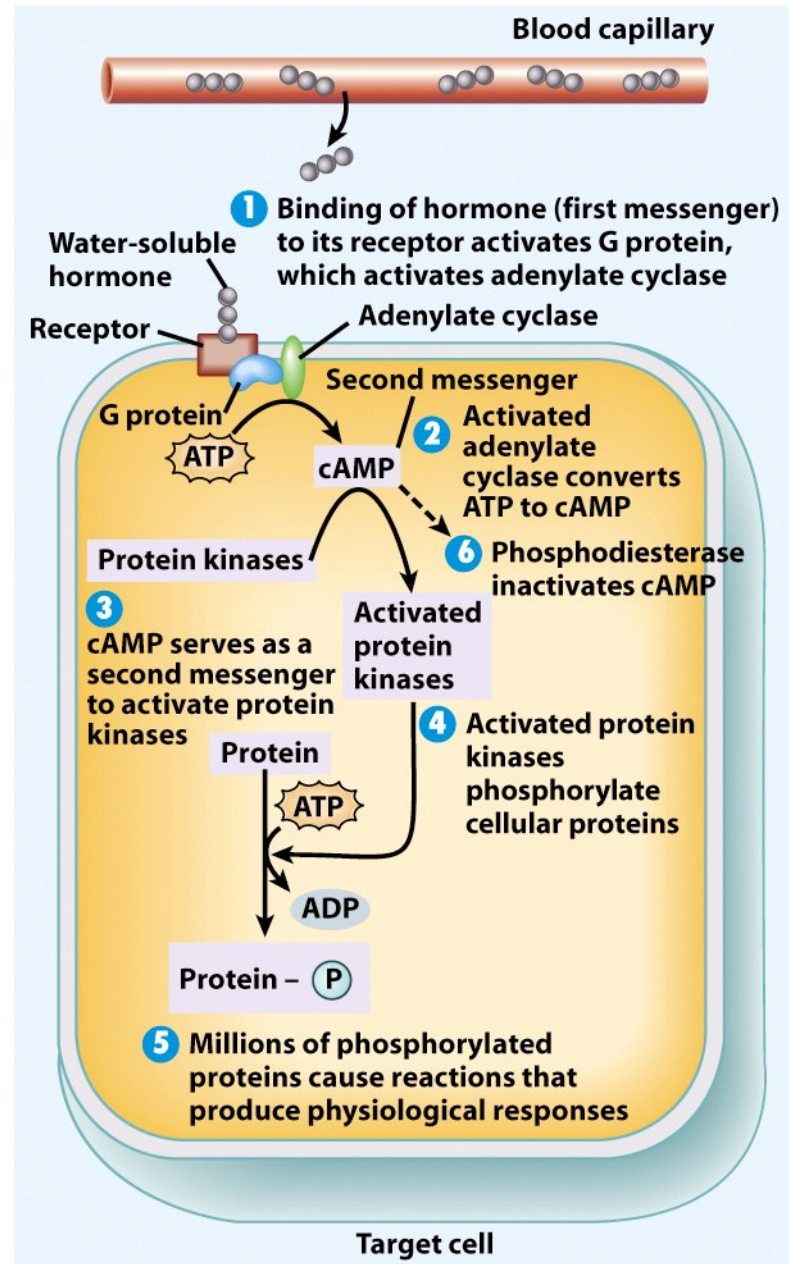
性腺類固醇的生成。只有卵巢具有高濃度的芳香環轉化酶（aromatase），為兩種雌激素雌素酮（estrone）與雌二醇（estradiol）生成所需。

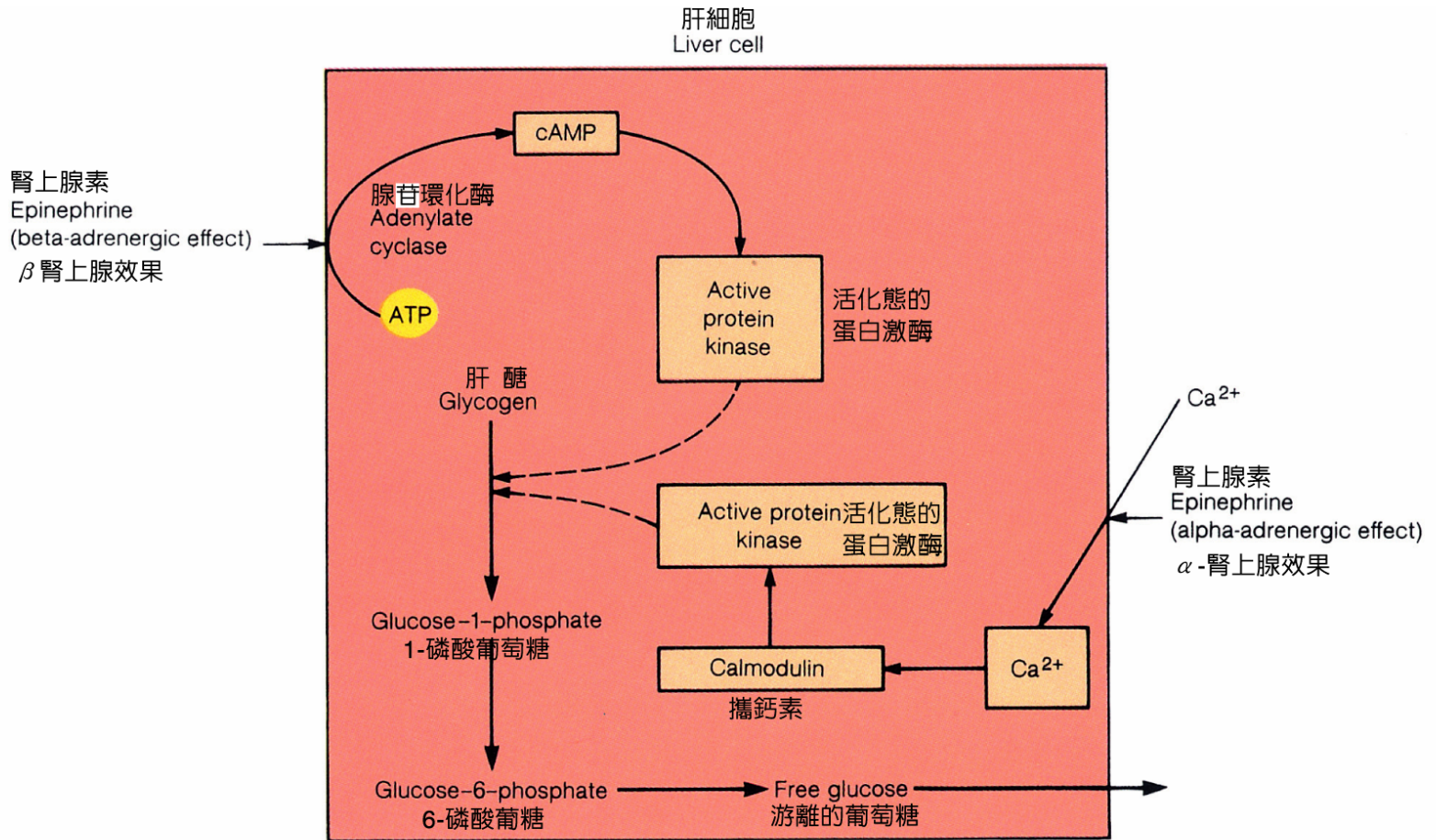
Categories of Hormones

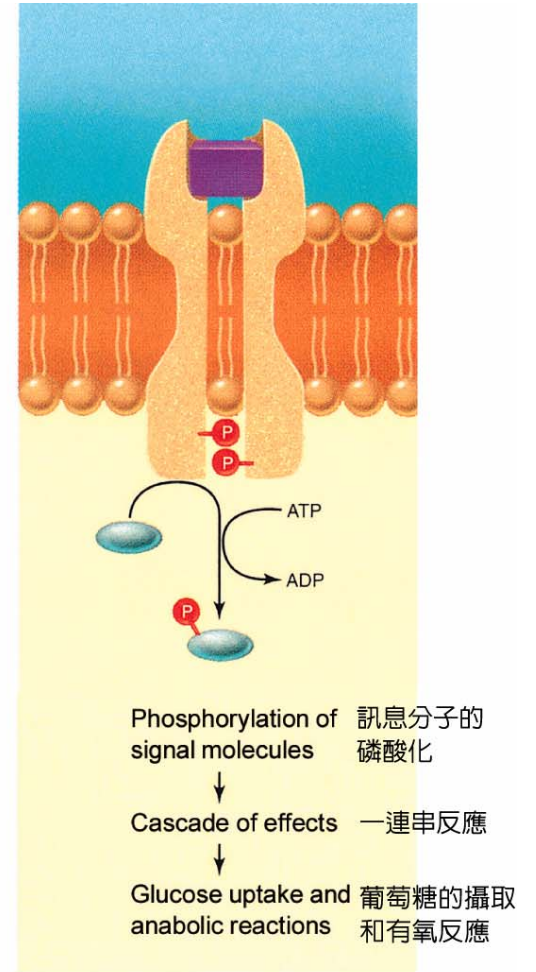
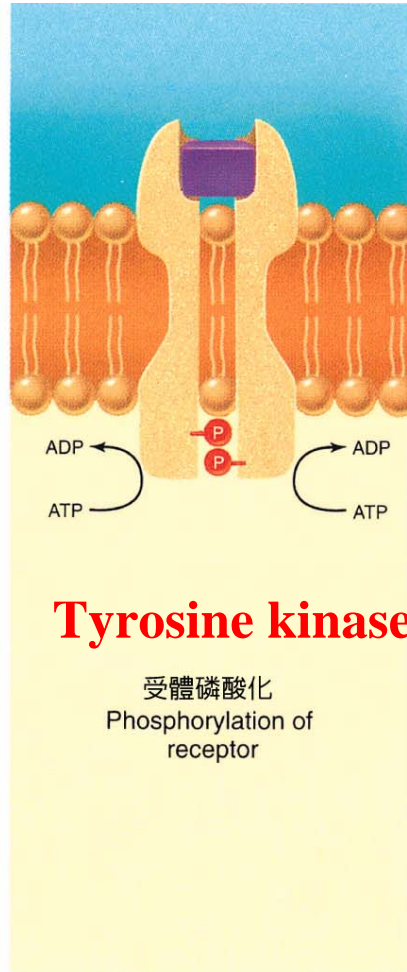
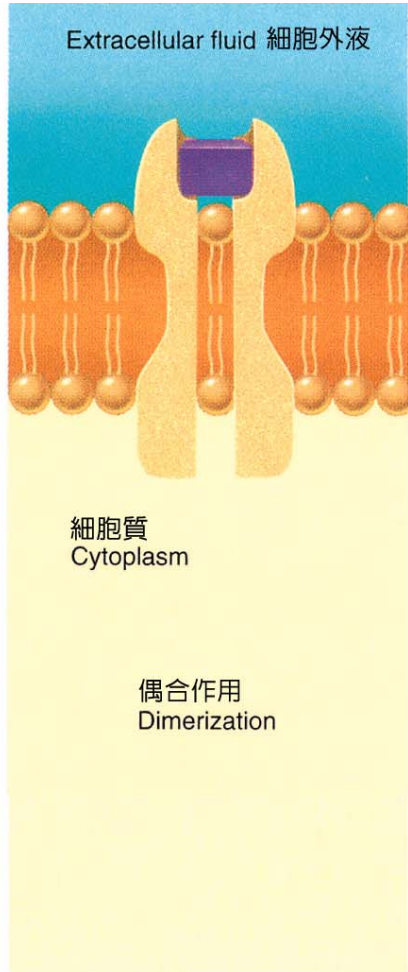
依接受器所在位置:

Types	Major From in Plasma	Location of Receptors	Signal Transduction Mechanisms	Rate of Excretion/ Metabolism
Peptides and catecholamines (Water-Soluble Hormones)	Free	Plasma membrane	1. Second messenger 2. Enz activation by receptor (JAK kinase): 3. Intrinsic enz activity of receptor (tyrosine kinase)	Fast (minutes)
Steroids and thyroid hormones (Lipid-Soluble Hormones)	Protein-bound	Cell interior	Intracellular receptors directly alter gene transcription	Slow (hours to days)

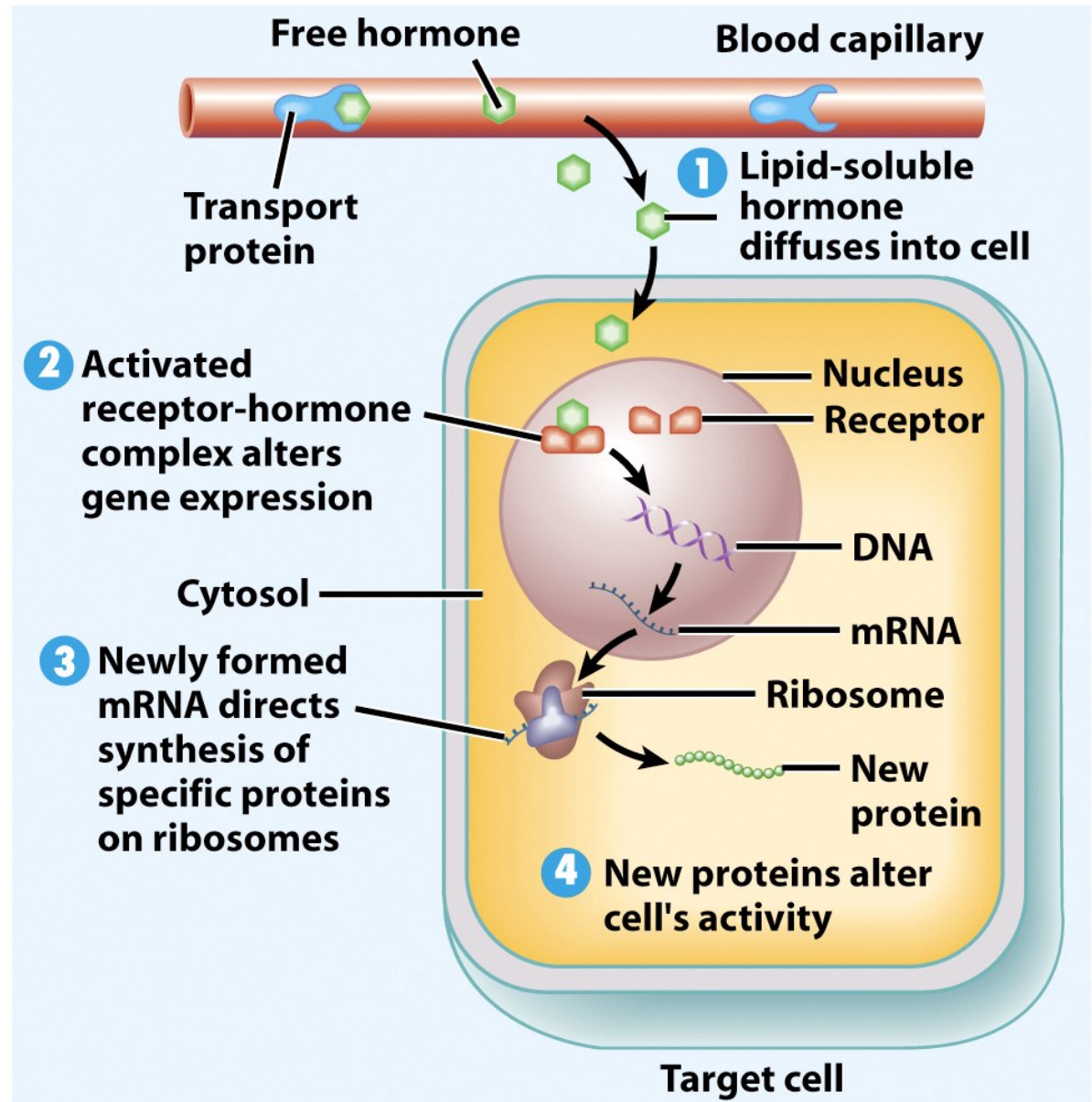
Action of Water-Soluble Hormones







Action of Lipid-Soluble Hormones



Nuclear Receptors

1. Steroid hormones:

Adrenal cortex -Cortisol

Aldosterone

Sex hormones -Estrogens

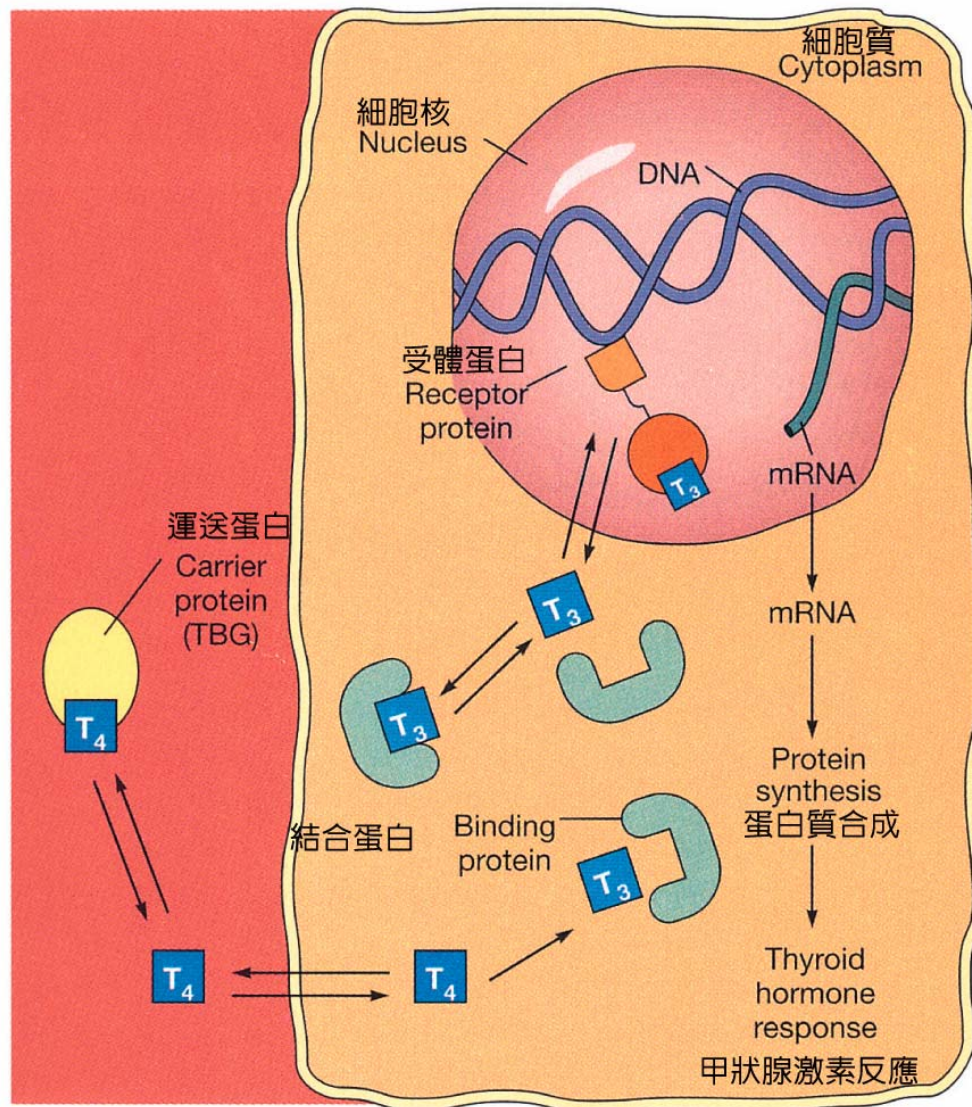
Progesterone

Androgens

2. Sterols -vitamin D

3. Thyroid hormone

4. Retinoic acid(視網酸)



Blood
血液

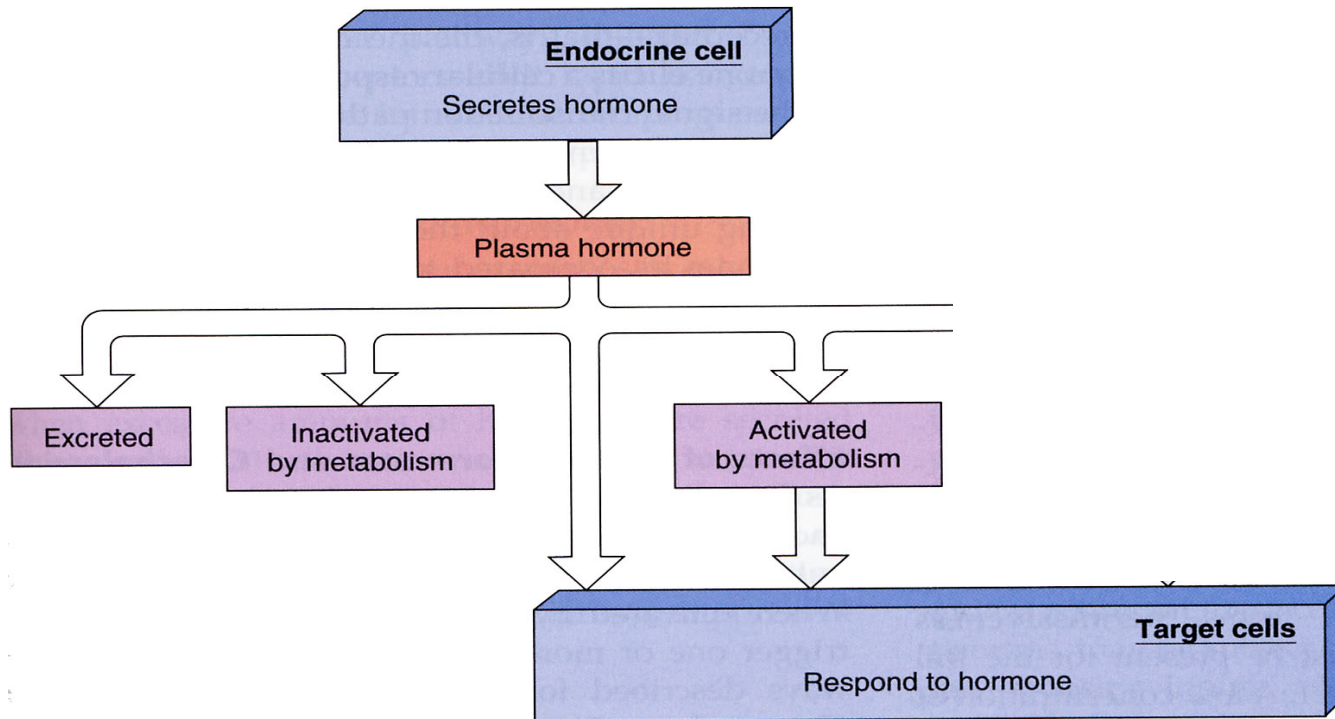
Target cell
標的細胞

General Mechanisms of Hormone Action

- ❖ Hormone binds to **cell surface** or **receptor inside** target cell
- ❖ Cell may then
 - synthesize new molecules
 - change permeability of membrane
 - alter rates of reactions
- ❖ Each target cell responds to hormone differently
 - At liver cells---insulin stimulates glycogen synthesis
 - At adipocytes---insulin stimulates triglyceride synthesis
- ❖ Synthetic drugs may block receptors for naturally occurring hormones
 - Normally, progesterone levels drop once/month leading to menstruation. Progesterone levels are maintained when a woman becomes pregnant.
 - RU486 (mifepristone)** binds to the receptors for progesterone preventing progesterone from sustaining the endometrium in a pregnant woman
 - brings on menstrual cycle
 - used to induce abortion

Misoprostol (Cytotec)

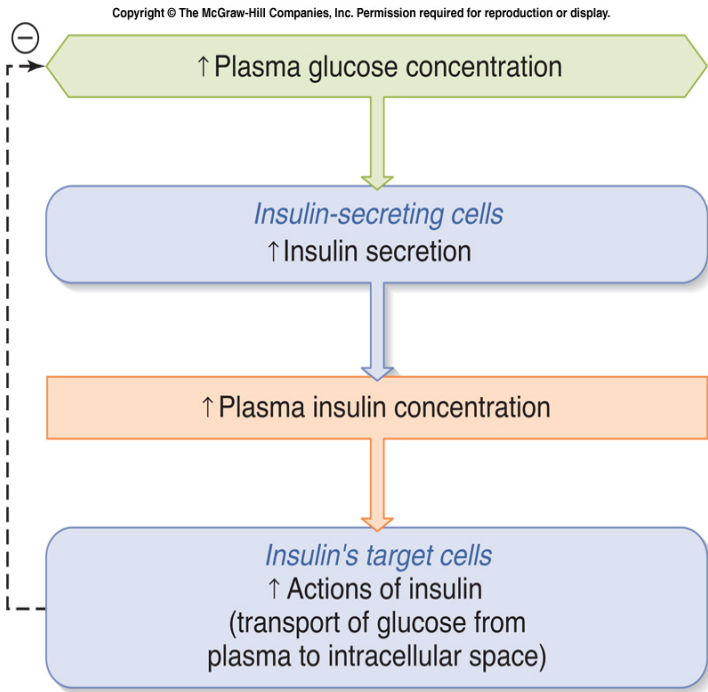
Hormone Metabolism and Excretion



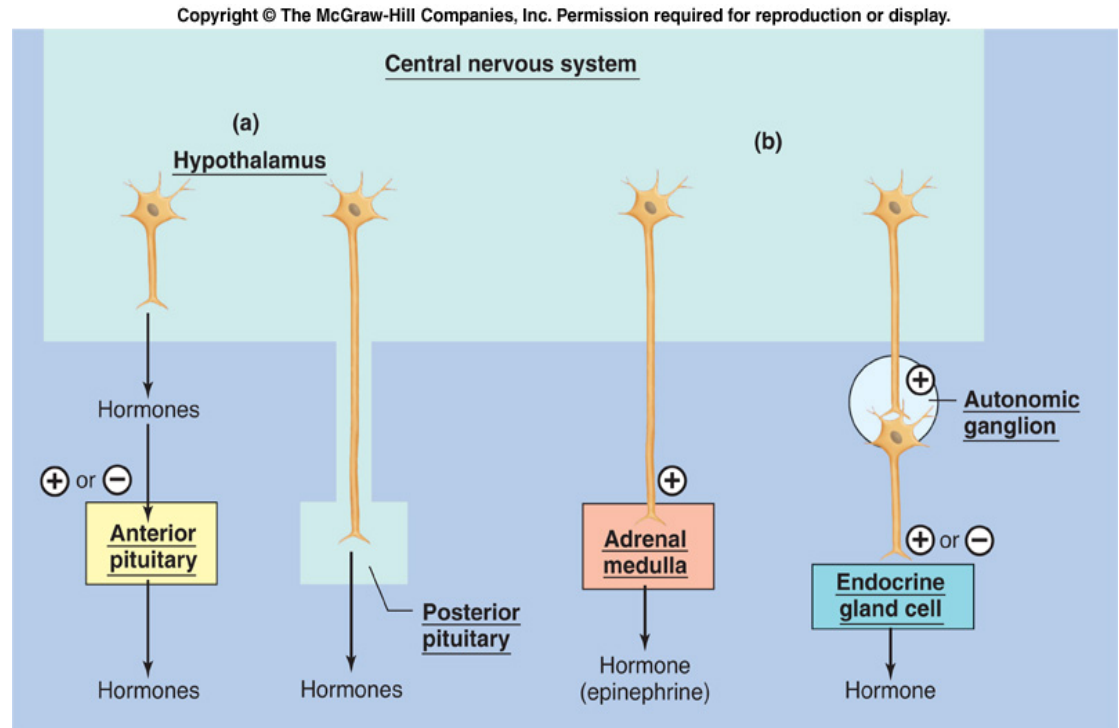
Control of Hormones Secretion

Negative Feedback Control

1. Ions or Nutrients



2. NTs of neurons



3. Other hormones: tropic hormones

Hypothalamus

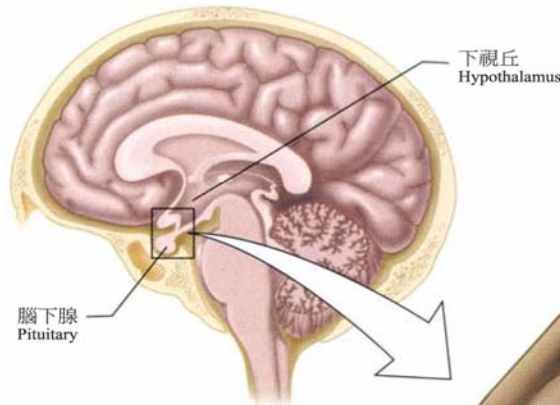
- ❖ 位於腦部的pituitary gland上方，hypothalamus與pituitary gland以垂體門脈系統的血管聯繫：hypothalamus與pituitary gland的前葉聯繫，前葉又稱腺垂體（anterior lobe；adenohypophysis），是靠血管來聯繫；若是在後葉又稱神經垂體（posterior lobe；neurohypophysis），則是靠神經來聯繫。
- ❖ 下視丘是由許多神經核，也就是許多神經細胞所組成。在神經末梢中突（median eminence）停止，當神經末梢釋放出激素（下視丘所分泌），也就是releasing factor則釋放出來後會被微血管吸收，則這地方稱為門脈系統，會透過血液循環跑到pituitary gland前葉，而其前葉有許多細胞，而細胞上有許多接受器，一結合，就會分泌出激素2（trophic hormones）是由pituitary gland所分泌。
- ❖ 下視丘 hormones 分泌呈現脈動型（pulsatile pattern）且受到許多因素影響如日照、四季變化、情緒等。
- ❖ 下視丘所分泌釋放的激素是以其所調控的腦下腺激素來命名。如甲釋素（thyrotropin-releasing hormone；TRH）去刺激腦下腺甲狀腺刺激素（thyrotropin或thyroid-stimulating hormone，TSH）的合成及分泌。

Pituitary Gland

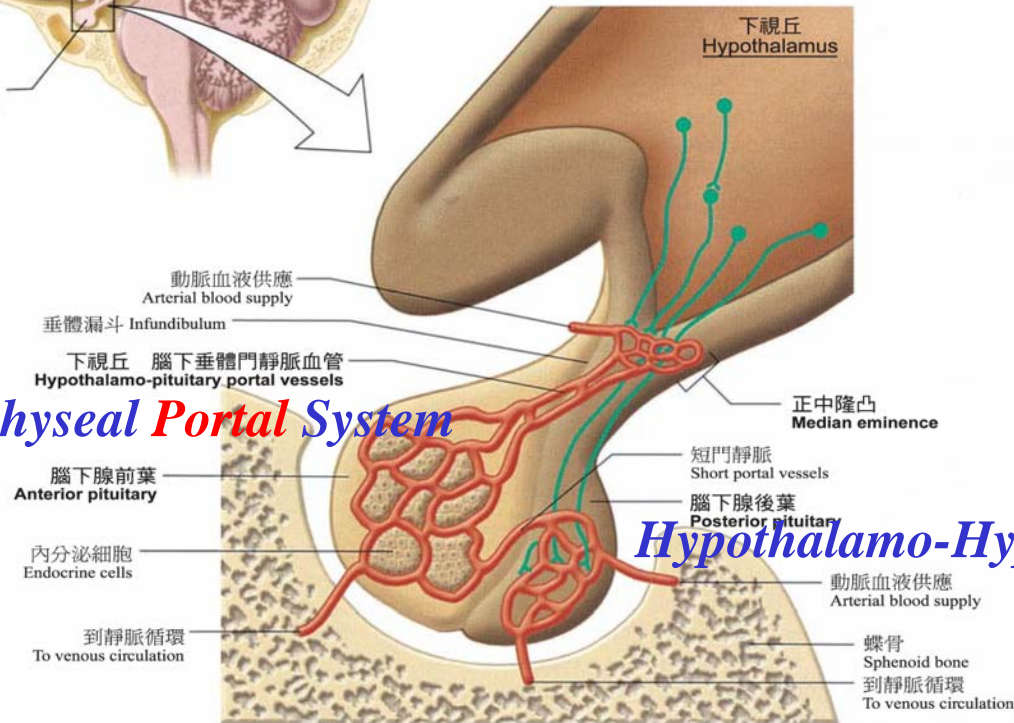
- ❖ 位於腦部底層的蝶鞍 (sella turcia) 中，以腦下垂體柄 (pituitary stalk) 或漏斗 (infundibulum) 懸起來，所以下視丘與腦下垂體靠 pituitary stalk 來相連接起來。在 pituitary stalk 中有垂體門脈系統，因此下視丘藉著血管系統將其激素送到 pituitary stalk 產生作用而去分泌。
- ❖ 胚胎再發育時，由咽喉向腦部形成一個突起稱為雷氏囊 (Rathke's pouch) 而腦中第三腦室的部分組織也向咽喉部延伸與雷氏囊合併而形成腦下垂體，其中由雷氏囊所形成的部分稱之為腺垂體 (adenohypophysis)。由第三腦室所形成的部分稱之為神經垂體 (neurohypophysis)。
- ❖ 腦下垂體可分為三部份：1. 腦下腺前葉 (anterior lobe) 由雷氏囊形成，又稱 adenohypophysis。2. 中葉是前葉與後葉接合部份。3. 腦下腺後葉 (posterior lobe) 由第三腦室形成，又稱 neurohypophysis。

Hypothalamus & Pituitary Gland

(a)



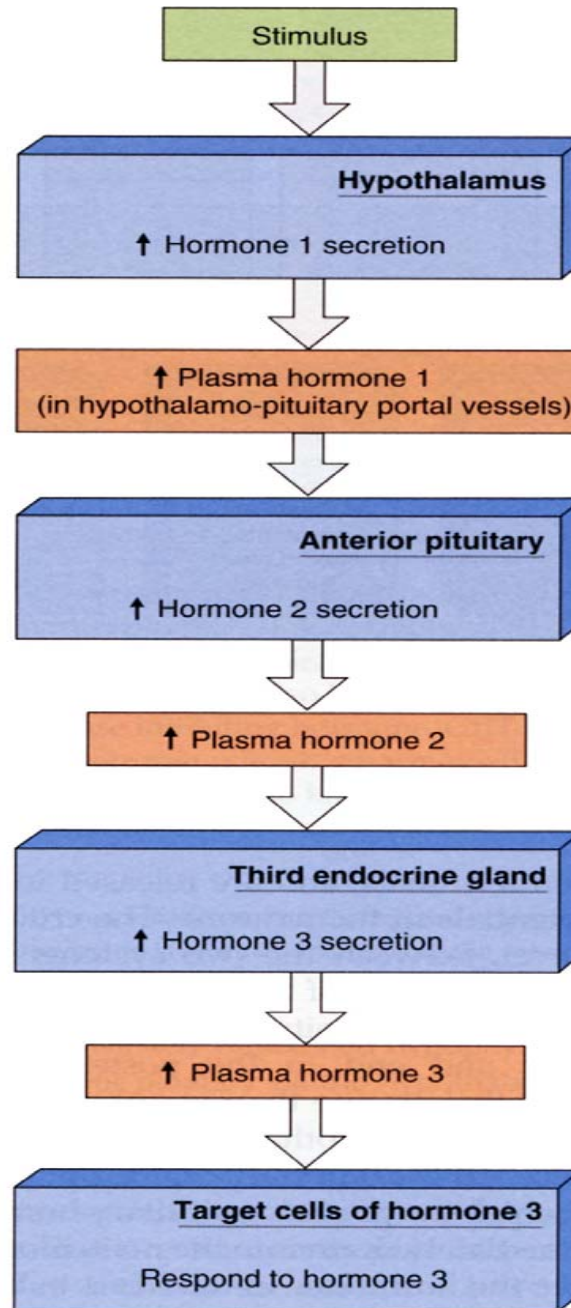
(b)



Hypothalamo-Hypophyseal Portal System

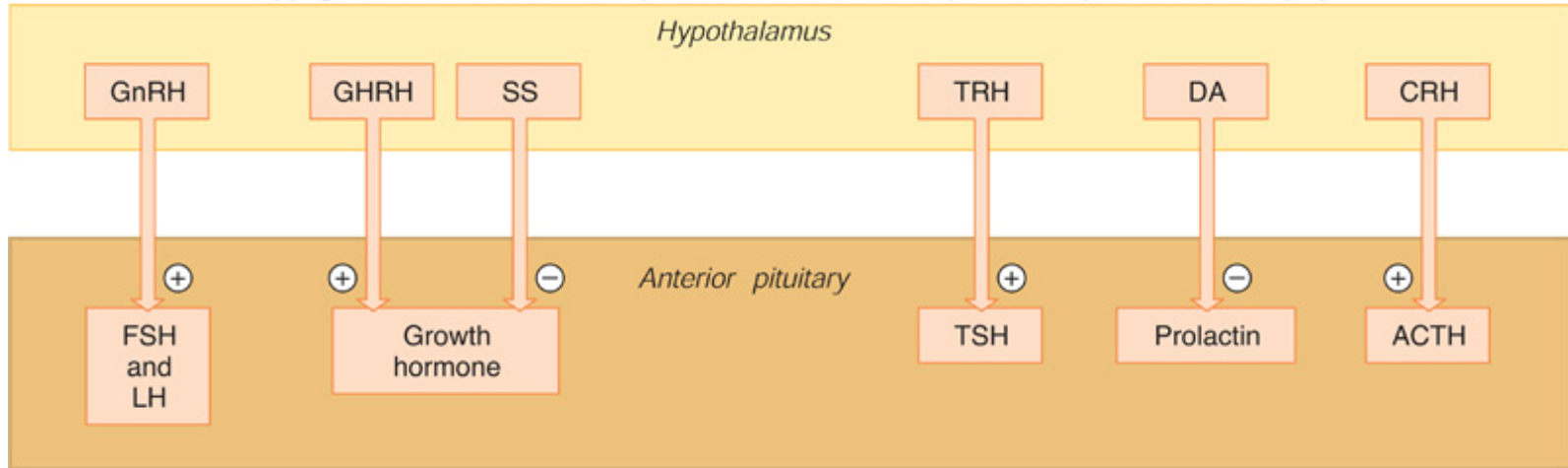
Hypothalamo-Hypophyseal Tract

A typical 3-hormone sequence of hormone control



Hypothalamic Hormones

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

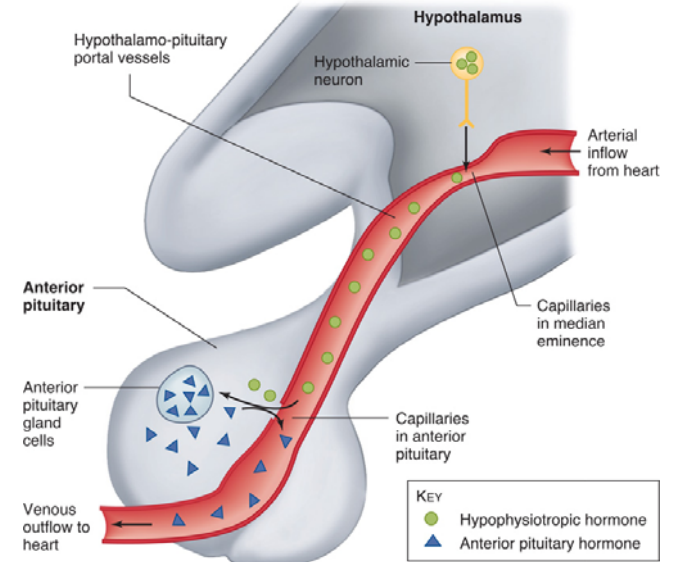


Major known hypophysiotropic hormones	Major effect on anterior pituitary
Corticotropin-releasing hormone (CRH)	Stimulates secretion of ACTH
Thyrotropin-releasing hormone (TRH)*	Stimulates secretion of TSH
Growth hormone-releasing hormone (GHRH)	Stimulates secretion of GH
Somatostatin (SS)	Inhibits secretion of GH
Gonadotropin-releasing hormone (GnRH)	Stimulates secretion of LH and FSH
Dopamine (DA)‡	Inhibits secretion of prolactin

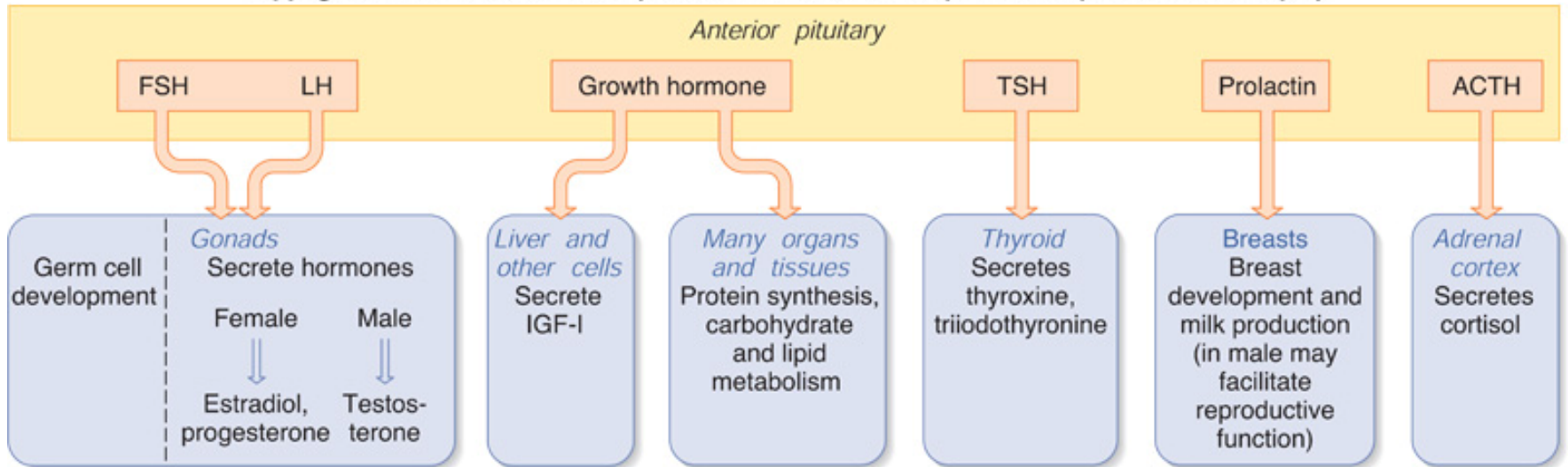
*TRH can also stimulate the release of prolactin, but whether this occurs physiologically is unclear.

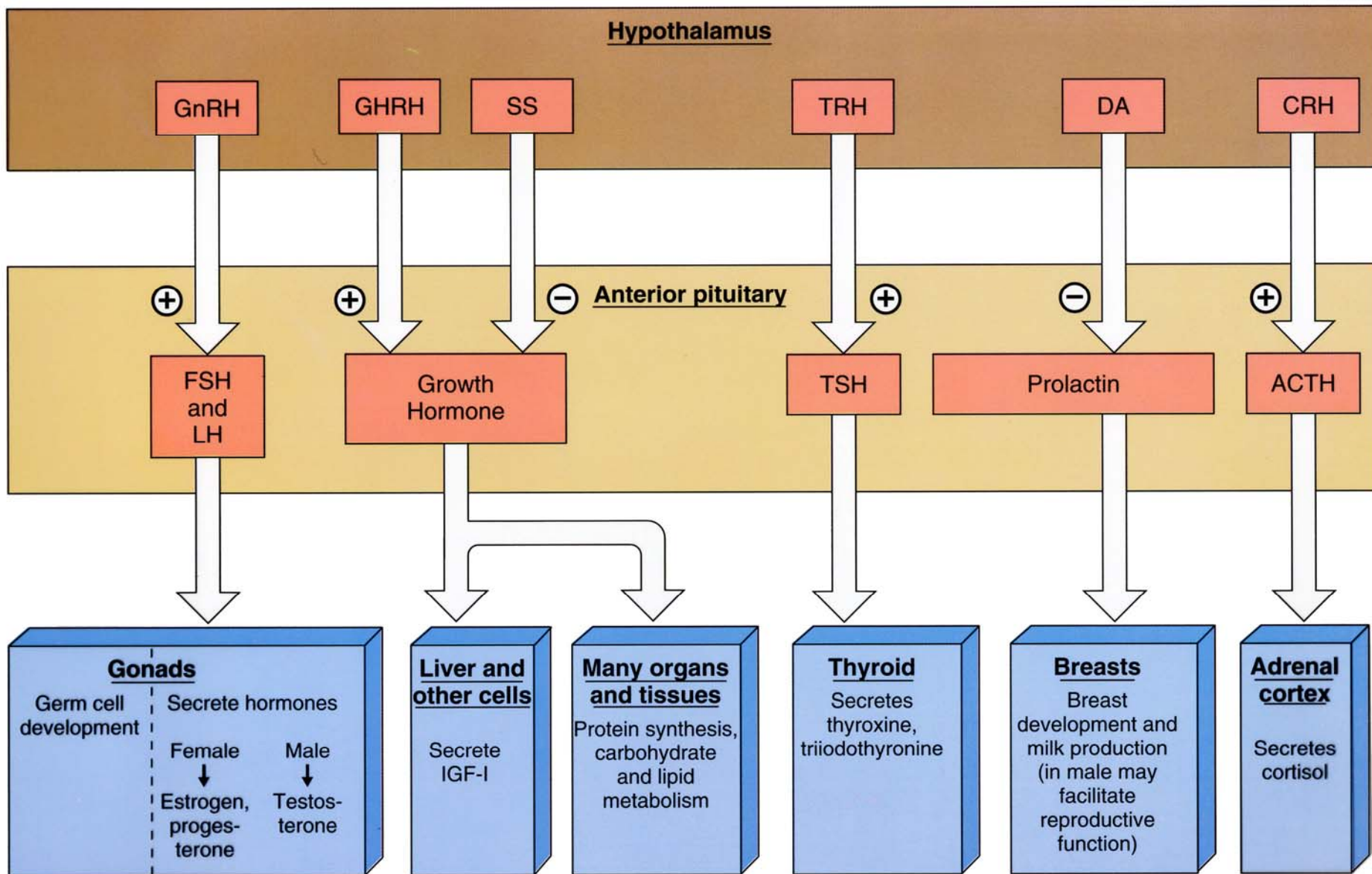
‡Dopamine is a catecholamine; all the other hypophysiotropic hormones are peptides.

Anterior Pituitary Hormones



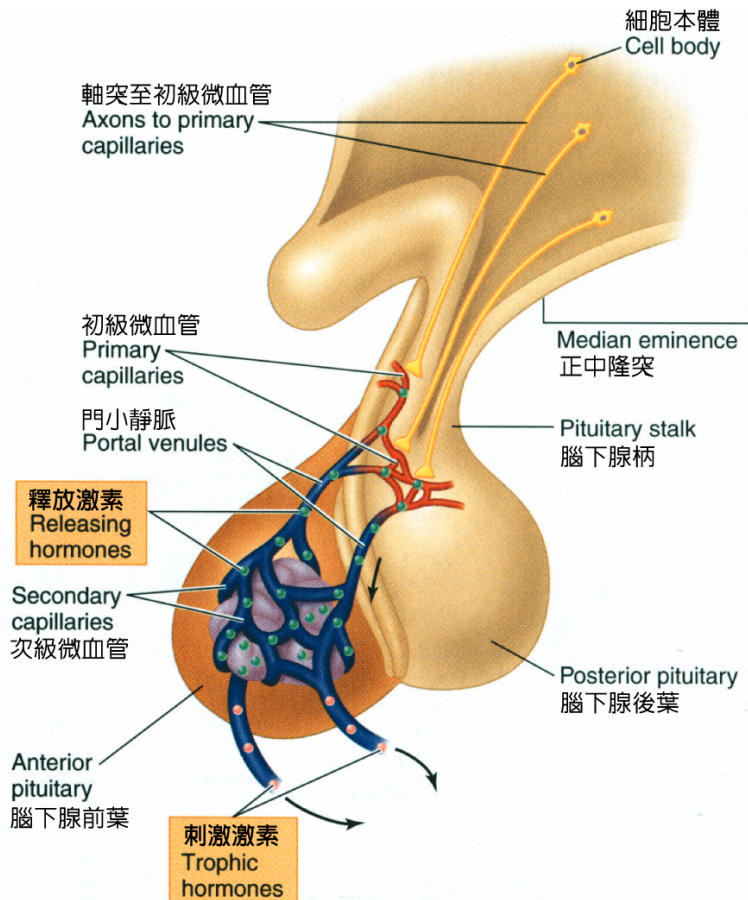
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.





下視丘激素	腦下腺前葉影響	腦下腺前葉激素作用
<p>皮釋素 (CRH ; corticotropin releasing hormone)</p>	<p>刺激腎上腺皮促素(ACTH)的分泌</p>	<p>刺激腎上腺皮質的分泌</p>
<p>性釋素 (GnRH ; gonadotropin releasing hormone)</p>	<p>刺激濾泡刺激素(FSH)和黃體刺激素(LH) 的分泌</p>	<p>刺激性腺產生配子和性類固醇的分泌</p>
<p>泌乳激素抑制激素 (PIH ; prolactin inhibiting hormone ; PIF : dopamine)</p>	<p>抑制泌乳激素(PRL)的分泌</p>	<p>刺激乳腺產生乳汁</p>
<p>體制素 (SS ; somatostatin)</p>	<p>抑制生長激素(GH)和甲狀腺激素(TSH) 的分泌</p>	<p>刺激許多器官的同化代謝和成長</p>
<p>甲釋素 (TRH ; thyrotropin releasing hormone)</p>	<p>刺激TSH的分泌</p>	<p>刺激甲狀腺素的分泌</p>
<p>生長素釋素 (GHRH ; growth hormone releasing hormone)</p>	<p>刺激生長激素(GH) 的分泌</p>	<p>刺激許多器官的同化代謝和成長</p>

Anterior Pituitary Gland (Adenohypophysis)



- ❖ The blood supply to the anterior pituitary is from the *superior hypophyseal arteries*.
- ❖ Hormones of the anterior pituitary and the cells that produce the:
 - Human growth hormone (hGH) is secreted by **somatotrophs**.
 - Thyroid-stimulating hormone (TSH) is secreted by **thyrotrophs**.
 - Follicle-stimulating hormone (FSH) and luteinizing hormone (LH) are secreted by **gonadotrophs**.
 - Prolactin (PRL) is secreted by **lactotrophs**.
 - Adrenocorticotrophic hormone (ACTH) and melanocyte-stimulating hormone (MSH) are secreted by **corticotrophs**.

腦下腺前葉激素	作用地方	激素刺激	調節方法
腎上腺皮促素 [ACTH] (adrenocorticotropic hormone)	腎上腺皮質 (adrenal cortex)	分泌糖皮質激素 (glucocorticoids)	被CRH刺激；被glucocorticoids抑制
甲狀腺激素 [TSH] (thyroid stimulating hormone)	甲狀腺 (thyroid gland)	分泌甲狀腺素 (thyroid hormones)	被TRH刺激及thyroid hor.所抑制
生長激素 [GH] (growth hormone ; somatotropic hormone)	大多數組織 (沒有專一性)	<ul style="list-style-type: none"> ❶ 脂肪分解會增加 ❷ 增加血糖 ❸ protein合成增加 	被SS所抑制；被GHRH所刺激
濾泡刺激素 [FSH] (follicle stimulating hormone)	性腺 (gonads)	<ul style="list-style-type: none"> ❶ 配子 (gametes) 精子和卵子產生 ❷ 性類固醇分泌 	被GnRH所刺激；被性類固醇抑制
黃體刺激素 [LH] (luteinizing hormone)	性腺	<ul style="list-style-type: none"> ❶ 性激素分泌 ❷ 排卵 ❸ 黃體形成 	被GnRH所刺激
泌乳激素[PRL] (prolactin)	乳腺	乳汁的產生	被PIH = PIF抑制

TABLE 18.4 Summary of the Principal Actions of Anterior Pituitary Hormones










Hormone and Target Tissues	Principal Actions
<p>Human growth hormone (hGH) or somatotropin</p>  <p>Liver</p>	<p>Stimulates liver, muscle, cartilage, bone, and other tissues to synthesize and secrete insulinlike growth factors (IGFs); IGFs promote growth of body cells, protein synthesis, tissue repair, lipolysis, and elevation of blood glucose concentration.</p>
<p>Thyroid-stimulating hormone (TSH) or thyrotropin</p>  <p>Thyroid gland</p>	<p>Stimulates synthesis and secretion of thyroid hormones by thyroid gland.</p>
<p>Follicle-stimulating hormone (FSH)</p>  <p>Ovaries</p>  <p>Testes</p>	<p>In females, initiates development of oocytes and induces ovarian secretion of estrogens. In males, stimulates testes to produce sperm.</p>

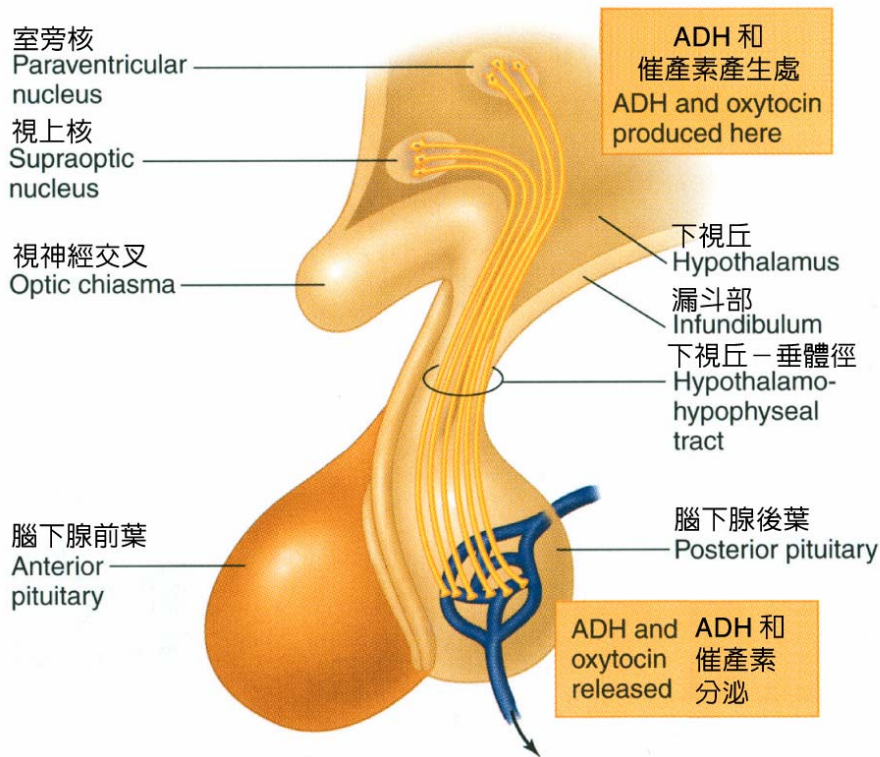
Table 18-4 part 1 Principles of Anatomy and Physiology, 11/e
© 2006 John Wiley & Sons

TABLE 18.4 Summary of the Principal Actions of Anterior Pituitary Hormones

Hormone and Target Tissues	Principal Actions
<p>Luteinizing hormone (LH)</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>Ovaries</p> </div> <div style="text-align: center;">  <p>Testes</p> </div> </div>	<p>In females, stimulates secretion of estrogens and progesterone, ovulation, and formation of corpus luteum. In males, stimulates testes to produce testosterone.</p>
<p>Prolactin (PRL)</p> <div style="text-align: center;">  <p>Mammary glands</p> </div>	<p>Together with other hormones, promotes milk secretion by the mammary glands.</p>
<p>Adrenocorticotrophic hormone (ACTH) or corticotropin</p> <div style="text-align: center;">  <p>Adrenal cortex</p> </div>	<p>Stimulates secretion of glucocorticoids (mainly cortisol) by adrenal cortex.</p>
<p>Melanocyte-stimulating hormone (MSH)</p> <div style="text-align: center;">  <p>Brain</p> </div>	<p>Exact role in humans is unknown but may influence brain activity; when present in excess, can cause darkening of skin.</p>

***Pro-opio-melanocortin (POMC):
MSH ACTH endorphine***

Posterior Pituitary Gland (Neurohypophysis)



- ❖ Although the posterior pituitary gland does not synthesize hormones, it does store and release two hormones.
 - Hormones made by the hypothalamus and stored in the posterior pituitary are **oxytocin (OT)** and **antidiuretic hormone (ADH)**.
 - The neural connection between the hypothalamus and the neurohypophysis is via the *hypothalamo-hypophyseal tract*.

腦下腺後葉激素	作用地方	生理作用	調節方法
抗利尿激素 [ADH ; AVP] (antidiuretic hormone ; vasopressin)	腎小管及血管	❶ 排尿 ↓ ❷ 血壓 ↑	受滲透度增加而刺激
催產素 [OX] (oxytocin)	子宮及乳腺	❶ 促使子宮肌肉收縮具有催產或引產的作用。 ❷ 乳腺分泌乳汁	❶ 生產時子宮被興奮，會引起催產素分泌會增加 ❷ 陰道刺激時，會引起催產素分泌會增加 ❸ 哺乳時刺激乳頭，會引起催產素分泌會增加

TABLE 18.5 Summary of Posterior Pituitary Hormones

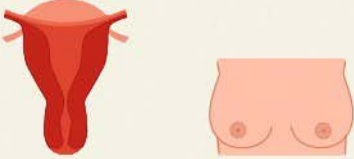
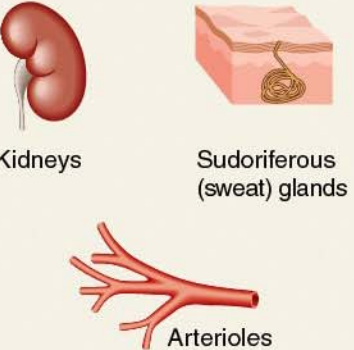
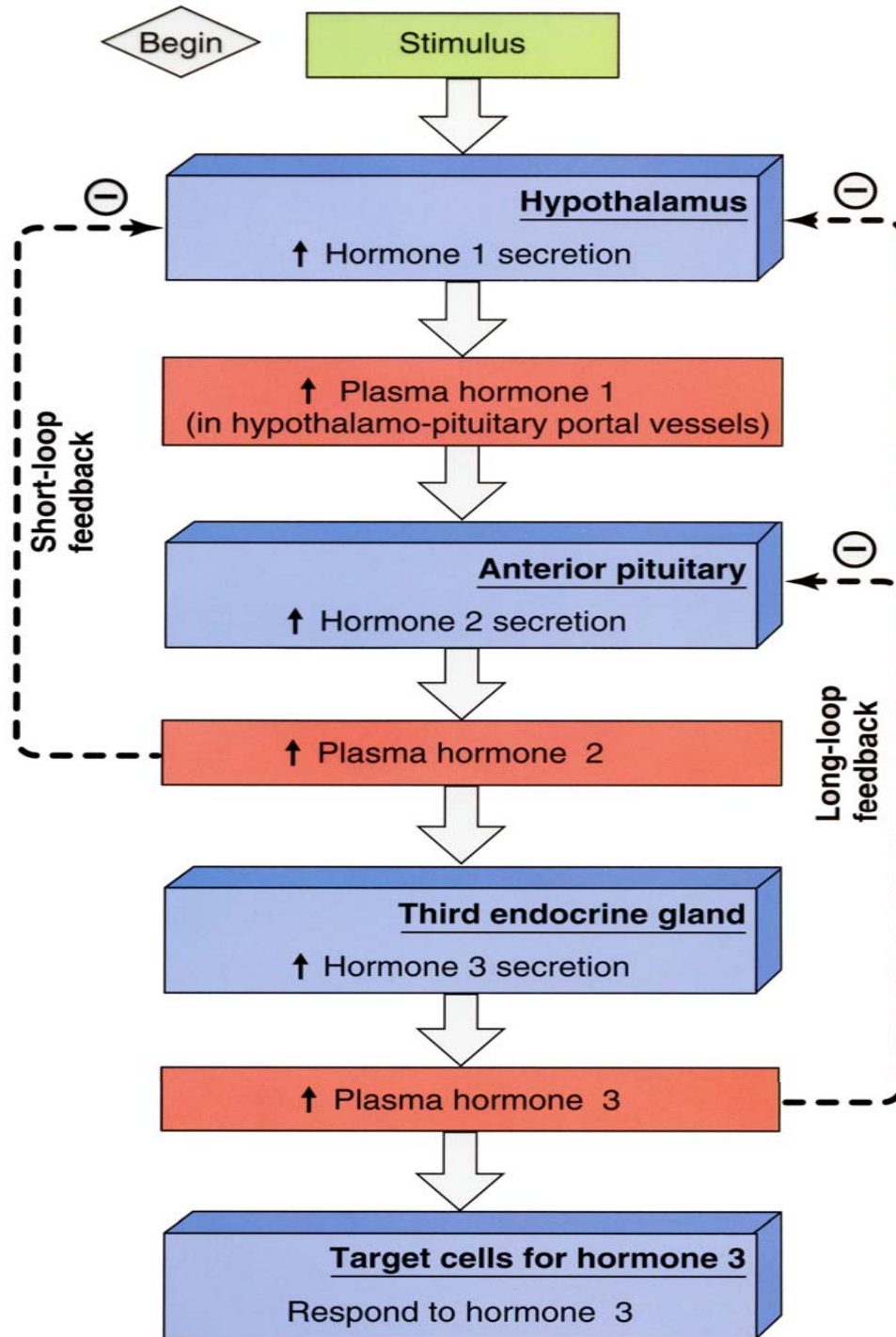
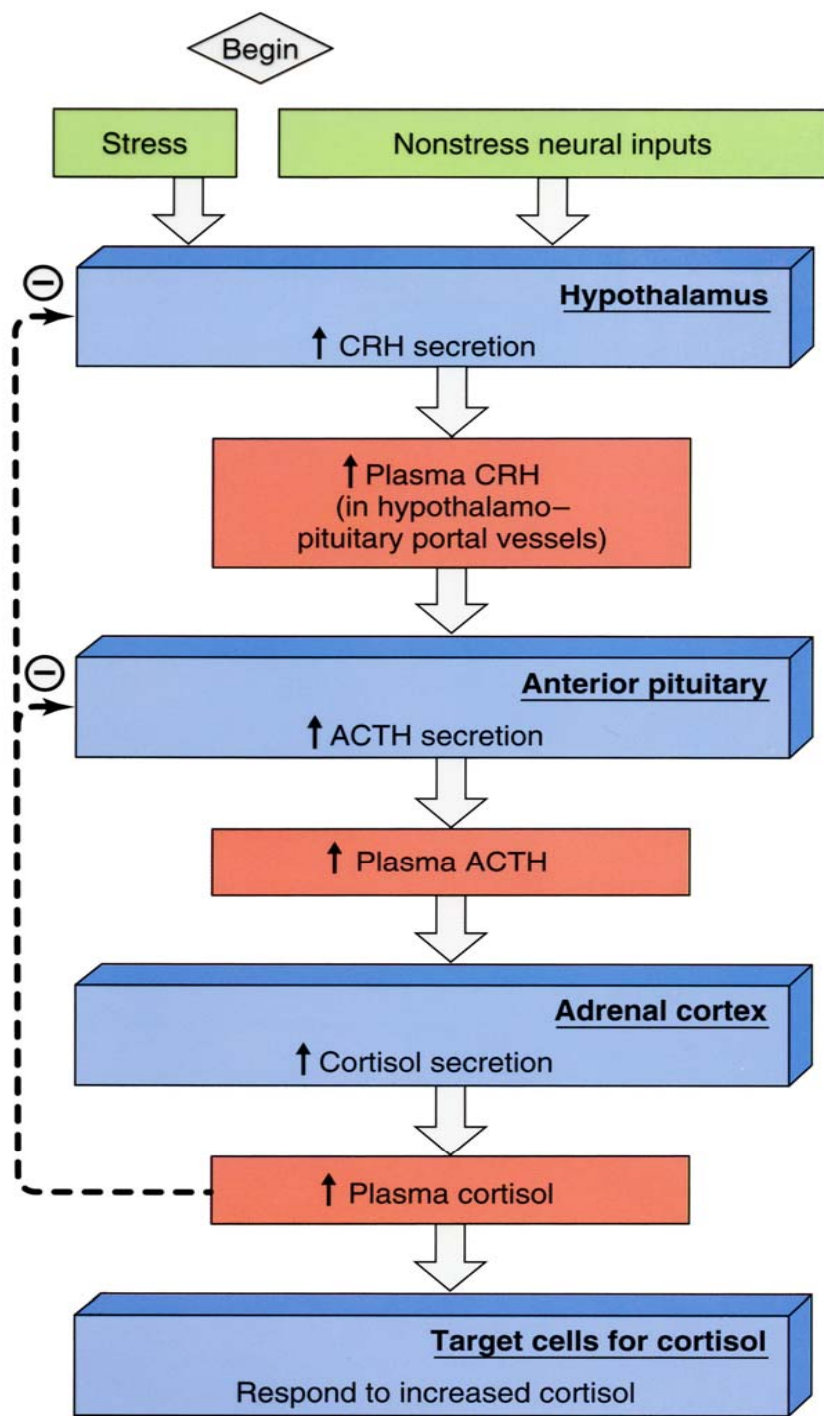
Hormone and Target Tissues	Control of Secretion	Principal Actions
<p>Oxytocin (OT)</p>  <p>Uterus Mammary glands</p>	<p>Neurosecretory cells of hypothalamus secrete OT in response to uterine distention and stimulation of nipples.</p>	<p>Stimulates contraction of smooth muscle cells of uterus during childbirth; stimulates contraction of myoepithelial cells in mammary glands to cause milk ejection.</p>
<p>Antidiuretic hormone (ADH) or vasopressin</p>  <p>Kidneys Sudoriferous (sweat) glands</p> <p>Arterioles</p>	<p>Neurosecretory cells of hypothalamus secrete ADH in response to elevated blood osmotic pressure, dehydration, loss of blood volume, pain, or stress; low blood osmotic pressure, high blood volume, and alcohol inhibit ADH secretion.</p>	<p>Conserves body water by decreasing urine volume; decreases water loss through perspiration; raises blood pressure by constricting arterioles.</p>

Table 18-5 Principles of Anatomy and Physiology, 11/e
 © 2006 John Wiley & Sons

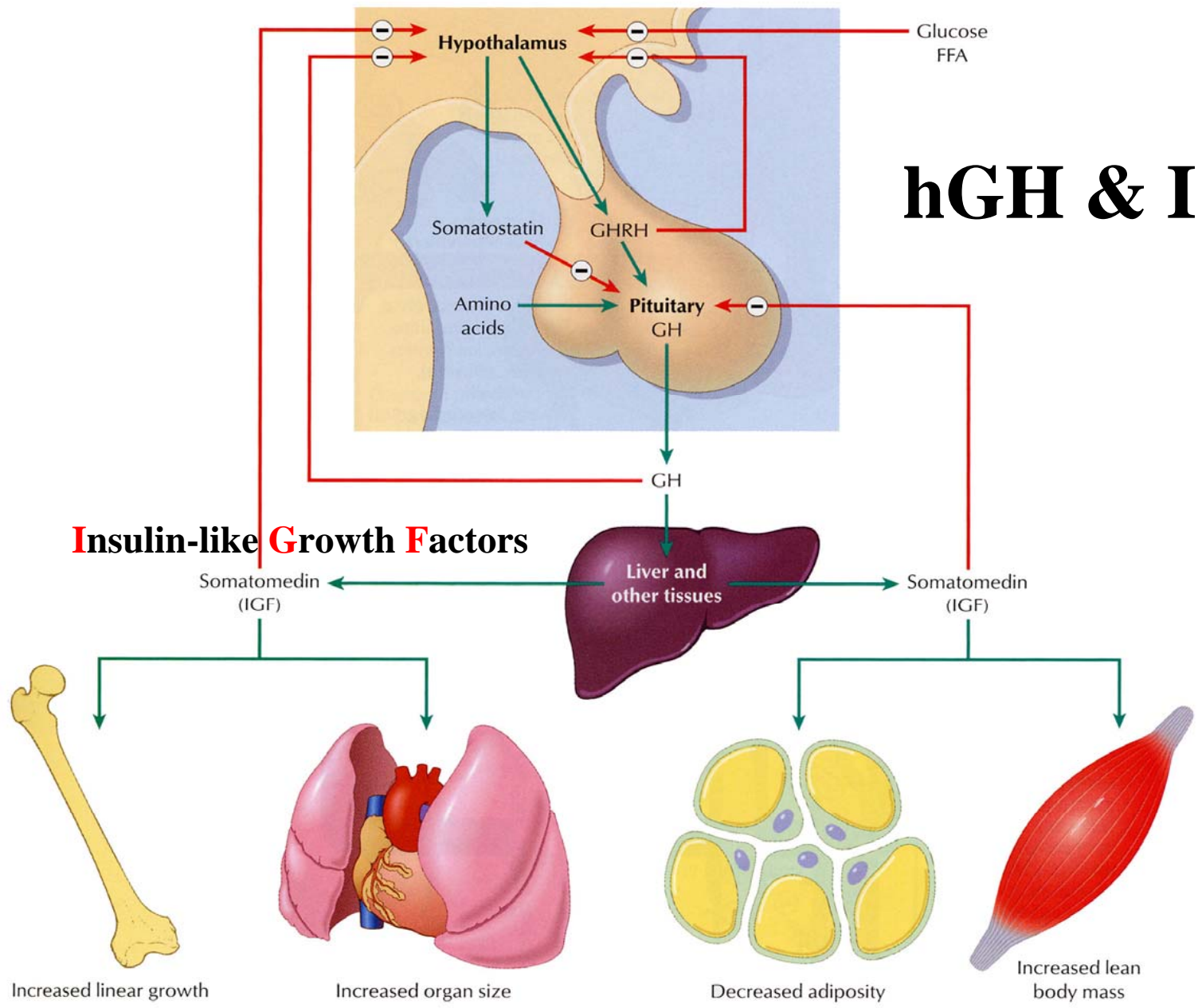




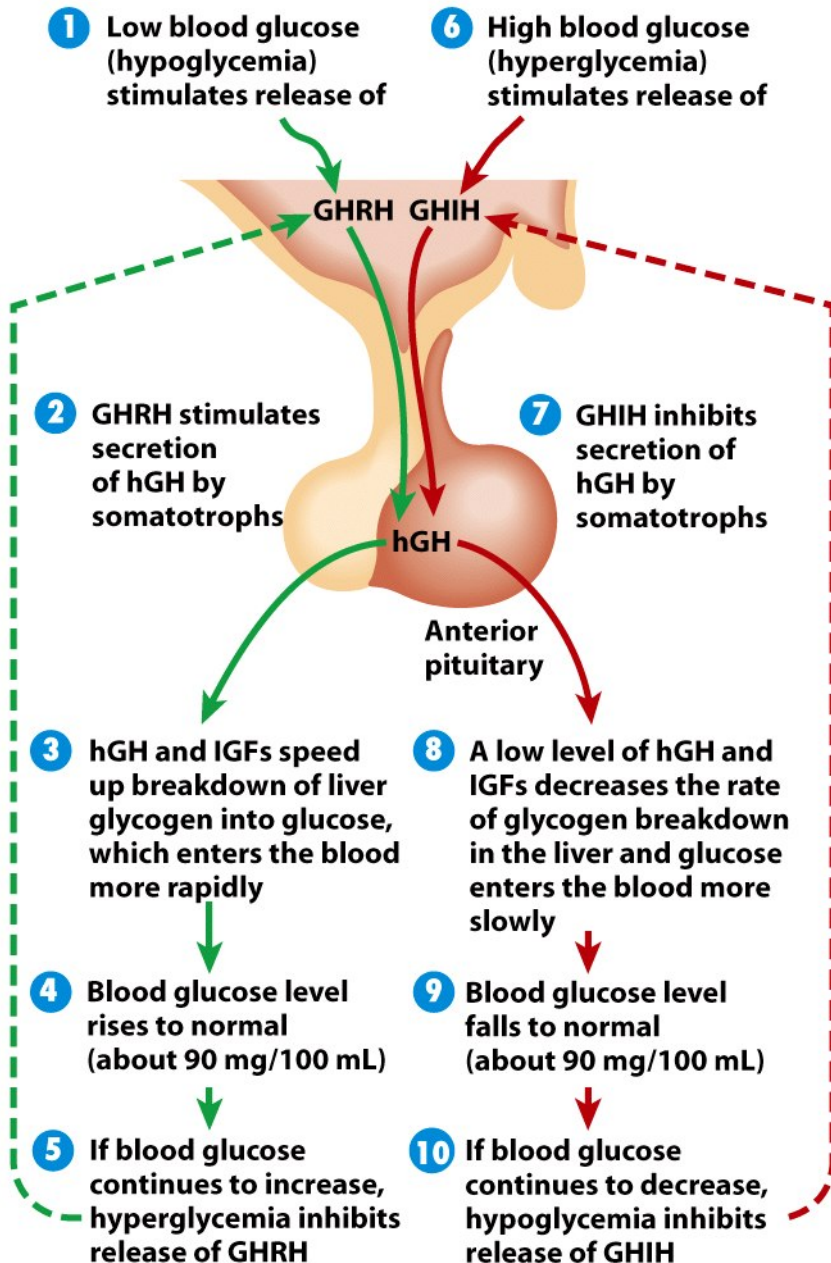
Types of Endocrine Disorders

- I. Endocrine disorders may be classified as **hyposecretion**, **hypersecretion**, and target-cell **hyporesponsiveness** or **hyperresponsiveness**.
 - a. **Primary** disorders are those in which the defect is in the cells that secrete the hormone.
 - b. **Secondary** disorders are those in which there is too much or too little tropic hormone.
 - c. Hyporesponsiveness is due to an alteration in the receptors for the hormone, to disordered postreceptor events, or to failure of normal metabolic activation of the hormone in those cases requiring such activation.
- II. These disorders can be distinguished by measurements of the hormone and any tropic hormones under both basal conditions and during experimental stimulation of the hormone's secretion.

hGH & IGF



Regulation of hGH



- ❖ Low blood sugar stimulates release of **GHRH** from hypothalamus
 - anterior pituitary releases more hGH, more glycogen broken down into glucose by liver cells (**diabetogenic effect**)
- ❖ High blood sugar stimulates release of **GHIH (SS)** from hypothalamus
 - less hGH from anterior pituitary, glycogen does not breakdown into glucose

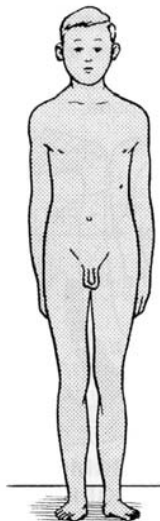
UNDERACTIVITY OF ANTERIOR PITUITARY **GH** ↓

Deficiency or absence of **somatotroph** cells

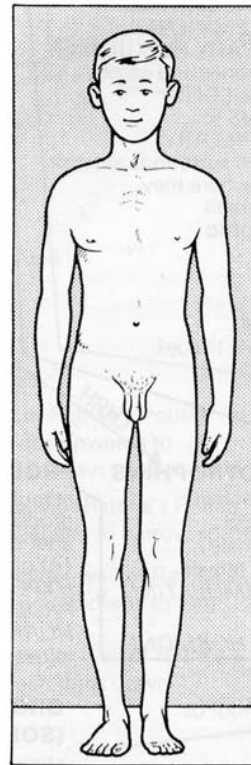
↓
Underproduction of *growth hormone (somatotrophin)*

LORAIN DWARF

Delayed skeletal growth and retarded sexual development but alert, intelligent, well proportioned child.



AGE 13



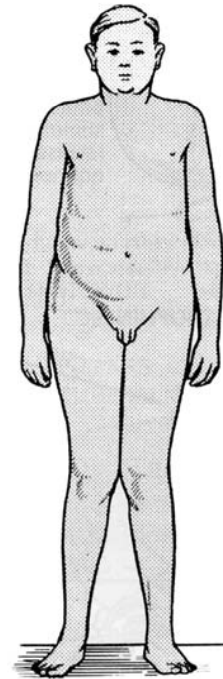
NORMAL CHILD
AGE 13

Destructive disease of part of anterior pituitary (usually with damage to posterior pituitary and/or hypothalamus)

↓
Underproduction of *growth and other endocrine-trophic hormones*

FRÖHLICH'S DWARF

Stunting of growth, obesity (large appetite for sugar); arrested sexual development; lethargic; somnolent; mentally subnormal.



AGE 13

If atrophy of other endocrine glands
↓
Signs of deficiency of their hormones.

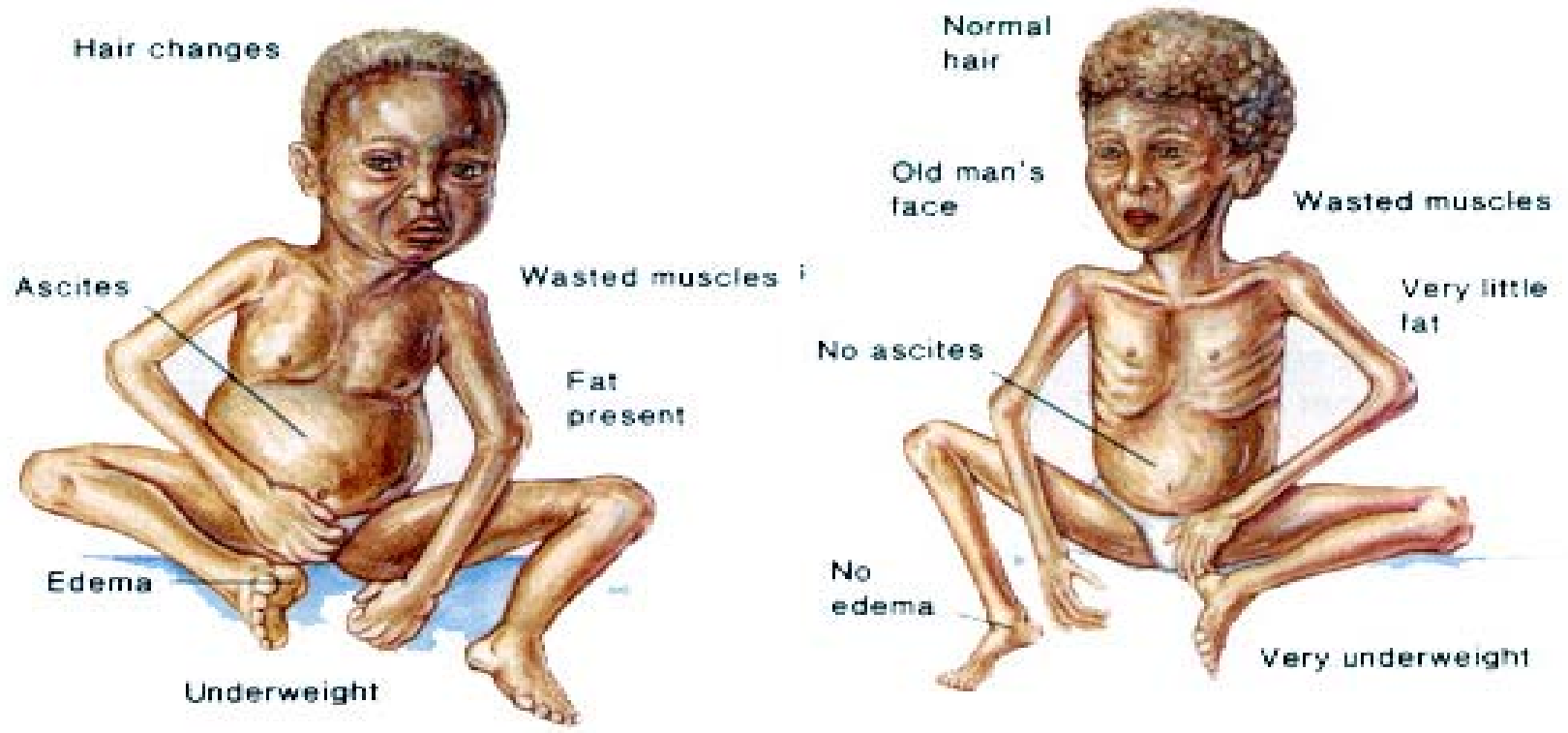
Laron Dwarf [GH] normal GH-R defects

Growth hormone restores growth and development pattern to normal.

A similar condition occurs in adults without dwarfing but with suppression of sex functions and regression of secondary sex characteristics.

Growth and gonadotrophic hormones aid in restoring patient to normal.

紅孩症 (紅嬰症、惡性營養不良症)



(a) Kwashiorkor 誇希奧科病

(b) Marasmus

somatomedin ↓

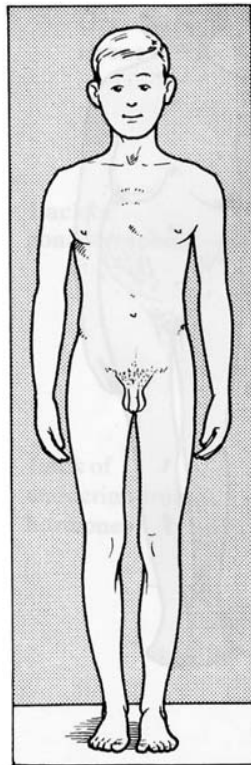
GH ↑ OVERACTIVITY OF PITUITARY SOMATOTROPH CELLS

Functional overactivity (or tumour) chiefly of the **SOMATOTROPH** cells of the anterior pituitary leads to → **GIANTISM** in the CHILD: **ACROMEGALY** in the ADULT

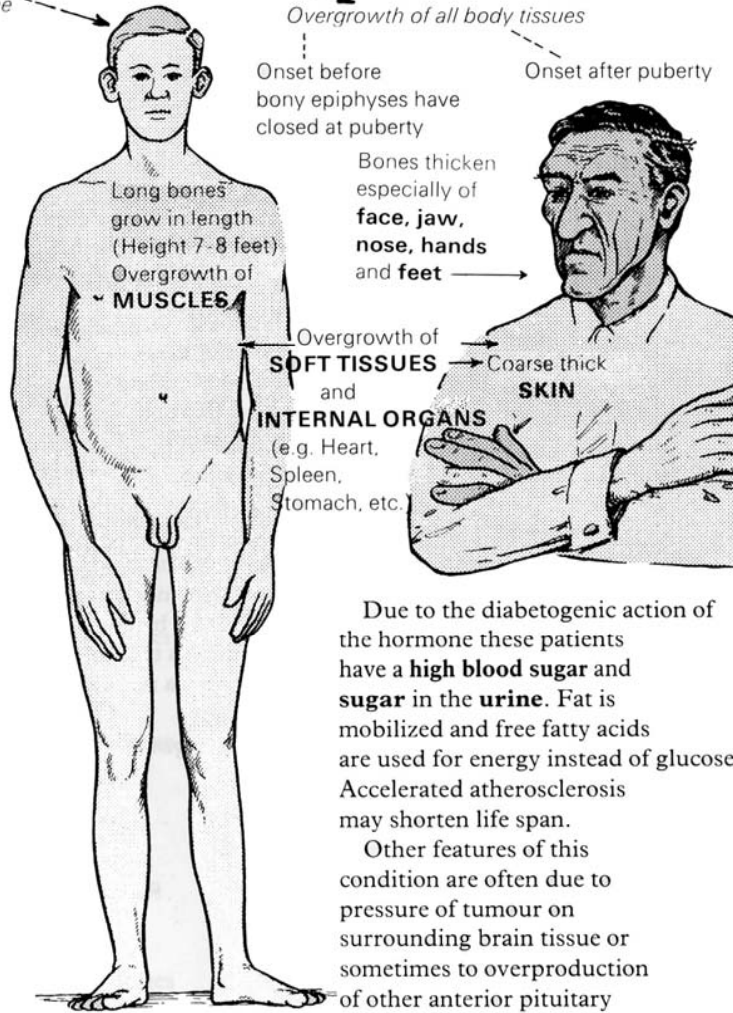
Overproduction of *growth Hormone*

General Circulation

Increases **NITROGEN** retention. Influences Protein, Carbohydrate and Fat metabolism of **ALL CELLS** of the body.



NORMAL CHILD
AGE 13



AGE 13

Overgrowth of all body tissues

Onset before bony epiphyses have closed at puberty

Onset after puberty

Bones thicken especially of **face, jaw, nose, hands and feet**

Overgrowth of **SOFT TISSUES** and **INTERNAL ORGANS** (e.g. Heart, Spleen, Stomach, etc.)

Coarse thick **SKIN**

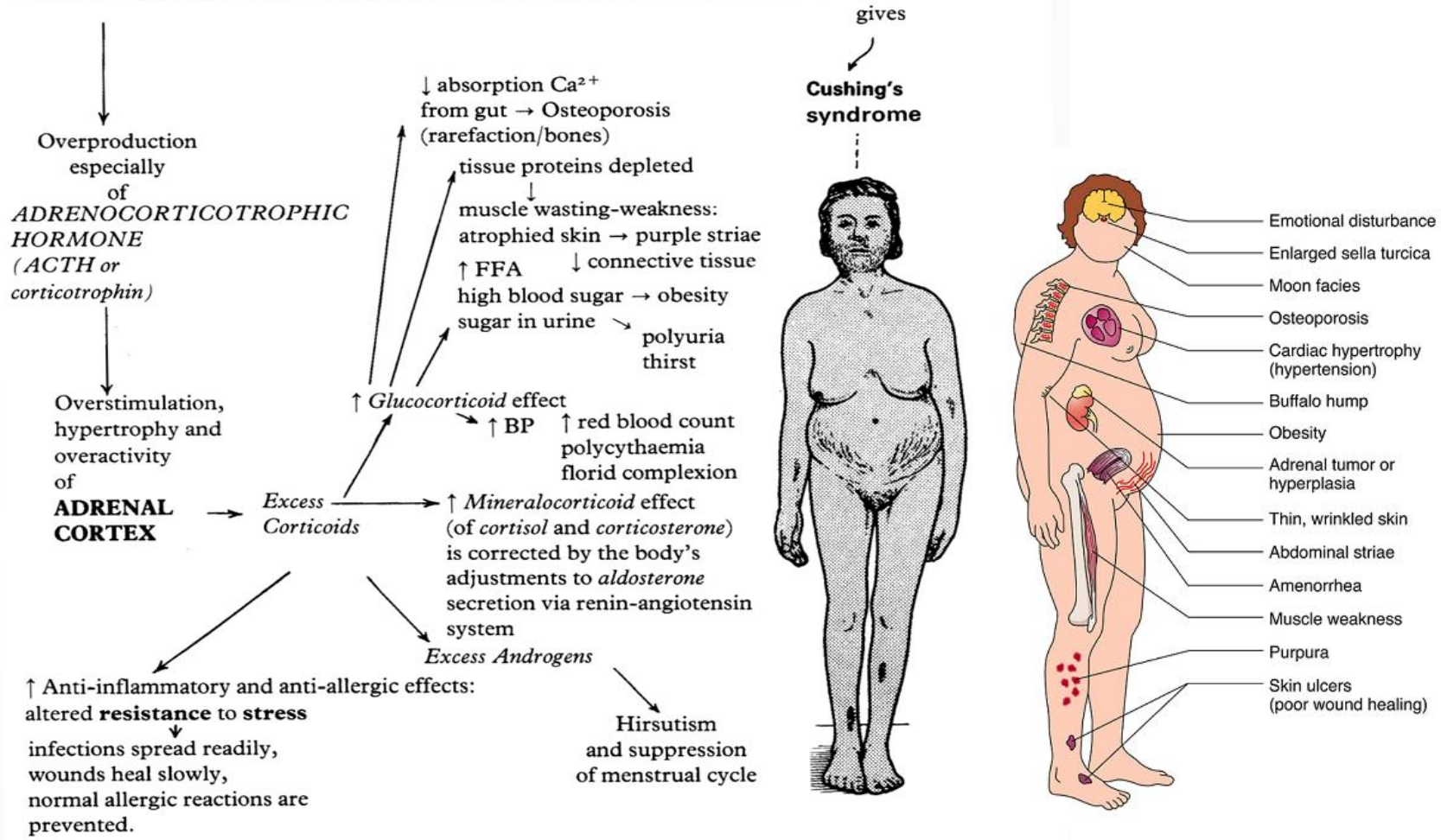
Due to the diabetogenic action of the hormone these patients have a **high blood sugar** and **sugar** in the **urine**. Fat is mobilized and free fatty acids are used for energy instead of glucose. Accelerated atherosclerosis may shorten life span.

Other features of this condition are often due to pressure of tumour on surrounding brain tissue or sometimes to overproduction of other anterior pituitary hormones.

Destruction of the overactive tissue – usually by surgery or radiation therapy – prevents progress of the condition.

OVERACTIVITY OF PITUITARY CORTICOTROPH CELLS **ACTH** ↑

Overactivity (often due to tumour) of the **corticotroph** cells of the anterior pituitary



This condition is usually indistinguishable clinically from that seen in primary overactivity or tumour of the adrenal cortex itself.

The syndrome is here shown in the adult woman.

Overproduction of *thyroid stimulating hormone* → Overactivity of **thyroid** gland.

ANTIDIURETIC HORMONE

osmolality ↑

Increased concentration of **plasma sodium**

due to **lack of dietary water** or to **loss of body water** from sweat glands (in sweat) lungs (in expired air) gut (in faeces)

or to **excess dietary salt** results in

Increased osmotic pressure of blood → shrinks osmoreceptors → stimulates →

[Diminished concentration of plasma sodium due to e.g. excess intake of water

↓
Dilution of blood stream

↓
Diminished osmotic pressure

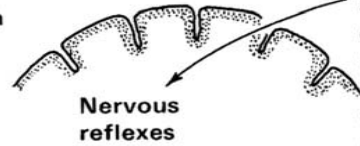
↓
Fall in activity of the osmoreceptors

↓
Fall in output of *ADH*

↓
Diminished reabsorption of water

↓
Increased output of dilute urine

↓
Restores **osmotic pressure relationships** to normal]



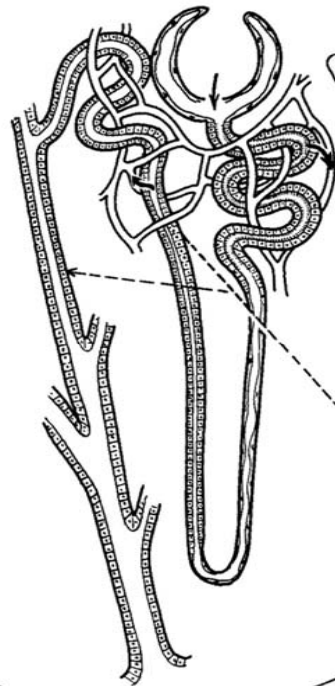
Stimuli from external environment (e.g. painful stimuli) and **emotional stress**

Carotid, aortic baroreceptors and stretch receptors in L. atrium

Stimulate

Inhibit

SUPRAOPTIC NUCLEUS



Nerve cells transmit impulses along axons of SUPRAOPTICOHYPHOPHYSEAL TRACT to POSTERIOR PITUITARY to cause discharge of **ANTIDIURETIC HORMONE (ADH)** into BLOOD STREAM for **direct action** on CELLS LINING DISTAL and COLLECTING TUBULES of KIDNEY NEPHRON *ADH* increases their permeability to water

↓
Augments reabsorption of **water** from **glomerular filtrate** in DISTAL CONVOLUTED TUBULE and in COLLECTING TUBULES

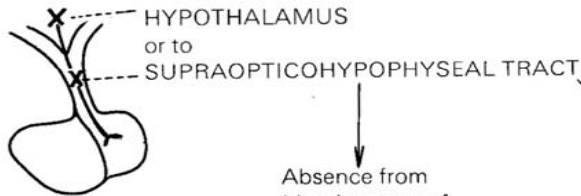
↓
Reduces output of **urine** to **balance and restore osmotic pressure relationships** to normal.

maintain **fluid equilibrium**

ADH binds to V_2 receptors on capillary side of duct cells → activates adenylate cyclase → increases cyclic AMP → activates a protein kinase on luminal side of cell → phosphorylates a membrane protein → increases permeability of cell membrane to water.

ADH ↓ UNDERACTIVITY OF POSTERIOR PITUITARY

Damage, by **injury** or **disease**, to



causes

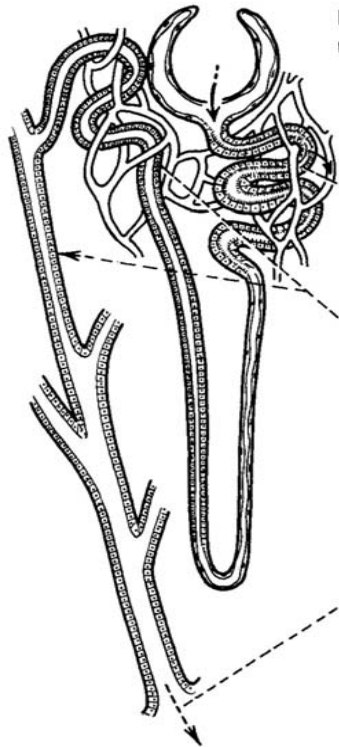
If pituitary gland alone is removed *ADH* continues to be secreted from cut axons.

DIABETES INSIPIDUS characterized by **excessive production** of **dilute urine** and **excessive thirst**

Absence from blood stream of **ANTIDIURETIC HORMONE (ADH)**

Diminished reabsorption of water...from

Normal **glomerular filtrate** – of about 180 litres per day.



REABSORPTION of
from
PROXIMAL CONVOLUTED TUBULE

about 140 litres of glomerular filtrate water is outside the influence of *ADH*.

REABSORPTION of
from
DISTAL CONVOLUTED TUBULE and COLLECTING DUCT is reduced.
(Cells lining collecting duct remain impermeable to water)

about 40 litres per day normally under *ADH* control.

Increased **elimination** of **water**

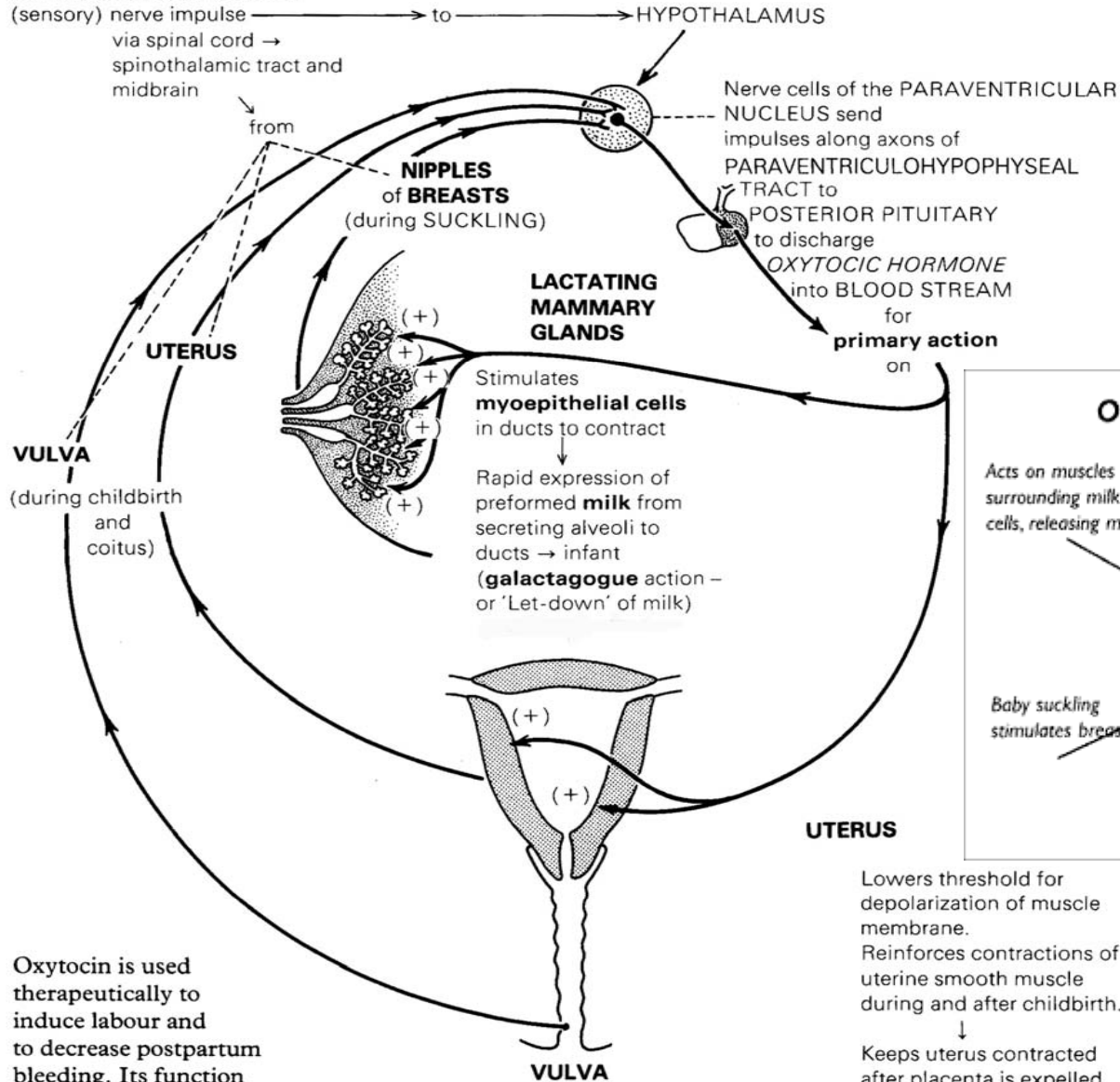
→ **Urinary volume** rises

Usually 4-6 litres but can be 12-15 litres of **pale dilute urine** excreted/day (about 200 mOsm/l) instead of normal 1-1½ litres straw coloured more concentrated fluid (1000–1400 mOsm/l)

Constant thirst ——— occurs

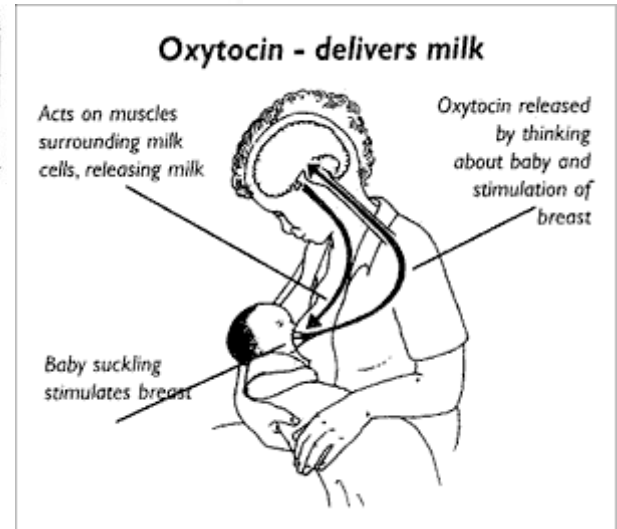
Replacement of *ADH* restores to normal elimination of water and symptoms of thirst.

Secretion of hormone, **OXYTOCIN**, seems to depend on **afferent** (sensory) nerve impulse

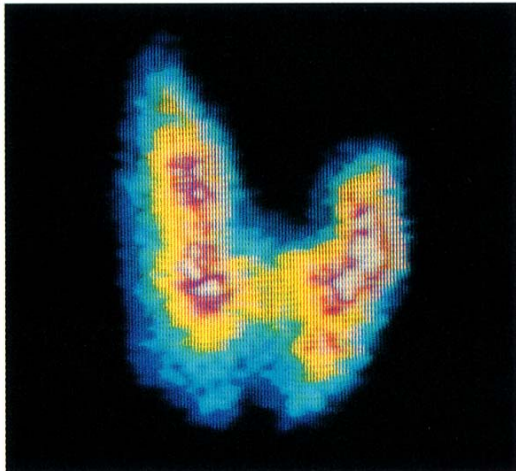
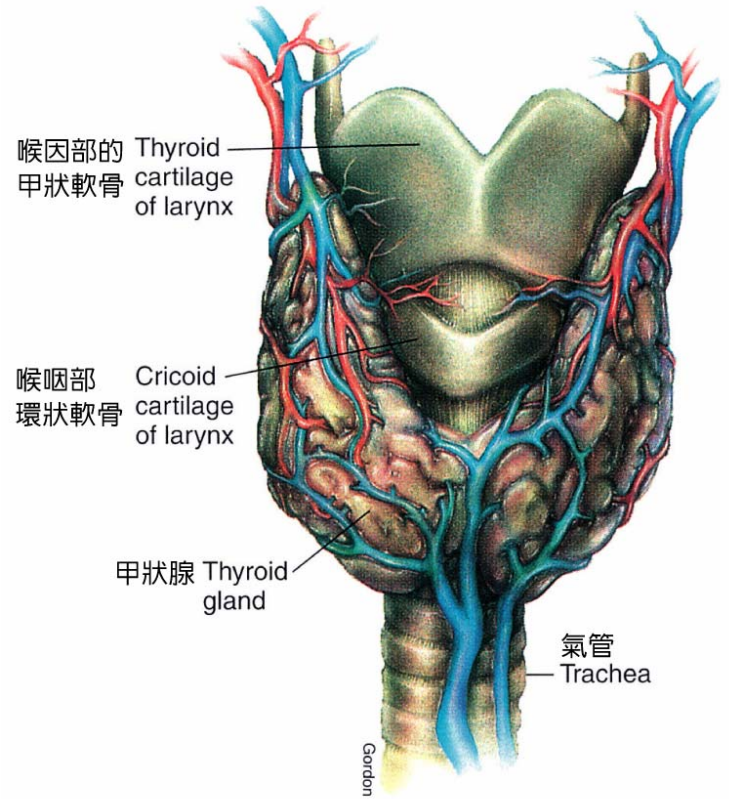
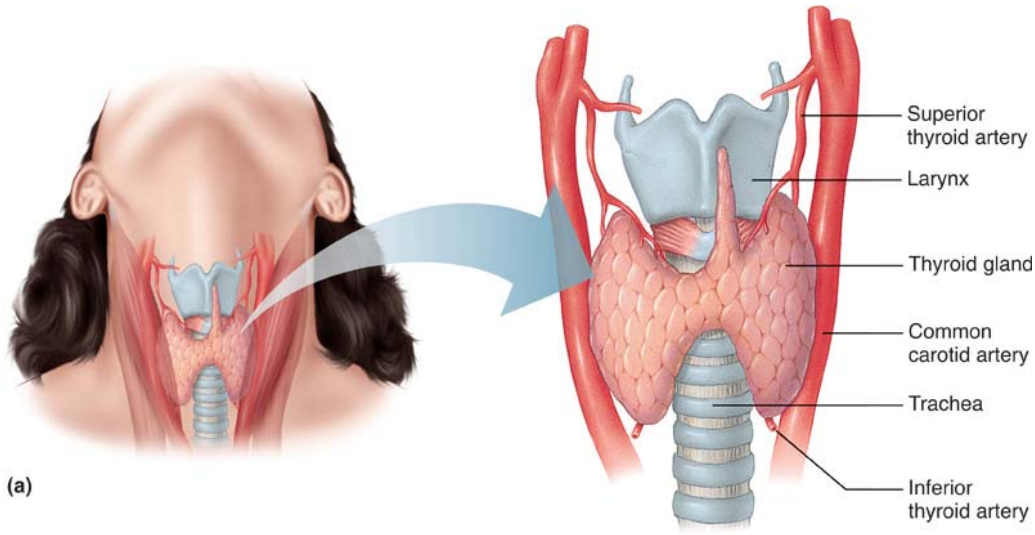


Oxytocin is used therapeutically to induce labour and to decrease postpartum bleeding. Its function in the male is unknown.

Lowers threshold for depolarization of muscle membrane.
Reinforces contractions of uterine smooth muscle during and after childbirth.
↓
Keeps uterus contracted after placenta is expelled, thus helps haemostasis.



Thyroid Gland



(a)

Histology of Thyroid Gland

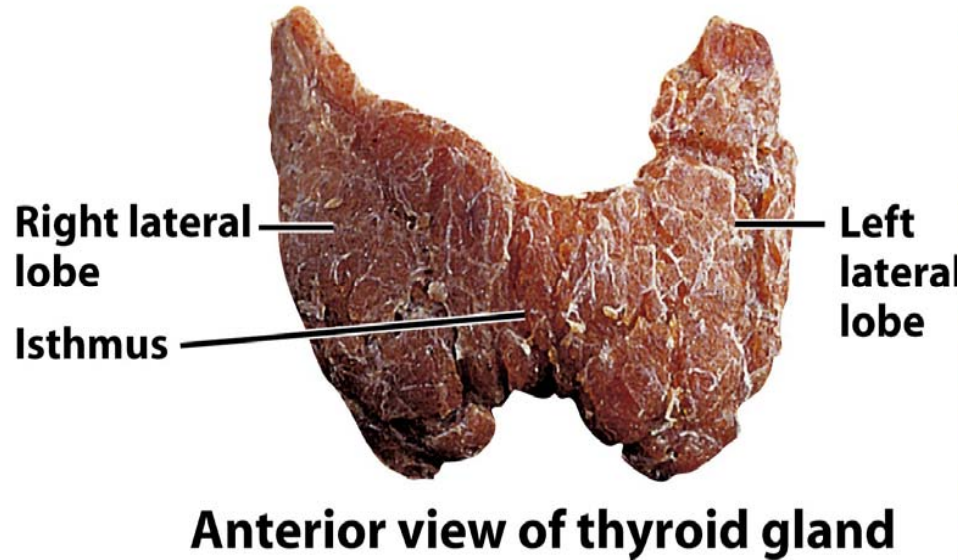
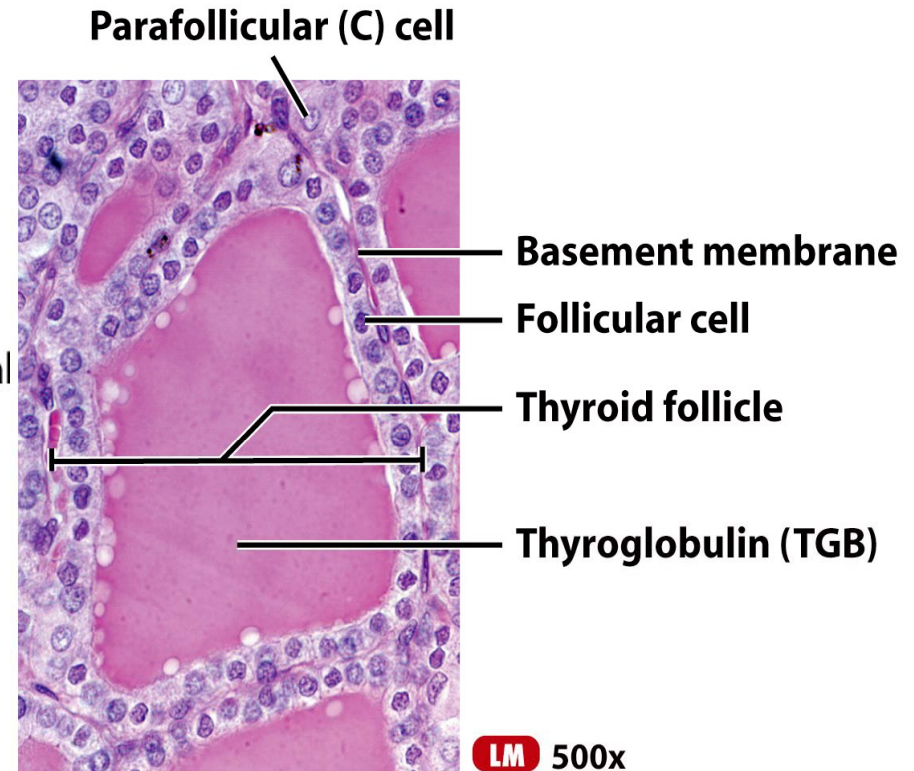


Figure 18-10c Principles of Anatomy and Physiology, 11/e



Thyroid follicles

Figure 18-10b Principles of Anatomy and Physiology, 11/e

- ❖ Follicle = sac of stored hormone (colloid) surrounded by follicle cells that produced it--**T3 & T4**
- ❖ Inactive cells are short
- ❖ In between cells called parafollicular cells--produce **calcitonin**

Thyroid Hormone

特性	T4	T3
I 的數目 (位置)	4個 (3 , 5 , 3' , 5')	3個 (3 , 5 , 3')
生合成	DIT+DIT	MIT (monoiodide tyrosine; 一個碘的酪胺酸) +DIT(兩個碘的酪胺酸)
生物活性	1倍	4~5倍
Half-life(半衰期)	A week	A day
血中濃度	99.6%	0.35%
Free form	0.1	1
Binding affinity with TBG	10倍	1倍

TBG (thyroxine-binding globulin) T4 > T3

TBPA (thyroxine-binding prealbumin) T4 > T3

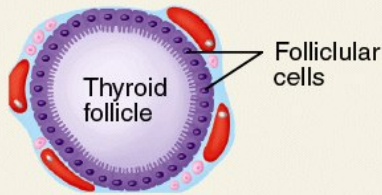
Albumin T4 < T3

Thyroid Hormone

TABLE 18.6 Summary of Thyroid Gland Hormones

Hormone and Source

T₃ (triliodothyronine) and **T₄ (thyroxine)** or **thyroid hormones** from follicular cells



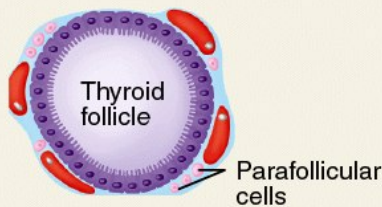
Control of Secretion

Secretion is increased by thyrotropin-releasing hormone (TRH), which stimulates release of thyroid-stimulating hormone (TSH) in response to low thyroid hormone levels, low metabolic rate, cold, pregnancy, and high altitudes; TRH and TSH secretions are inhibited in response to high thyroid hormone levels; high iodine level suppresses T₃/T₄ secretion.

Principal Actions

Increase basal metabolic rate, stimulate synthesis of proteins, increase use of glucose and fatty acids for ATP production, increase lipolysis, enhance cholesterol excretion, accelerate body growth, and contribute to development of the nervous system.

Calcitonin (CT) from parafollicular cells

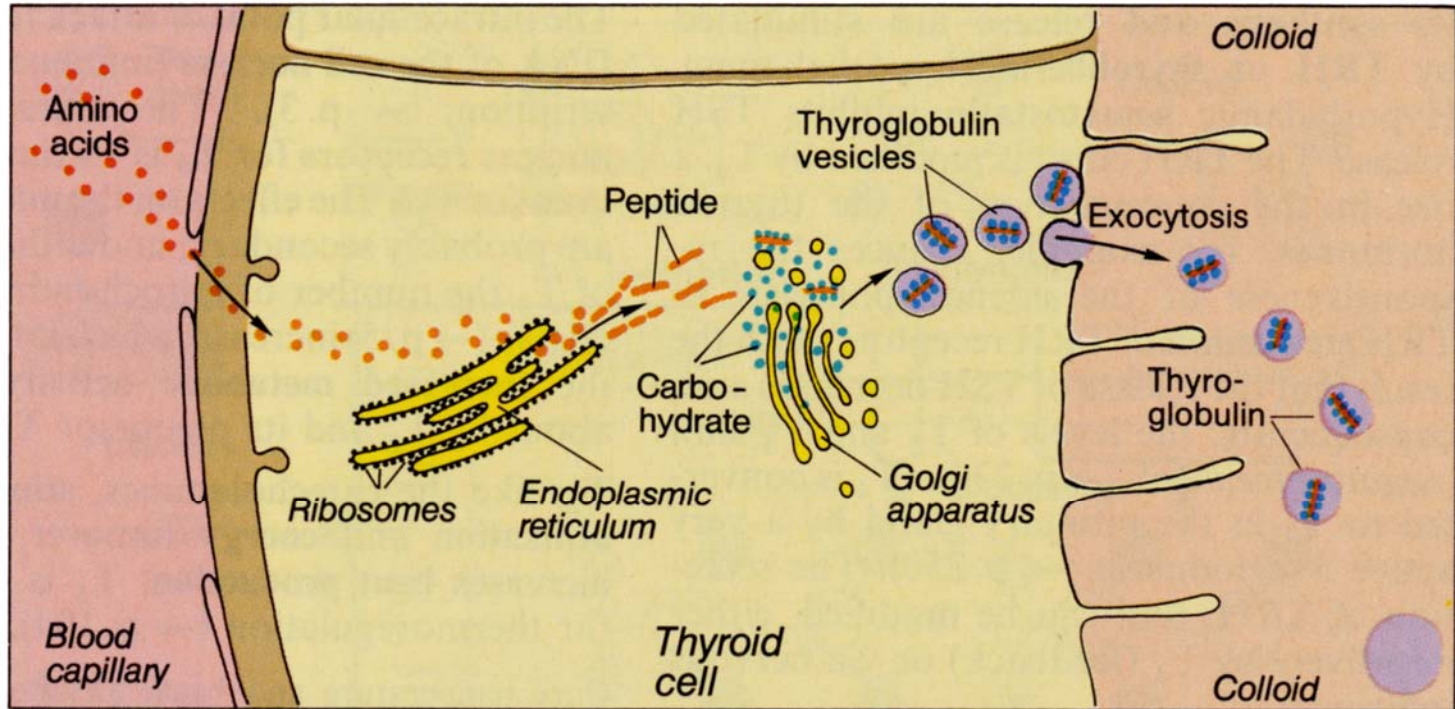


High blood Ca²⁺ levels stimulate secretion; low blood Ca²⁺ levels inhibit secretion.

Lowers blood levels of Ca²⁺ and HPO₄²⁻ by inhibiting bone resorption by osteoclasts and by accelerating uptake of calcium and phosphates into bone matrix.

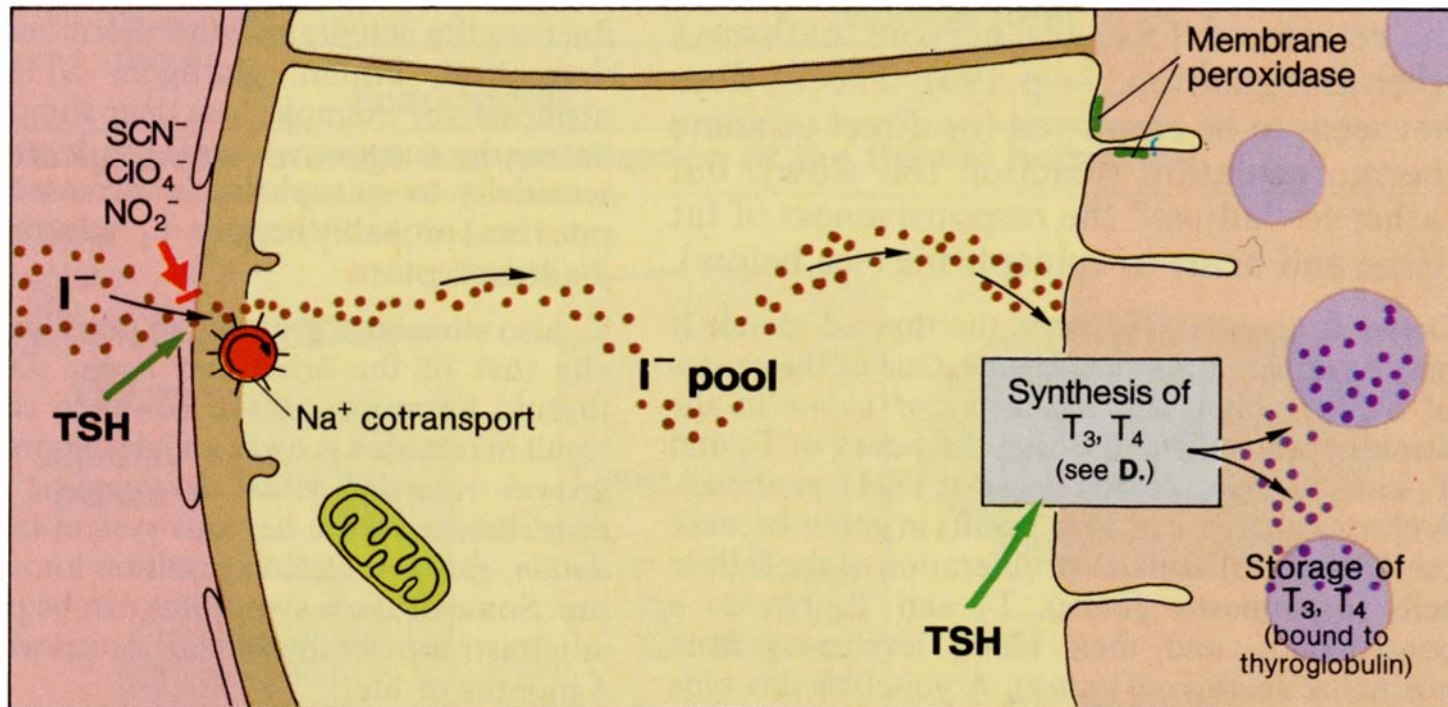
Synthesis of Thyroid Hormone

TGB (tyrosine residue) + Iodide



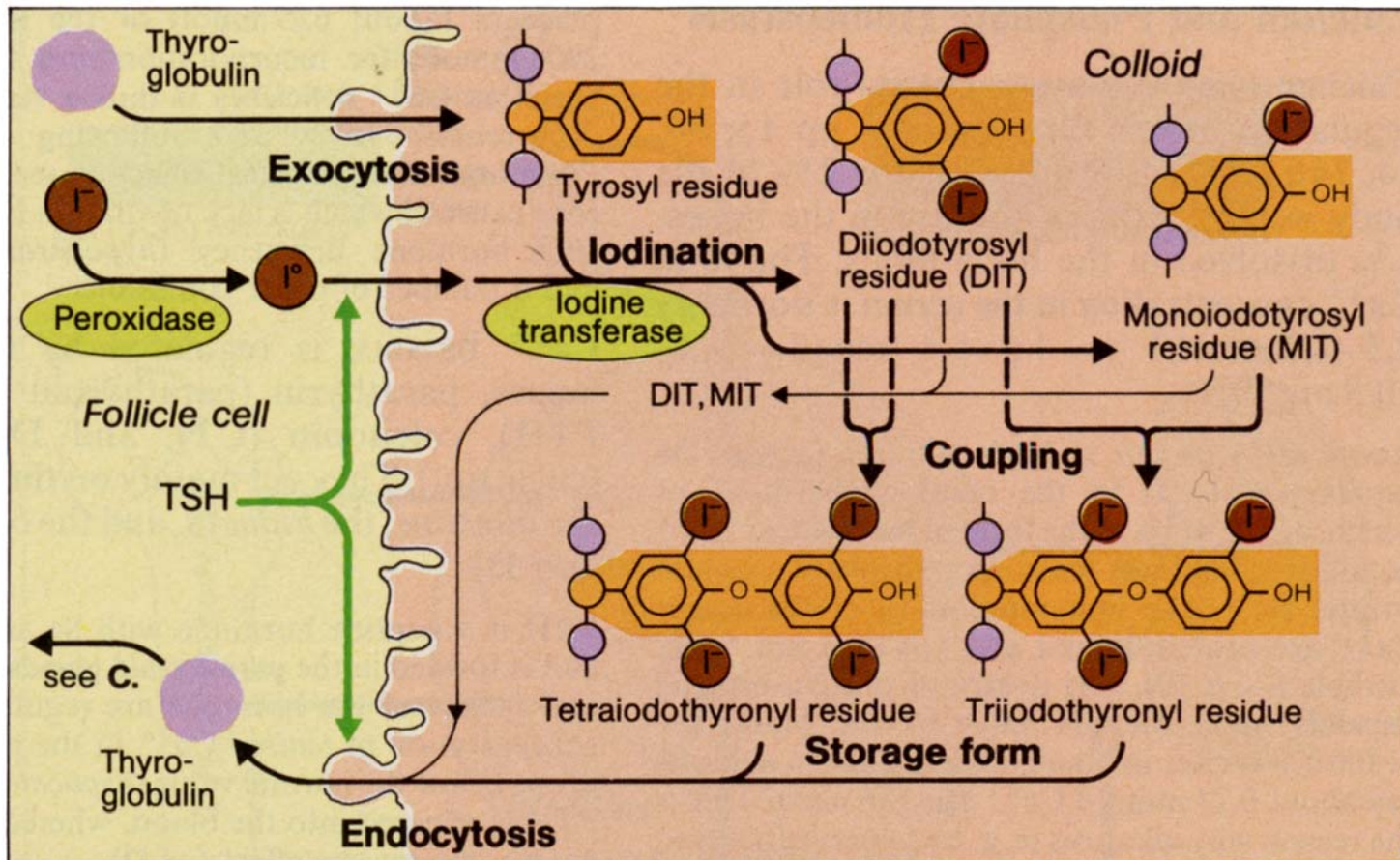
A. Synthesis of thyroglobulin

Synthesis of Thyroid Hormone



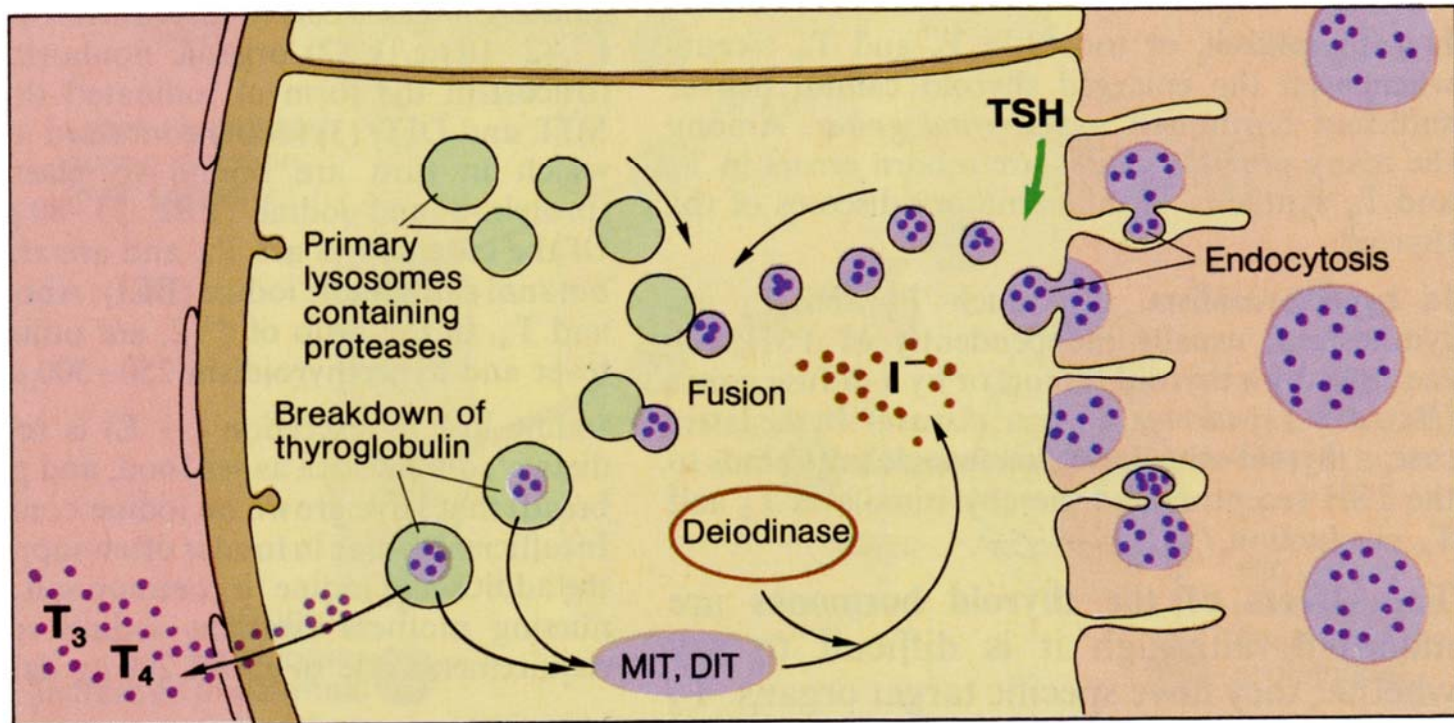
B. Iodine uptake, synthesis and storage of thyroid hormones
(Iodide trapping)

Synthesis of Thyroid Hormone



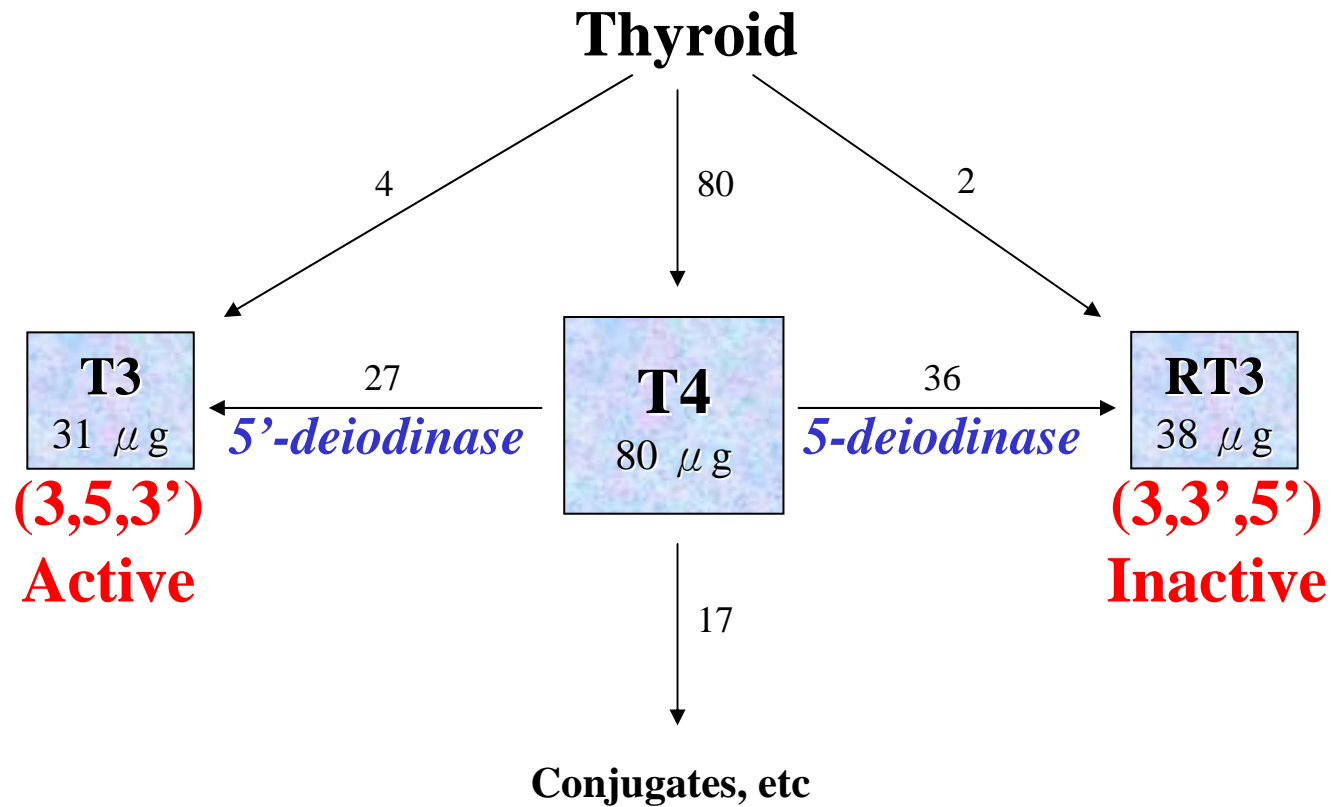
D. Synthesis, storage and mobilization of the thyroid hormones

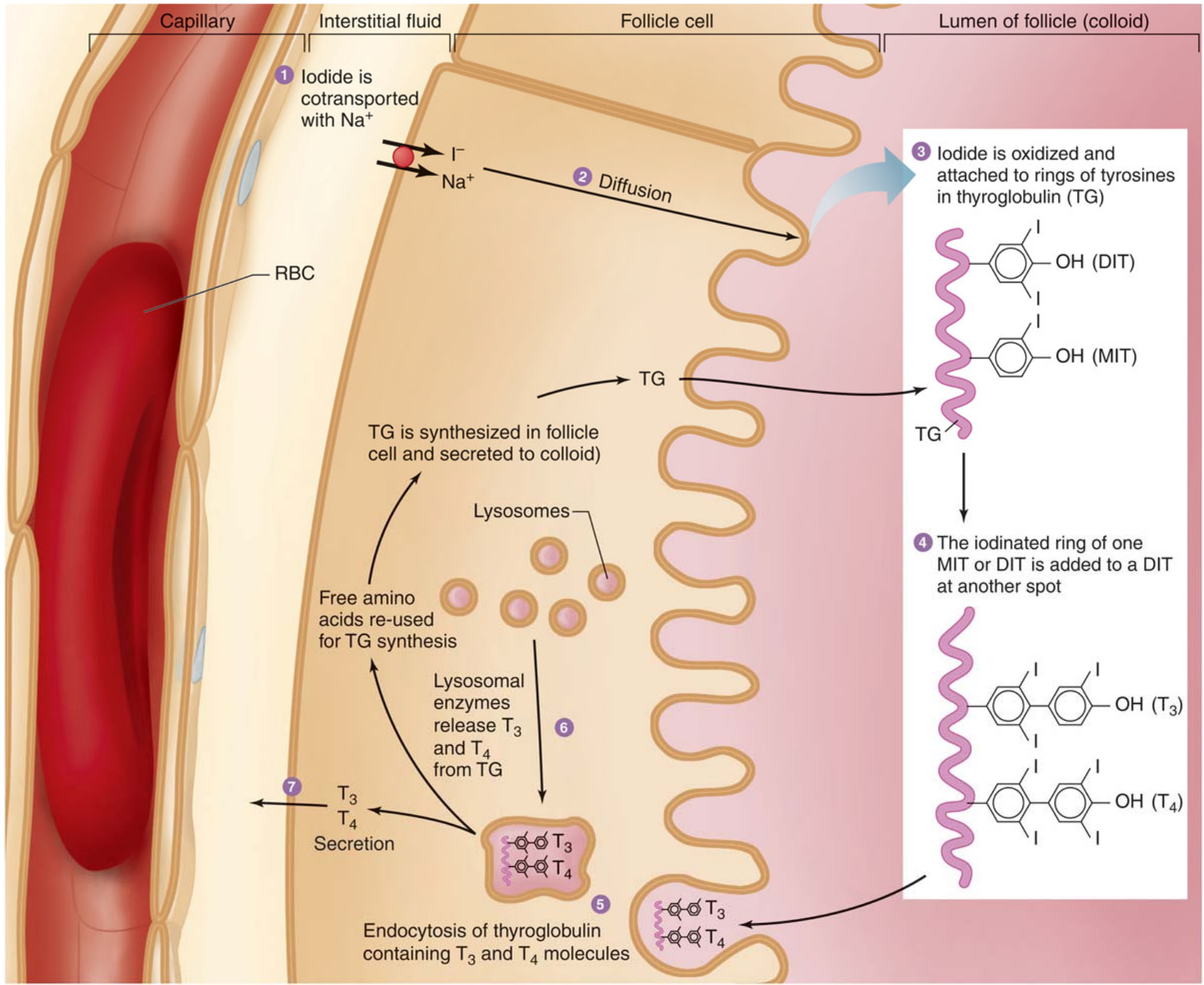
Secretion of Thyroid Hormone

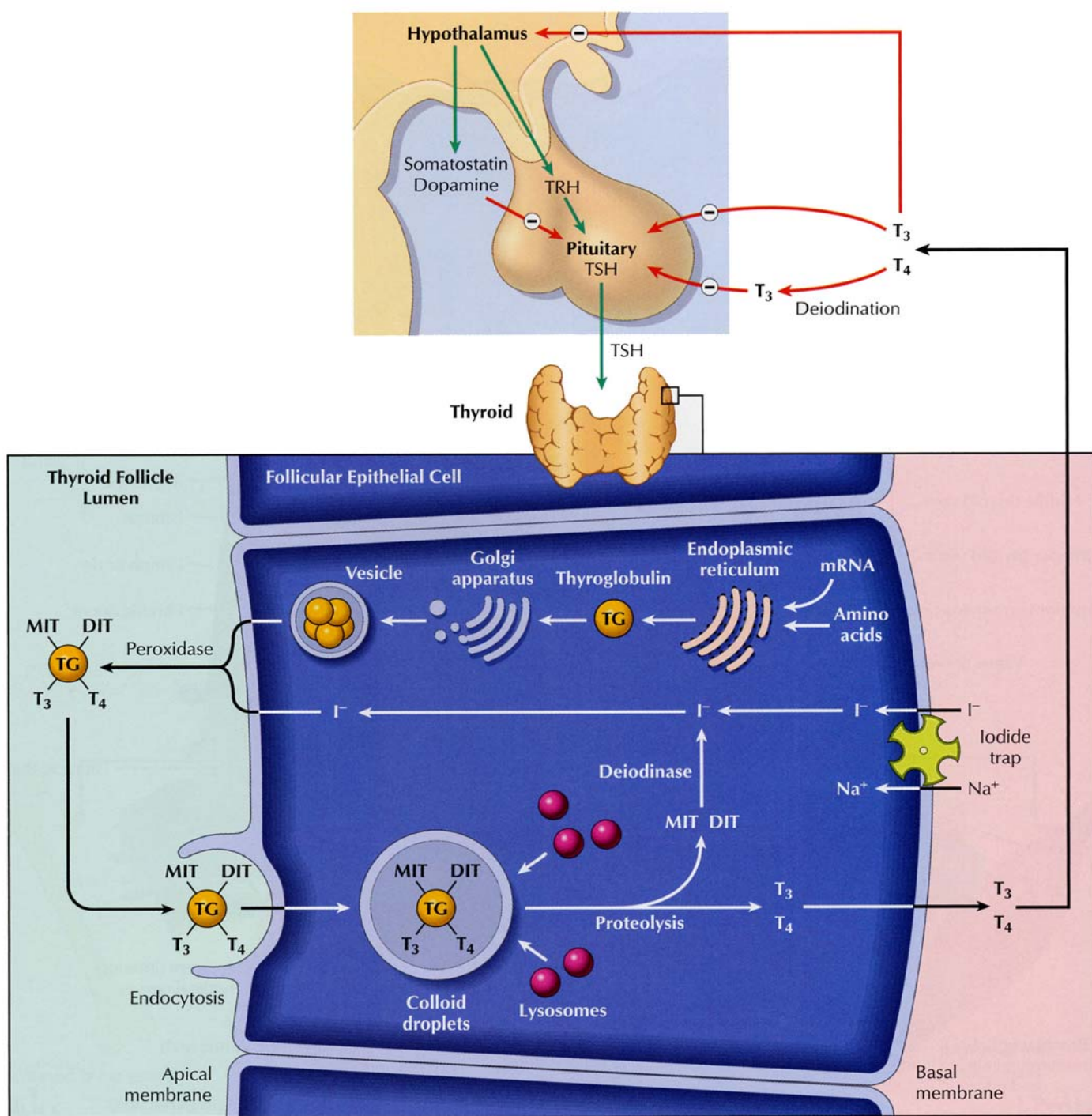


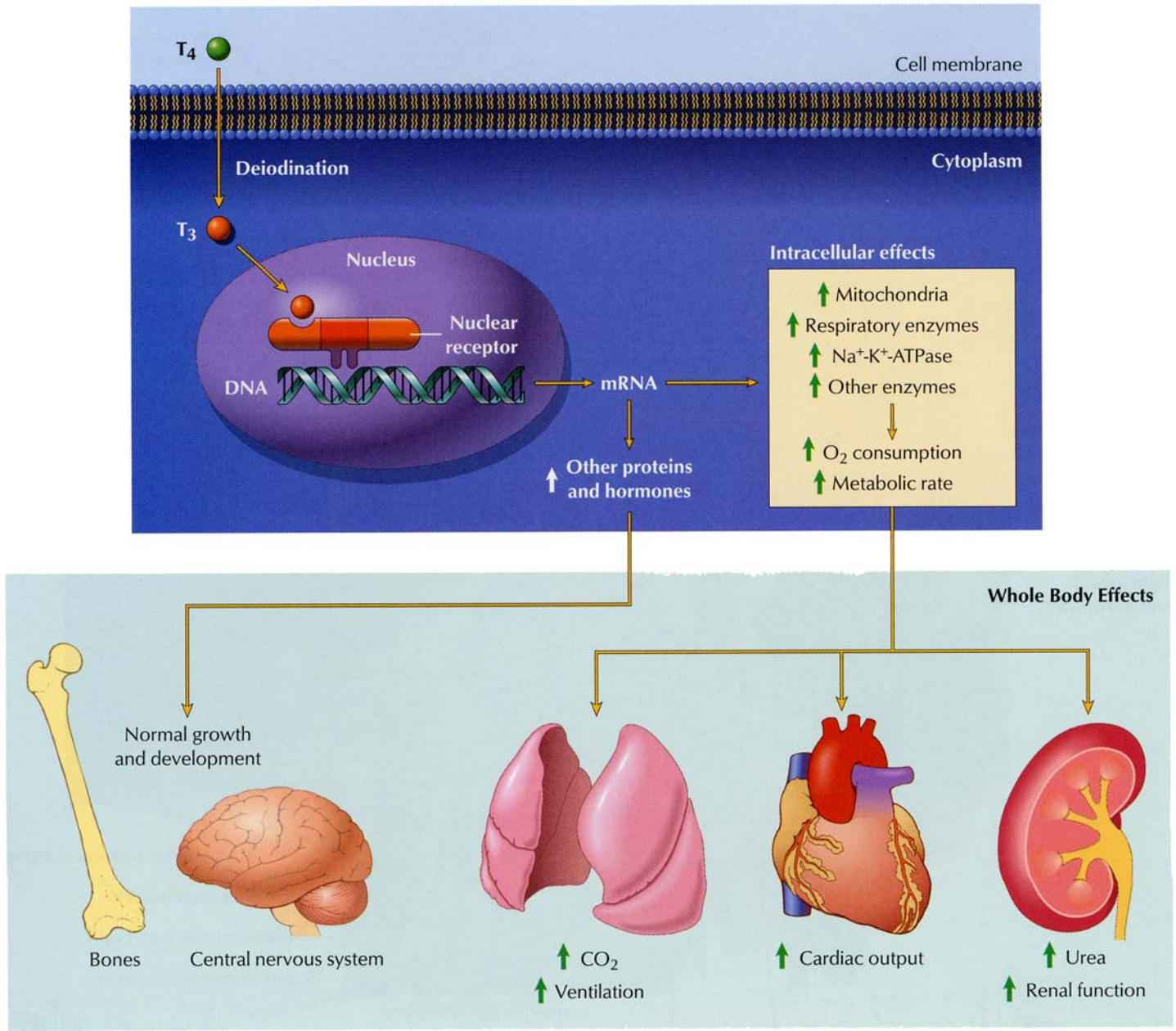
C. Secretion of thyroid hormones

Secretion of Thyroid Hormone





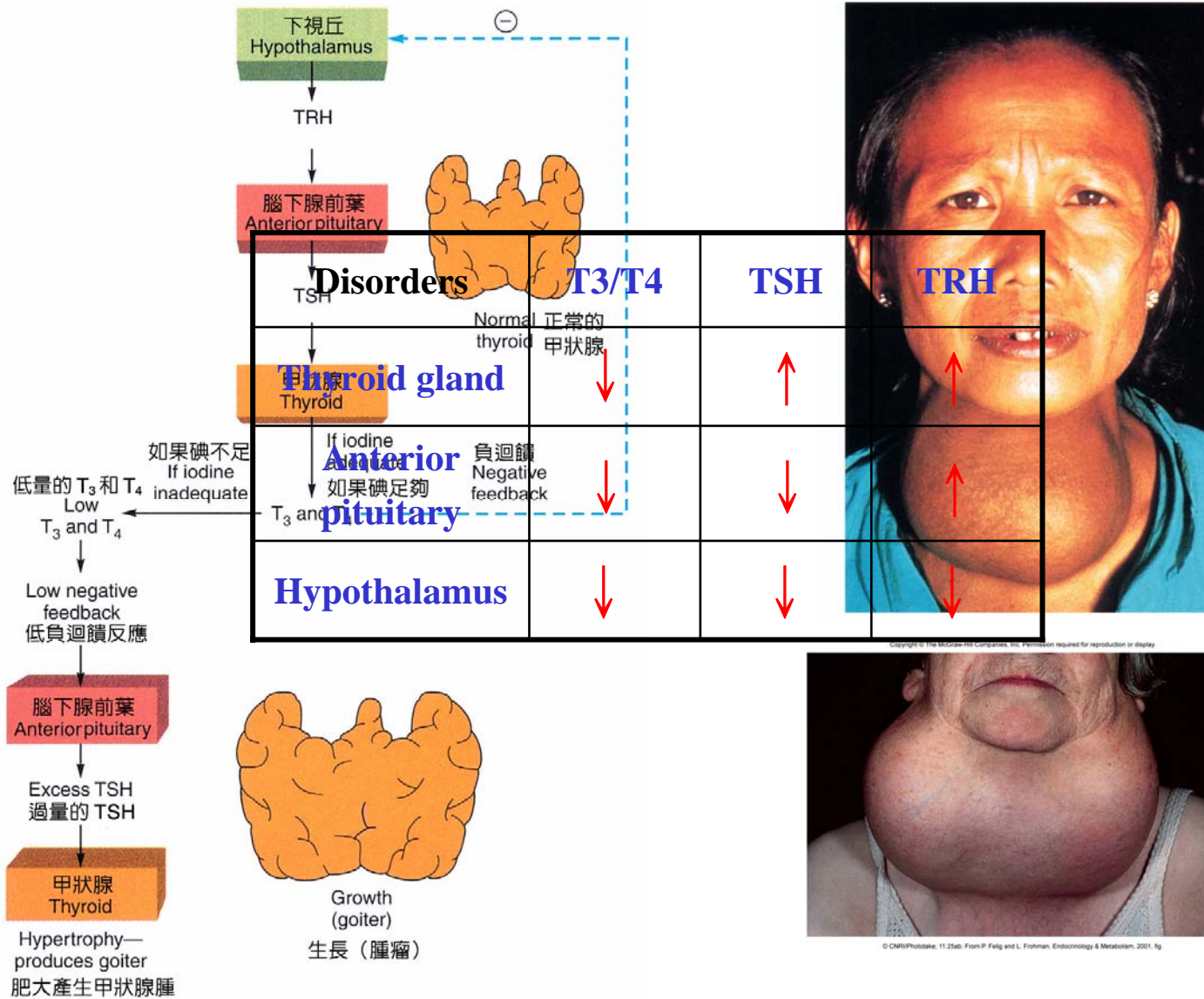




Function of Thyroid Hormone

- ❖ 生熱作用(**calorigenesis**) — 其身體Metabolic rate \uparrow ，且加速醣類的分解作用以及葡萄糖的新生(利用glucose來產生能量)。
- ❖ 營養的代謝 — 可增加腸胃道對醣類的吸收速率。
- ❖ 肌肉功能的影響 — 其可增加心肌及骨骼肌的收縮能力，所以當T₄ and T₃濃度 \uparrow ，會產生肌肉顫抖。
- ❖ 神經系統的影響 — 可提高思考速率及敏感度，但過多會造成神經質、焦慮或妄想等精神異常現象；若不足則會造成思想過慢及警覺性降低等症狀。
- ❖ 呼吸系統的影響 — 可增加呼吸頻率(換氣 \uparrow)及深度，這是因為Metabolic rate \uparrow 造成O₂ consumption及CO₂的生成增加所引起。
- ❖ 其他 — 一般而言，過多的 thyroid hormone 會造成體重下降；過少則體重會增加。血流及心輸出量也因代謝速率提高而增加。

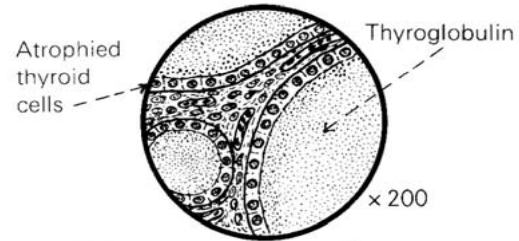
Endemic Goiter



UNDERACTIVITY OF THYROID

If the **thyroid** shows atrophy or destruction of its secretory cells or is inadequately stimulated by the anterior pituitary or hypothalamus:

甲狀腺機能低下症 (hypothyroidism)



Insufficient **hormonal secretion** released to blood stream.

Tissue oxidations are depressed, i.e. rate at which cells use energy is reduced.

The basal metabolic rate falls. Less heat is produced.

Body temperature falls (and person feels **cold**).

Energy units are stored with water.

Skin – Thick, leathery, puffy, yellow (due to circulating carotene).

Blood cholesterol increases.

Appetite is reduced; weight increases.

Gut movements sluggish → constipation.

Heart and respiratory rates and blood pressure reduced.

Thought processes slow down → lethargy; apathy; somnolence.

Hair – brittle, sparse, dry.

Slow, husky voice. Bone marrow suppressed → **anaemia**.

In the ADULT
↓
MYXOEDEMA (黏液水腫)



Protein complexes and water accumulate in skin

Slowing up of all bodily processes

In the CHILD – e.g. congenital absence of the gland

↓
CRETIN
(呆小症)



NB: Protruding tongue and pot belly.

↓
Gross dwarfing

Failure of skeletal sexual mental

} growth and development

All 'milestones' of babyhood are delayed.

THYROXINE (taken by mouth) restores individuals to normal.

Commonest form is **Graves' disease**. Produces increased thyroid hormone secretion, enlarged thyroid (**goitre**) and protrusion of eyeballs (**exophthalmos**). Caused by production of antibodies against person's own thyroid cells. These antibodies, *Thyroid-Stimulating Immunoglobulins (TSI)*, act like *Thyroid-Stimulating Hormone (TSH)* and release thyroid hormones (T_3 and T_4).

甲狀腺機能亢進症 (Hyperthyroidism)

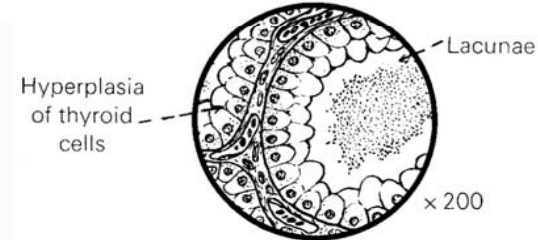
葛瑞夫氏症 (Grave's disease)

凸眼症
(exophthalmos)



Goitre

Surgical removal of part of the overactive gland or destruction by radioactive iodine reduces the thyroid activity.



Excess thyroid hormones are distributed by blood stream to the Tissues of the body. →

Speed up oxidations in the cells, i.e. rate at which all cells use **energy**.

The basal metabolic rate is raised, more heat is produced → rise in body temperature (person feels **warm**).

Skin hot and flushed.

Profuse sweating.

Energy stores of body (i.e. **glycogen** and **fat**) are depleted.

Appetite increases but weight falls.

Movements of digestive tract are increased → diarrhoea.

Heart and respiratory rates rise.

Blood pressure is raised.

Muscular tremor and nervousness are marked.

Person becomes excitable, irritable and apprehensive.

Speeding up of all bodily processes

CVS symptoms very important. T_3 and T_4 increase cAMP and number of β adrenergic receptors in heart, thus increase heart's sensitivity to *adrenaline*. Blocked by β -receptor blocking agents.

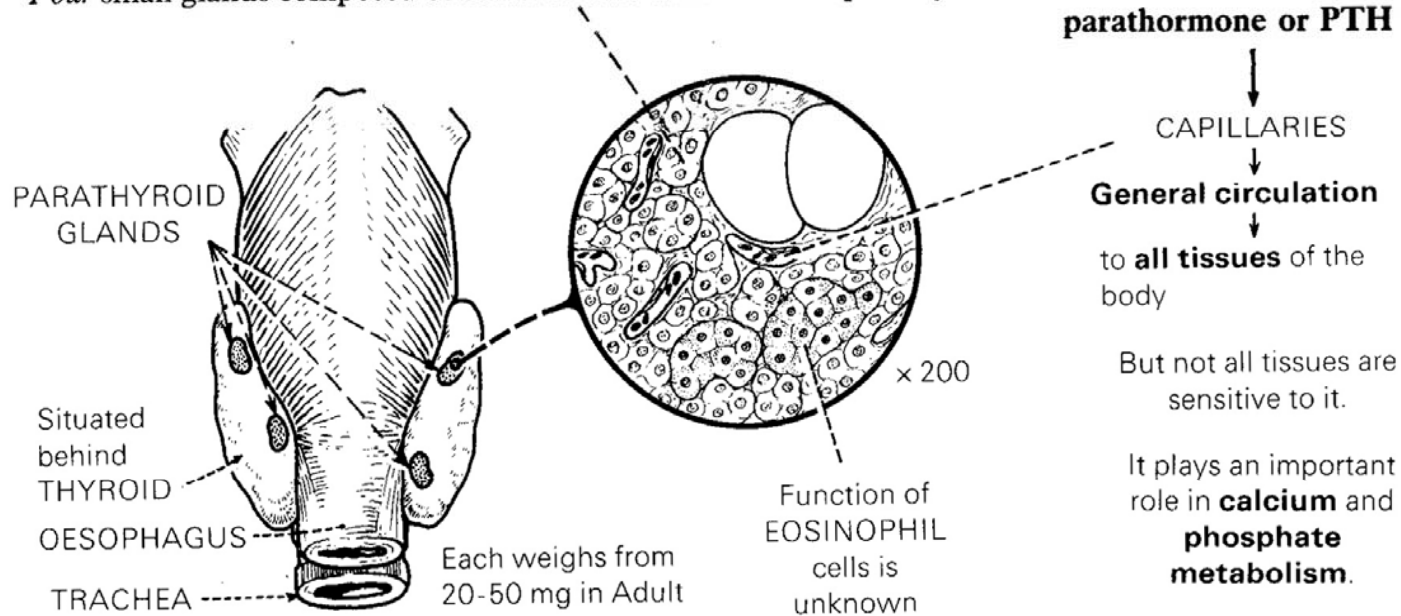
[**Exophthalmos** (protrusion of eyeballs) may be due to an action of antibody against a protein of extraocular muscles. It is not due to an excess of thyroid hormones.]

Parathyroid Gland

PARATHYROIDS

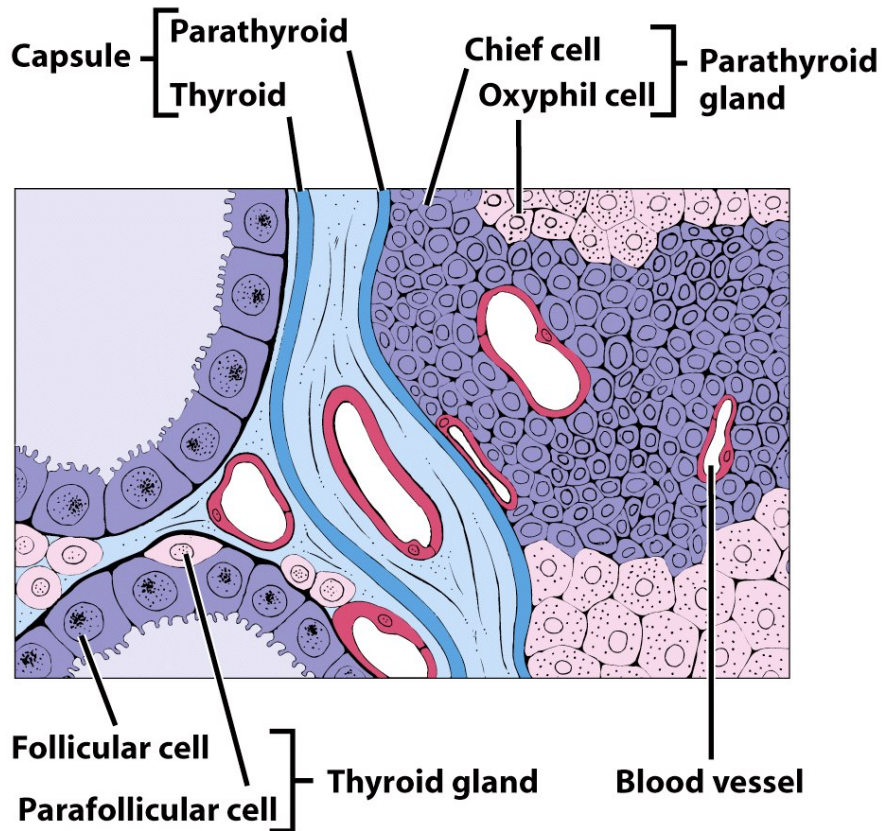
(Chief cells)

Four small glands composed of cords of cells which secrete parathyroid hormone –



These hormones, *parathormone*, *1, 25-dihydroxycholecalciferol* (1,25-DHCC) and *calcitonin* act on **kidney** and **gut** to keep blood ionized **calcium** constant (necessary for normal nerve and muscle excitability and blood coagulation).

Histology of Parathyroid Gland



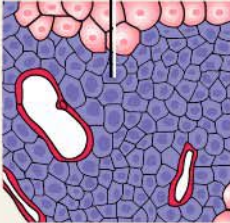
Portion of the thyroid gland (left) and parathyroid gland (right)

Figure 18-13c Principles of Anatomy and Physiology, 11/e
© 2006 John Wiley & Sons

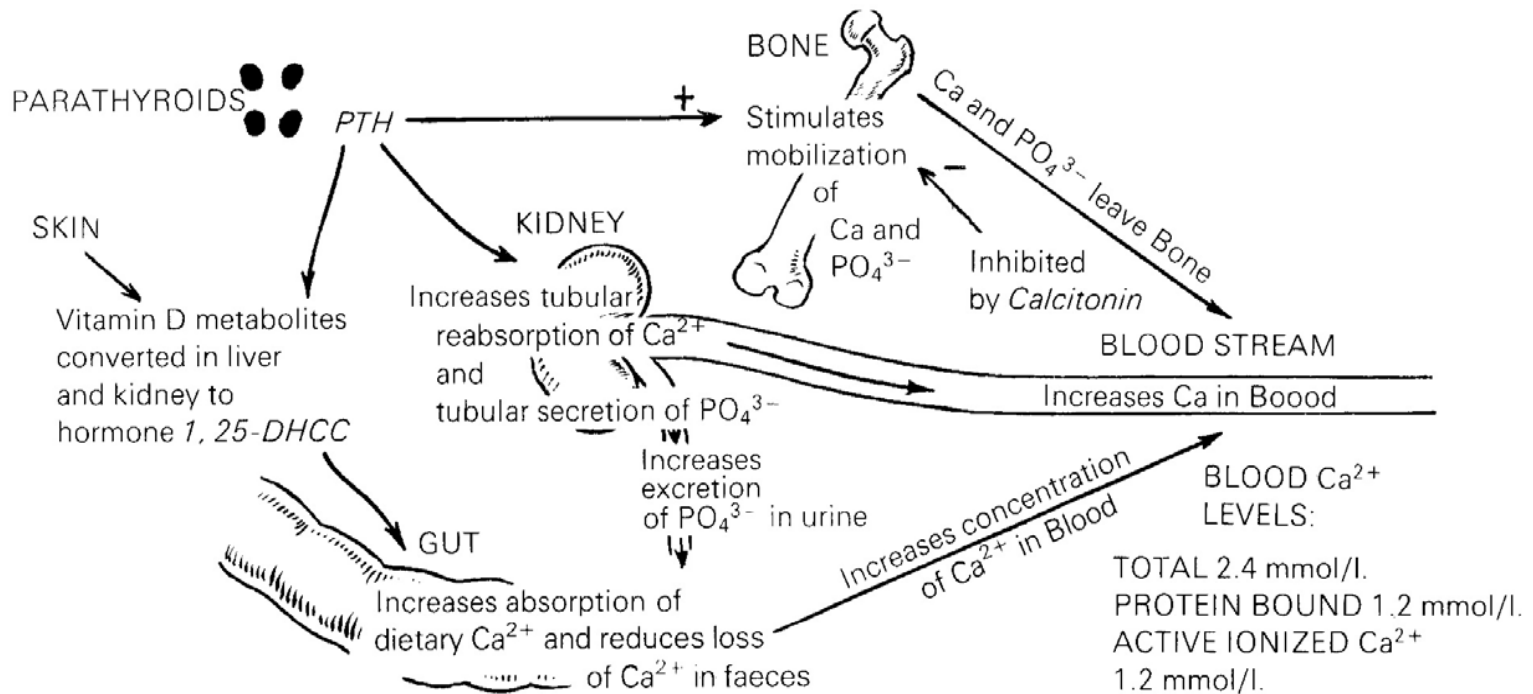
- ❖ The *parathyroid glands* are embedded on the posterior surfaces of the lateral lobes of the thyroid
 - *principal cells* produce *parathyroid hormone*
 - *oxyphil cells* ... function is unknown.
- ❖ *Parathyroid hormone (PTH)* regulates the homeostasis of **calcium** and **phosphate**
 - increase blood calcium level
 - decrease blood phosphate level
 - increases the number and activity of osteoclasts
 - increases the rate of Ca^{+2} and Mg^{+2} from reabsorption from urine and inhibits the reabsorption of HPO_4^{-2} so more is secreted in the urine
 - promotes formation of **calcitriol** (VitD3), which increases the absorption of Ca^{+2} , Mg^{+2} , and HPO_4^{-2} from the GI tract

Parathyroid Hormone

TABLE 18.7 Summary of Parathyroid Gland Hormone

Hormone and Source	Control of Secretion	Principal Actions
<p>Parathyroid hormone (PTH) from chief cells</p> <p>Chief cell</p> 	<p>Low blood Ca^{2+} levels stimulate secretion. High blood Ca^{2+} levels inhibit secretion.</p>	<p>Increases blood Ca^{2+} and Mg^{2+} levels and decreases blood HPO_4^{2-} level; increases bone resorption by osteoclasts; increases Ca^{2+} reabsorption and HPO_4^{2-} excretion by kidneys; and promotes formation of calcitriol (active form of vitamin D), which increases rate of dietary Ca^{2+} and Mg^{2+} absorption.</p>

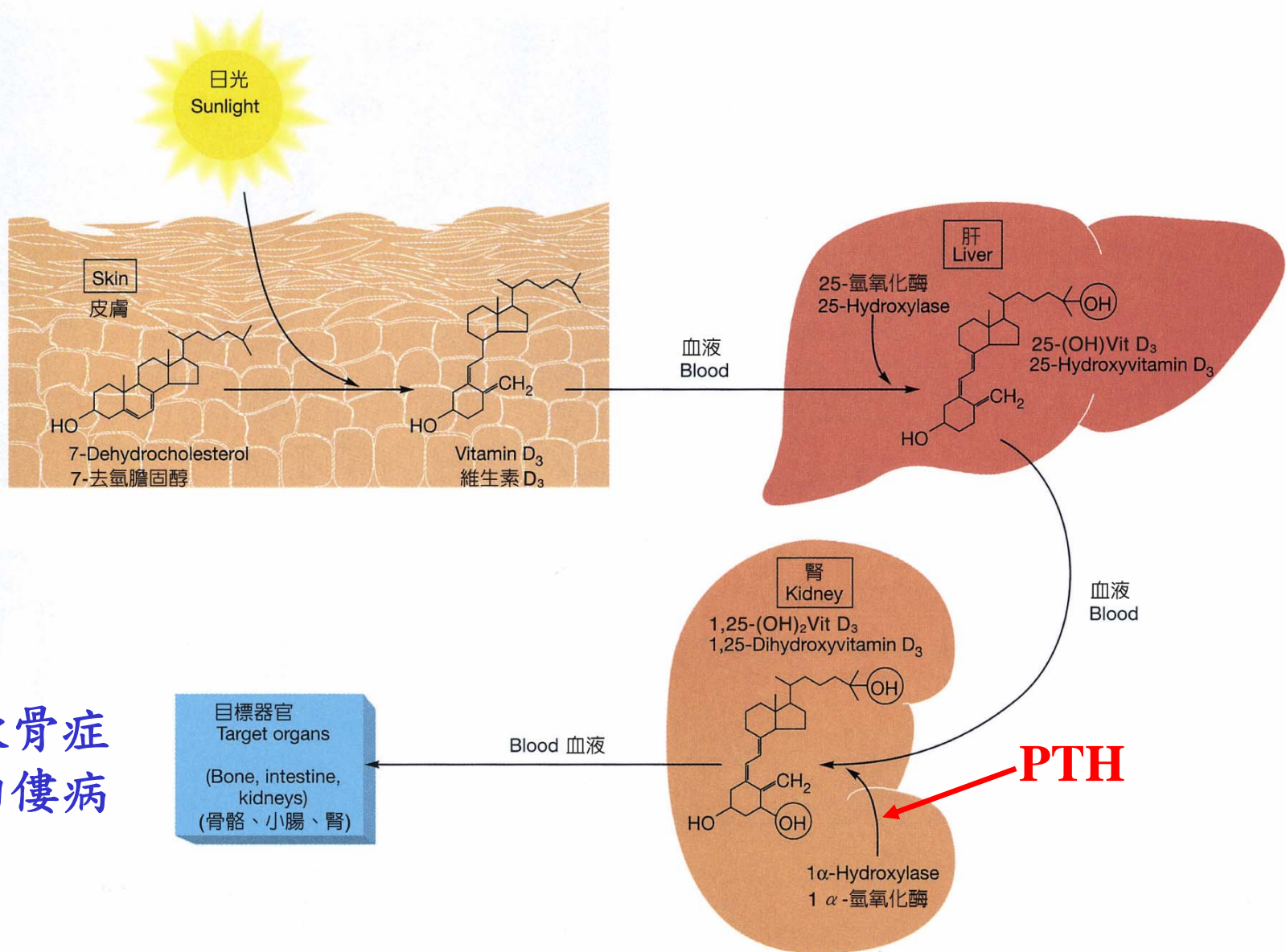
Parathyroid Hormone



In bones and kidneys PTH activates adenylate cyclase thus increasing cAMP. In bones, **osteoblasts** pump Ca^{2+} into extracellular fluid. This pump is stimulated by *1, 25-DHCC*.

Calcium ions in extracellular fluid control parathyroid activity. $\uparrow \text{Ca}^{2+}$ depresses PTH secretion. $\downarrow \text{Ca}^{2+}$ increases PTH secretion.

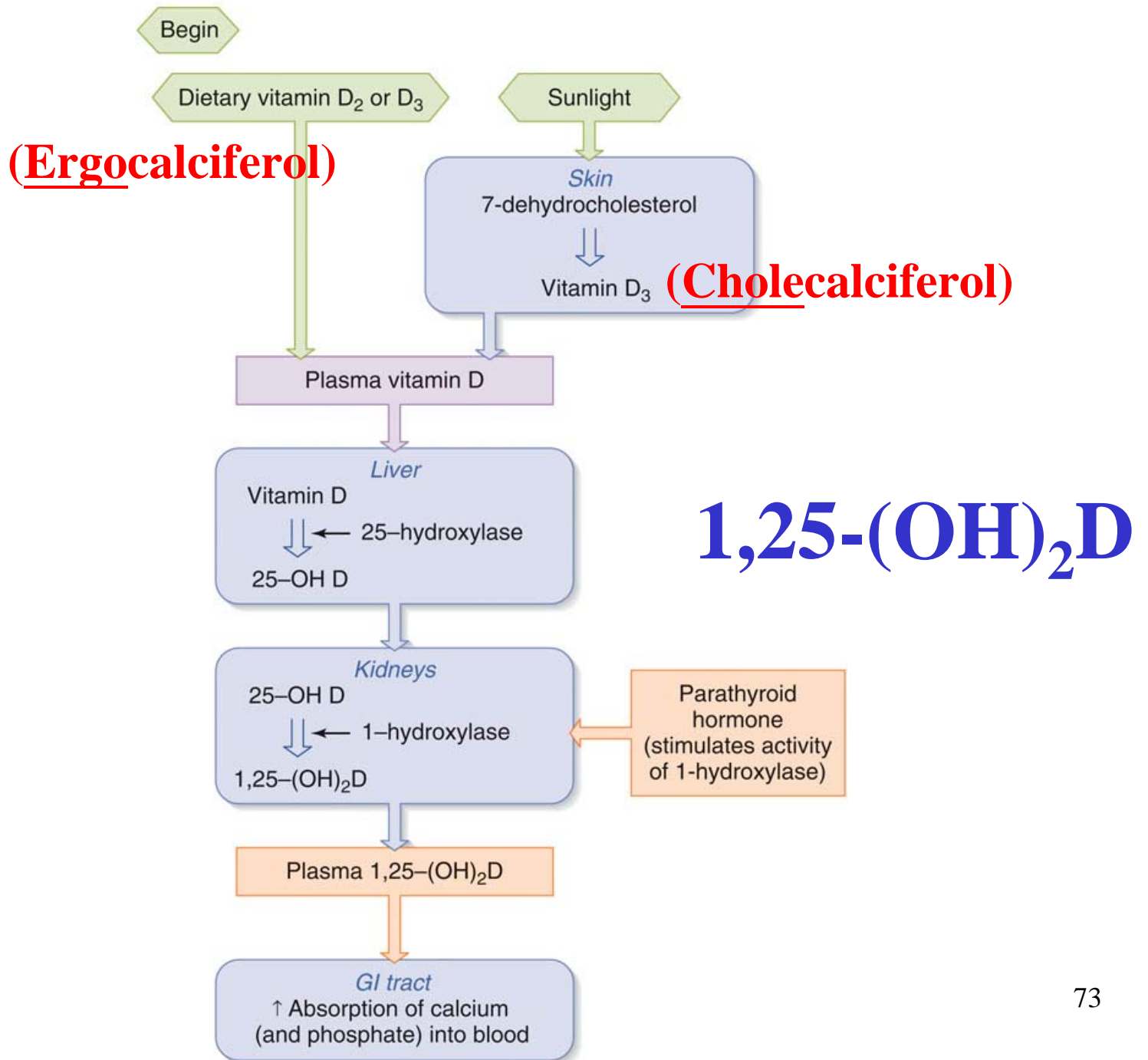
Synthesis of 1,25-(OH)₂Vit D₃



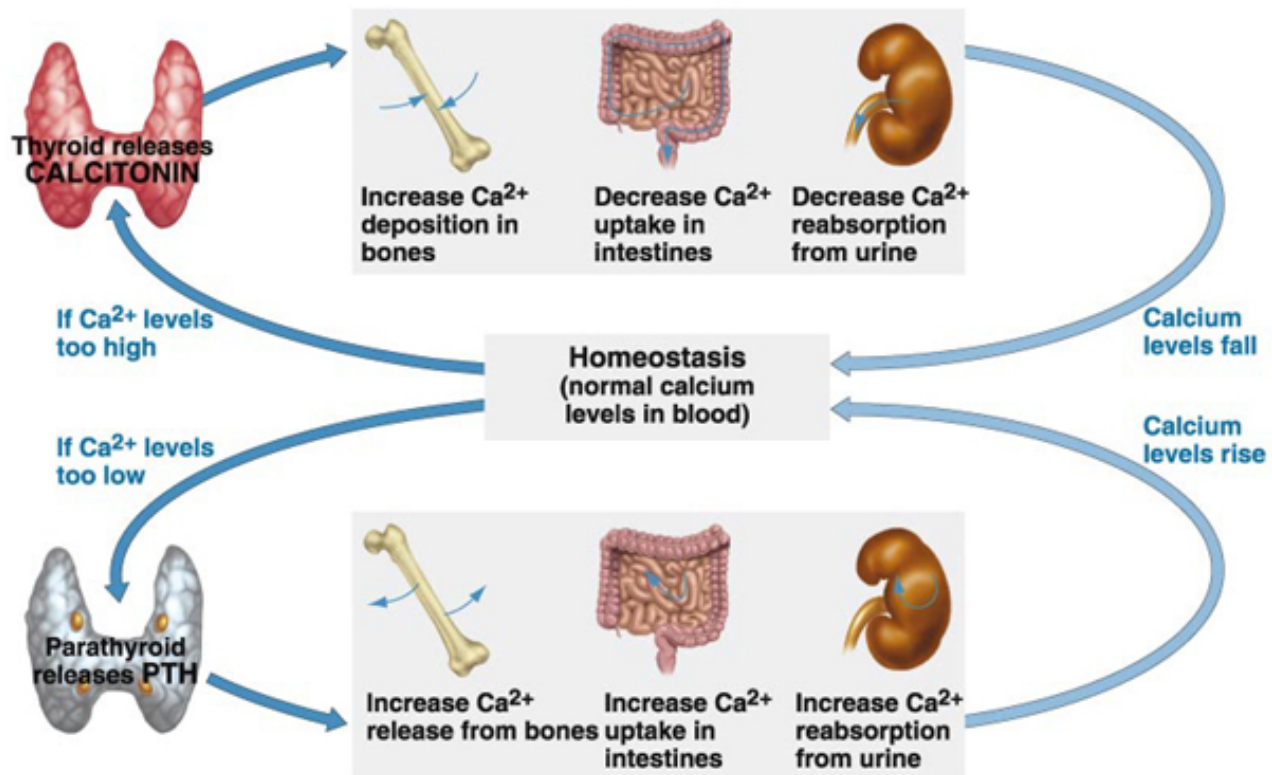
軟骨症
佝僂病

目標器官
Target organs
(Bone, intestine,
kidneys)
(骨骼、小腸、腎)

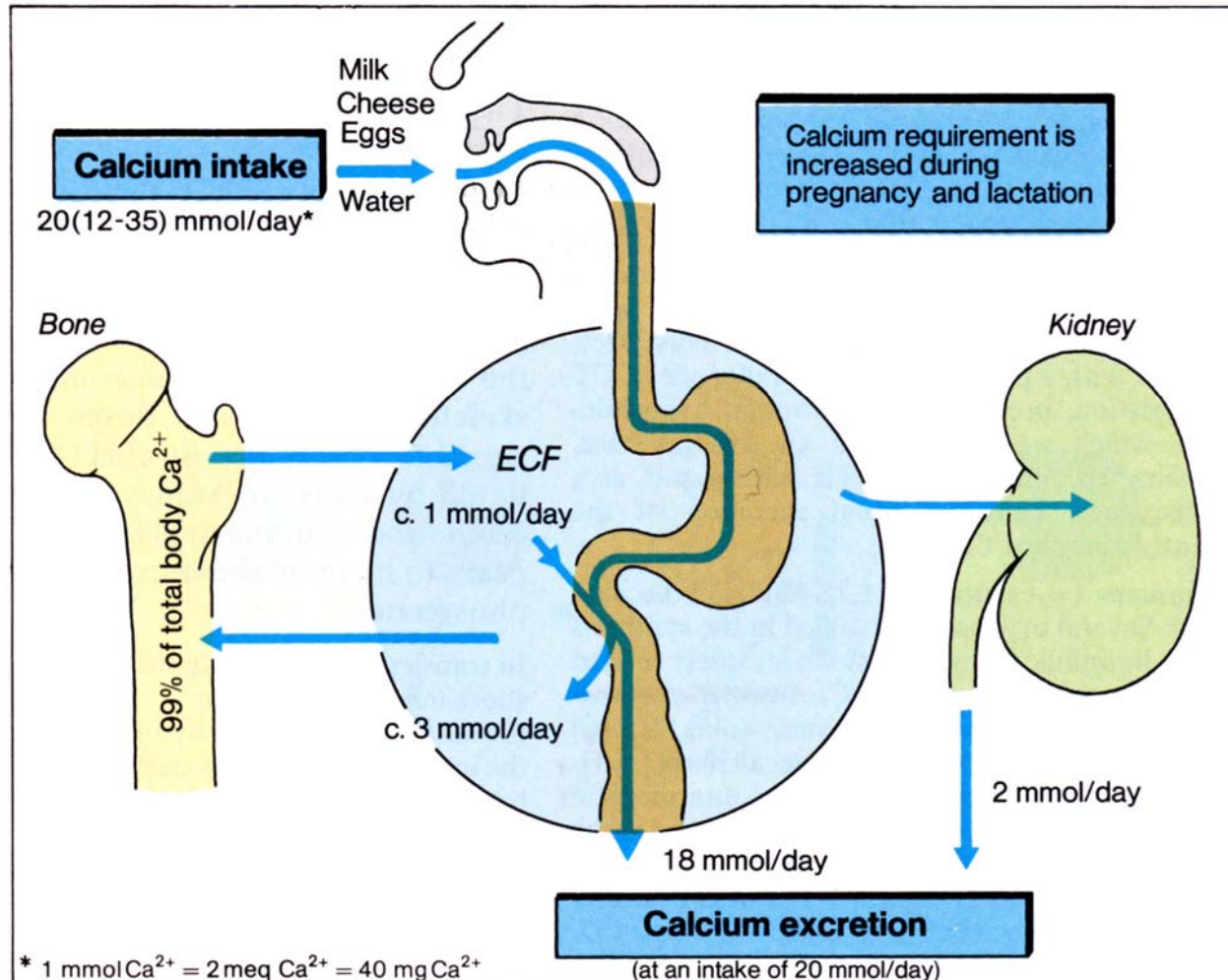
PTH



Calcitonin



Calcium Balance



A. Calcium balance

Table 11-7

Summary of Major Hormonal Influences on Bone Mass

Hormones that favor bone formation and increased bone mass

Insulin

Growth hormone

Insulin-like growth factor I (IGF-1)

Estrogen

Testosterone

Calcitonin

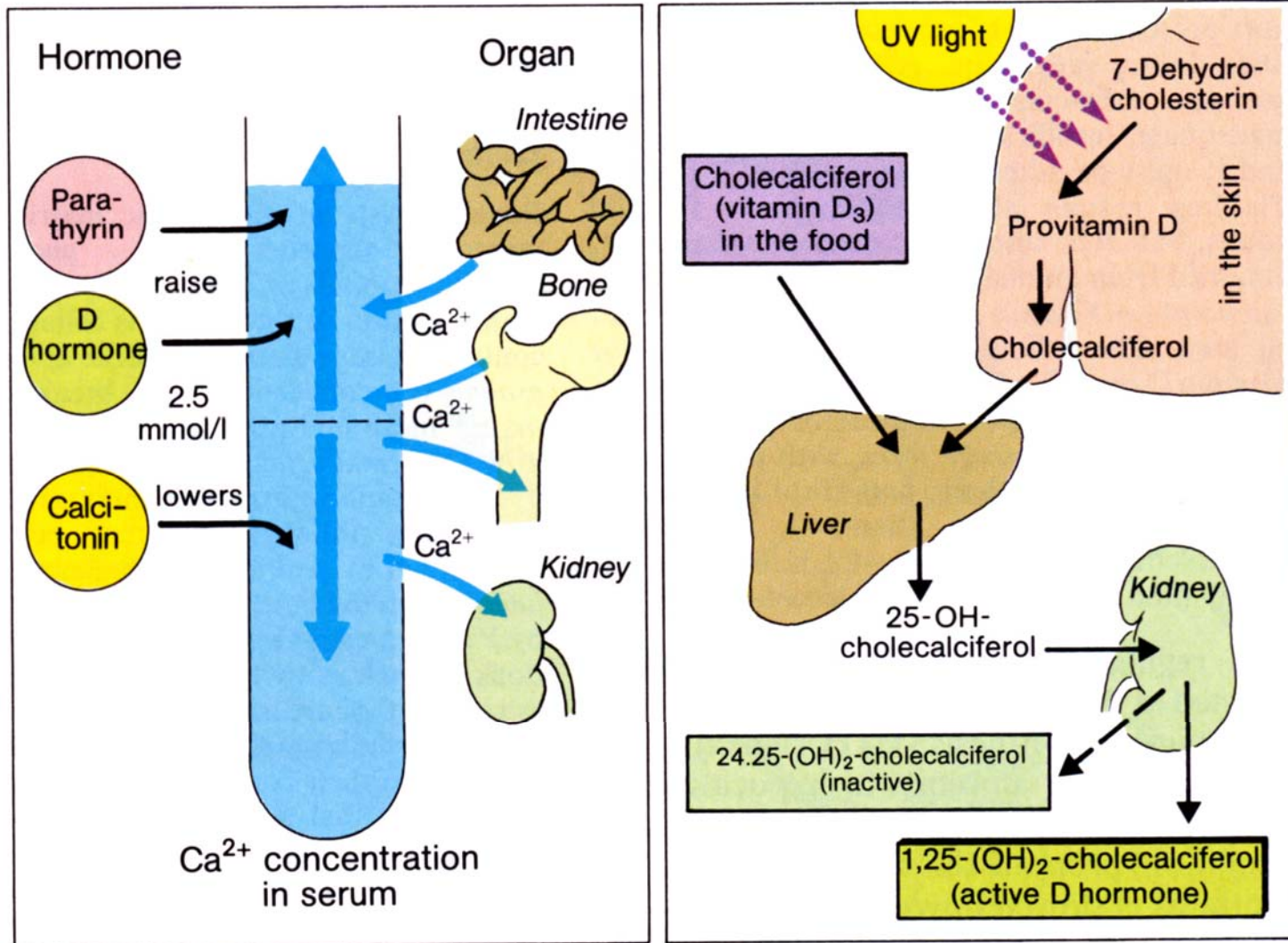
Hormones that favor increased bone resorption and decreased bone mass

Parathyroid hormone (chronic elevations)

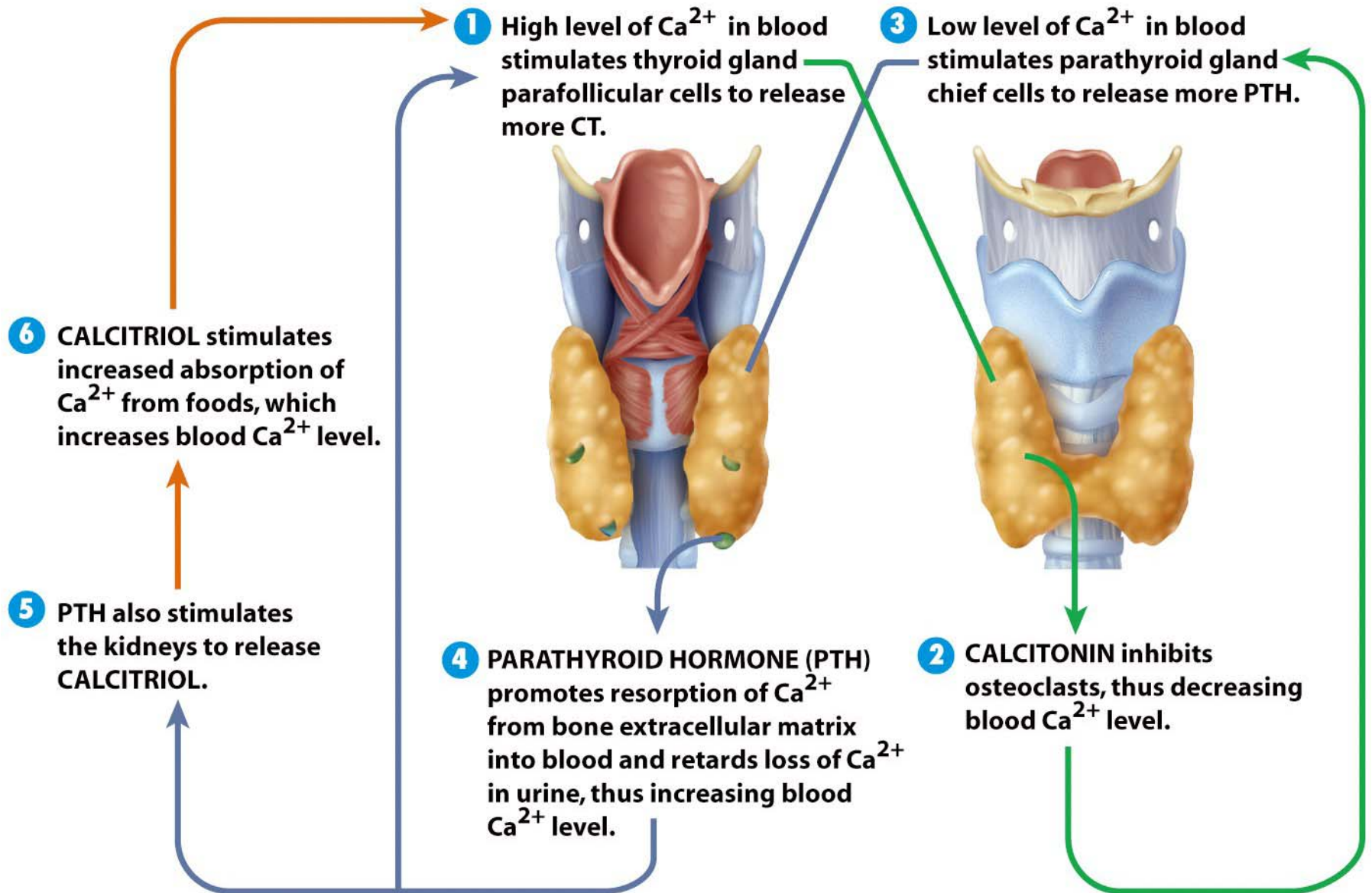
Cortisol

Thyroid hormones (T_4 and T_3)

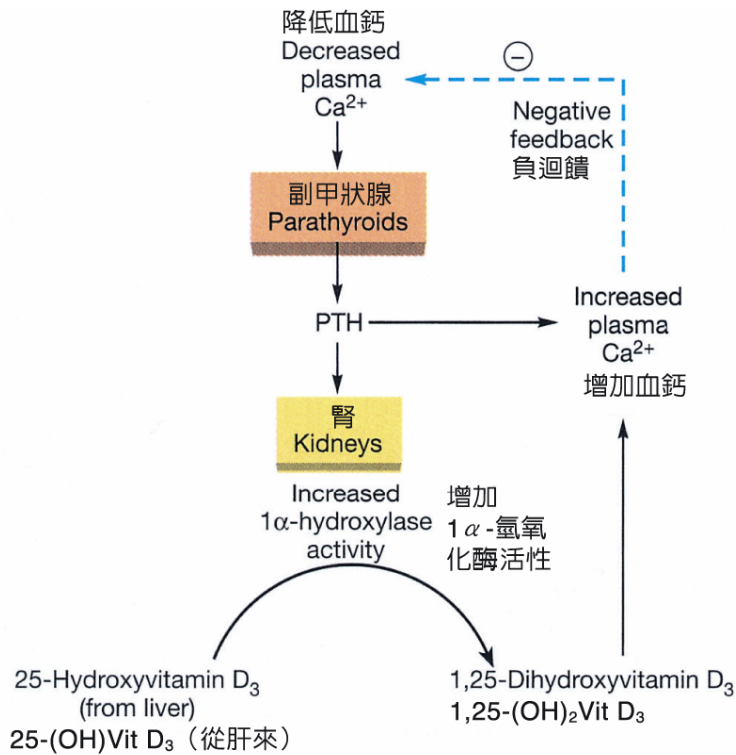
Regulation of Calcium Blood Levels



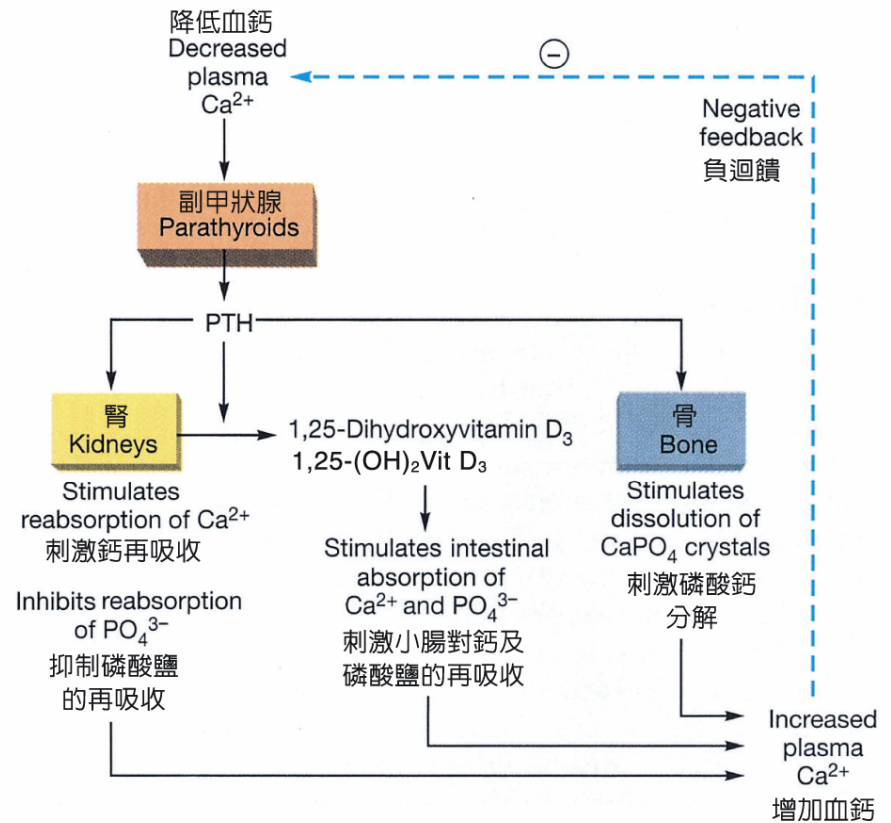
Regulation of Calcium Blood Levels



Regulation of Calcium Blood Levels



■ 圖 19.21 分泌副甲狀腺素的負迴饋機制。血鈣下降直接刺激副甲狀腺素的分泌，同時也刺激 $1,25\text{-(OH)}_2\text{Vit D}_3$ 的生成，因為副甲狀腺素刺激 $1,25\text{-(OH)}_2\text{Vit D}_3$ 在腎內形成的最後步驟。

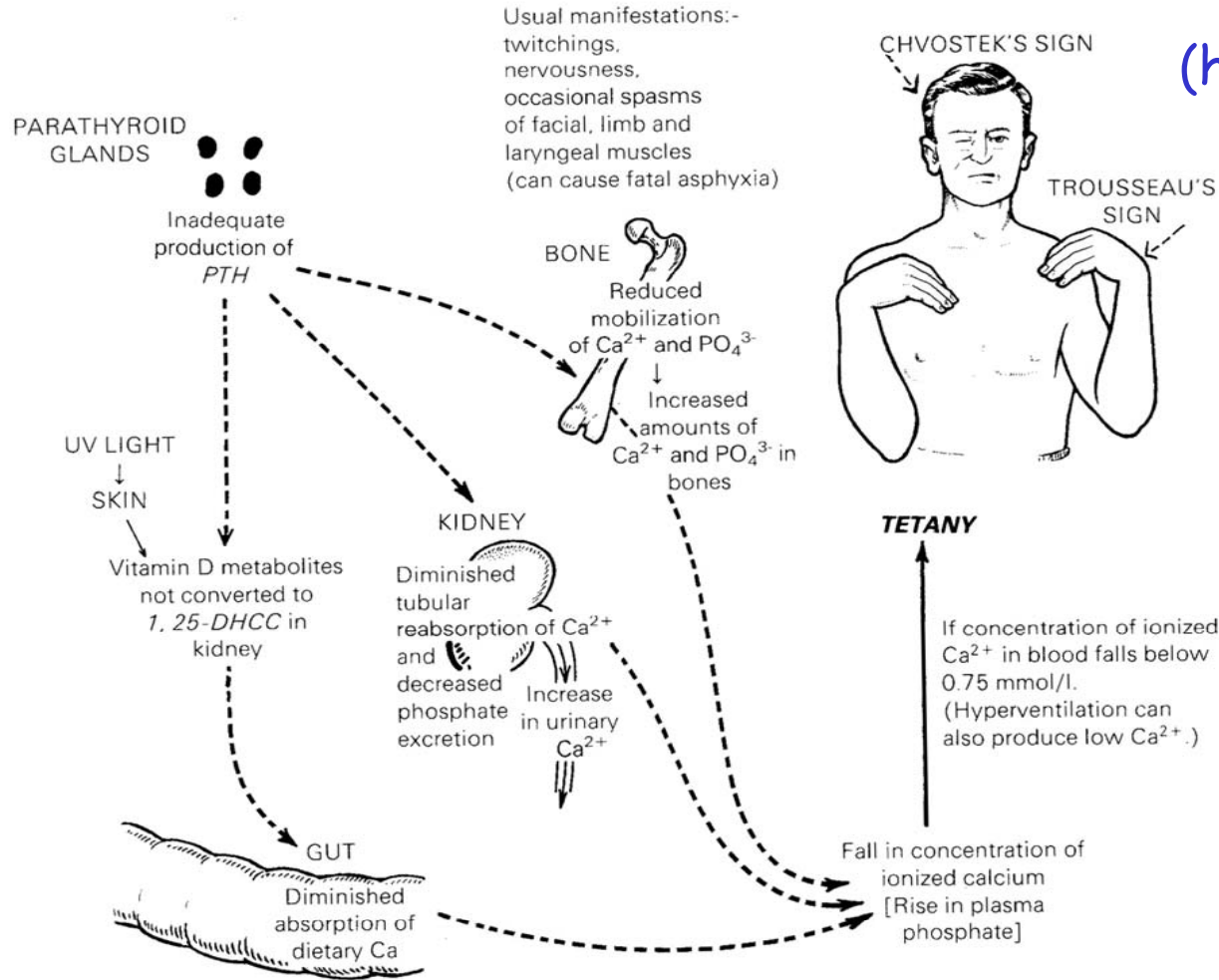


■ 圖 19.22 血漿中 Ca^{2+} 濃度的恆定。將低血鈣回復至正常而不提升血磷至異常的負迴饋循環。

UNDERACTIVITY OF PARATHYROIDS

Atrophy or removal of parathyroid tissue causes a fall in **blood calcium** level and increased excitability of neuromuscular tissue. This leads to severe convulsive disorder – **tetany**.

副甲狀腺機能症 (hypoparathyroidism)



Usual manifestations:-
twitchings,
nervousness,
occasional spasms
of facial, limb and
laryngeal muscles
(can cause fatal asphyxia)



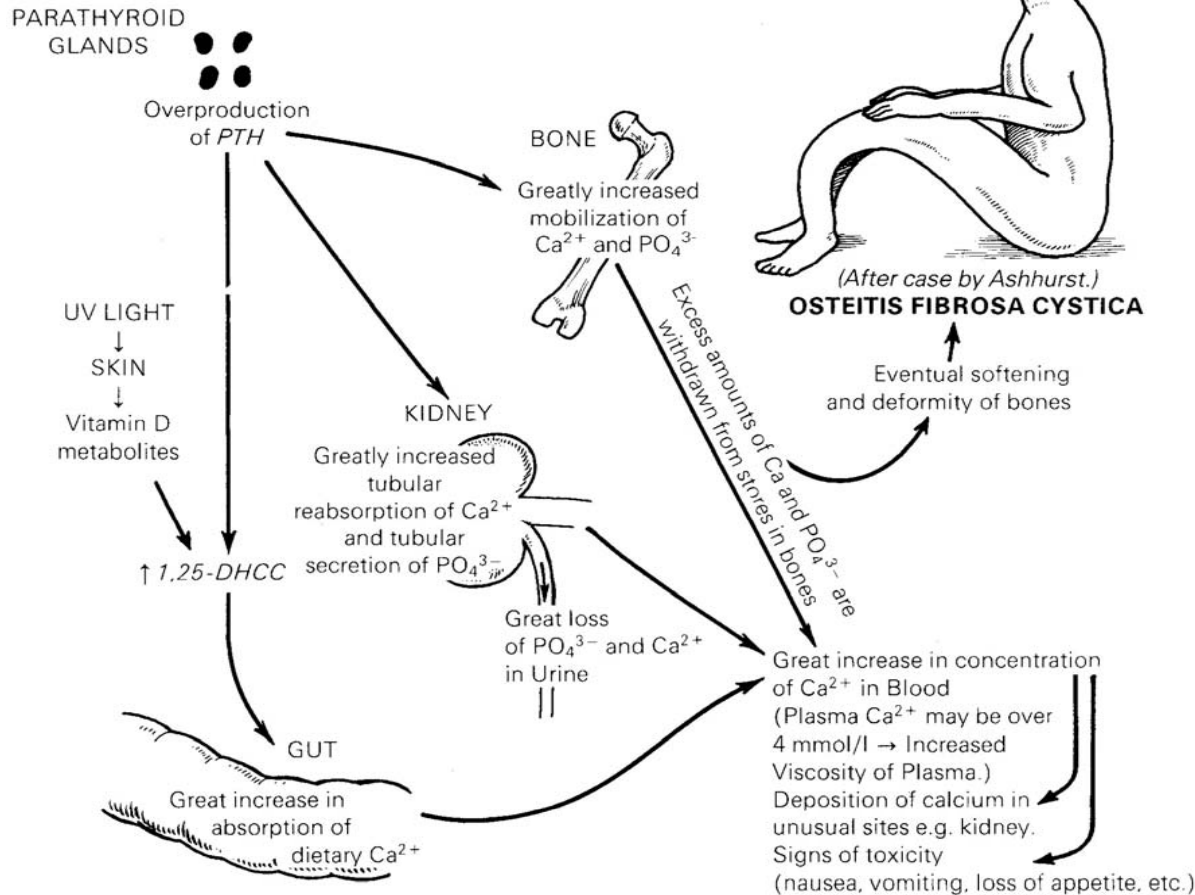
[Note the inverse relationship between plasma calcium and inorganic phosphate]

Symptoms are relieved by injection of calcium, large doses of a Vit. D compound and parathormone.

OVERACTIVITY OF PARATHYROIDS

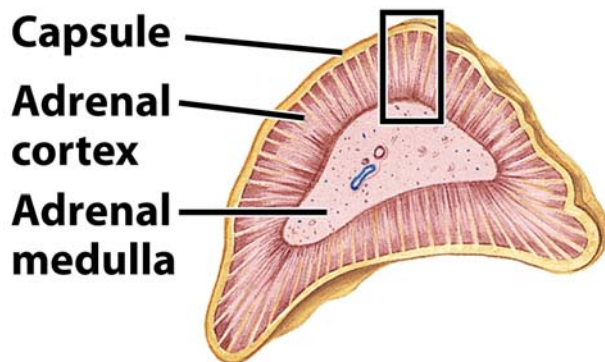
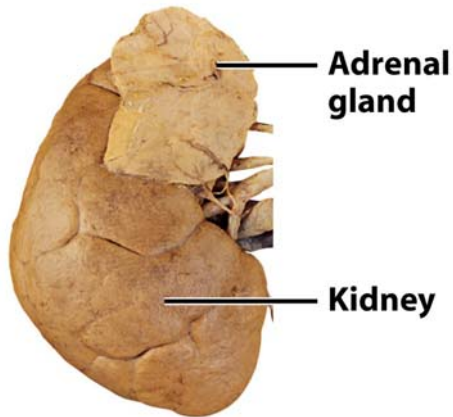
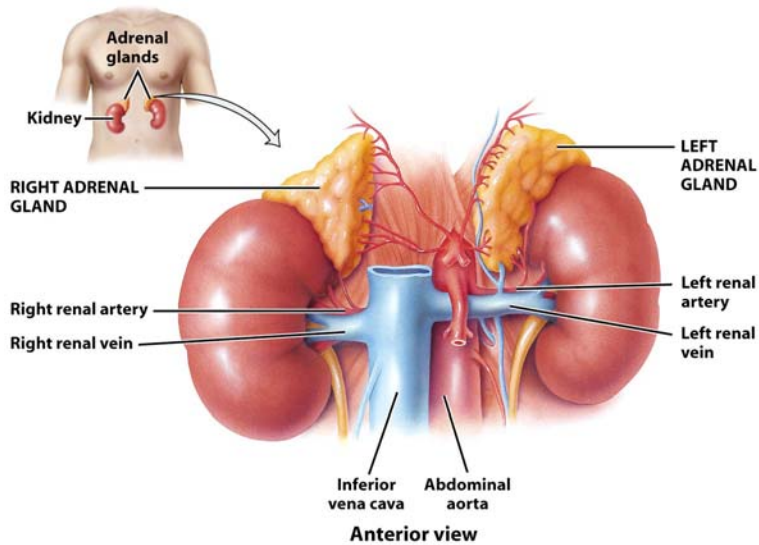
Overactivity of the parathyroids (due often to tumour) leads to rise in **blood calcium** level and eventually to **osteitis fibrosa cystica**.

副甲狀腺機能亢進症 (hyperparathyroidism)



The increased level of blood calcium eventually leads to excessive loss of **calcium in urine** (in spite of ↑ reabsorption) and also of **water** since the salts are excreted in solution. **Polyuria** and **thirst** result.

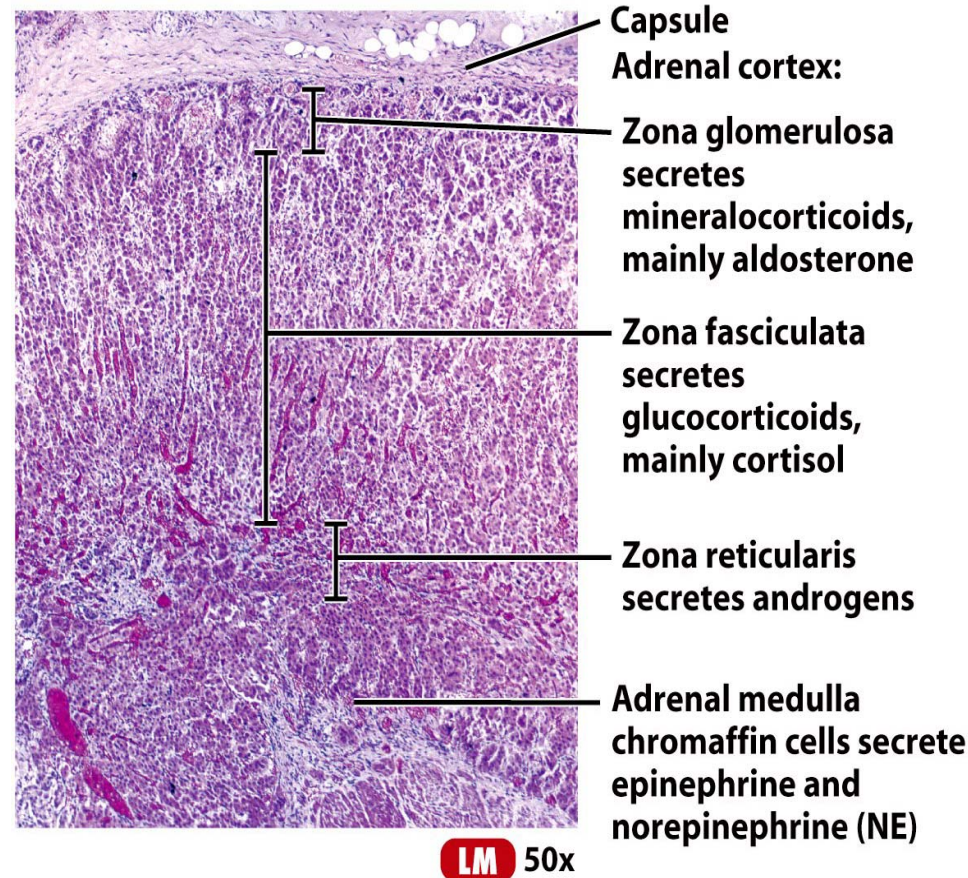
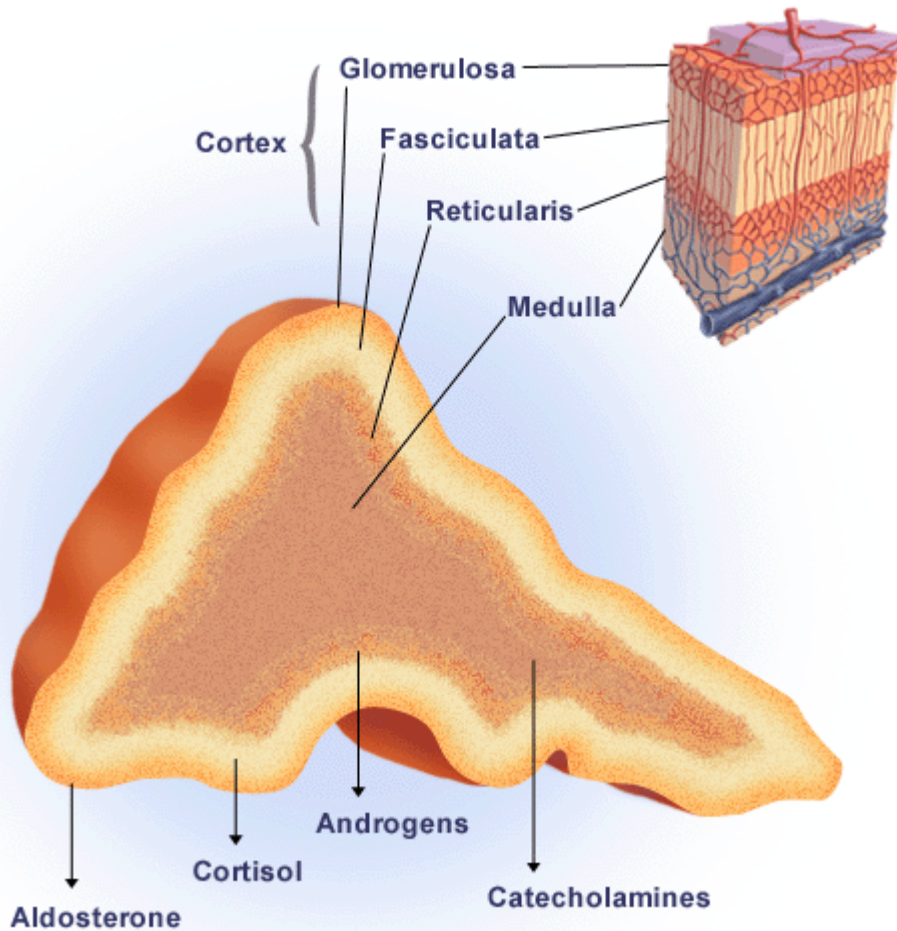
Excision of the overactive parathyroid tissue abolishes syndrome.



Adrenal Gland

- ❖ The *adrenal glands* are located superior to the kidneys
- ❖ 3 x 3 x 1 cm in size and weighs 5 grams
- ❖ consists of an outer cortex and an inner medulla.
 - **Cortex** produces 3 different types of hormones from 3 zones of cortex
 - **Medulla** produces epinephrine & norepinephrine

Adrenal Cortex



Subdivisions of the adrenal gland

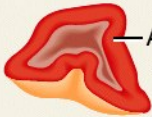
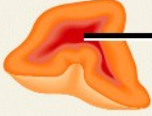
Figure 18-15d Principles of Anatomy and Physiology, 11/e

Adrenal Gland Hormones

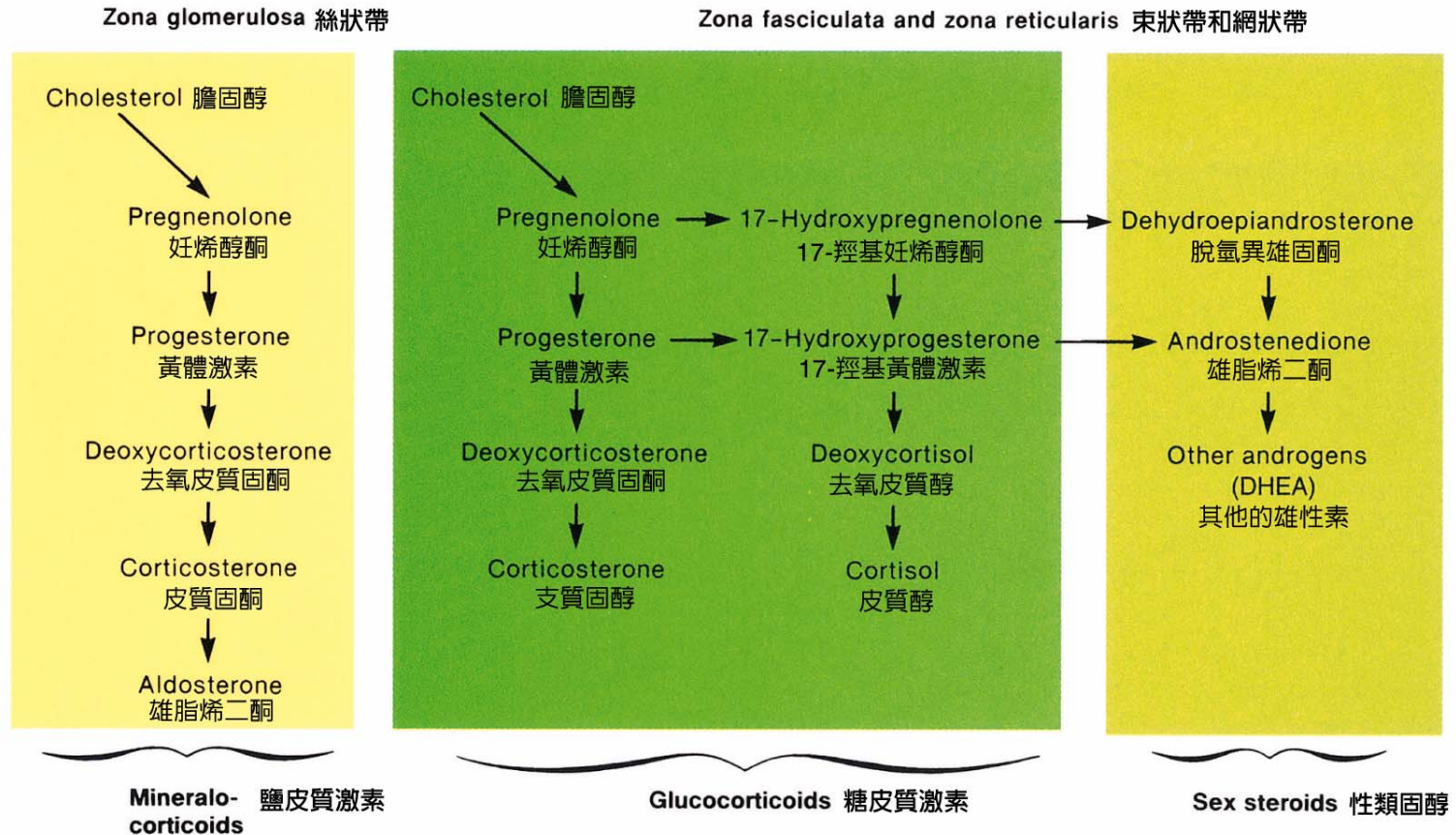
名稱	特性
腎上腺皮質 (adrenal cortex)	<p>1.分泌 corticosteroid (皮質類固醇) , 來自胚胎的中胚層 , 佔 adrenal gland 的 80~90% 。</p> <p>2.分為三層 :</p> <ul style="list-style-type: none">①絲 (球) 狀帶 (zona glomerulosa) : aldosterone 分泌 mineralcorticoids (礦物質皮質類固醇) 佔15% 。②束狀帶 (zona fasciculata) : cortisol 分泌 glucocorticoids (糖質皮質類固醇) 佔25% 。③網狀帶 (zona reticularis) : androgens & estrogens 分泌性類固醇 (sex steroids) 佔60% 。
腎上腺髓質 (adrenal medulla)	<p>分泌 catecholamine , EP : NE分泌比例 4 : 1 , 來自胚胎的外胚層 , 佔 adrenal gland 的 10~20% 。</p>

Adrenal Gland Hormones

TABLE 18.8 Summary of Adrenal Gland Hormones

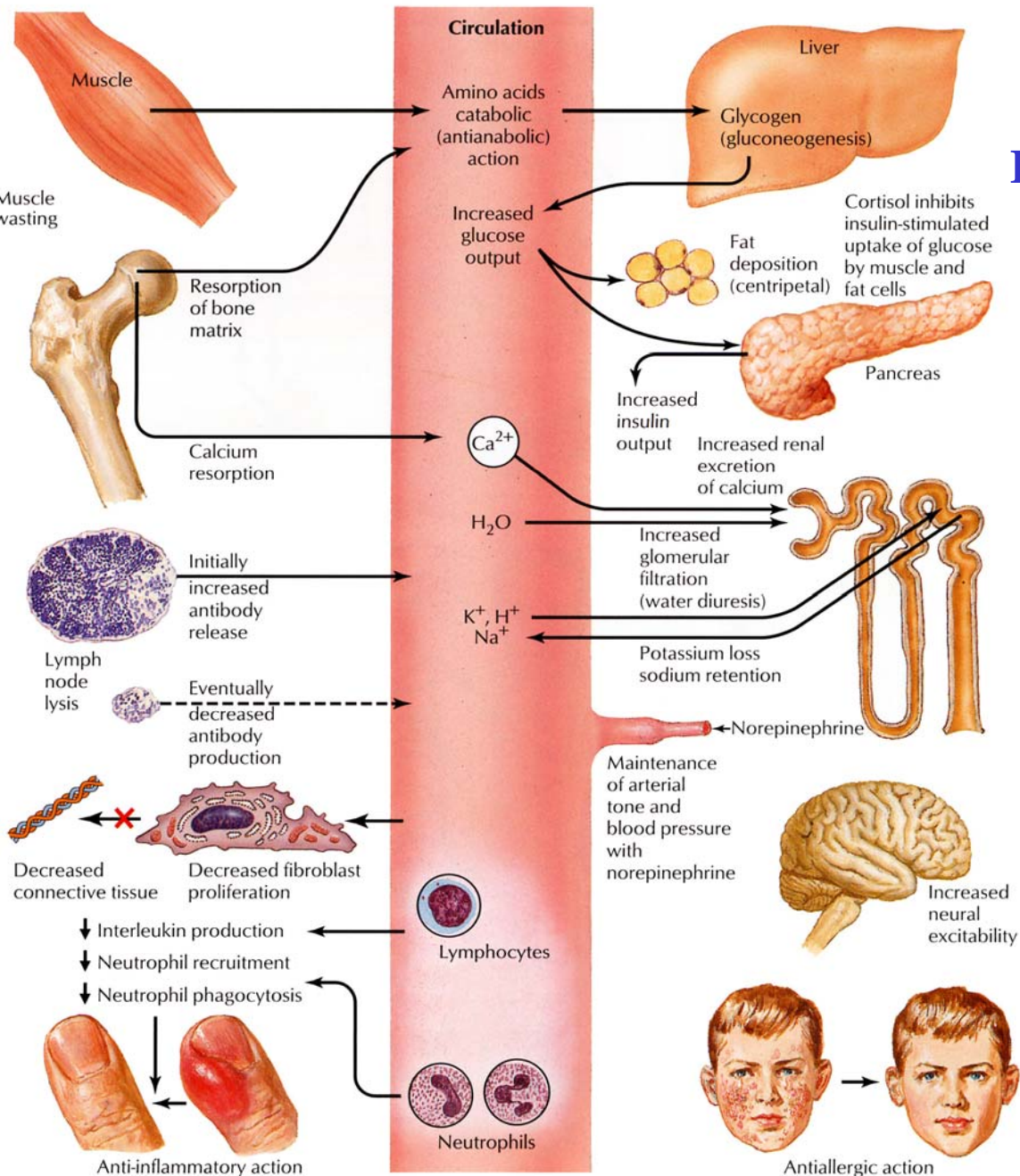
Hormones and Source	Control of Secretion	Principal Actions
Adrenal Cortex Hormones		
Mineralocorticoids (mainly aldosterone) from zona glomerulosa cells	Increased blood K^+ level and angiotensin II stimulate secretion.	Increase blood levels of Na^+ and water and decrease blood level of K^+ .
Glucocorticoids (mainly cortisol) from zona fasciculata cells	ACTH stimulates release; corticotropin-releasing hormone (CRH) promotes ACTH secretion in response to stress and low blood levels of glucocorticoids.	Increase protein breakdown (except in liver), stimulate gluconeogenesis and lipolysis, provide resistance to stress, dampen inflammation, and depress immune responses.
Androgens (mainly dehydroepiandrosterone or DHEA) from zona reticularis cells	ACTH stimulates secretion.	Assist in early growth of axillary and pubic hair in both sexes; in females, contribute to libido and are source of estrogens after menopause.
 Adrenal cortex		
Adrenal Medulla Hormones		
Epinephrine and norepinephrine from chromaffin cells (嗜鉻細胞)	Sympathetic preganglionic neurons release acetylcholine, which stimulates secretion.	Produce effects that enhance those of the sympathetic division of the autonomic nervous system (ANS) during stress.
 Adrenal medulla		

Synthesis of Adrenal Gland Hormones



Functions of Adrenal Cortex Hormones

激素名稱	功能
Aldosterone	<ol style="list-style-type: none"> 1. 增加腎臟對Na⁺及水的再吸收 2. 增加腎臟對K⁺及H⁺的排出 3. 血管收縮
Cortisol	<ol style="list-style-type: none"> 1. 糖質新生作用 (blood sugar ↑) 2. 抑制骨骼合成，抑制Vit D的生成及作用 3. 增加腎臟血流量，同時抑制ADH的作用 (多尿) 4. 抗發炎及抗過敏作用 5. 抑制免疫反應
Androgens & estrogens	增加第二性徵發育.....

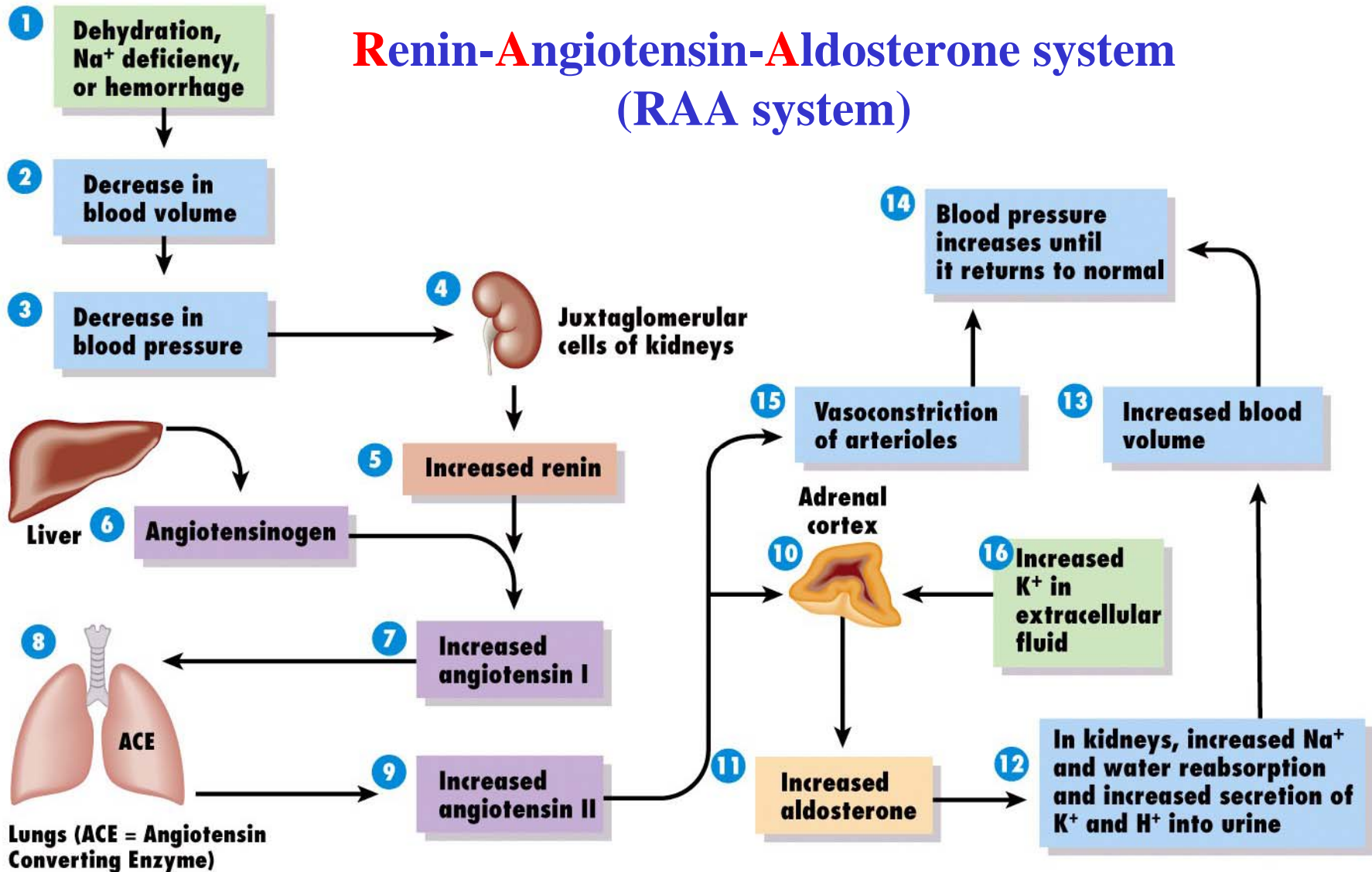


Functions of Cortisol

- ✓ increase rate of protein catabolism & lipolysis
- ✓ conversion of amino acids to glucose
- ✓ stimulate lipolysis
- ✓ provide resistance to stress by making nutrients available for ATP production
- ✓ raise BP by vasoconstriction
- ✓ anti-inflammatory effects reduced (skin cream)
- ✓ reduce release of histamine from mast cells
- ✓ decrease capillary permeability
- ✓ depress phagocytosis.....

Regulation of Aldosterone

Renin-Angiotensin-Aldosterone system (RAA system)



Stimuli

↓ Blood pressure
↓ Blood flow to kidney

Juxtaglomerular apparatus in kidney

Renin

Angiotensinogen

Angiotensin I

Converting enzyme

Angiotensin II

Hypothalamus

Aldosterone

Thirst

Salt and water
retention by kidney

Vasoconstriction
of arterioles

*Negative feedback
response*

↑ Blood volume

↑ Blood pressure

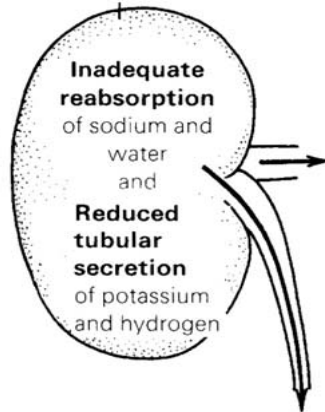
UNDERACTIVITY OF ADRENAL CORTEX

Atrophy of adrenal cortex (occasionally occurs with destructive disease of the gland, e.g. tuberculosis, cancer.)

gives
inadequate production of all *corticoids*:-

(Primary Adrenal Insufficiency)

↓ 'MINERALOCORTICOID' EFFECT:



Blood sodium level falls (hyponatraemia)
Hydrogen retention
Potassium retention (Increase in blood urea eventually)
Excessive loss of sodium and water in urine (polyuria)
Potassium level falls in Urine

ADDISON'S DISEASE

body fluid volume decreases (dehydration)

Blood volume falls

blood pressure falls

(hypotension)

↑ risk of

circulatory failure

metabolic acidosis

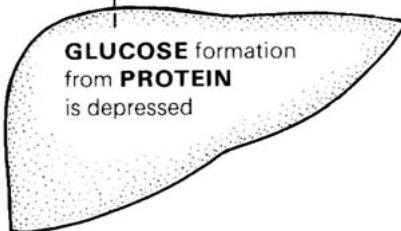
Potassium intoxication

↓ (hyperkalaemia)

Muscular weakness and wasting

↓ 'ADRENAL ANDROGEN' EFFECT: Females show loss of pubic and axillary hair.

↓ 'GLUCOCORTICOID' EFFECT:



Fasting blood sugar level low (hypoglycaemia) ... may be fatal.
Reduced mobilization of proteins and fat causes lack of energy for metabolism.

Patients show

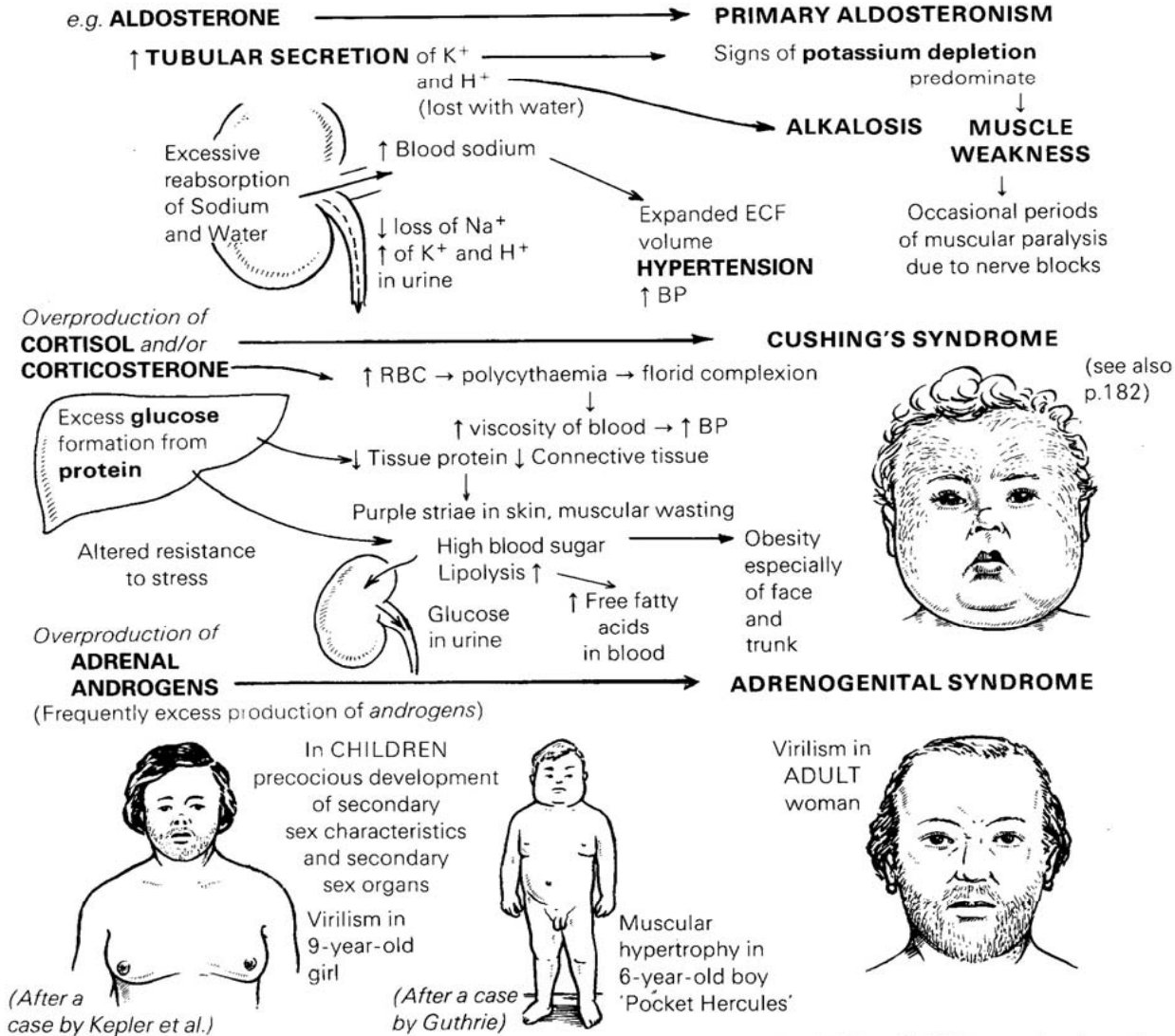
Great muscular weakness and wasting.
great loss of weight. loss of appetite
hypotension.
vomiting and abdominal pain.
anaemia (↓ RBC formation)
pigmentation of exposed and pressure areas of **skin** (due to rise in *ACTH* which has melanophore-stimulating properties).
↓ resistance to **stress** and **infections**.
Increased eosinophils and lymphocytes in blood.

If untreated, eventually fatal.

Administration of *cortisol*, a synthetic mineralocorticoid, and sodium chloride restores individual to normal.

OVERACTIVITY OF ADRENAL CORTEX

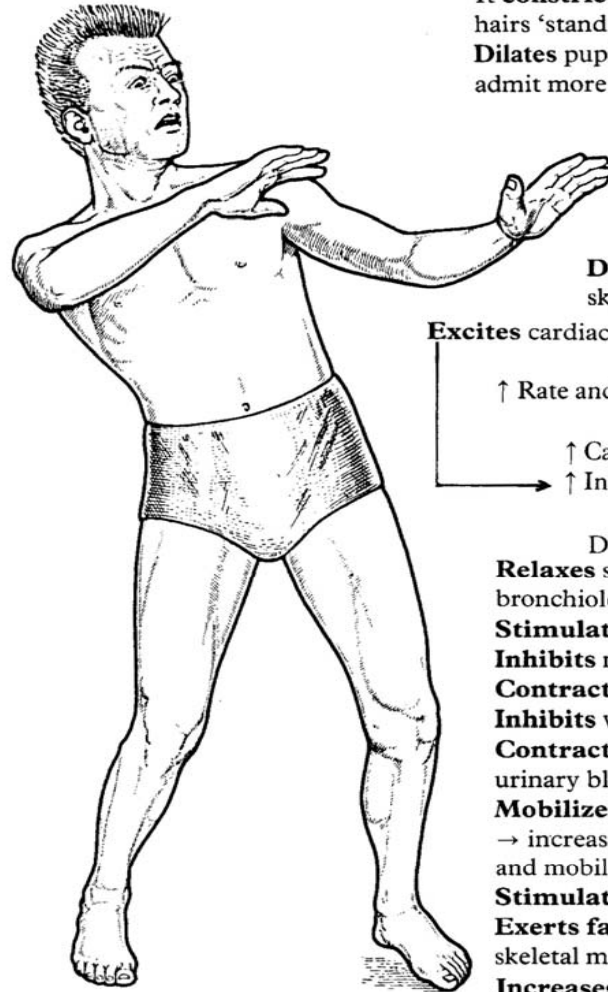
Overactivity or tumour of adrenal cortex may give overproduction of any or all of the corticoids:



Administration of *cortisone* depresses pituitary secretion of *ACTH* → inhibits production of the abnormal steroids.

Removal of the over-secreting tissue or tumour restores individual. In **secondary** hyperaldosteronism *excess aldosterone* is the result of *increased renin* secretion.

Under quiet resting conditions the blood contains very little *adrenaline*. During excitement or circumstances which demand special efforts *adrenaline* is released into the blood stream, and is responsible for the following actions summed up as the '**fight or flight**' function of the adrenal medullae.



It **constricts** smooth muscle of skin → hairs 'stand on end'; 'Gooseflesh'.

Dilates pupil of eye to admit more light.

Constricts smooth muscle of abdominal blood vessels and cutaneous blood vessels → pallor with fright.

Dilates smooth muscle in arterioles of skeletal muscles.

Excites cardiac muscle

↓
↑ Rate and force of contraction

↓
↑ Cardiac output

↓
↑ In local metabolites

↓
Dilates coronaries

Relaxes smooth muscle in wall of bronchioles → better supply of air to alveoli.

Stimulates respiration.

Inhibits movements of digestive tract.

Contracts sphincters of gut.

Inhibits wall of urinary bladder.

Contracts ureters and sphincter of urinary bladder.

Mobilizes muscle and liver glycogen

→ increase in blood sugar, and mobilizes depot fat → ↓ free fatty acid.

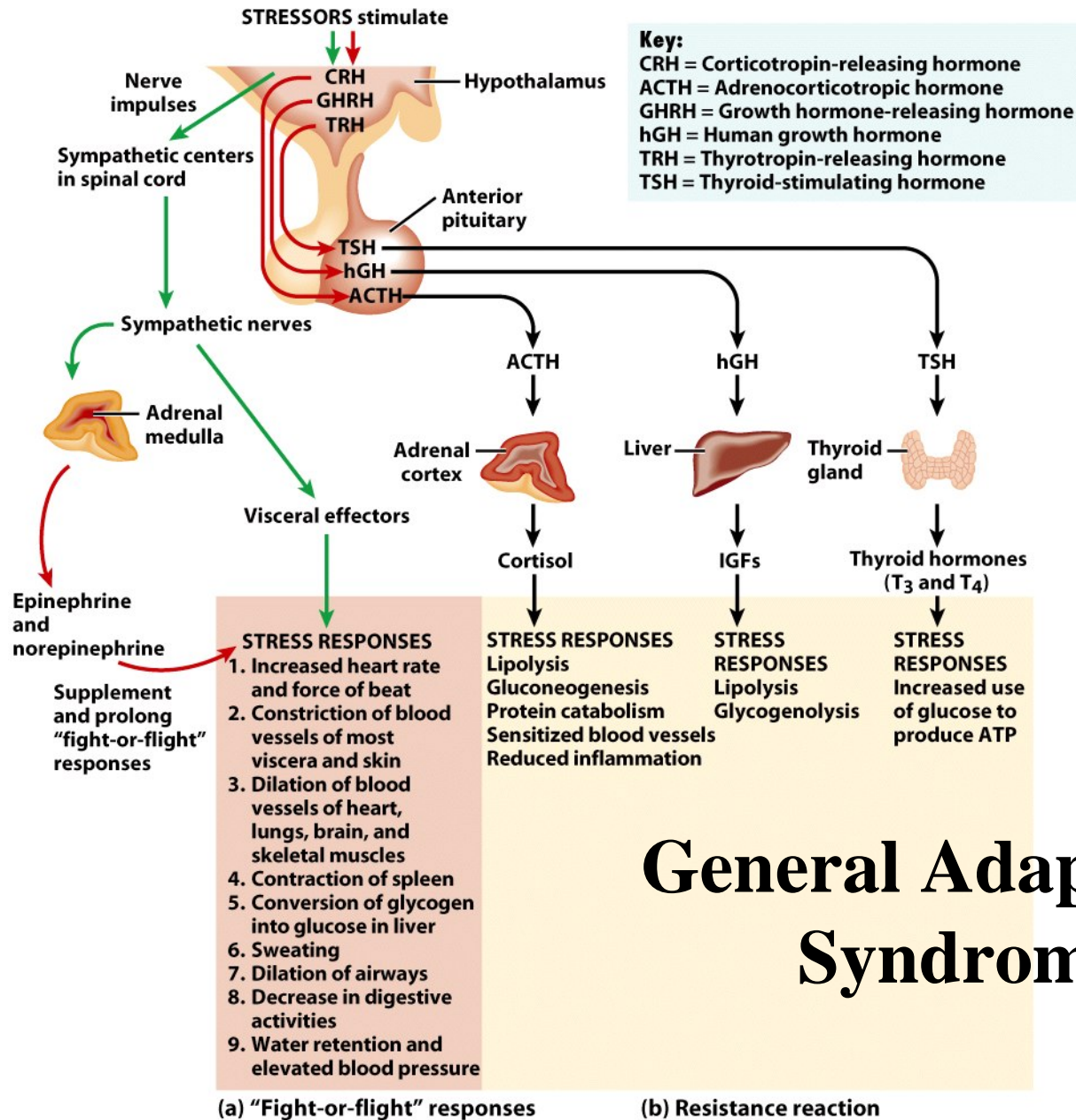
Stimulates metabolism → ↑ BMR

Exerts favourable effect on contracting skeletal muscle → fatigues less readily.

Increases coagulability of blood.

Most of these effects can also be produced by stimulating sympathetic nerve fibres.

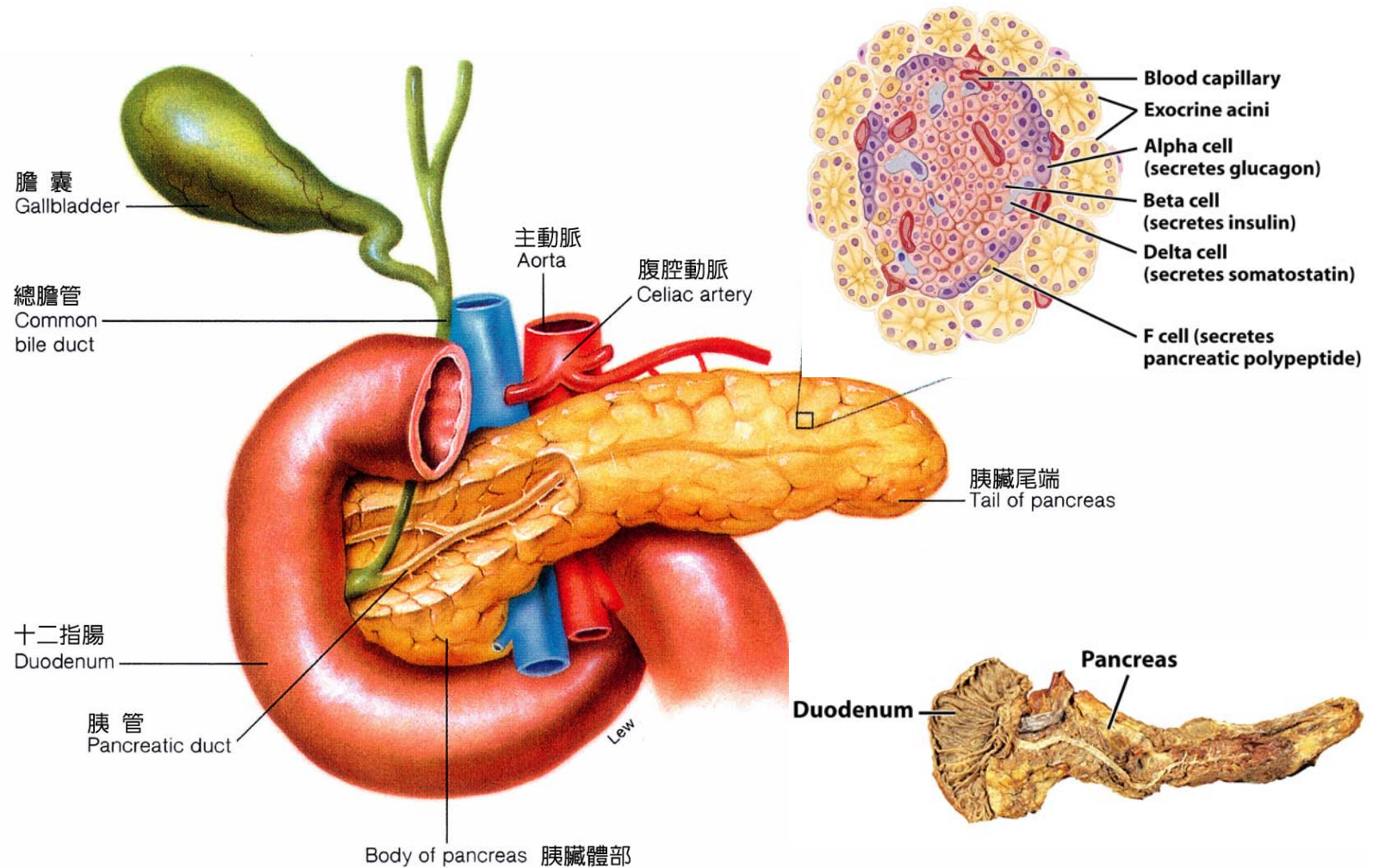
The adrenal medullae are not essential to life – but without them the body is less able to face emergencies and conditions of stress.



Pheochromocytoma

- ❖ 腎上腺髓質的腫瘤是指**嗜鉻性細胞瘤** (Pheochromocytoma)。這腫瘤造成腎上腺素和正腎上腺素過量的分泌，其產生的結果類似交感神經系統連續的刺激。這症狀包括代謝率升高、高血糖、尿糖、神經質、消化系統問題和出汗。在這情況下，並不會花太久的時間就變成全身性疲勞，造成病人易感染其他疾病。

Anatomy of Pancreas



❖ Cells (99%) in **acini** produce digestive enzymes

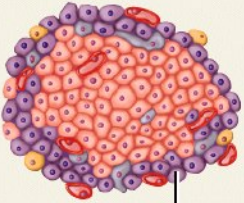
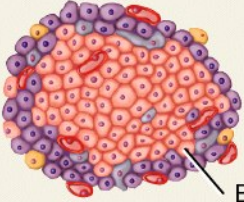
❖ Endocrine cells in **pancreatic islets** produce hormones 96

Pancreatic Islet (Islet of Langerhans)

Cell types	特性
A cell (α cell)	分泌 Glucagon (29 aa) ; 約佔20~25 % 。
B cell (β cell)	分泌 Insulin (51 aa) ; 約佔60~70 % 。
D cell (δ cell)	分泌 SS ; 約佔10 % 。
F cell	分泌 pancreatic polypeptide

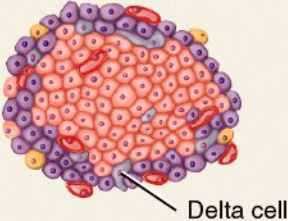
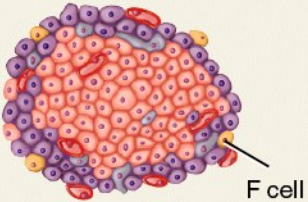
Pancreatic Islet Hormones

TABLE 18.9 Summary of Pancreatic Islet Hormones

Hormone and Source	Control of Secretion	Principal Actions
<p>Glucagon from alpha cells of pancreatic islets</p>  <p>Alpha cell</p>	<p>Decreased blood level of glucose, exercise and mainly protein meals stimulate secretion; somatostatin and insulin inhibit secretion.</p>	<p>Raises blood glucose level by accelerating breakdown of glycogen into glucose in liver (glycogenolysis), converting other nutrients into glucose in liver (gluconeogenesis), and releasing glucose into the blood.</p>
<p>Insulin from beta cells of pancreatic islets</p>  <p>Beta cell</p>	<p>Increased blood level of glucose, acetylcholine (released by parasympathetic vagus nerve fibers), arginine and leucine (two amino acids), glucagon, GIP, hGH, and ACTH stimulate secretion; somatostatin inhibits secretion.</p>	<p>Lowers blood glucose level by accelerating transport of glucose into cells, converting glucose into glycogen (glycogenesis), and decreasing glycogenolysis and gluconeogenesis; also increases lipogenesis and stimulates protein synthesis.</p>

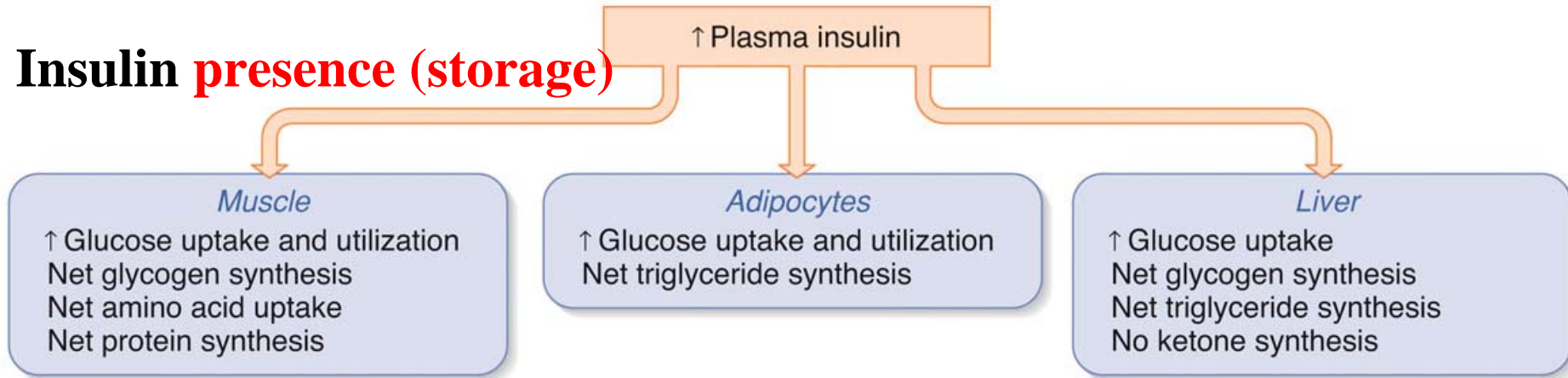
Pancreatic Islet Hormones

TABLE 18.9 Summary of Pancreatic Islet Hormones

Hormone and Source	Control of Secretion	Principal Actions
<p>Somatostatin from delta cells of pancreatic islets</p> 	<p>Pancreatic polypeptide inhibits secretion.</p>	<p>Inhibits secretion of insulin and glucagon and slows absorption of nutrients from the gastrointestinal tract.</p>
<p>Pancreatic polypeptide from F cells of pancreatic islets</p> 	<p>Meals containing protein, fasting, exercise, and acute hypoglycemia stimulate secretion; somatostatin and elevated blood glucose level inhibit secretion.</p>	<p>Inhibits somatostatin secretion, gallbladder contraction, and secretion of pancreatic digestive enzymes.</p>

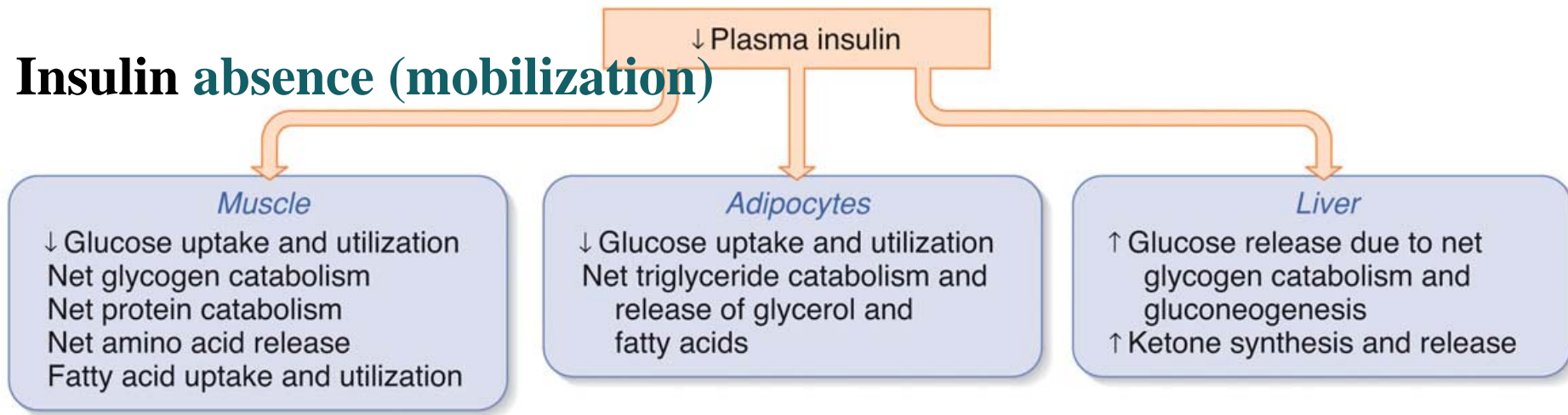
Target-cell Responses of Insulin

Insulin presence (storage)



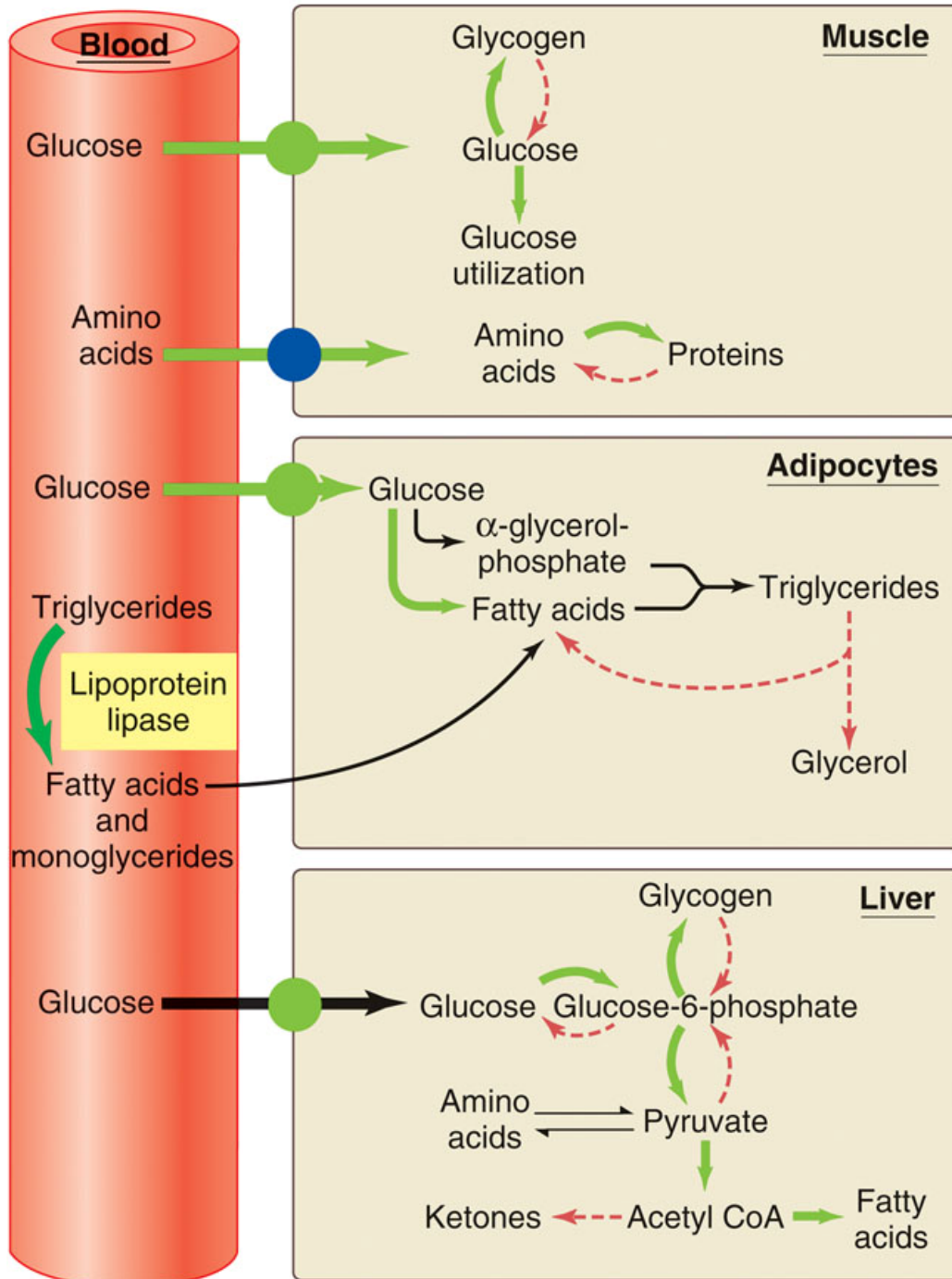
(a)

Insulin absence (mobilization)



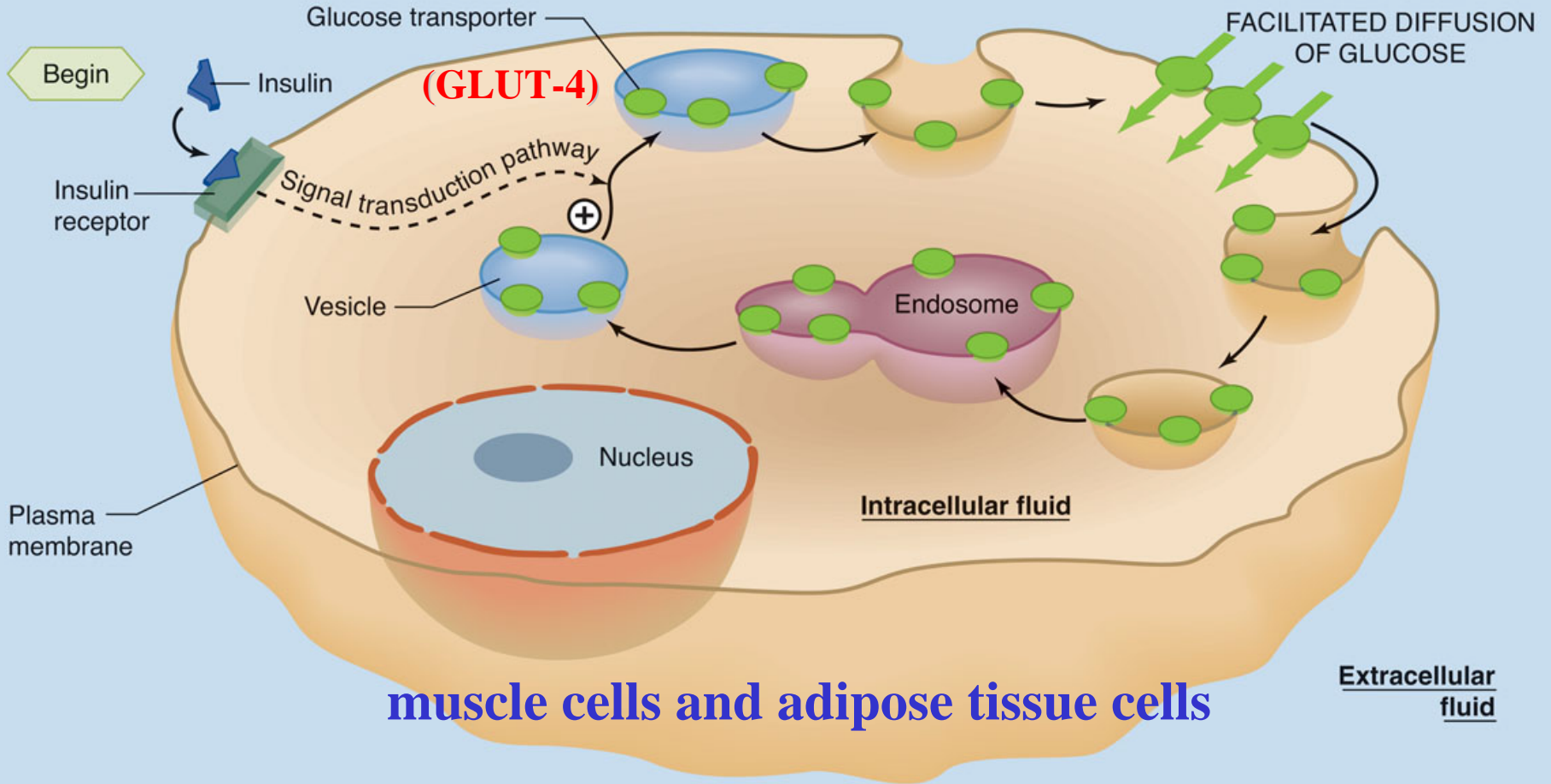
(b)

酮体(ketone body) : Acetone , Acetoacetate , β -hydroxybutyrate¹⁰⁰



Insulin Action

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

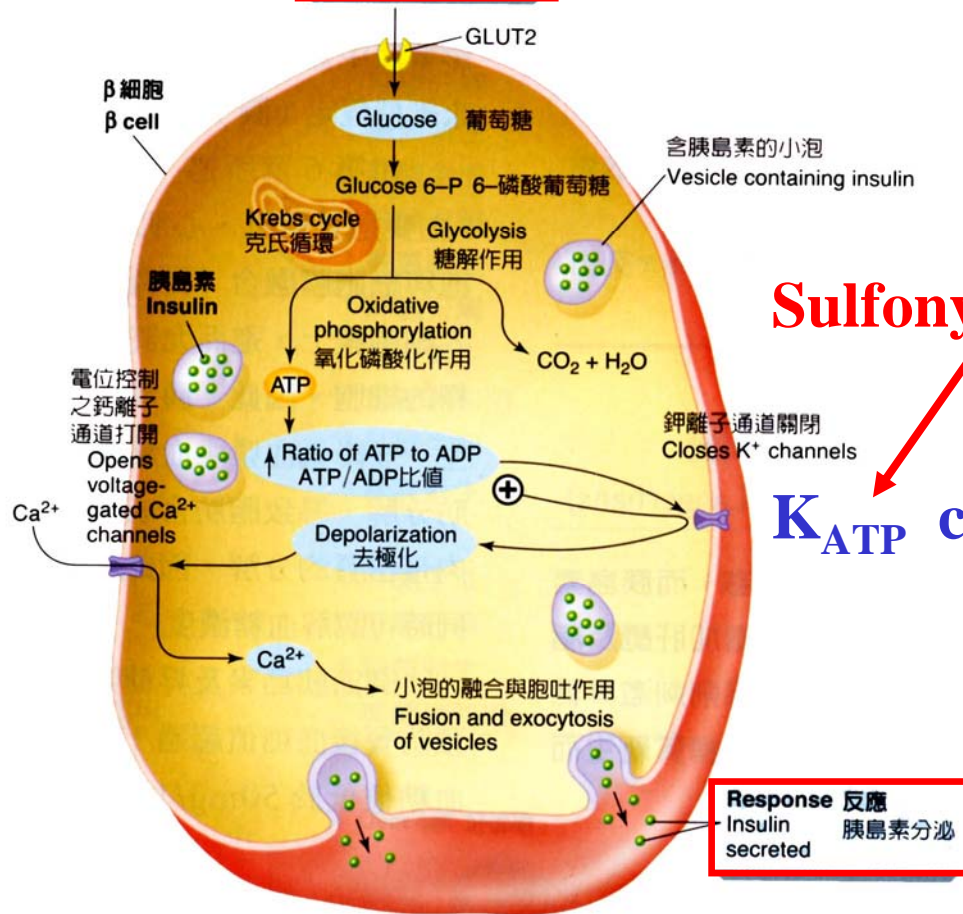


Regulation of Insulin Secretion

禁食 (65-105 mg/dl)

Stimulus 刺激
Blood glucose 血糖

進食 (140-150 mg/dl)

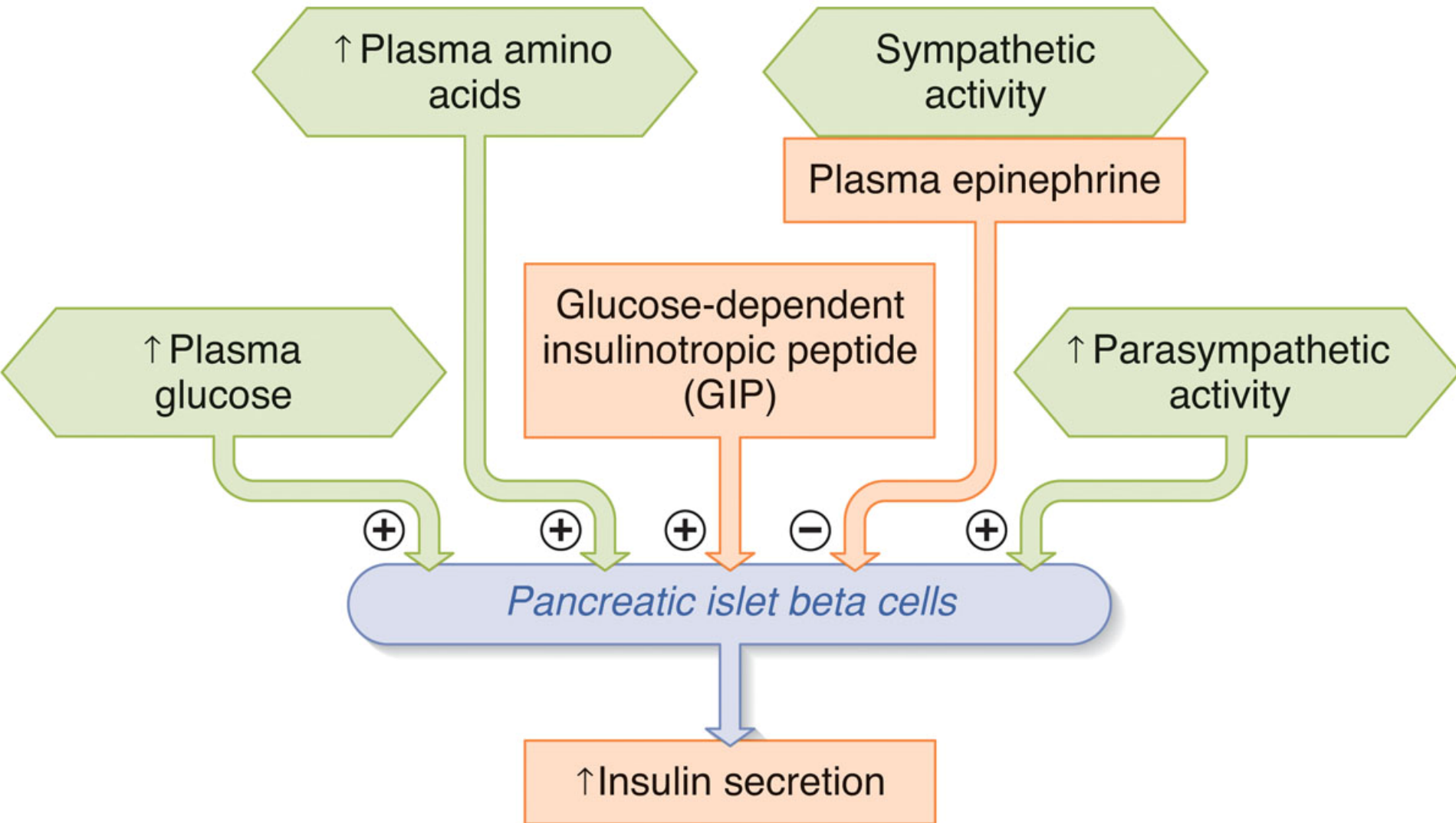


Sulfonylurea therapy

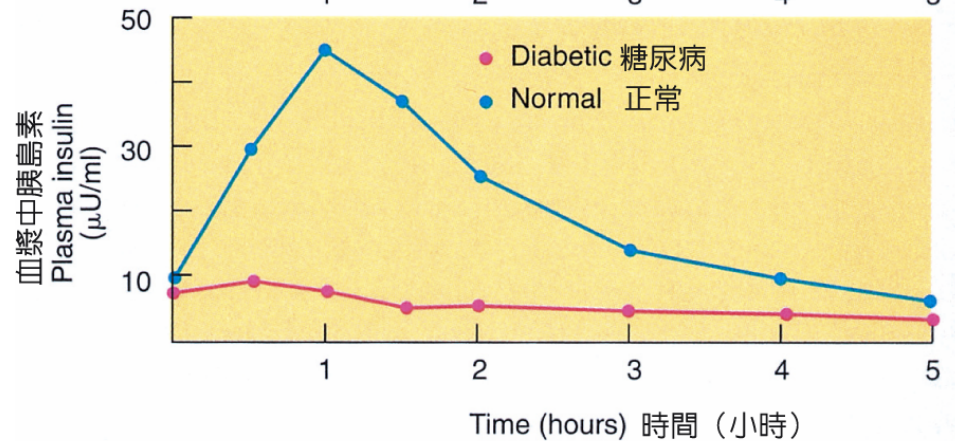
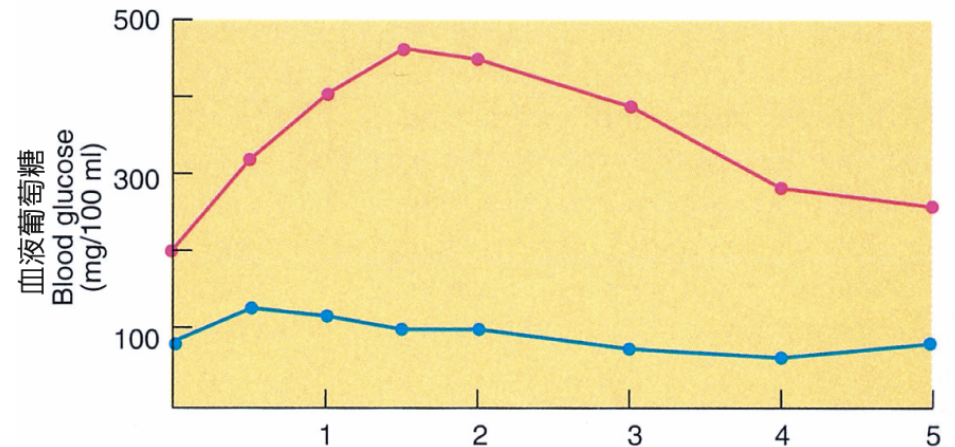
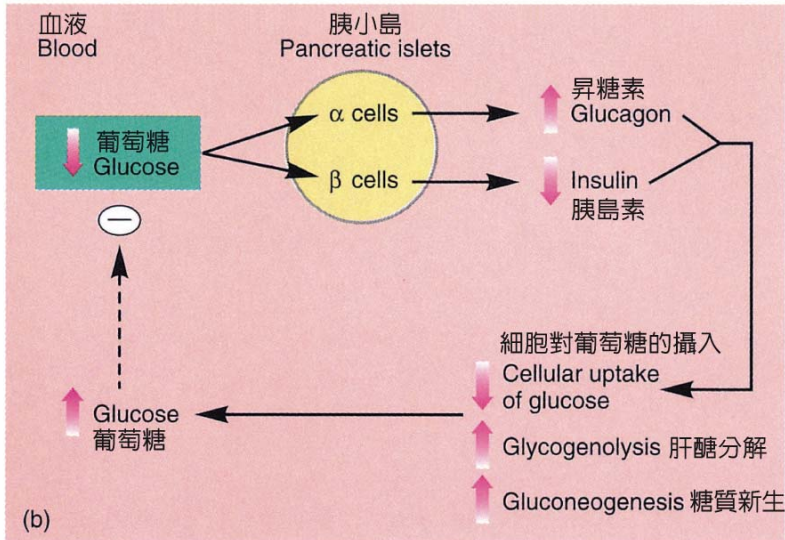
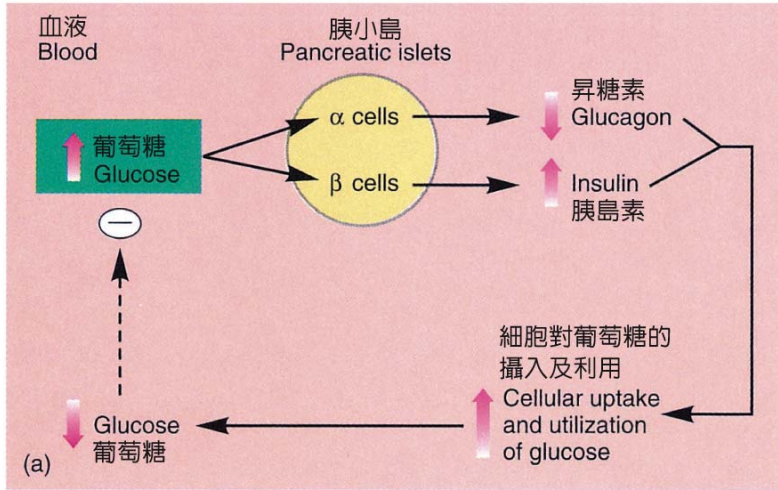
K_{ATP} channel

Regulation of Insulin Secretion

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

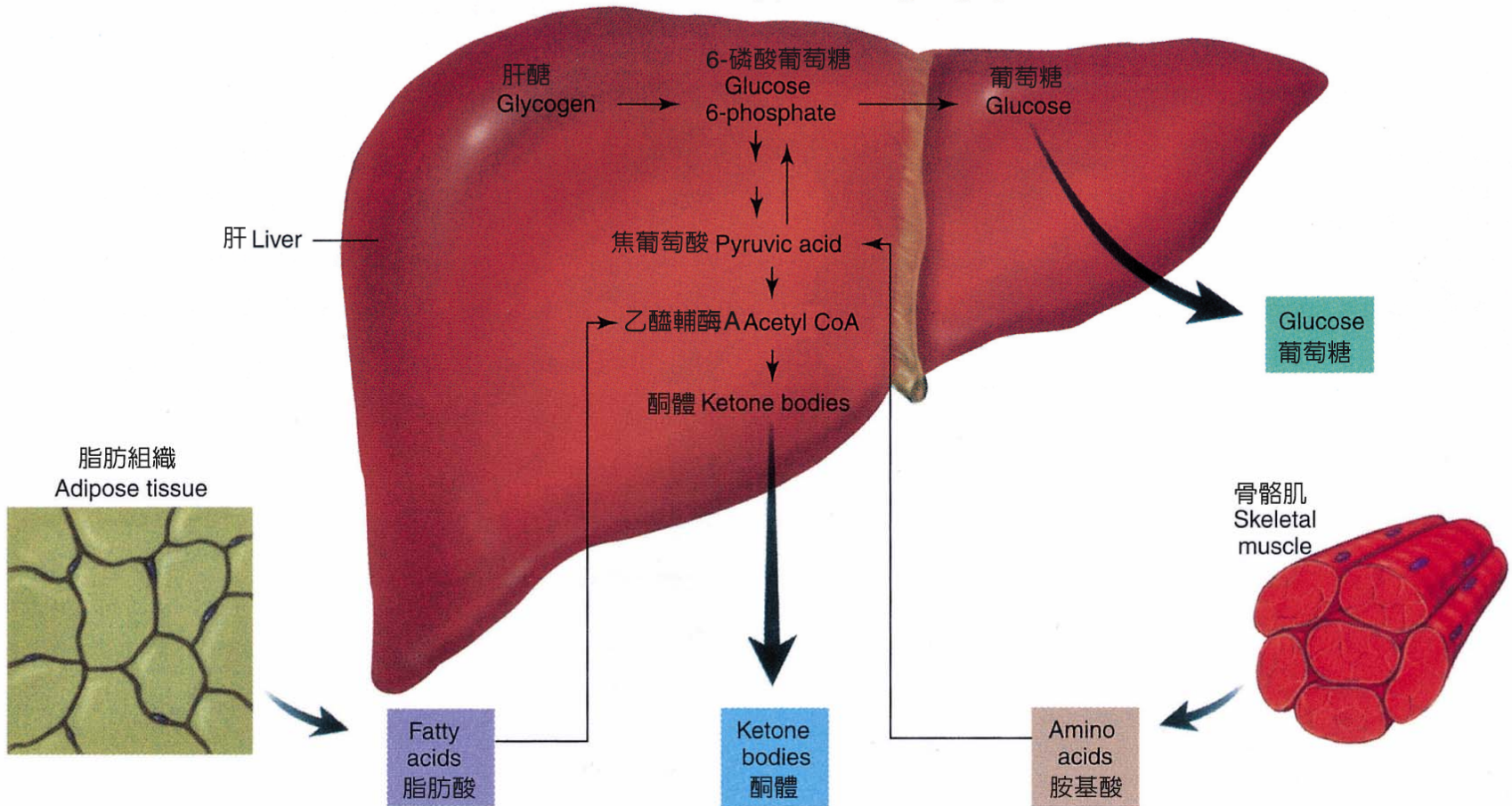


Insulin/Glucagon Secretion: Blood Glucose

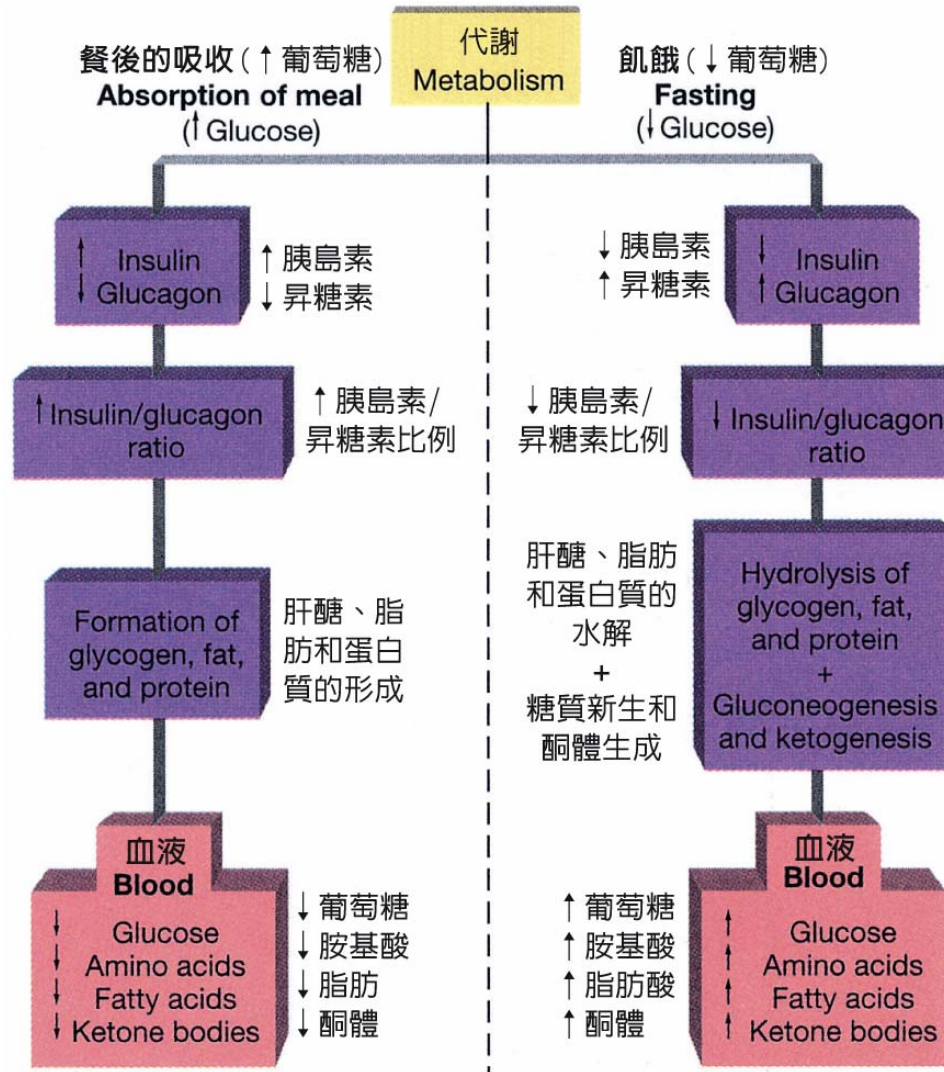


Insulin/Glucagon Secretion: Fasting

飢餓 (↓胰島素, ↑昇糖素)
Fasting (↓insulin, ↑glucagon)



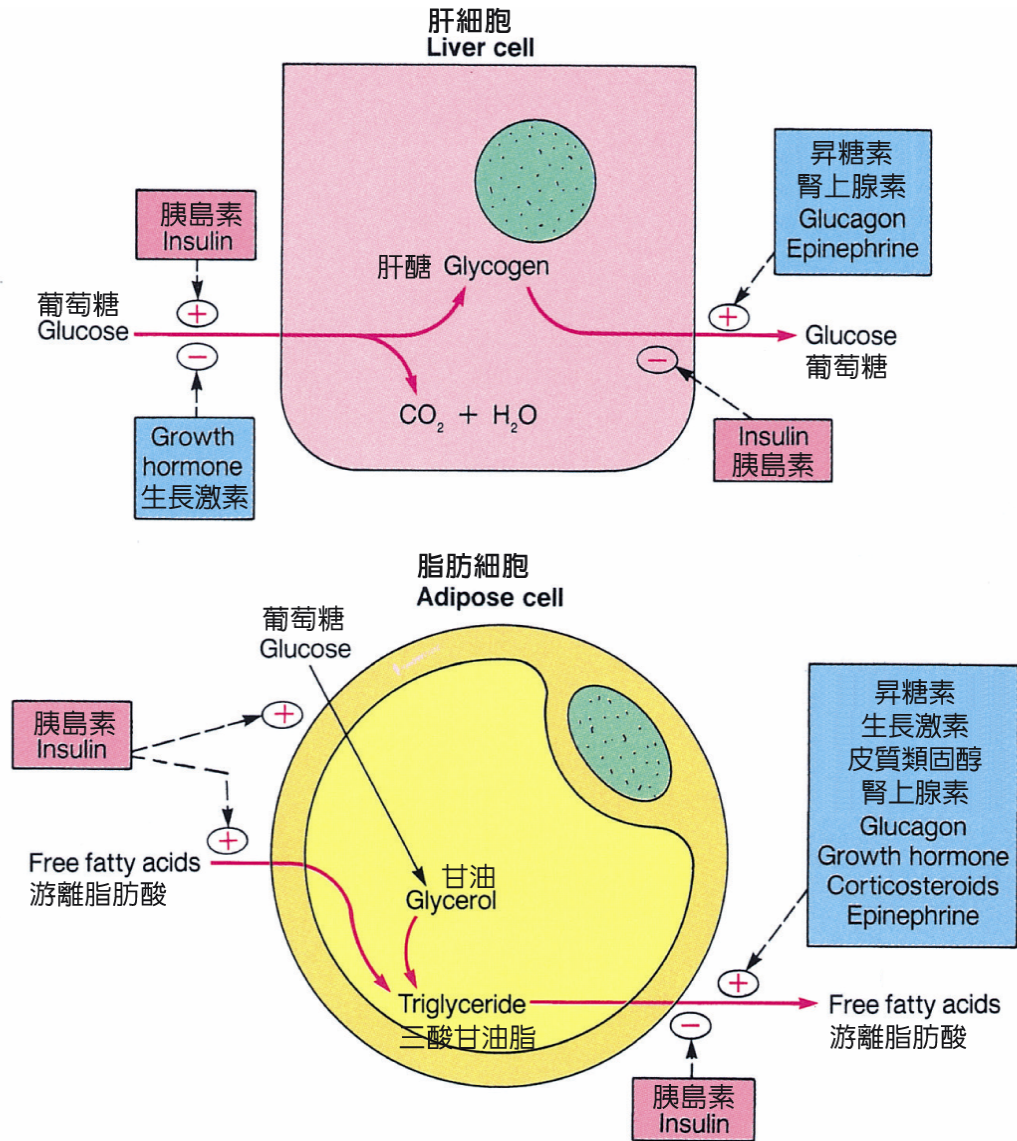
Regulation of Insulin/Glucagon Secretion



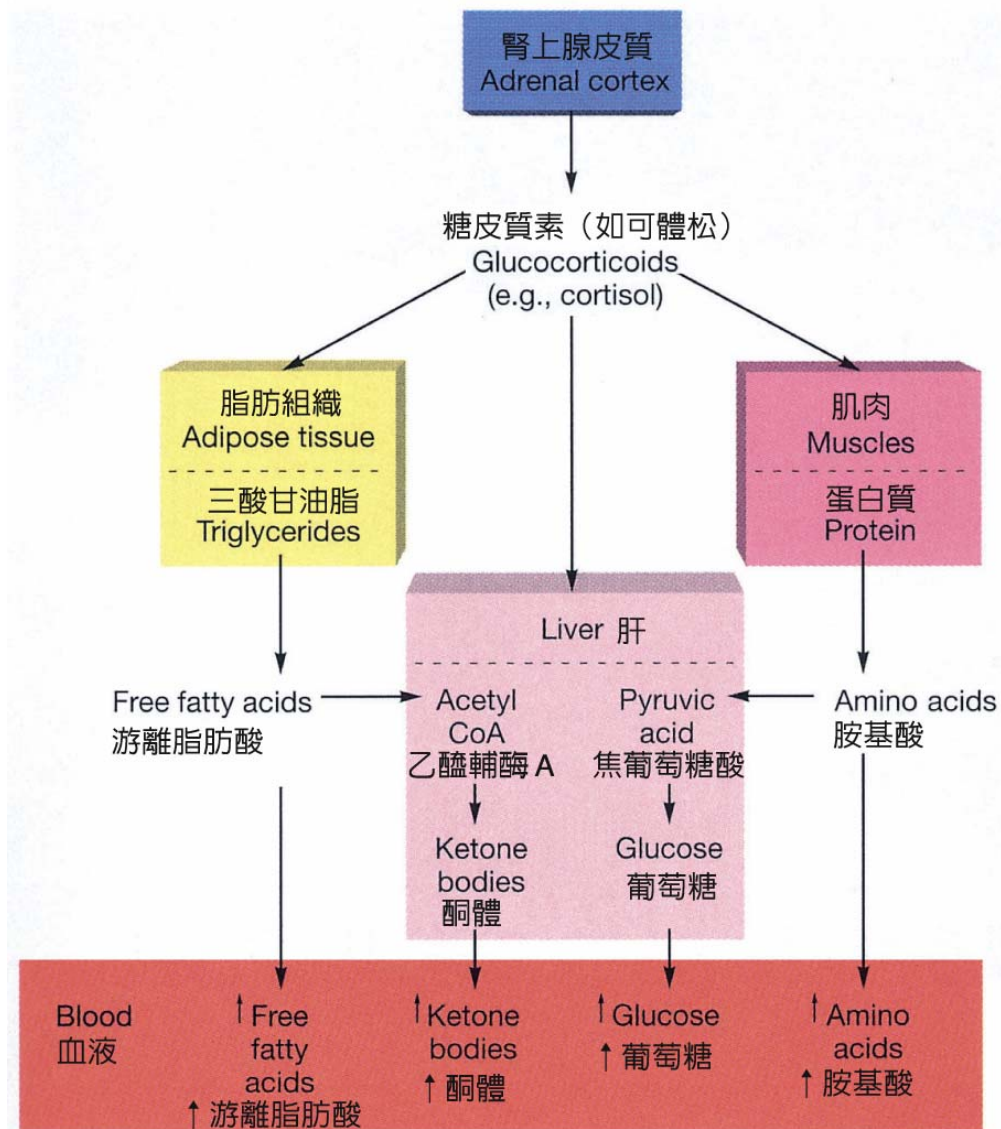
Metabolic Effects of Hormones

激 素	血 糖	碳水化合物的代謝	蛋白質代謝	脂肪代謝
胰島素	下 降	↑ 肝糖生成 ↓ 肝糖分解 ↓ 糖質新生作用	↑ 蛋白質合成	↑ 脂肪生成 ↓ 脂肪分解 ↓ 酮體生成
昇糖素	上 升	↓ 肝糖生成 ↑ 肝糖分解 ↑ 糖質新生作用	無直接作用	↑ 脂肪分解 ↑ 酮體生成
生長激素	上 升	↑ 肝糖生成 ↑ 肝糖分解 ↓ 葡萄糖利用	↑ 蛋白質合成	↓ 脂肪生成 ↑ 脂肪分解 ↑ 酮體生成
糖皮質素	上 升	↑ 肝糖生成 ↑ 糖質新生作用	↓ 蛋白質合成	↓ 脂肪生成 ↑ 脂肪分解 ↑ 酮體生成
腎上腺素	上 升	↓ 肝糖生成 ↑ 肝糖分解 ↑ 糖質新生作用	無直接作用	↑ 脂肪分解 ↑ 酮體生成
甲狀腺素	無作用	↑ 葡萄糖利用	↑ 蛋白質合成	無直接作用

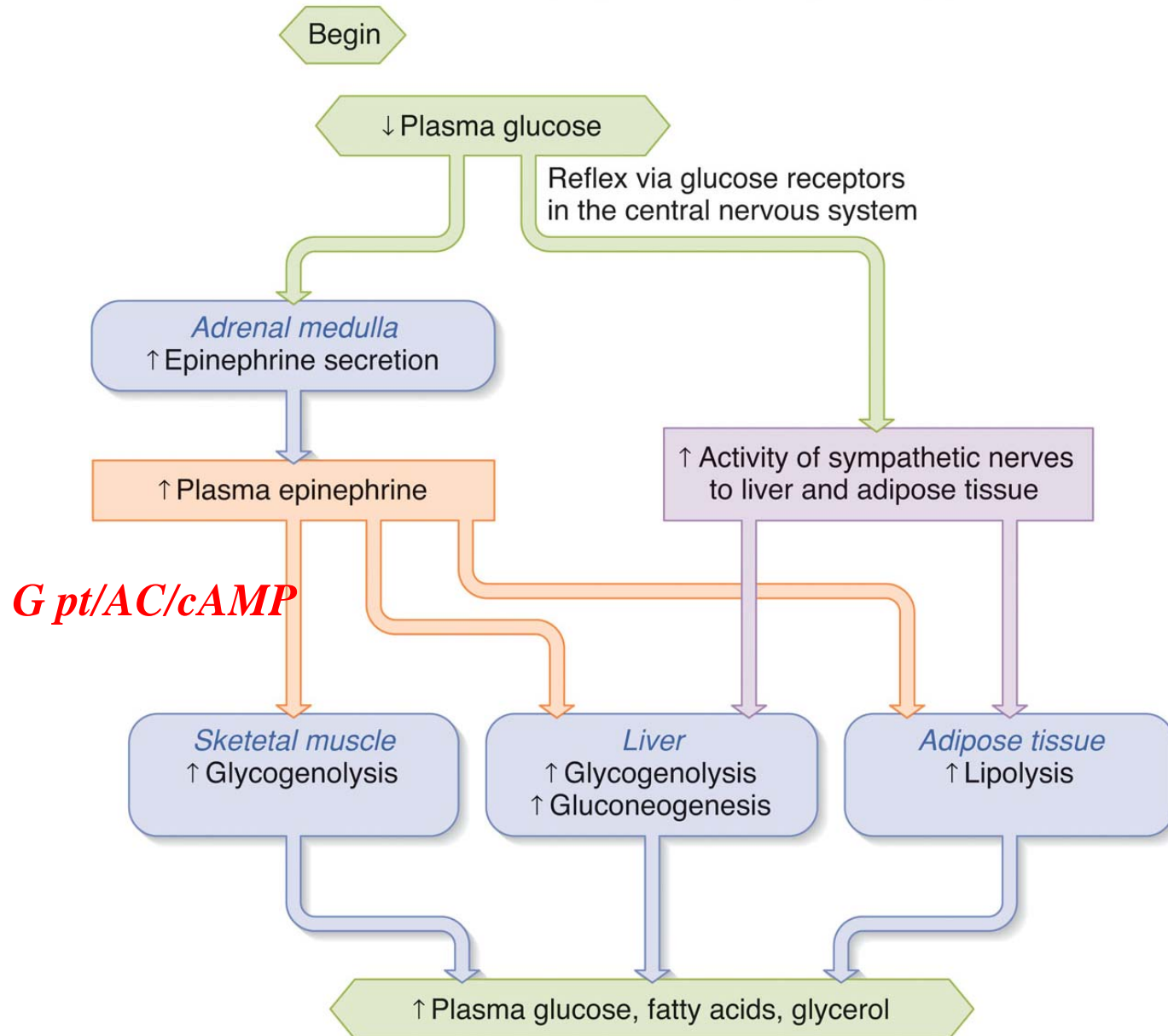
Metabolic Effects of Hormones



Metabolic Effects of Cortisol



Metabolic Effects of EP/Sym Nerves



Syphon Honey

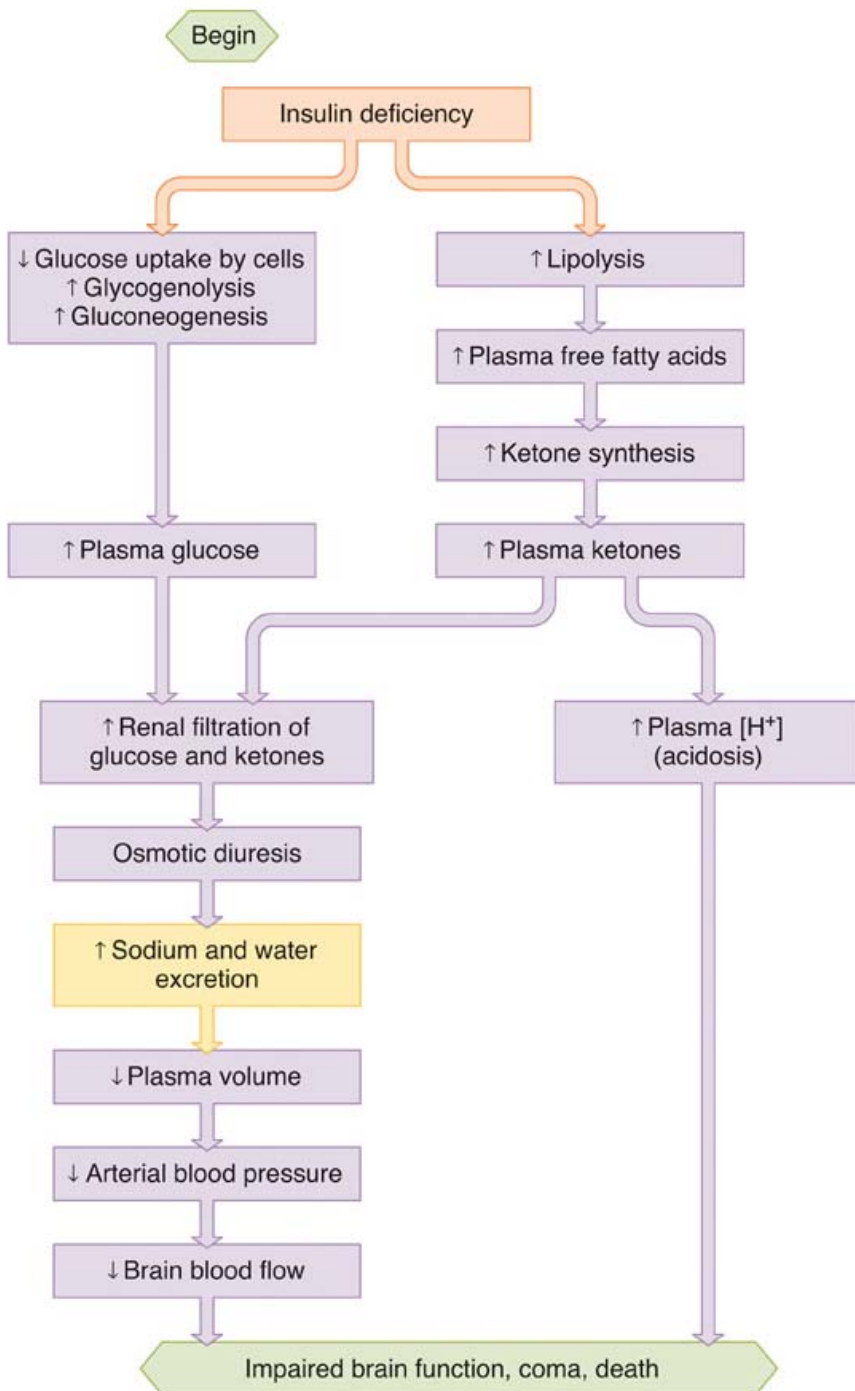
Diabetes Mellitus

特性	依賴型(第一型) IDDM	非依賴型(第二型) NIDDM
發生年紀	< 20歲 (幼發型DM)	> 40歲 (成年型DM)
症狀發生	快	慢
所佔比率	10%	90%
發生酮酸症	經常	很少
和肥胖有關	很少	經常
小島的β細胞(疾病初期)	受損	健全
胰島素分泌	減少	正常或增加
對抗小島細胞的 自身免疫抗體	有	無
治療	注射胰島素	飲食、運動、口服降血糖藥 (sulfonylureas)

IDDM

NIDDM

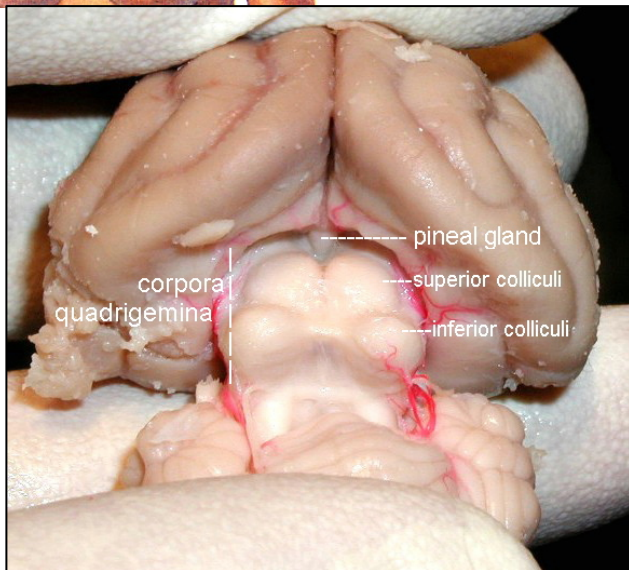
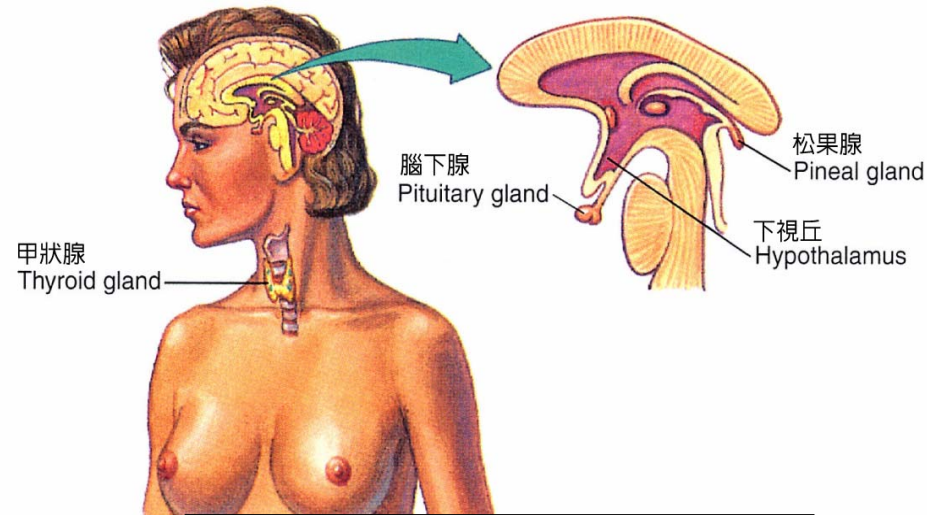




Diabetic Ketoacidosis IDDM

Excessive urine production
(polyuria)
Excessive thirst
(polydipsia)
Excessive eating
(polyphagia)

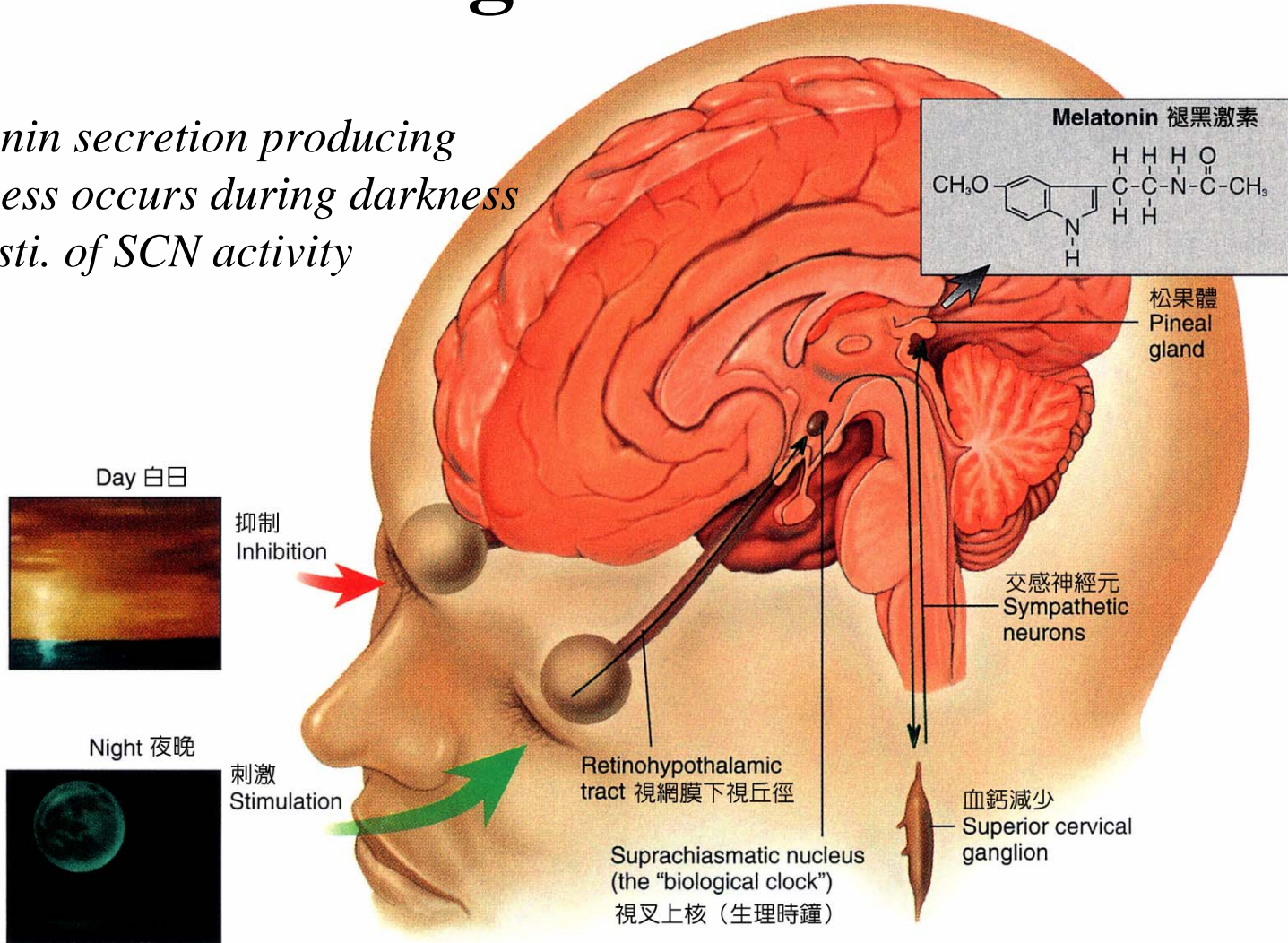
Pineal Gland



- ❖ Small gland attached to 3rd ventricle of brain
- ❖ Consists of pinealocytes & neuroglia
- ❖ Melatonin responsible for setting of biological clock
- ❖ Jet lag & Seasonal Affective Disorder (SAD) treatment is bright light

Effect of Light on Pineal Gland

- *Melatonin secretion producing sleepiness occurs during darkness due to sti. of SCN activity*



■ 圖 11.31 褪黑激素的分泌。起源於上頸神經節的交感神經軸突刺激松果腺分泌褪黑激素。這些神經元的活性是由下視丘的視交叉上核所調節，視交叉上核設定日變週期。節律由視網膜神經元導入光／暗週期。

生活可以很多角度

有位老師進了教室，在白板上點了一個黑點。
他問班上的學生說「這是什麼？」
大家都異口同聲說「一個黑點。」

老師故作驚訝的說

「只有一個黑點嗎？這麼大的白板大家都沒有看見？」

試想

你看到的是什麼？每個人身上都有一些缺點，
但是你看到的是那些呢？
是否只有看到別人身上的"黑點"
卻忽略了他擁有了一大片的白板(優點)？
其實每個人必定都有許多的優點，
換一個角度去看吧!!你會有更多新的發現。