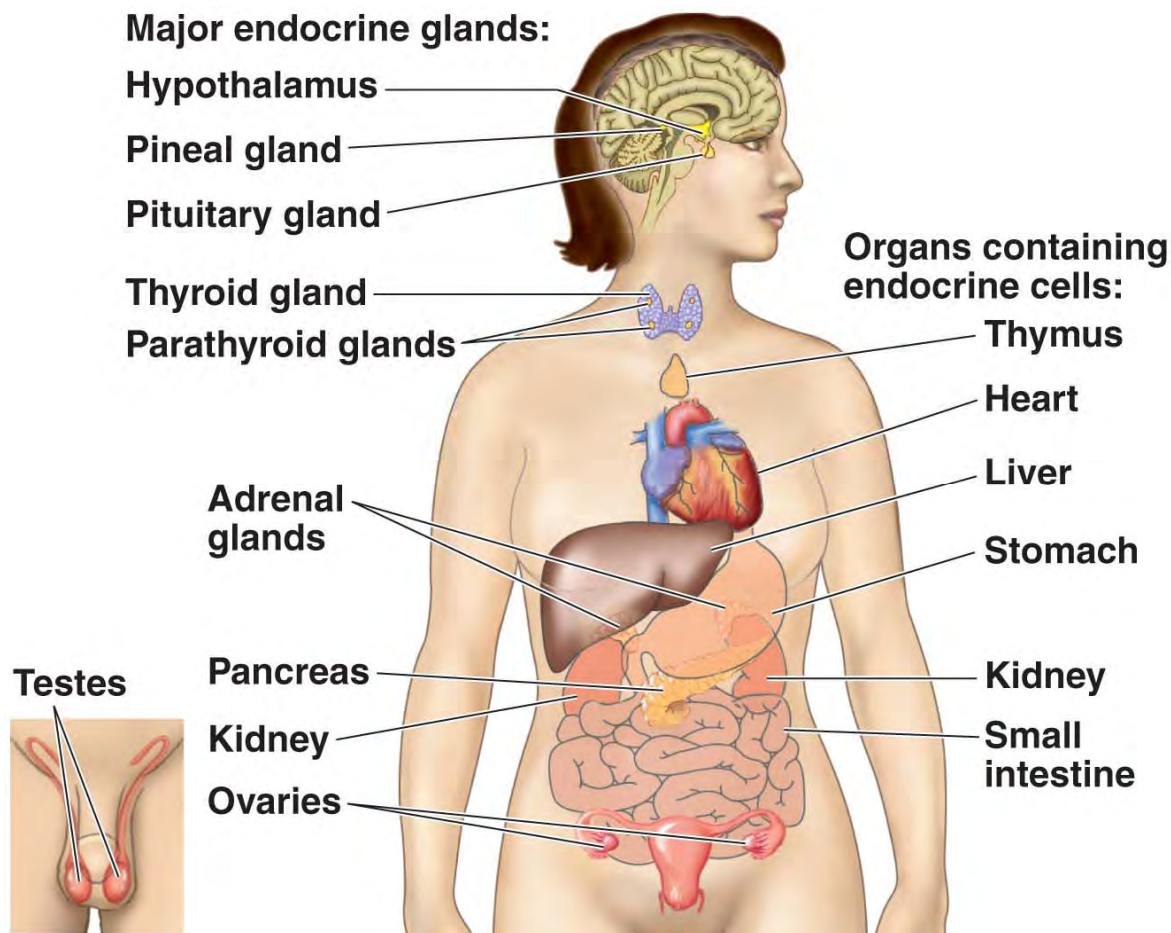


1 Hormones and the Endocrine System

Chapter 45



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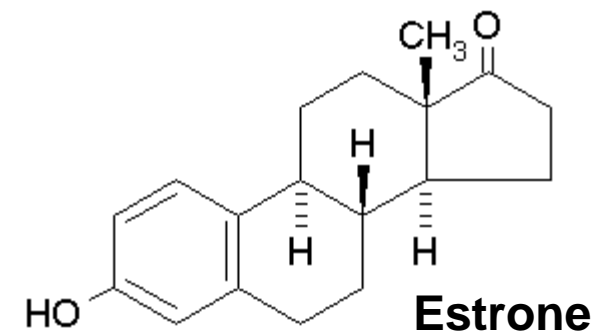
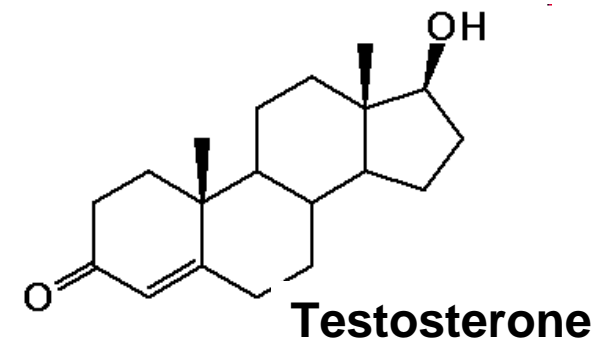
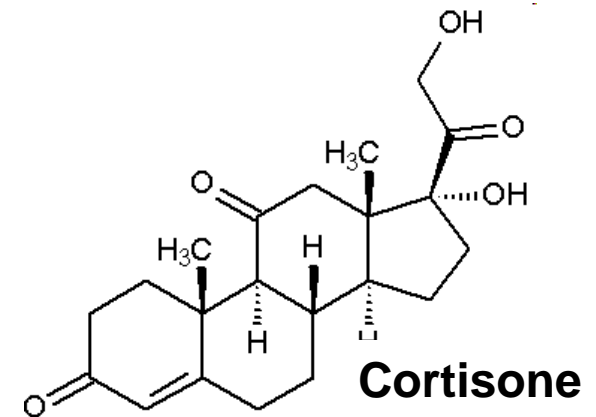


Figure 45.4 (Campbell 9th ed)

What is the Endocrine System?

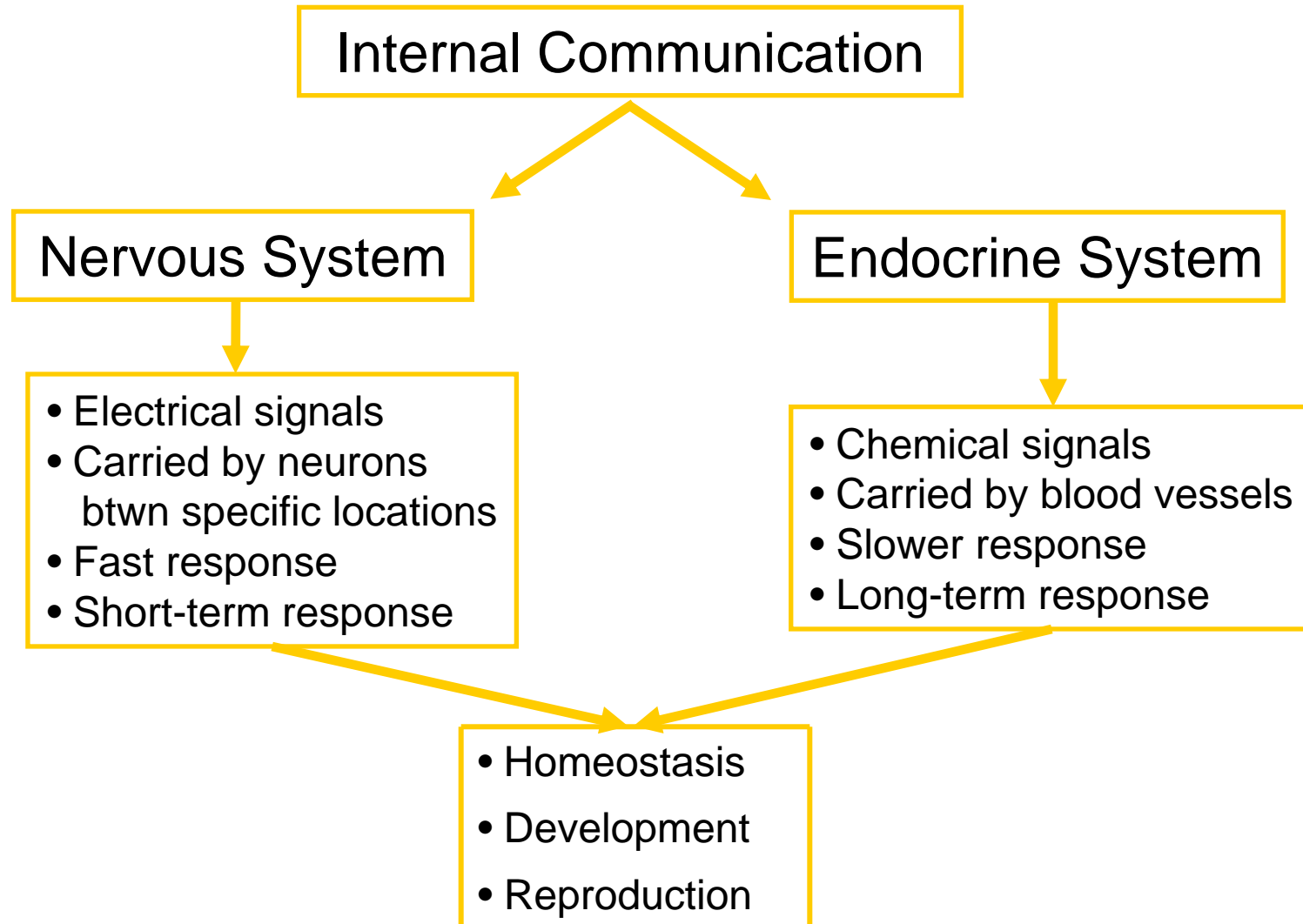
The glands and organs
that secrete chemicals (hormones)
into the circulatory system
for delivery via the blood and lymph
to affect the function of
distant organs, tissues and cells
involved in a variety of functions such as:

- | | | |
|-------------------------|------------------------------|----------------------------|
| • Growth | • Metabolic rate | • Mood |
| • Reproduction | (O ₂ consumption) | • Fight or flight response |
| • Development | • Osmoregulation | • Pain perception |
| • Digestion/ Metabolism | • Immunity | • Circadian rhythm |
| • Appetite control | • Melanin production | • Dreams? |

3

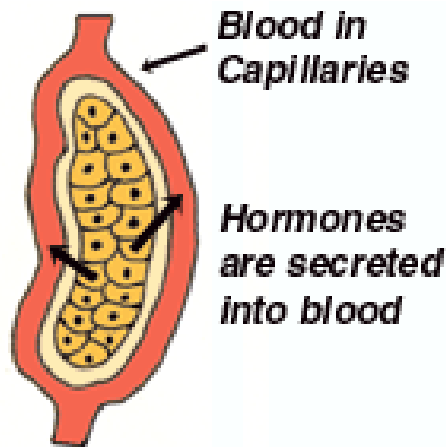
What is the Endocrine System?

Both the nervous and endocrine systems are involved in internal communication but their form and function differ significantly



The Endocrine system uses hormones to communicate between body parts

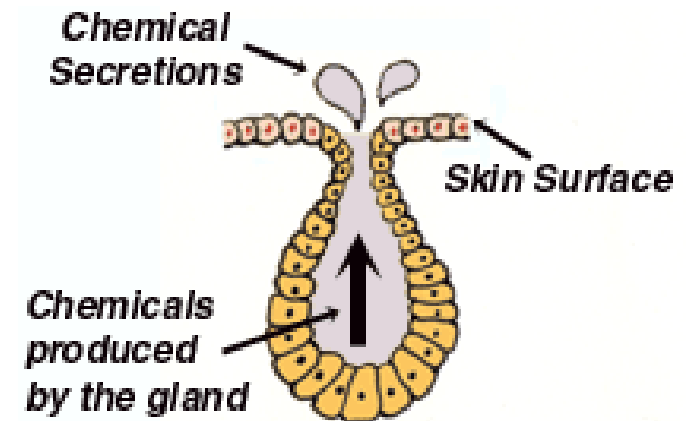
Hormone = Chemical signals secreted into circulatory system via endocrine glands or cells



Endocrine glands

- Secrete products directly into the circulatory system without ducts
- Secretions ARE used for communication btwn body parts thus are hormones
- ARE part of the endocrine system
- Some organs contain endocrine cells or tissues.

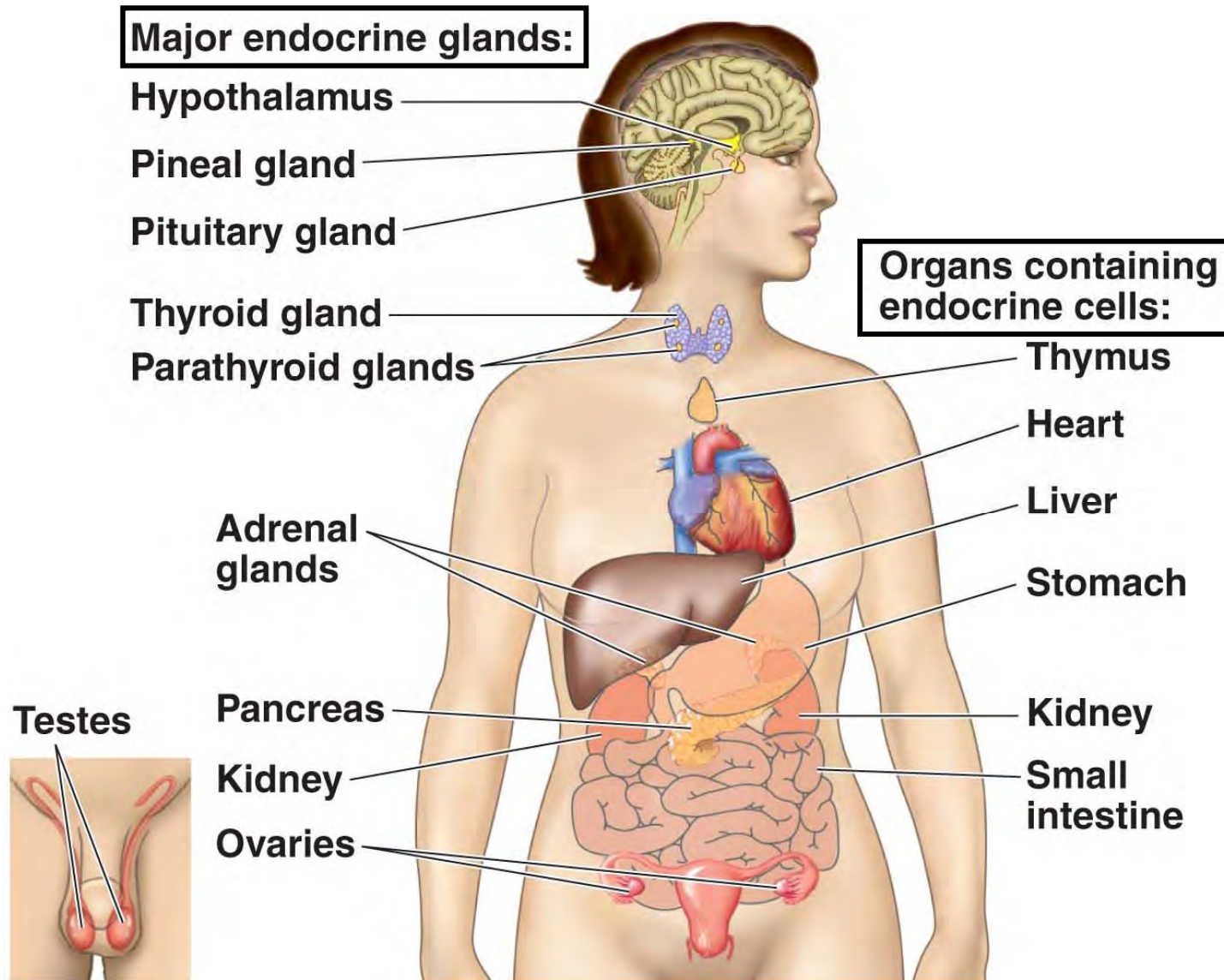
Gland
An organ that synthesizes and secretes a substance into the bloodstream or into ducts or cavities inside the body or on its outer surface.



Exocrine glands

- Secrete products into ducts that lead to the external environment
- Secretions are not used for communication btwn body parts thus are not hormones
- Are NOT part of the endocrine system

Major Endocrine glands and cells



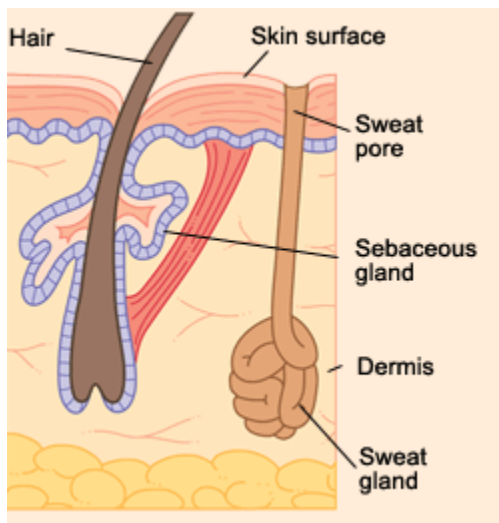
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Figure 45.4 (Campbell 9th ed)

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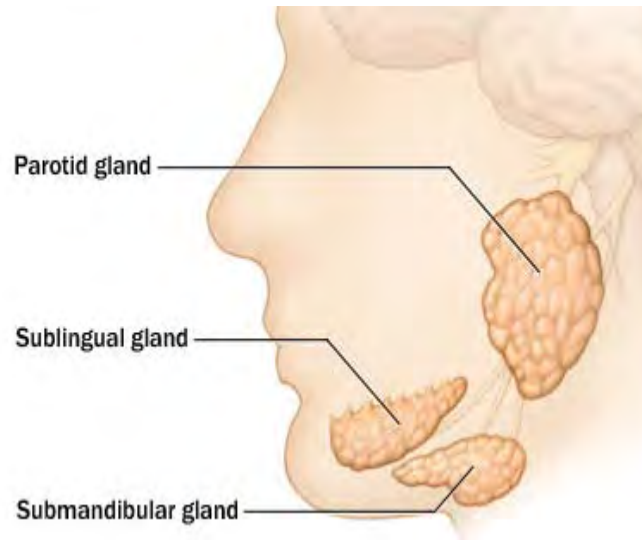
Examples of exocrine glands

Secrete products into ducts
that lead to external environment

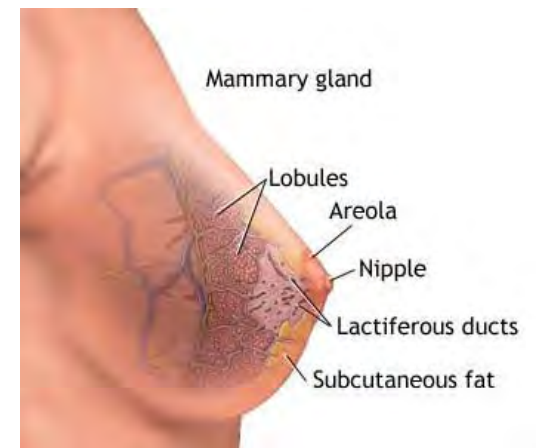


Sebaceous (oil) gland

Sweat gland



Salivary glands



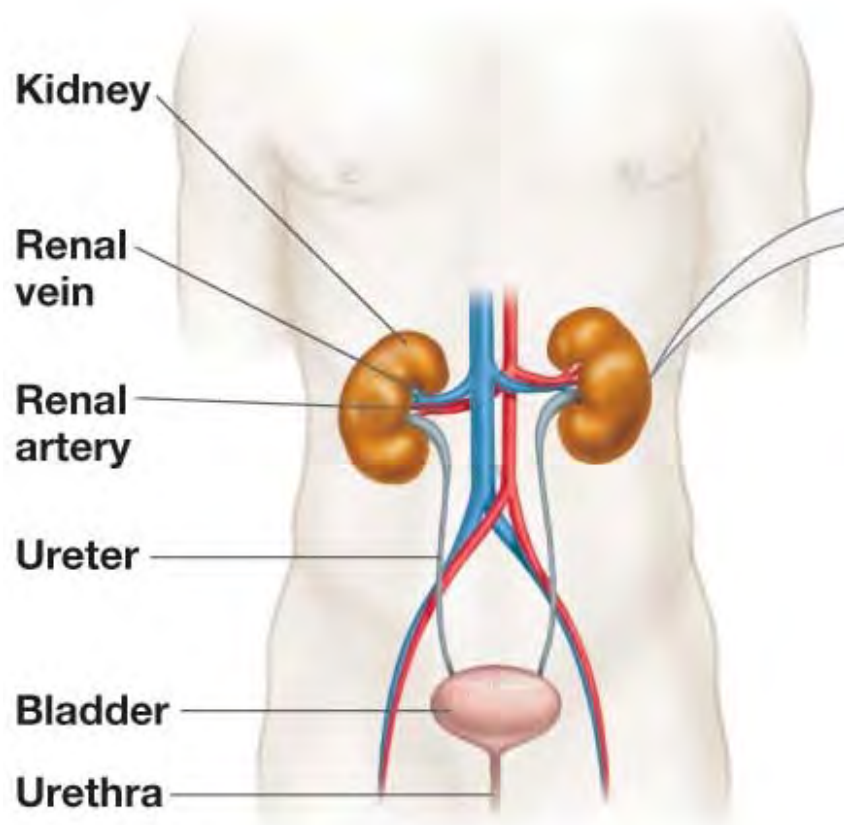
Mammary gland

Exocrine glands are NOT part of the endocrine system

9

Many organs are both endocrine and exocrine glands

Kidney



Exocrine

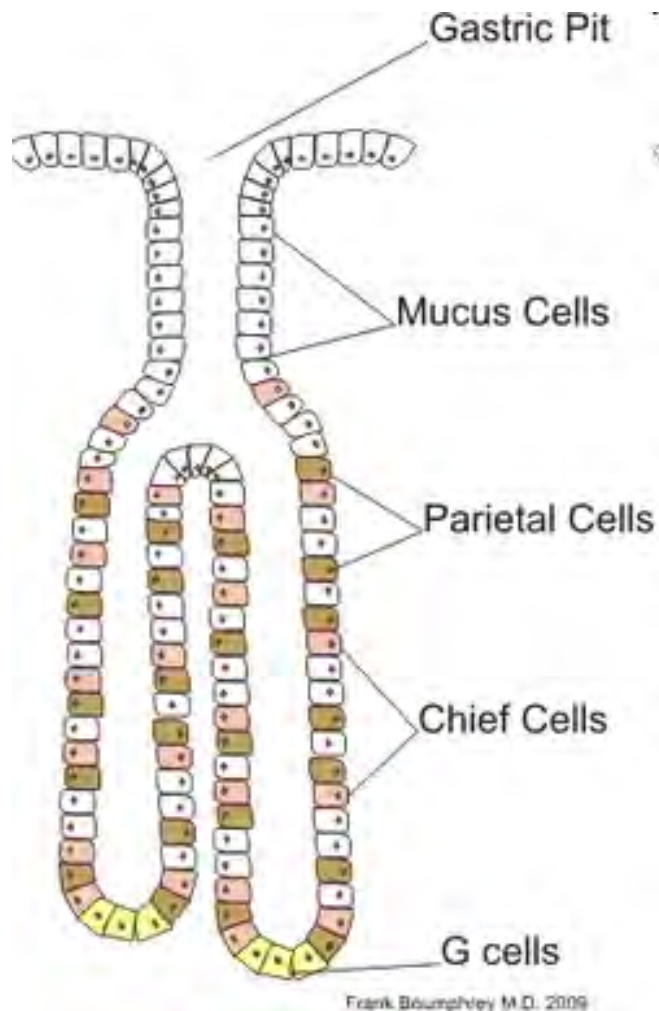
- Secrete from kidney into ureter
- Urine

Endocrine

- Secrete into blood
 - Erythropoietin
 - Stimulates RBC production in bone marrow
 - Thrombopoietin
 - Stimulates platelet production in bone marrow
 - Calcitriol
 - Renin

Many organs are both endocrine and exocrine glands

Stomach



Exocrine

- Secrete into lumen of gastric gland
 - Mucus cells - mucus
 - Parietal cells - H^+ and Cl^-
 - Chief cells - Pepsinogen

Endocrine

- G-cells secrete gastrin into blood
 - Gastrin stimulates HCl production



Coffee stimulates
gastrin release
increasing
HCl in stomach

11 Many organs are both endocrine and exocrine glands

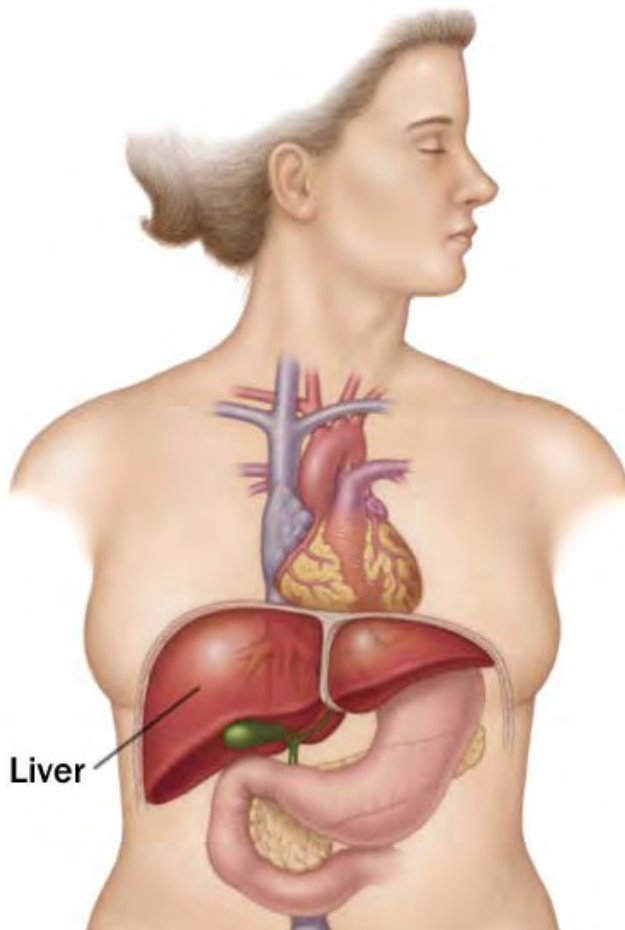
Liver

Exocrine

- Secretes bile into lumen of bile duct

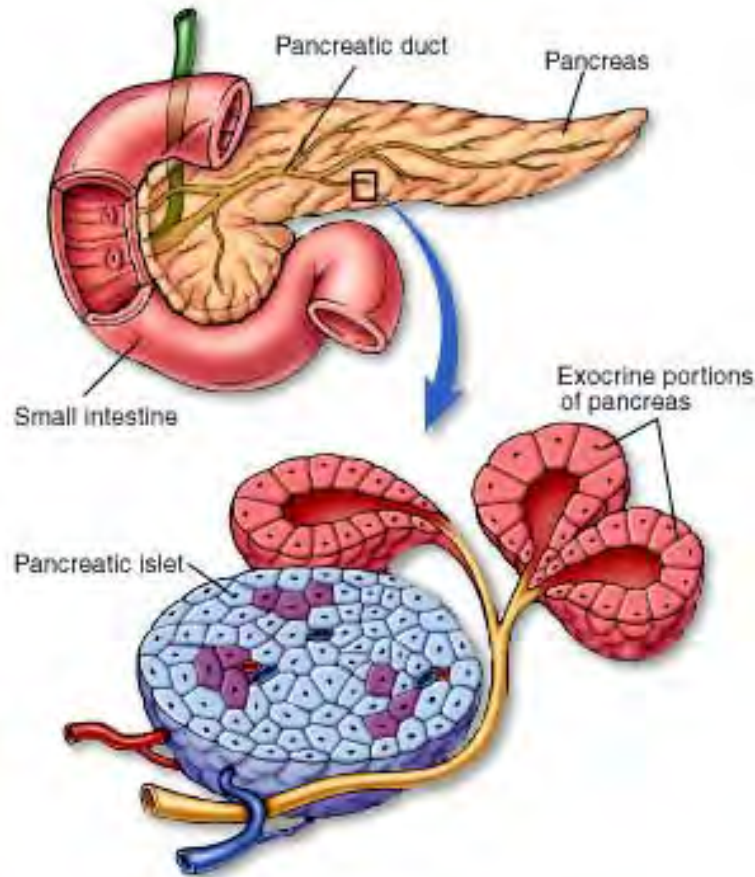
Endocrine

- Along with kidney, secretes thrombopoietin into blood
 - Stimulates platelet production in bone marrow (Megakaryocytopoiesis)
- Angiotensinogen: raises blood pressure
- Insulin-like growth factor 1 (IGF-1) important role in childhood growth



Many organs are both endocrine and exocrine glands

Pancreas



Exocrine

- Secretes bicarbonate and digestive enzymes into lumen of pancreatic duct (which goes into small intestine)

Endocrine

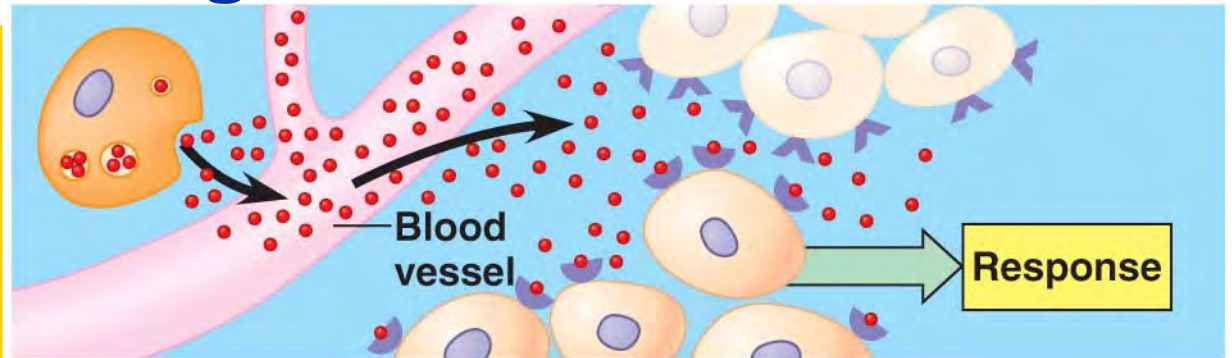
- Secretes insulin & glucagon into blood - regulates blood glucose level

13

Not all chemical signals are endocrine...

Distant
(Endocrine signaling)

Secrete chemicals into blood
to reach all body parts;
only target cells respond
(Chemical = hormone)

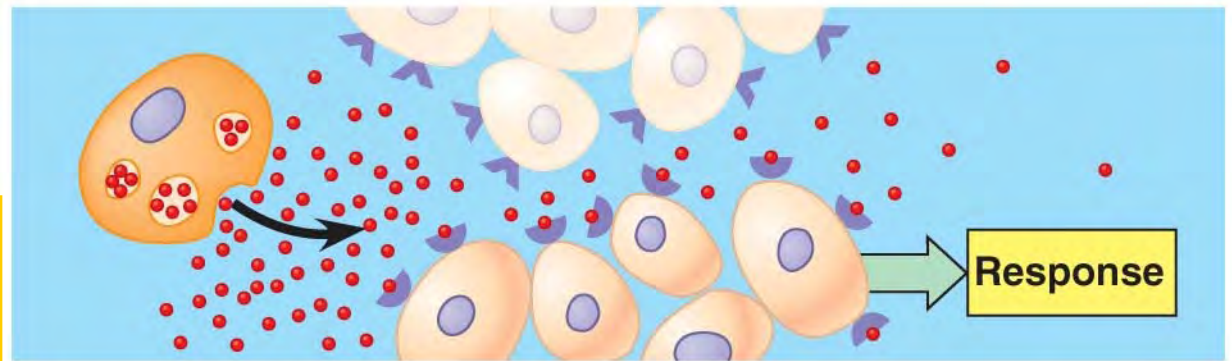


(a) Endocrine signaling

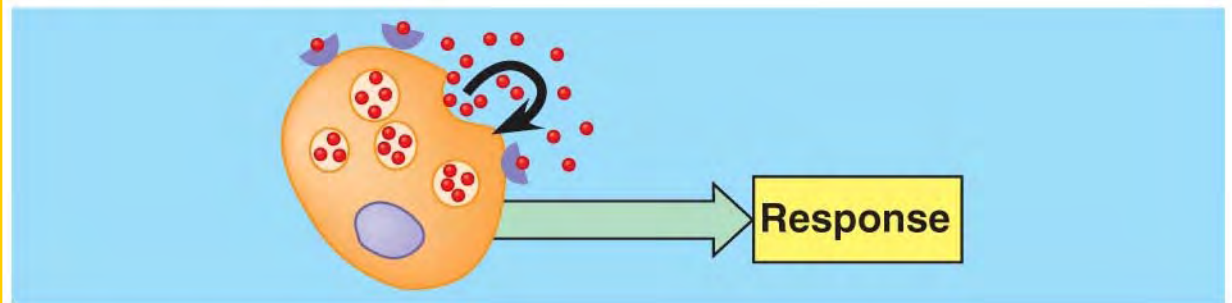
Local Regulators
(paracrine & autocrine signaling)

Secrete chemicals which affect
nearby cells or itself
(Chemical \neq hormone)

NOT part of the endocrine
system since local effect only
and not in blood



(b) Paracrine signaling



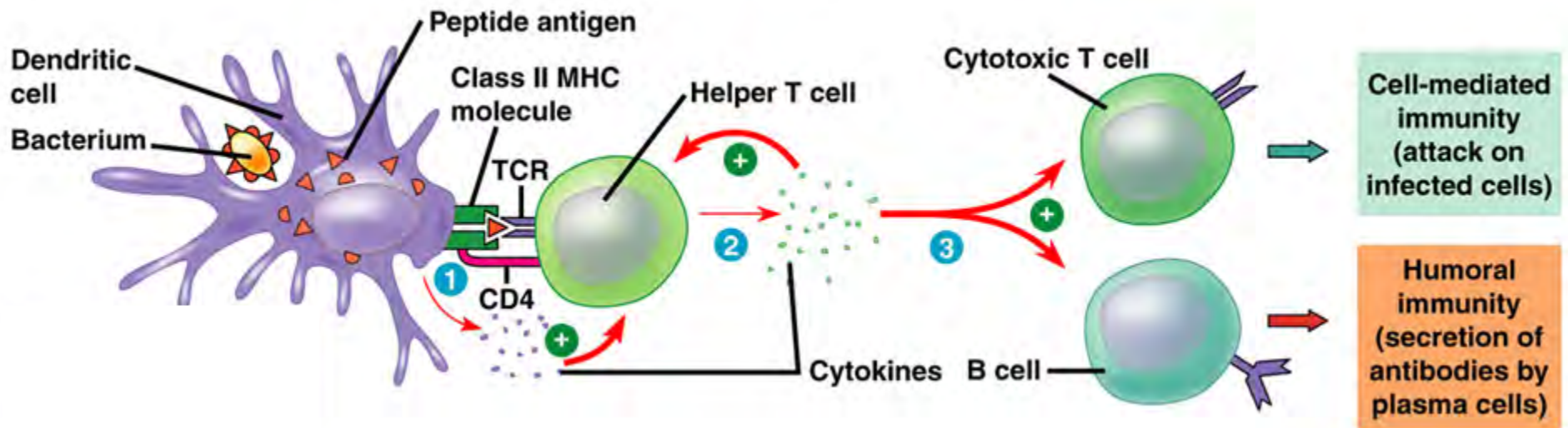
(c) Autocrine signaling

14

Paracrine/ autocrine signaling & Immunity

Chemicals (cytokines) secreted by macrophage activate nearby helper T-cell

Cytokines secreted by helper T-cell activates
B-cell and cytotoxic T-cell (paracrine) and itself (autocrine)



Infected body cells
secrete cytokines
which activate nearby NK cells

NK cells secrete chemicals
killing nearby infected cell

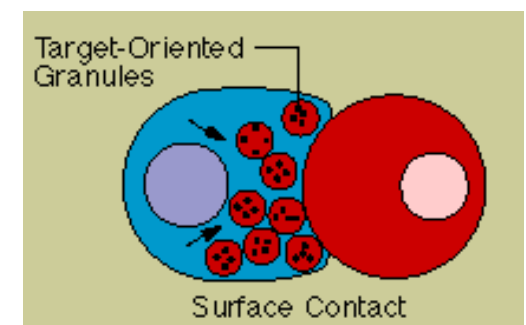
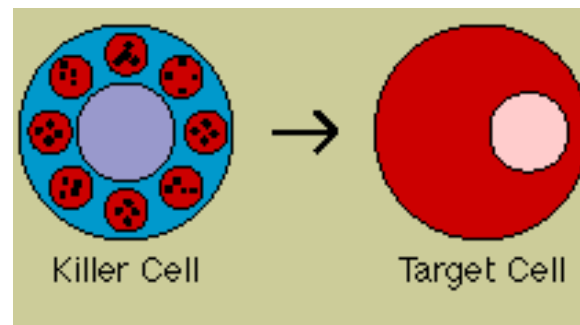
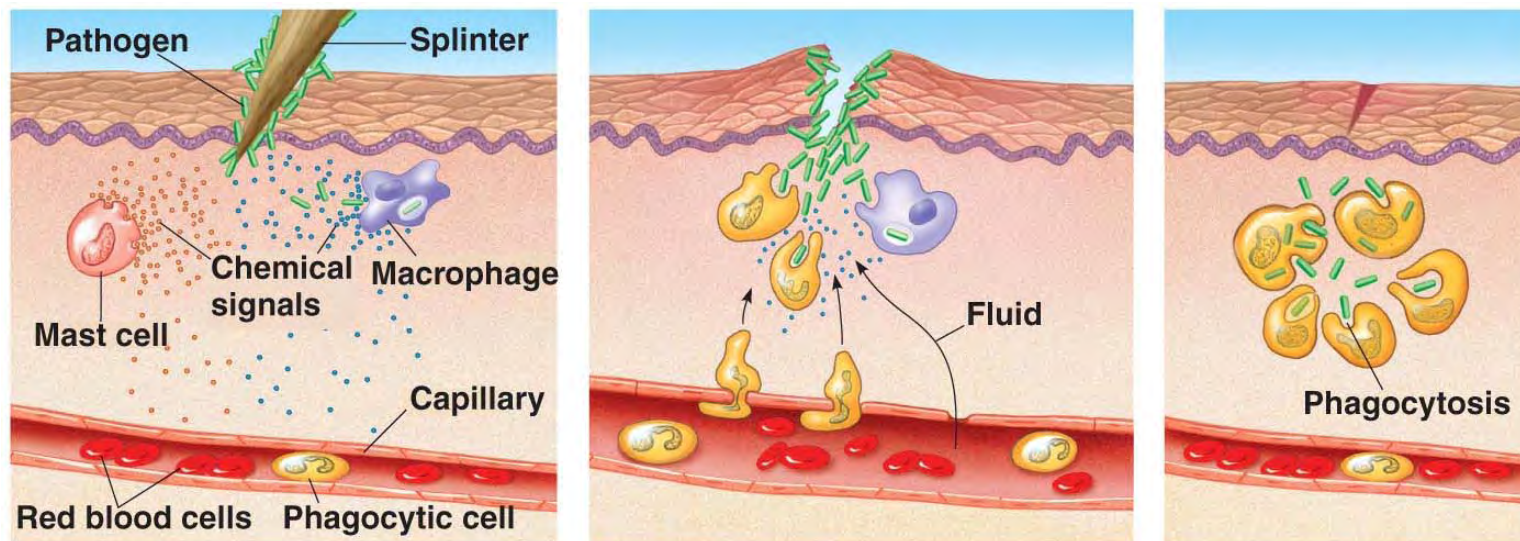


Figure 43.16 (Campbell 9th ed)

16

Paracrine Signaling & Immunity

- Histamine secreted by mast cells increases nearby blood vessel permeability
- Prostaglandins secreted by macrophages attract nearby phagocytic cells

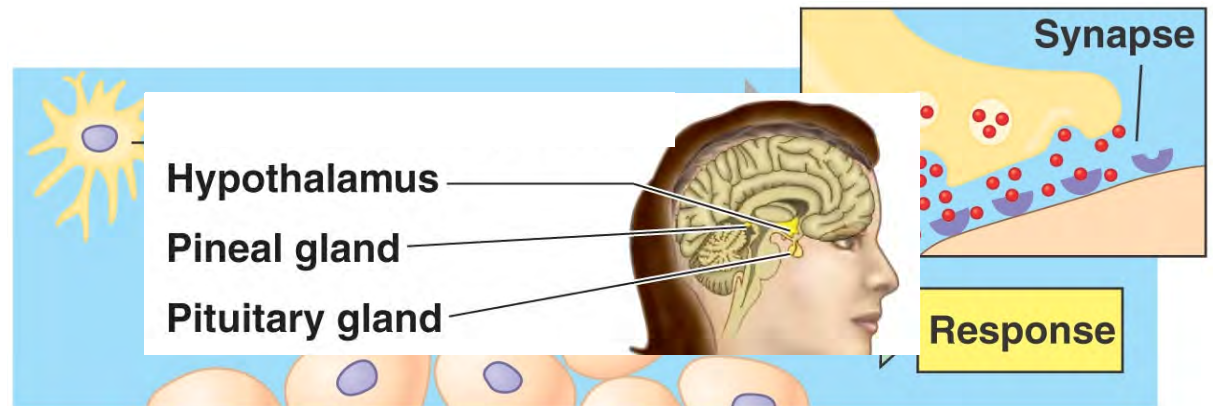


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In this case histamine is a local regulator but histamine is also released by cells in the gastric pit into the blood for different purposes so is a hormone in that case

Other Types of Signaling systems

Neurotransmitters are local regulators that cross synapses

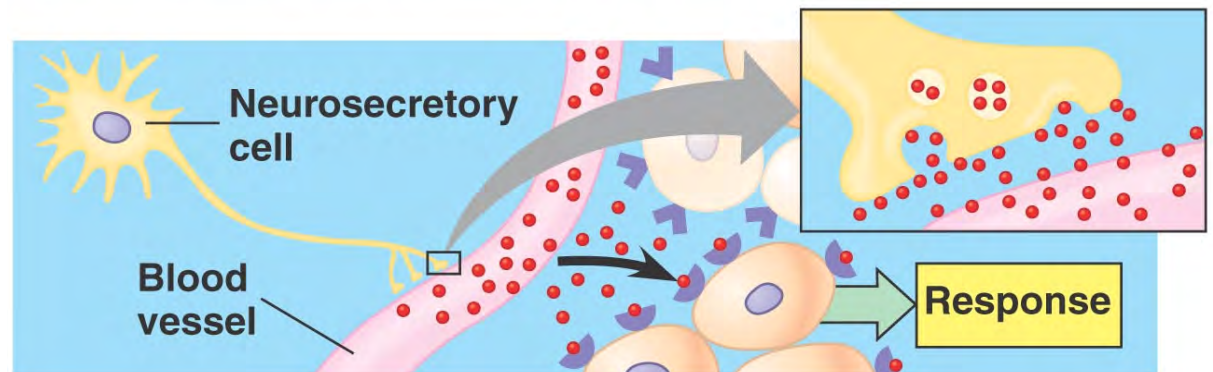


(d) Synaptic signaling

Neurohormones

Released from specialized neurons (neurosecretory cells) of nervous system organs into the blood

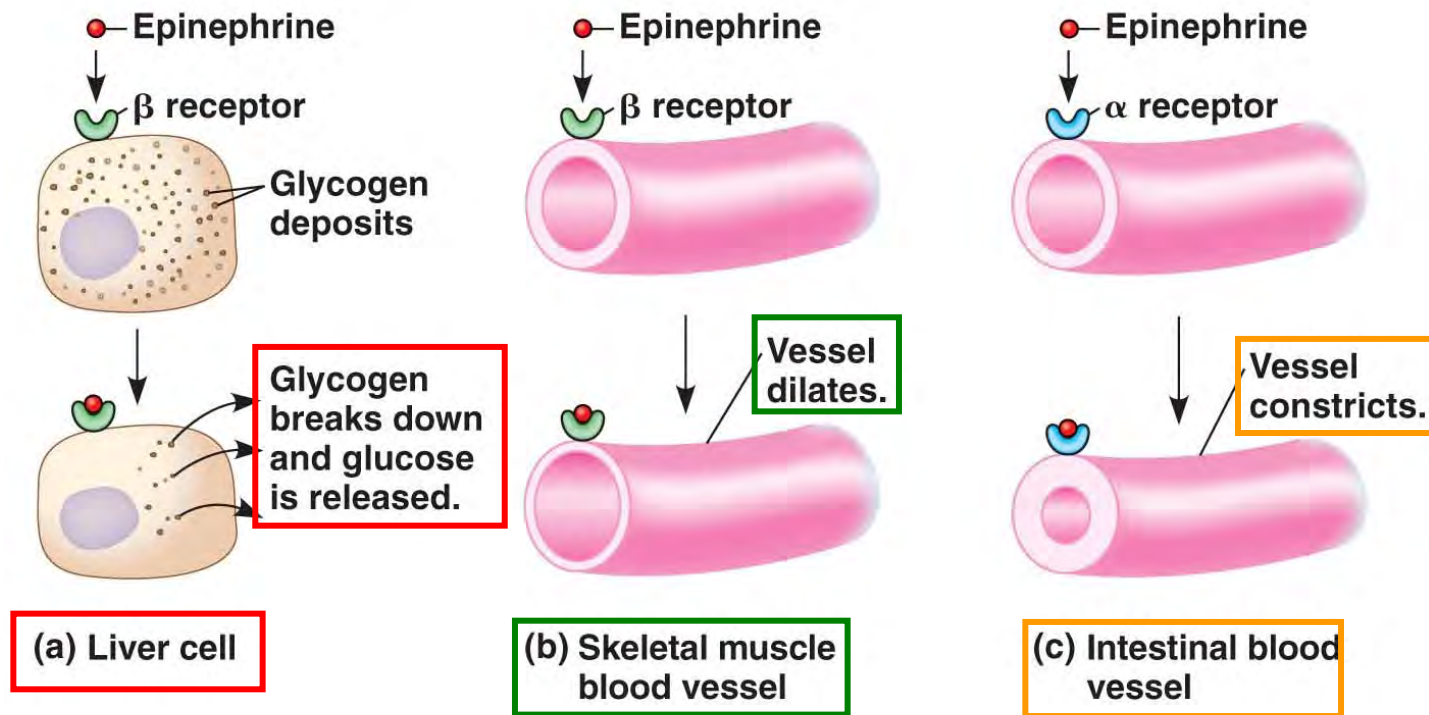
e.g. Anterior pituitary releases prolactin into blood which acts on mammary gland to produce milk



(e) Neuroendocrine signaling

One Hormone may have multiple effects depending on the target

e.g. Epinephrine (produced by adrenal gland) has multiple effects in mediating short-term stress



Neuroendocrine Signaling

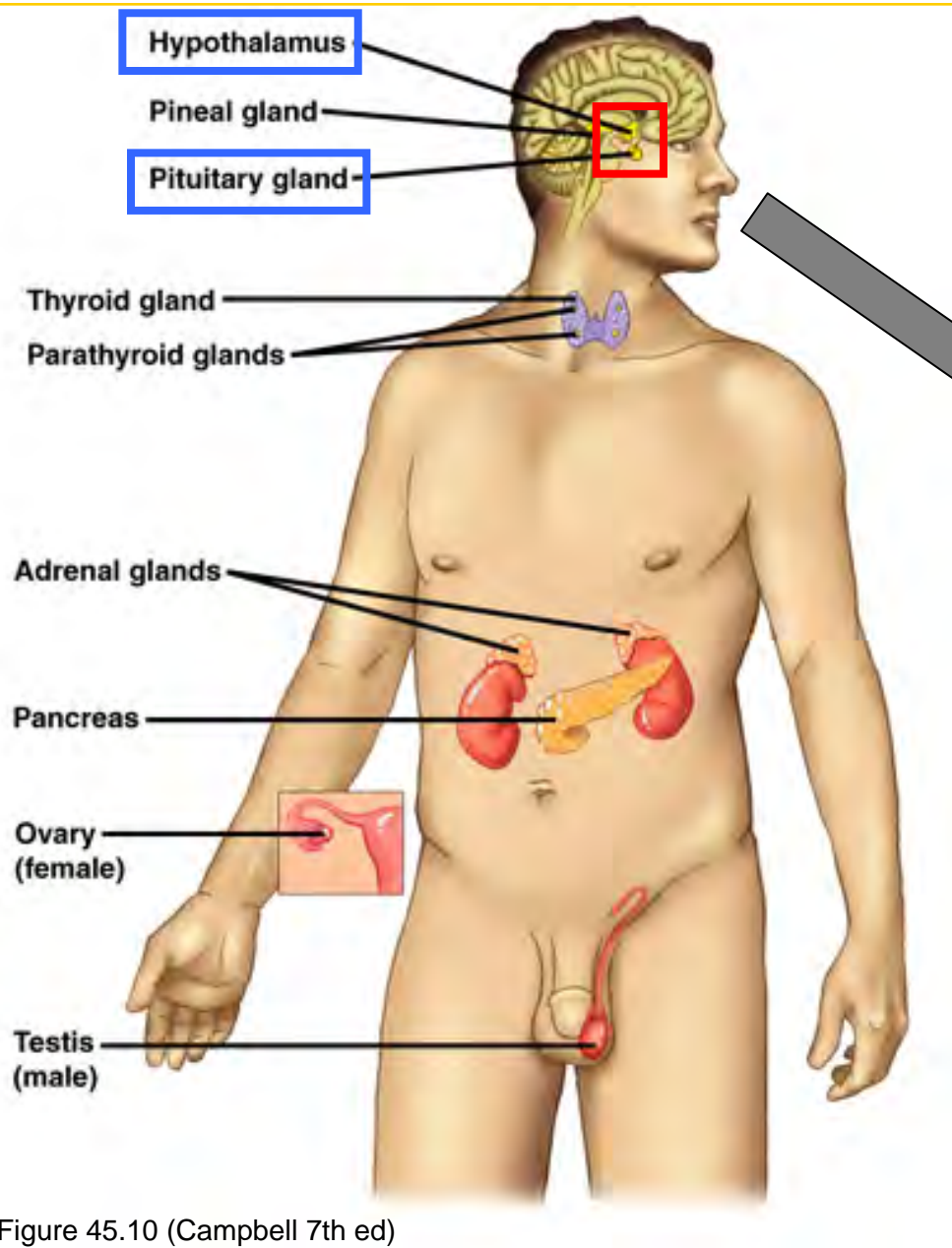


Figure 45.10 (Campbell 7th ed)

Hypothalamus & Pituitary
control much of
endocrine system

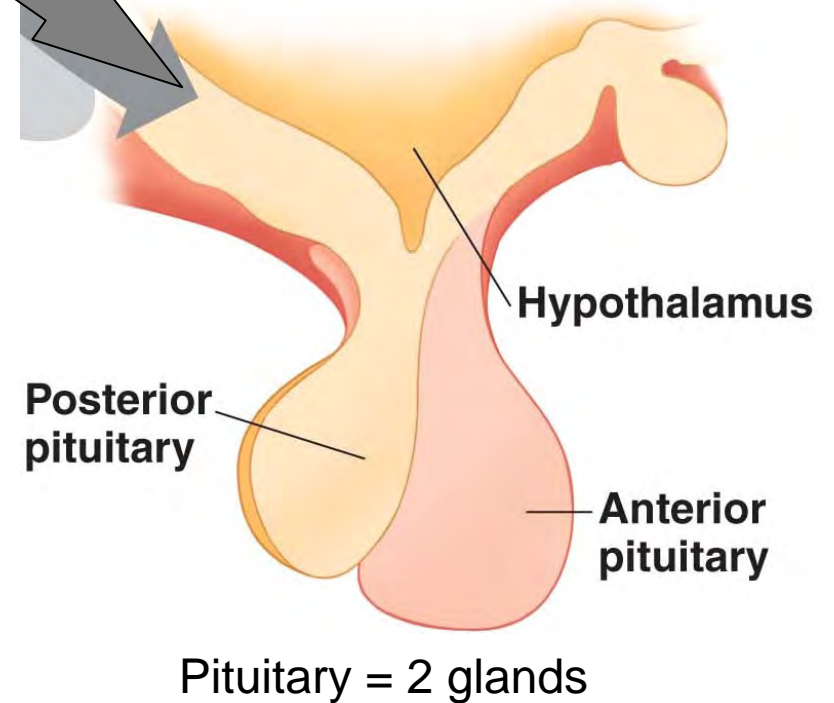
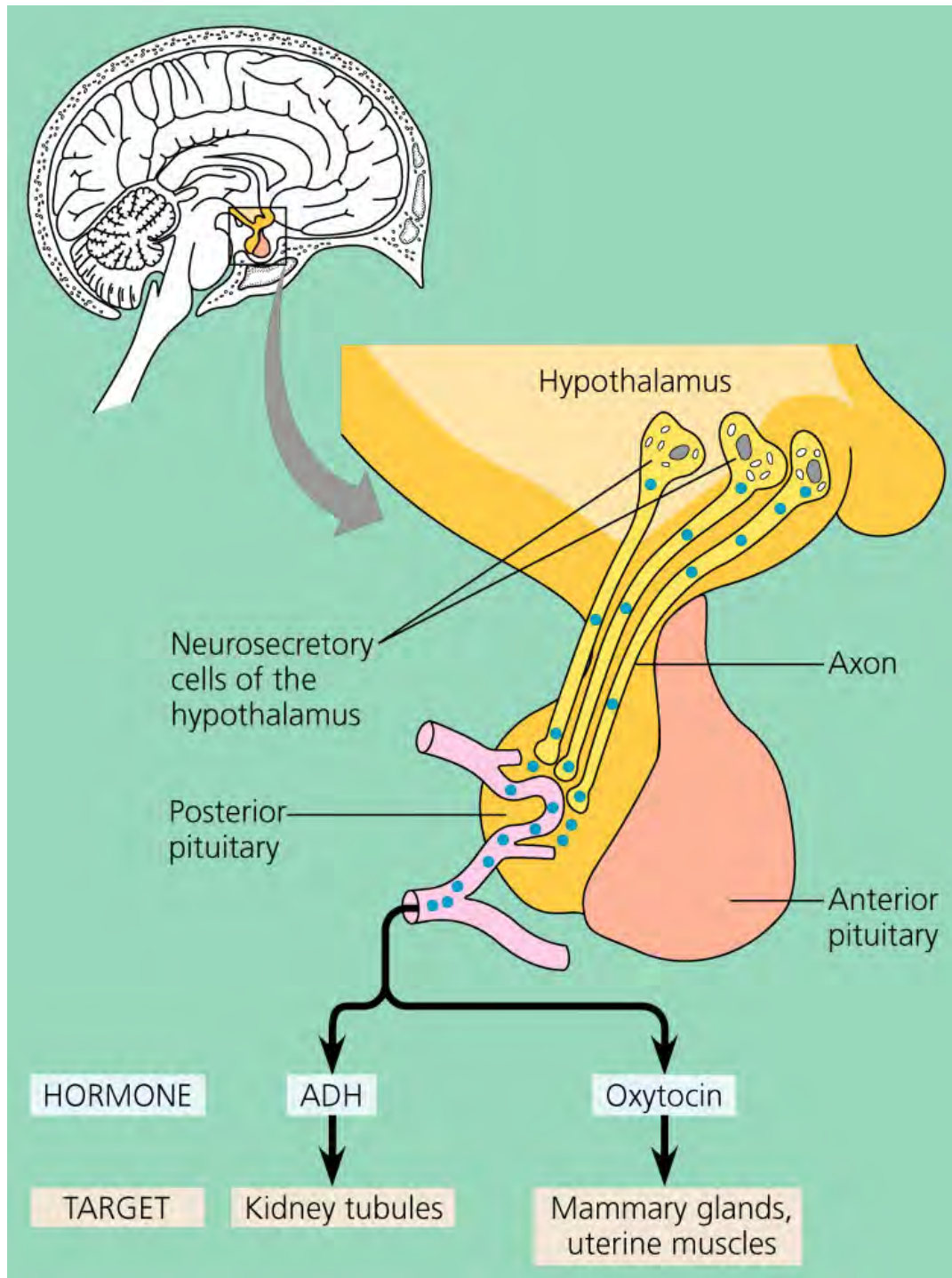


Figure 45.14 (Campbell 9th ed)

Posterior Pituitary Gland

Stores and secretes 2 hormones
made by hypothalamus

- ADH - Antidiuretic Hormone
- Oxytocin - reproduction



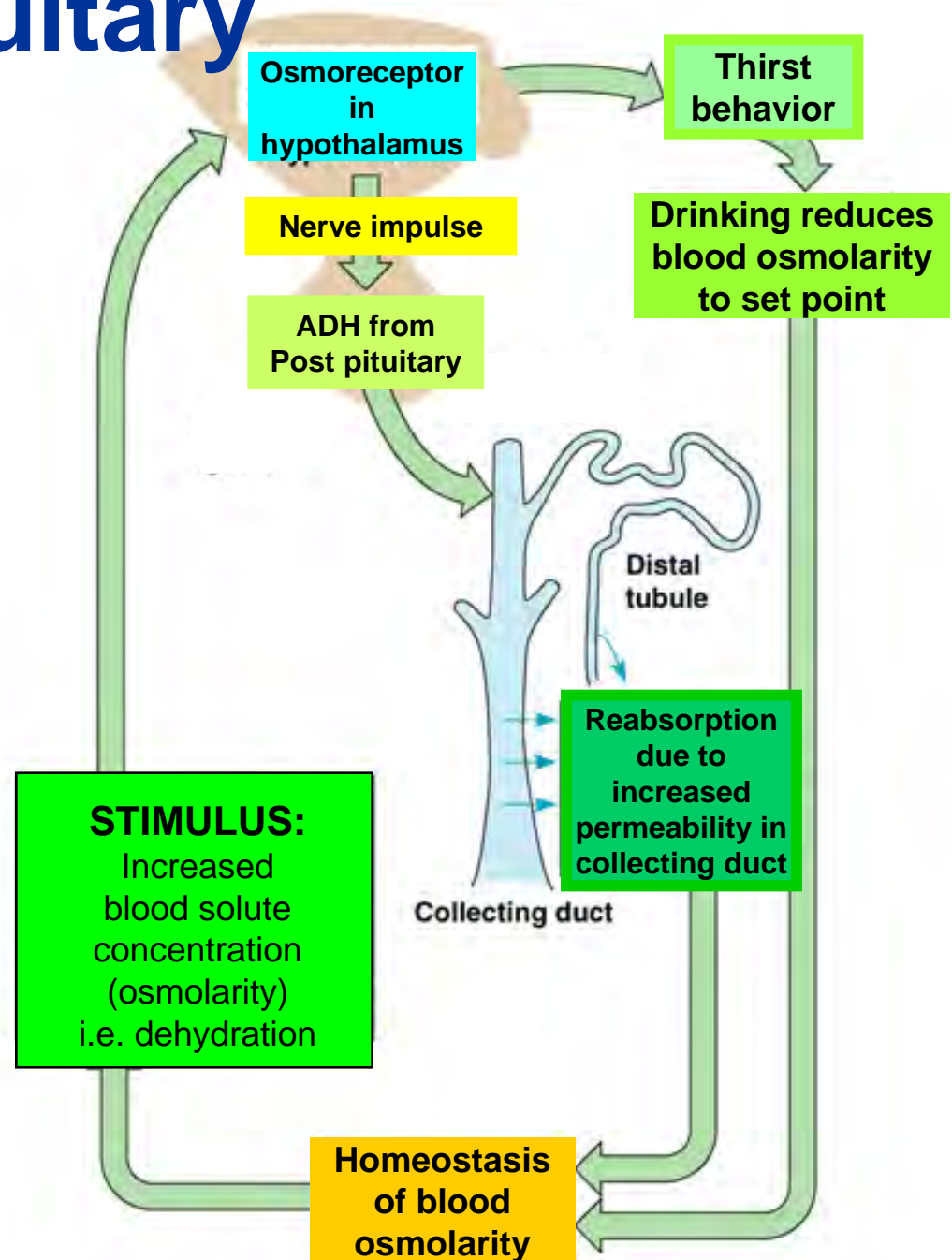
- Hypothalamus neurosecretory cells deliver hormones to posterior pituitary
- Hypothalamus stimulates post. pit. to release hormones via nervous signal

Figure 45.15 (Campbell 9th ed)

Posterior Pituitary

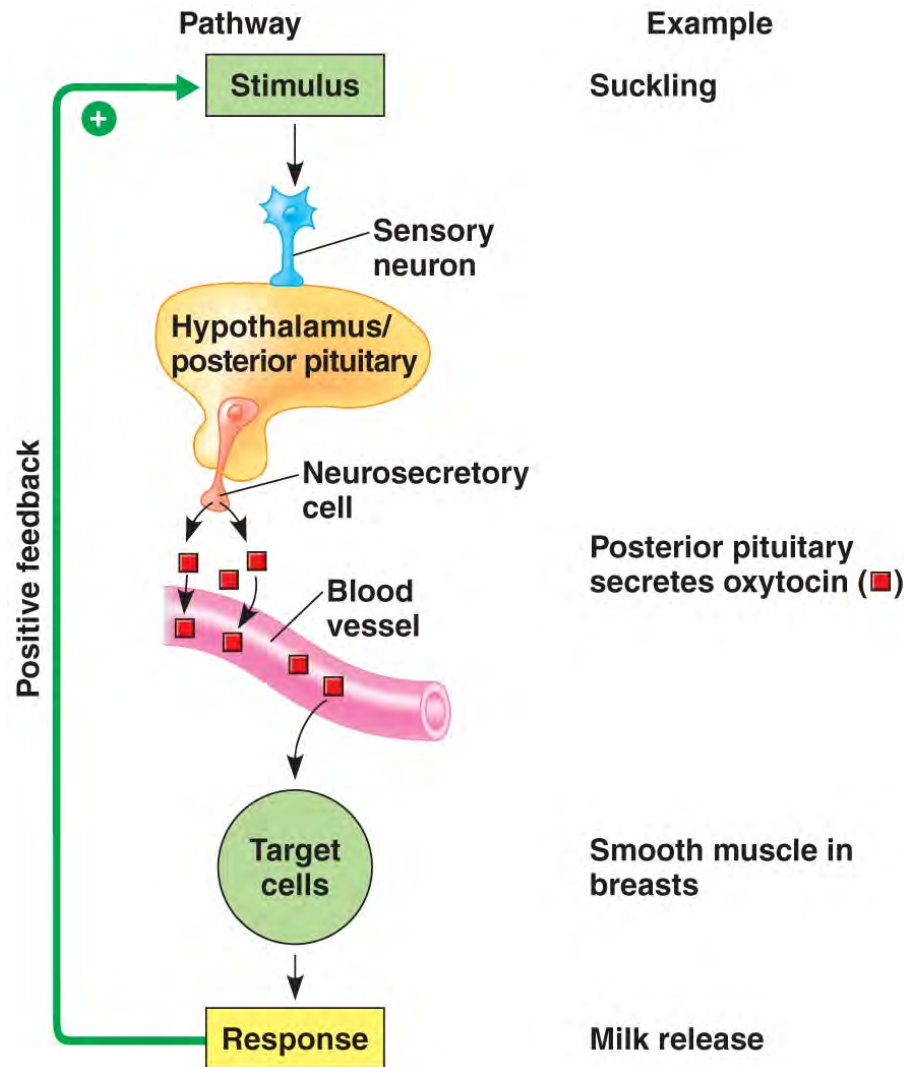
Effect of ADH

1. Increased blood [solute] (i.e. osmolarity) detected by osmoreceptor in hypothalamus (dehydration causes $>$ [solute] i.e. more solutes/ ml water)
2. Hypothalamus sends nerve impulse to posterior pituitary.
3. Post pituitary releases ADH into blood.
4. ADH goes to collecting duct in kidney and increases permeability to water.
5. Water moves out of collecting duct into blood, decreasing blood osmolarity.
6. Also stimulates thirst and drinking which causes blood osmolarity to decrease.



Posterior Pituitary & Reproduction

Oxytocin stimulates smooth muscles in breasts (and uterus)



1. Suckling detected by hypothalamus which signals posterior pituitary
2. Post pit releases oxytocin into blood
3. Oxytocin acts on smooth muscles in breast
4. Muscles contract releasing milk

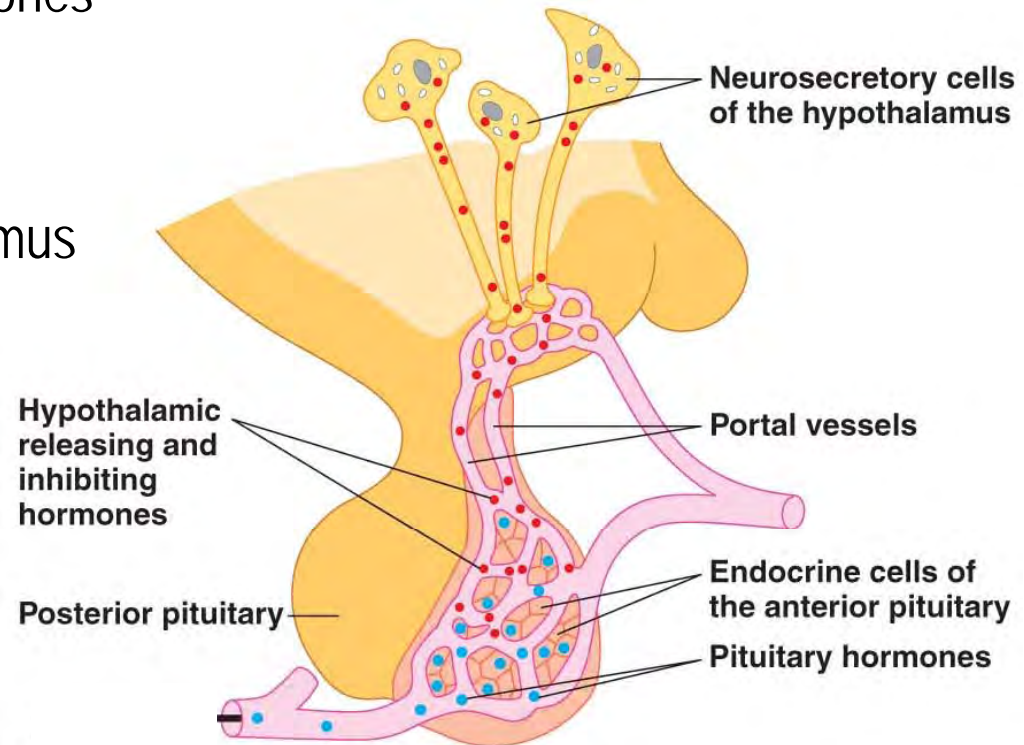
Figure 45.12 (Campbell 9th ed)

Anterior Pituitary Gland

- Synthesizes AND secretes hormones
(vs Post pit which stores/secretes)
- Controlled by hormones delivered directly from hypothalamus
(vs. post pit which is controlled by nerve impulse from hypothalamus)
- 2 classes of hormones control hormone release from the anterior pituitary
 1. Releasing hormones
 2. Inhibiting hormones

Each hormone synthesized by the ant. pit. has:

- 1 releasing
 - 1 inhibiting
- hormone that controls it.



Anterior Pituitary Gland

Produces hormones with tropic and/or non-tropic effects

Tropic hormones
regulate other endocrine organs

Non-tropic hormones
directly stimulate
target cells to induce effects

Some ant. pit. hormones
have both tropic
& non-tropic effects

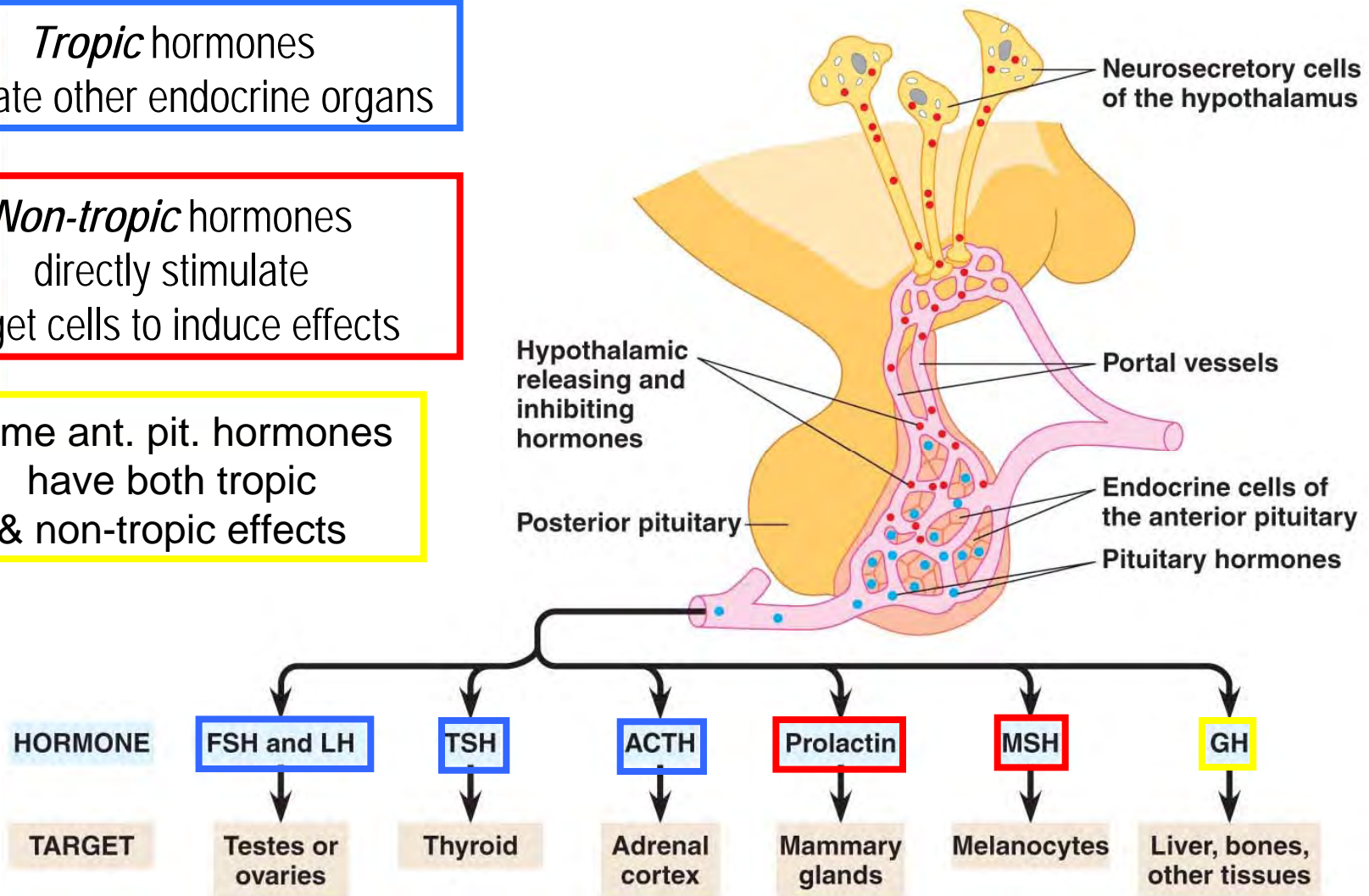


Figure 45.16 (Campbell 9th ed)

Only need to know TSH, prolactin, and GH

Anterior Pituitary Gland

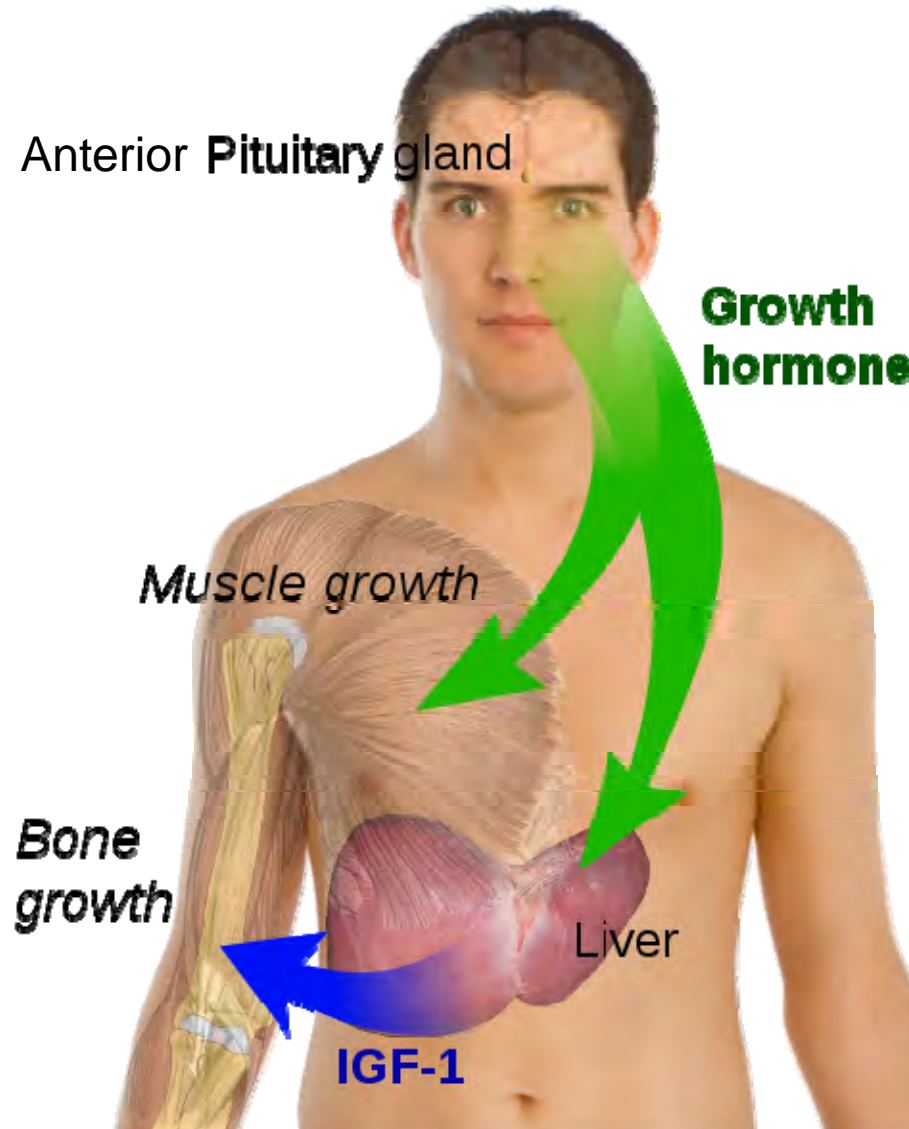
Growth Hormone has both tropic and nontropic effects

Tropic

Induces liver to release IGF-1 which regulates bone growth

Non-tropic

Acts directly on muscles to stimulate growth



Anterior Pituitary Gland

Abnormal levels of growth hormone

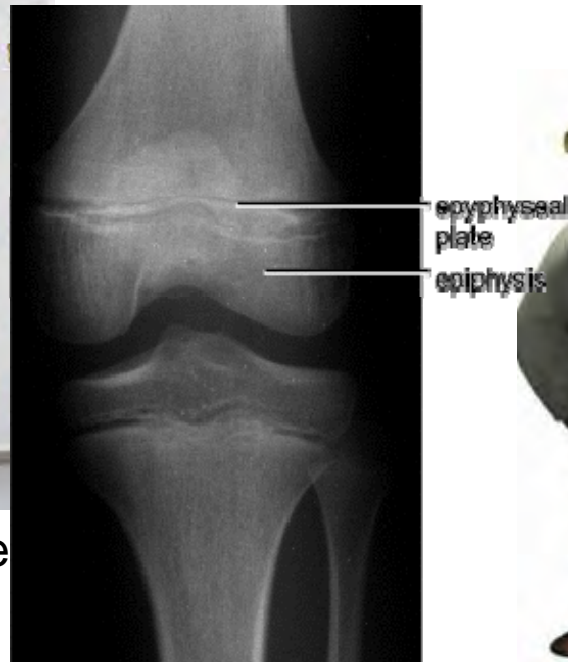
Dwarfism and gigantism



Excess/too little GH before epiphyseal plate closes

Acromegaly

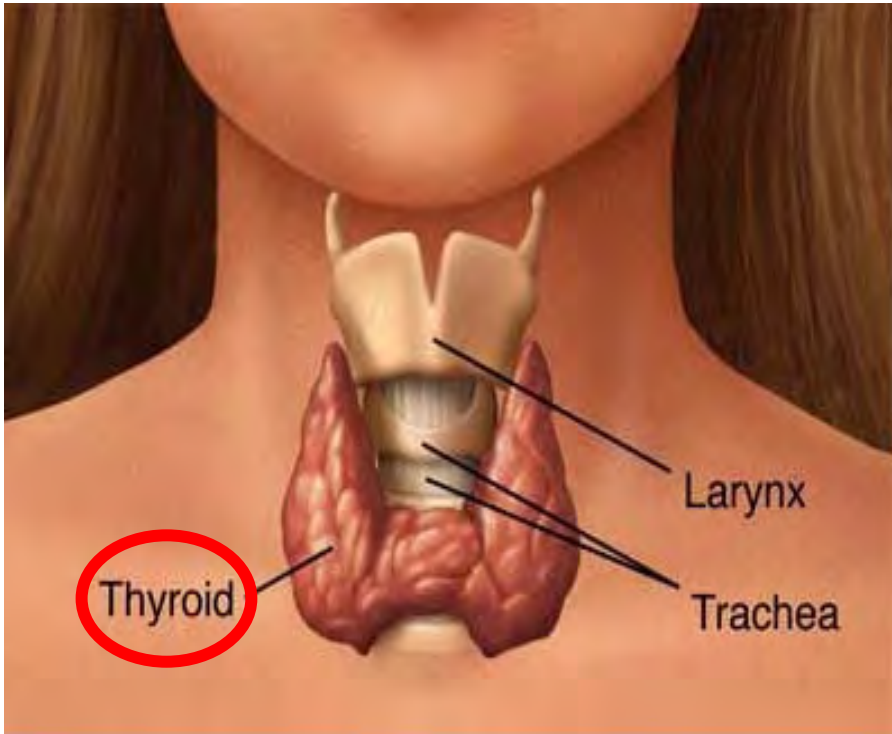
Benign tumor in anterior pit. causing too much GH after skeleton and other organs finish growing (i.e. after puberty) causing body tissues to gradually enlarge.



Maurice Tillet

Thyroid

- Absorbs and stores iodine
- Produces and secretes
 - T3, T4
 - Regulation of blood pressure, heart rate, digestion, reproduction
 - From AA Tyrosine + iodine
 - T4 → T3 in liver, kidney, spleen using selenium
 - T4 more stable / T3 more active
 - Calcitonin
 - Produced in C-cells of thyroid
 - C-cells bind Ca^{2+} in blood
 - Increased Ca^{2+} → calcitonin release
 - Inhibits uptake of Ca^{2+} from small intestine
 - Inhibits Ca^{2+} release from bones
 - Involved in bone growth?
 - Useful for prevention of osteoporosis?

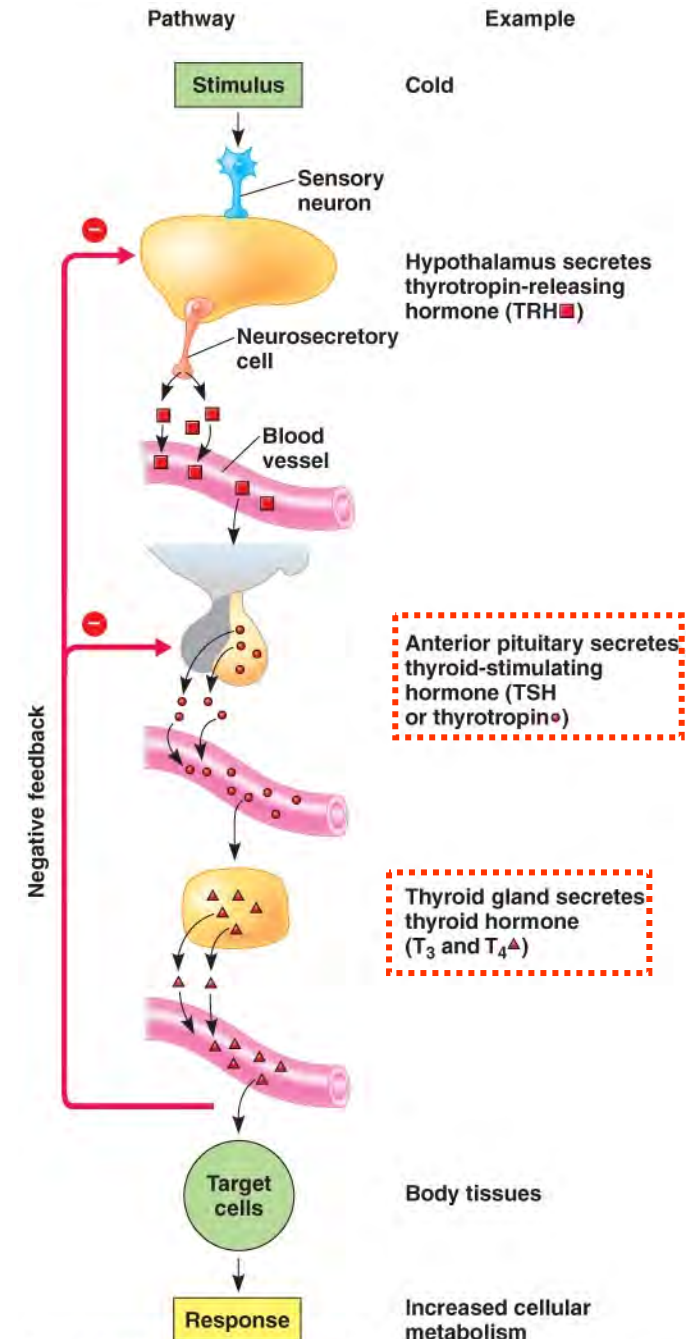


T4 = thyroxine
T3 = triiodothyronine

Thyroid Diseases

Hyperthyroidism

- Sweating, weight loss, high BP etc.
- e.g. Grave's disease
 - Autoimmune disease
 - Antibody binds to TSH receptor on anterior pituitary
 - Too much T3/T4 made
 - 5-10x more common in women



Thyroid Diseases

Hypothyroidism

- Weight gain, lethargy, cold intolerance, etc.
- Goiter
 - Low iodine leads to low T₃/T₄
 - Normally ↑ T₃/T₄ → ↓ TSH (neg fdbk) so lack of T₃/T₄ leads to high TSH since no neg fdbk

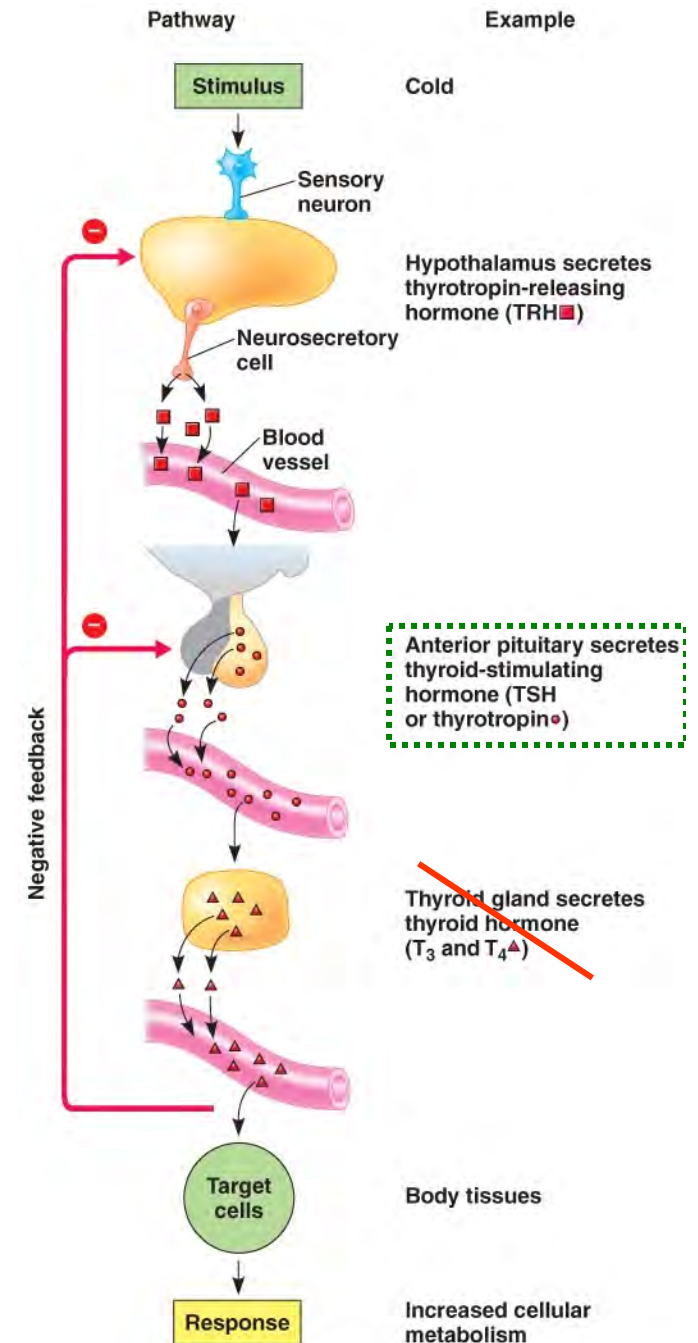
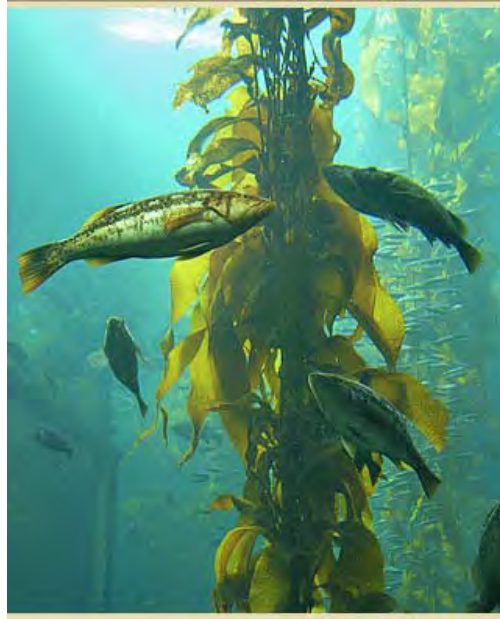


Figure 45.17 (Campbell 9th ed)

Iodine sources



High in seafood, sea vegetables (e.g. kelp or other seaweed), sea salt

Other sources depend on:

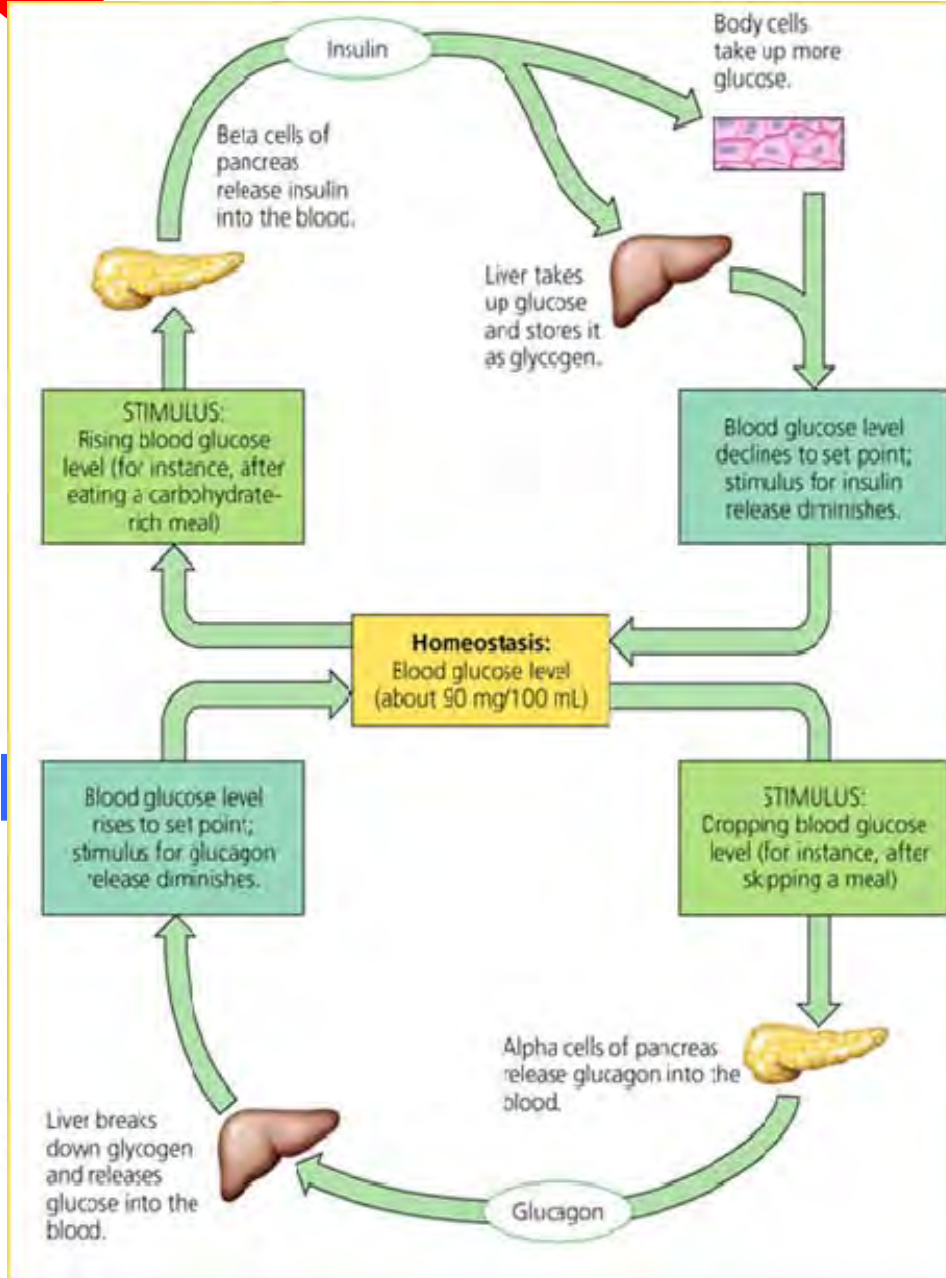
soil conditions:

Asparagus, garlic, lima beans, mushrooms, sesame seeds, soybeans, greens (e.g. spinach, collards), summer squash, strawberries

feed conditions:

cow's milk, yogurt, eggs, cheese

The Pancreas is an endocrine and exocrine gland



- Aids chemical digestion
 - Produces/releases bicarbonate & enzymes into duodenum
- Regulates glucose levels
 - Produces hormones:
 - Insulin \rightarrow $<$ blood glucose
 - Glucagon \rightarrow $>$ blood glucose
- Diabetes – excess glucose in blood and urine
 - Type I
 - low insulin production
 - Appears during childhood
 - Type II
 - Target cell insulin receptor malfunction
 - Usually occurs after age 40 but obesity lowers age

Figure 45.13 (Campbell 9th ed)

Sex Hormones

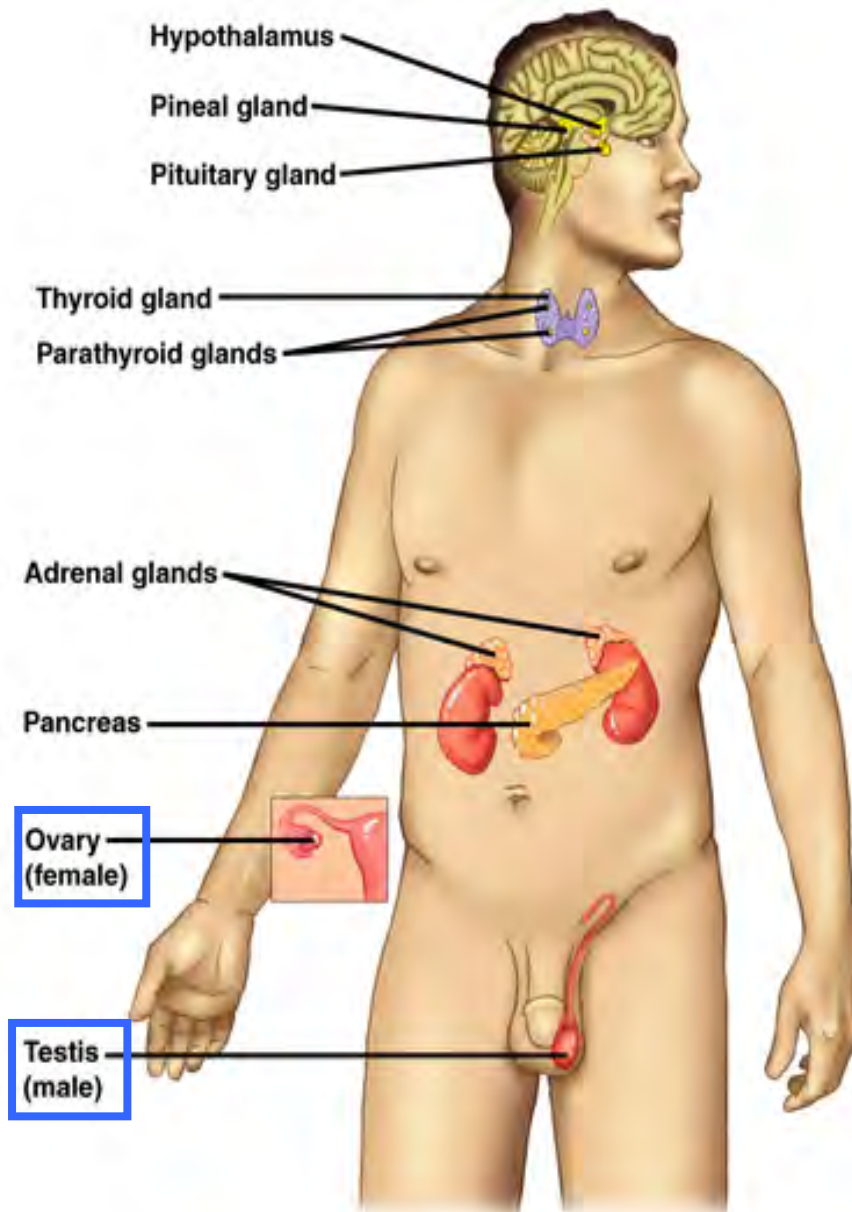


Figure 45.10 (Campbell 7th ed)

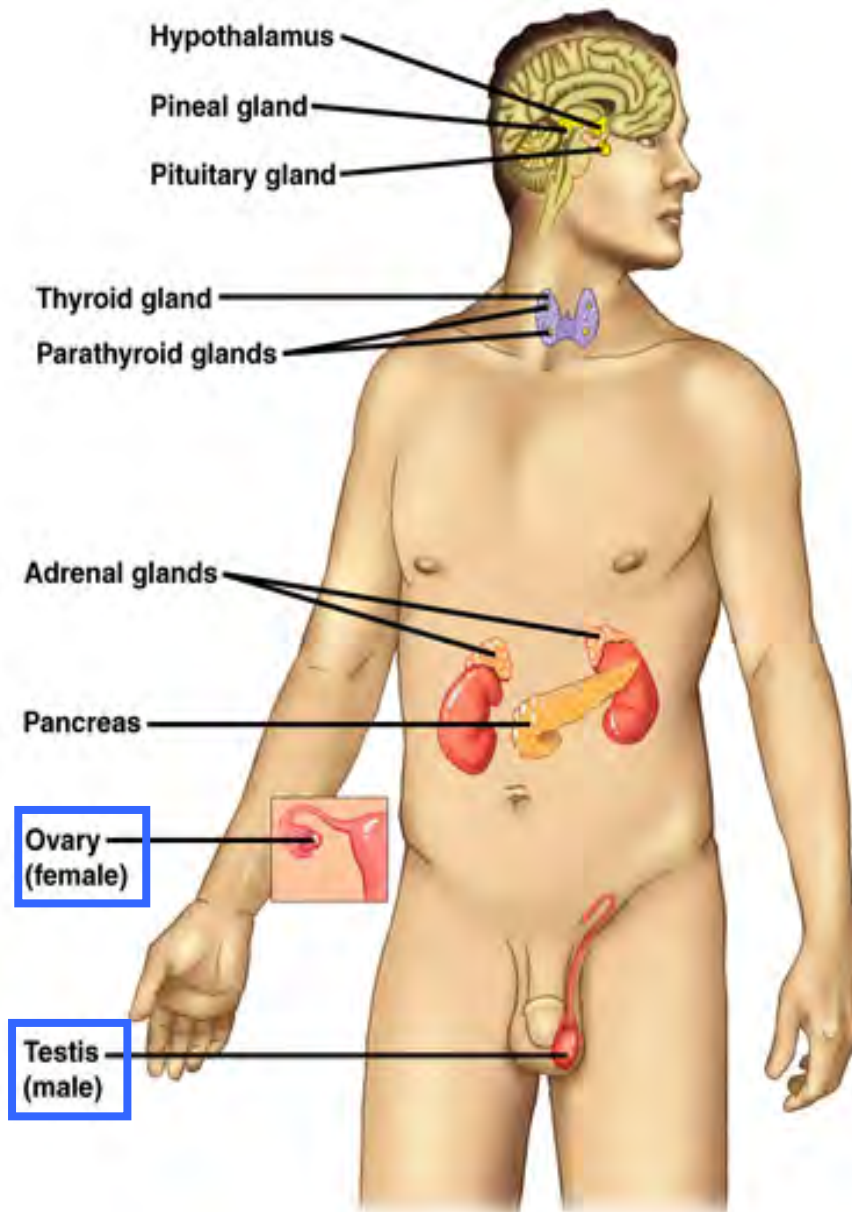
- Primarily produced by gonads but some by adrenal cortex
- Growth, develop., repro cycles, sex behavior
- 3 general types
 - All 3 types in both sexes in dif proportions
 - 1. Androgens
 - e.g. Testosterone (main testes product)
 - Fetal sex differentiation
 - Puberty
 - Termination of growth
 - Male 2^o sexual traits



Secondary Sexual Traits



Sex Hormones



- Primarily produced by gonads but some by adrenal cortex
- Growth, develop., repro cycles, sex behavior
- 3 general types
 - All 3 types in both sexes in dif proportions
 1. Androgens
 - e.g. Testosterone (main testes product)
 - Fetal sex differentiation
 - Puberty
 - Termination of growth
 - Male 2° sexual traits
 - Adult
 - Sperm development
 - Sex drive
 - Energy
 2. Estrogens
 - e.g. Estradiol
 - Female 2° sexual traits
 - Maintain female repro tract
 3. Progestogens
 - e.g. Progesterone
 - Prep/maintain uterus for embryo

Figure 45.10 (Campbell 7th ed)

Readings on which you will NOT be tested

- Chemical classes of hormones and Figure 45.5 (976-977)
- Cellular response pathways and Figures 45.6 to 45.8 (977-978)
- Coordination of neuroendocrine... and Figure 45.10 (980)
- Figure 45.17 –only need to know specific hormones discussed (985)
 - including TSH (tropic), prolactin (nontropic) and GH (both).
 - Also note that we discussed other non-tropic hormones produced by other endocrine glands/organs (e.g. oxytocin and ADH from posterior pit., all 3 thyroid hormones, insulin and glucagon from pancreas)
- Table 45.1 (986)
- Evolution of Hormone Function (988-989)
- Section 45.4 (989-993)

In general:

- You are NOT responsible for definitions of terms or sections included in the text but which were not discussed in lecture
- You are not responsible for the details of examples used in the text but not discussed in lecture. HOWEVER, these additional examples will help your understanding of concepts discussed and may be used on exams to test if you understand the general concepts.
- You ARE responsible for material covered in lecture but not included in the readings

- Next Chapter:
 - 48 – Nervous System