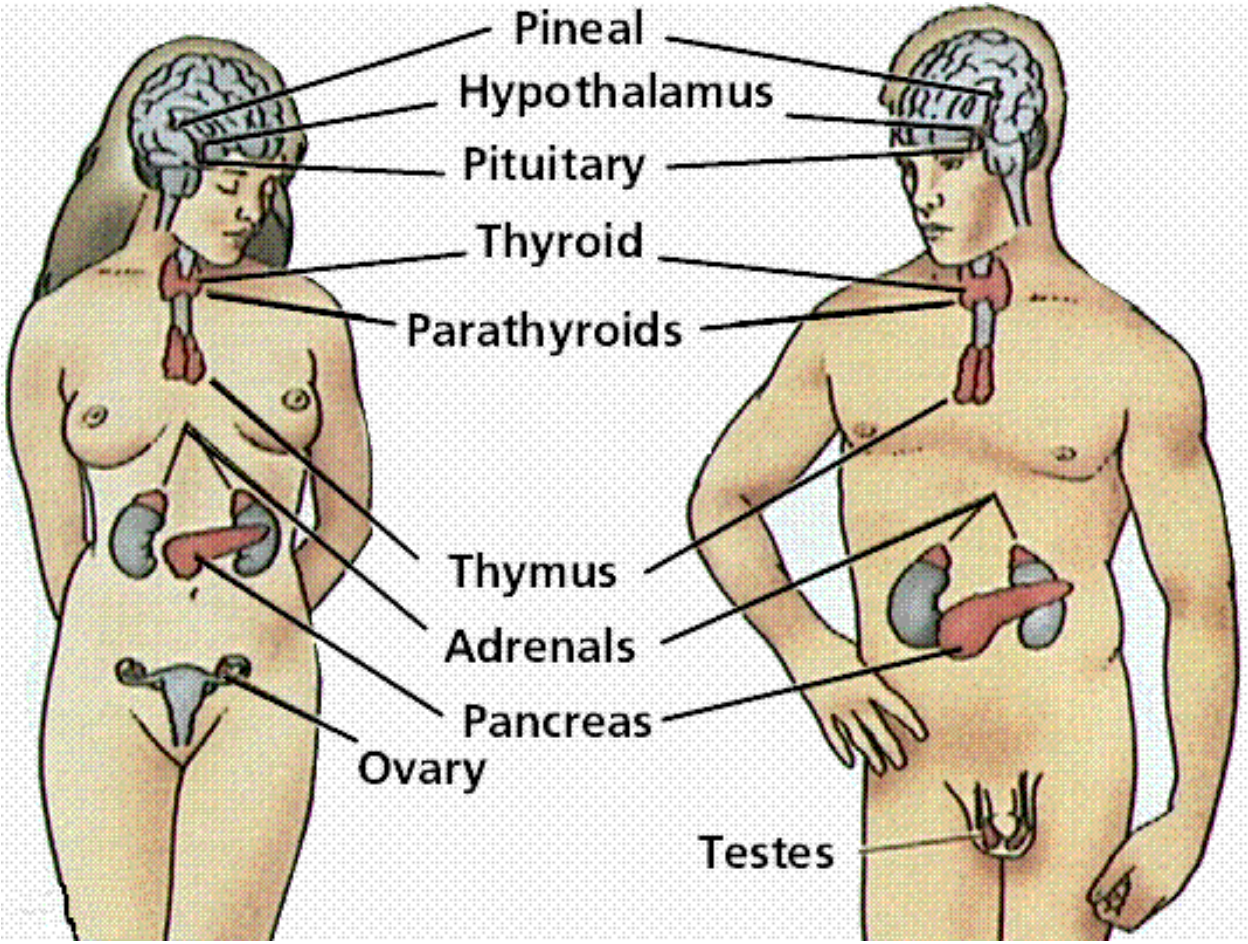
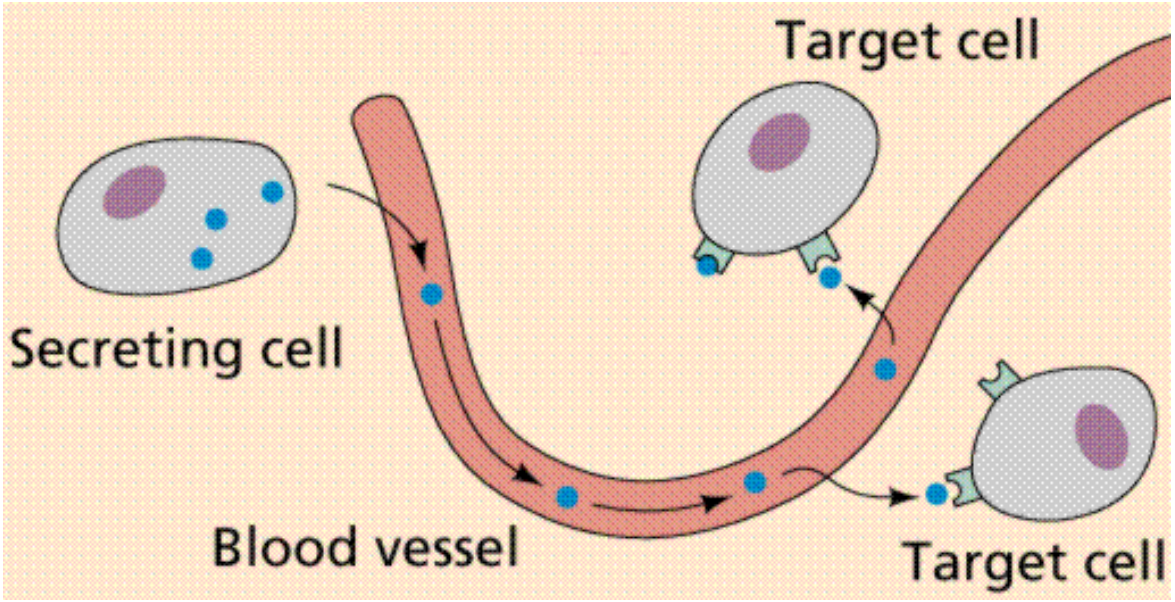
NOTES: CH 45 – Chemical Signals in Animals / The Endocrine System

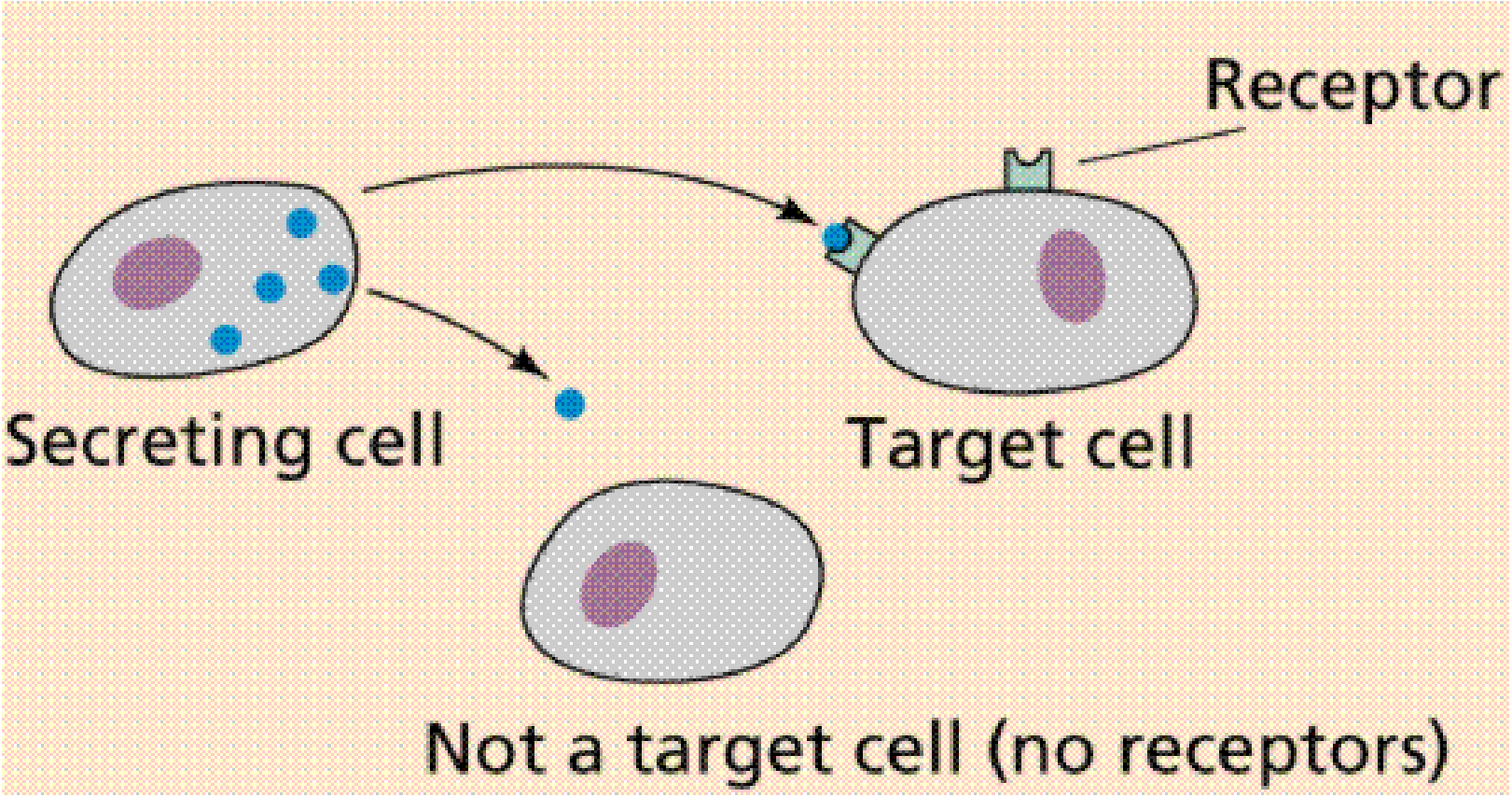


HORMONES

- **HORMONE** = a chemical signal secreted into body fluids (usually blood); communicates regulatory messages within the body.



- **<u>TARGET CELLS</u>** = cells equipped to <u>respond to specific hormones</u>



HOMEOSTASIS

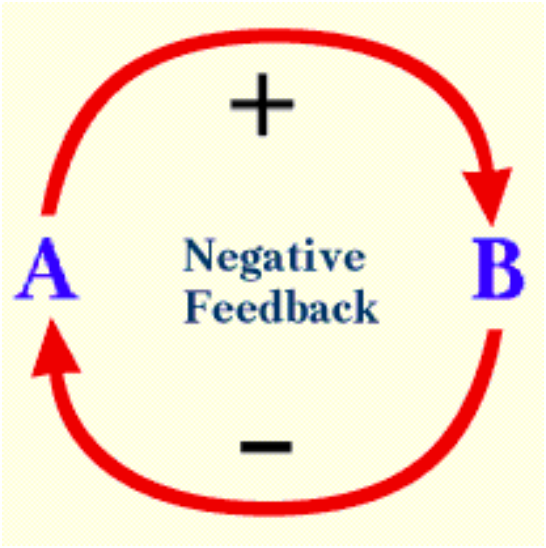
- **HOMEOSTASIS** = maintaining the internal environment at a constant level (or between narrow limits), including:

  -blood pH -oxygen / CO_2 levels

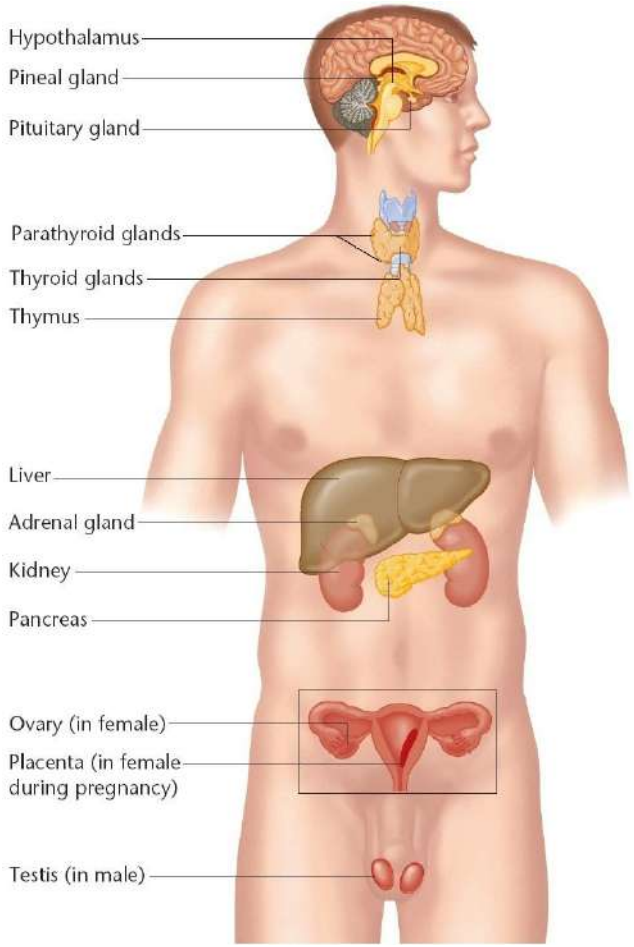
  -blood glucose -body temperature

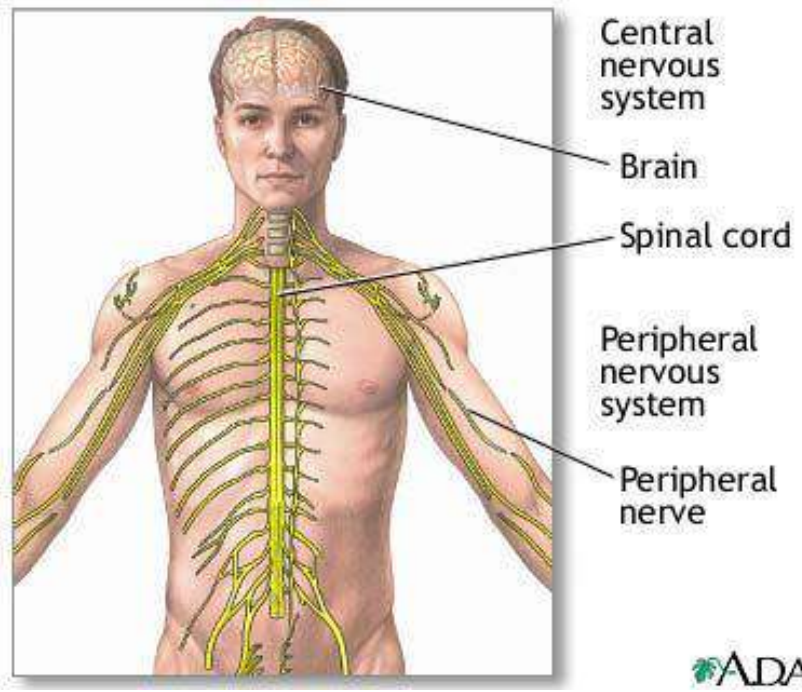
  -water balance

achieved through negative feedback!



**both the NERVOUS and ENDOCRINE systems are involved in maintaining HOMEOSTASIS!

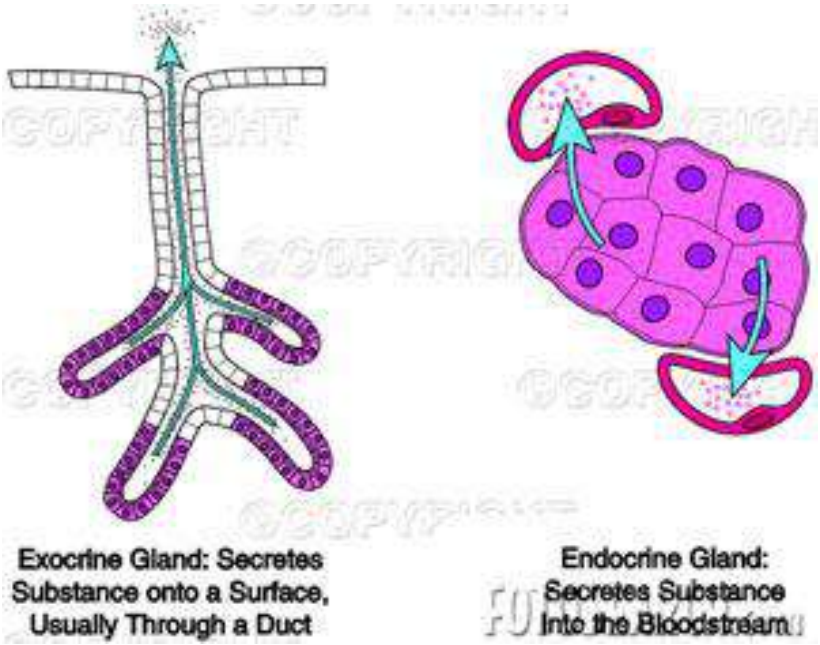




ENDOCRINE SYSTEM

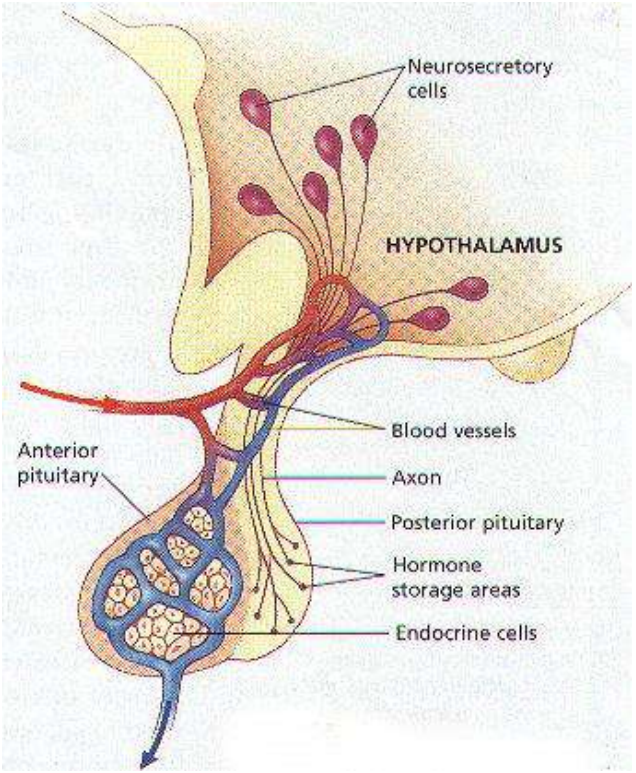
- **ENDOCRINE GLANDS** = hormone-secreting organs

("***ductless glands***" – they secrete hormones directly into blood/fluid)



there is much overlap with the nervous system

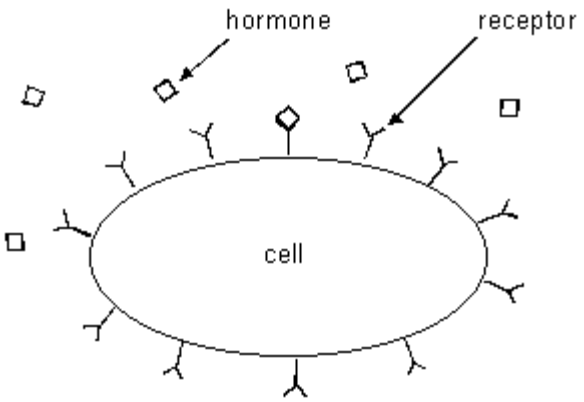
- **<u>NEUROSECRETORY CELLS</u>**: specialized nerve cells that secrete hormones

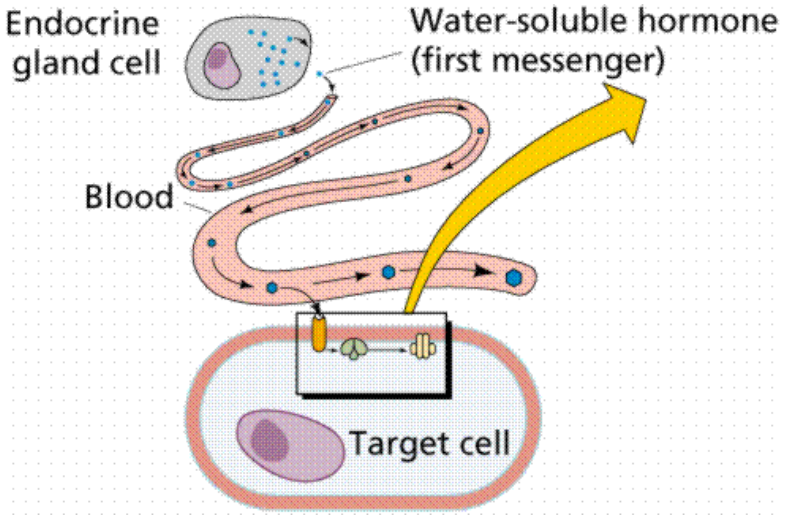


How do Chemical Signals Work?

- each chemical signal has a specific shape;
- hormone binds to specific receptor on target cell

  (cells are unresponsive if they lack the appropriate receptor);

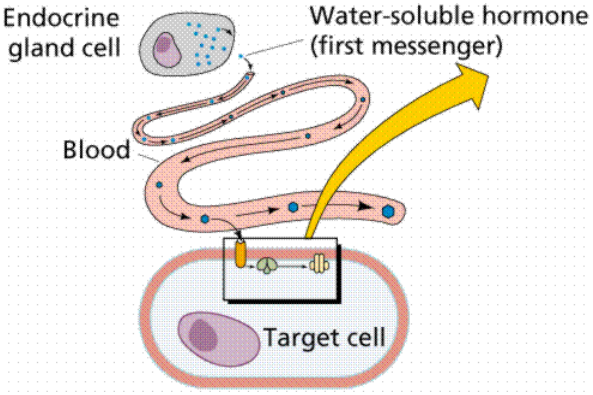


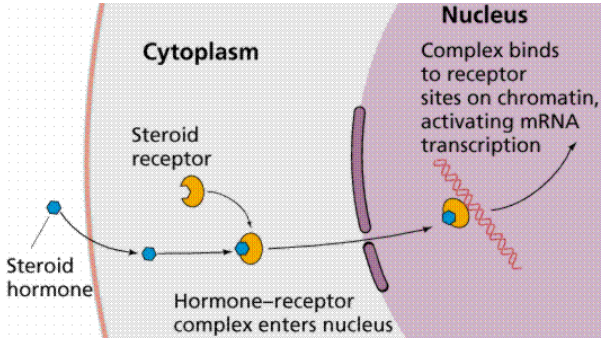


How do Chemical Signals Work?

-binding of a chemical signal to a receptor protein triggers chemical events within the target cell:

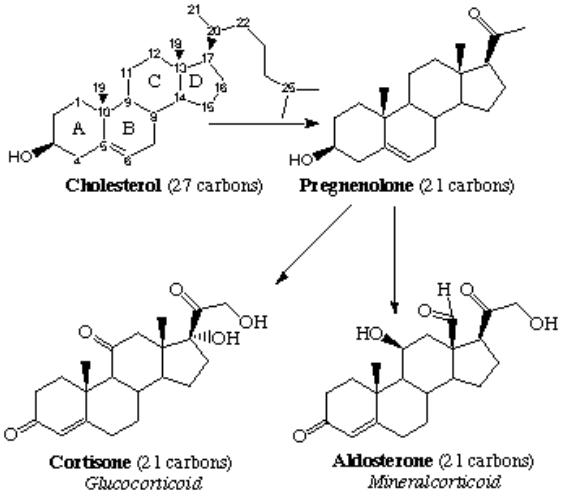
1) Binds to receptor on plasma membrane, OR
2) Binds to receptor INSIDE the cell





Types of Hormones:

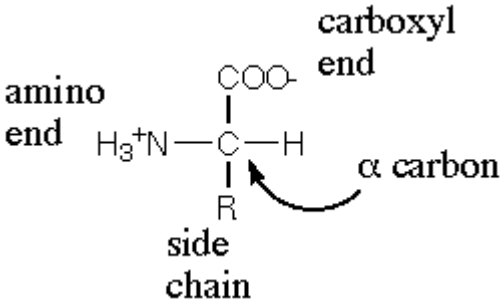
Hormones can be:



1) **STEROIDS**: synthesized from cholesterol

OR

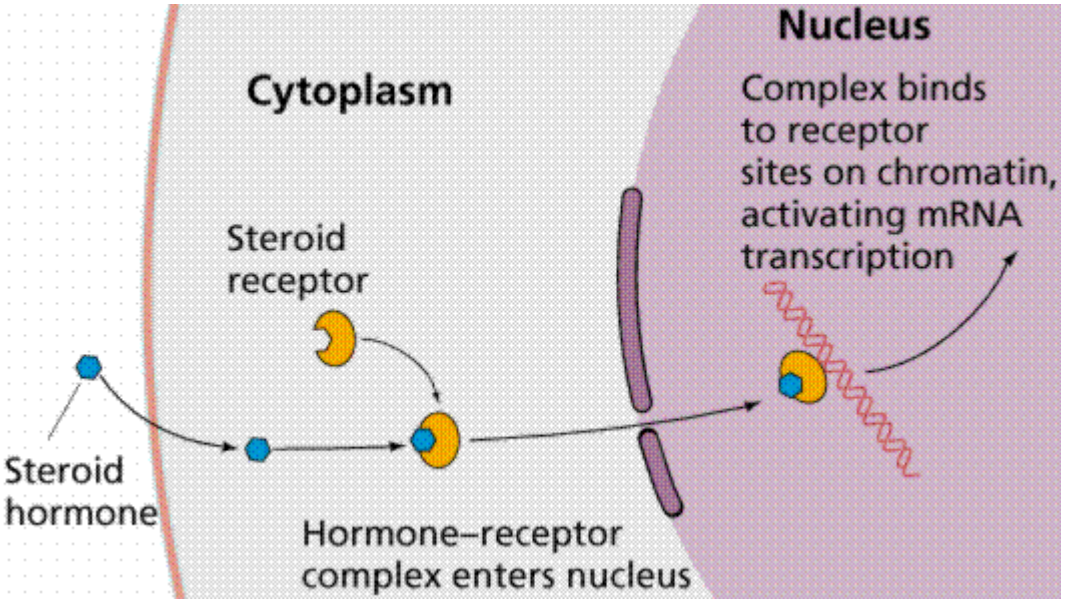
2) **Proteins / peptides / amines / glycoproteins**: syn. from amino acids

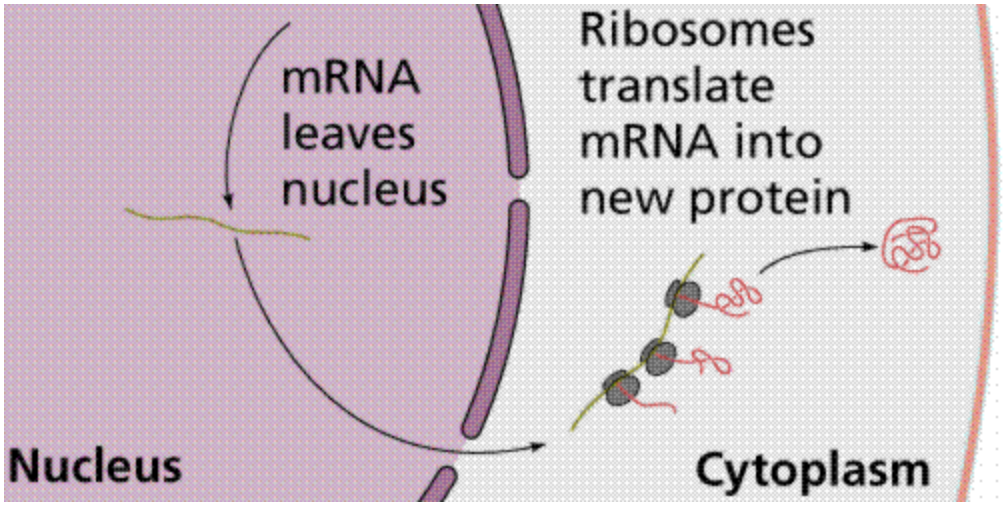


STEROID HORMONES

- Are insoluble in water / soluble in lipids
- Action once it reaches the target cell:

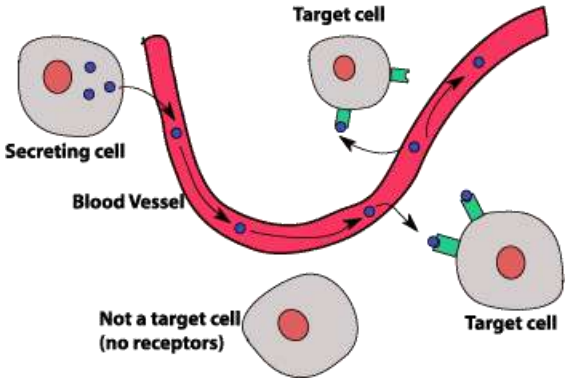
1) Diffuses through cell membrane;
2) May combine w/a protein (receptor);
3) This hormone-receptor complex binds to specific regions of target cell's DNA;
4) Activates transcription of RNA of that sequence;
5) mRNA is transcribed and target cell synthesizes proteins (e.g. enzymes, transport)


Nucleus
Cytoplasm
Complex binds to receptor sites on chromatin, activating mRNA transcription
Steroid receptor
Steroid hormone
Hormone–receptor complex enters nucleus

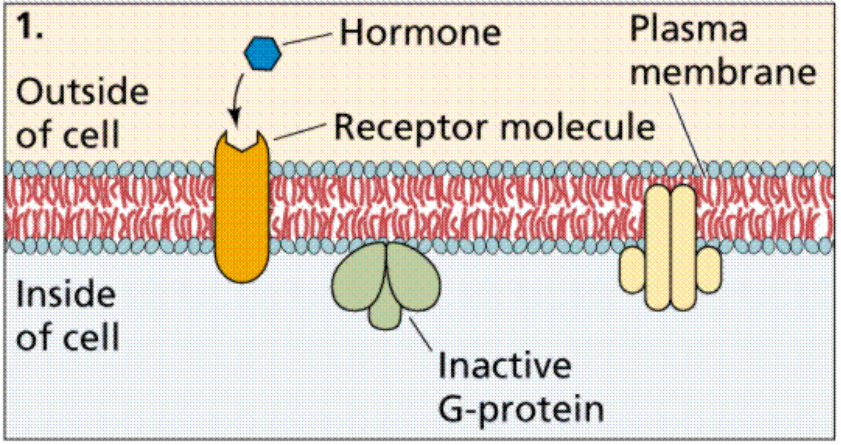

mRNA leaves nucleus
Ribosomes translate mRNA into new protein
Nucleus
Cytoplasm

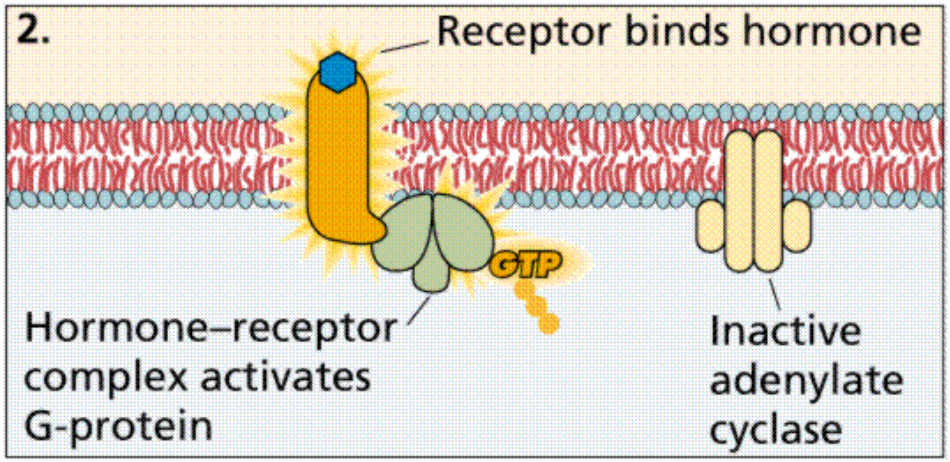
NONSTEROID HORMONES

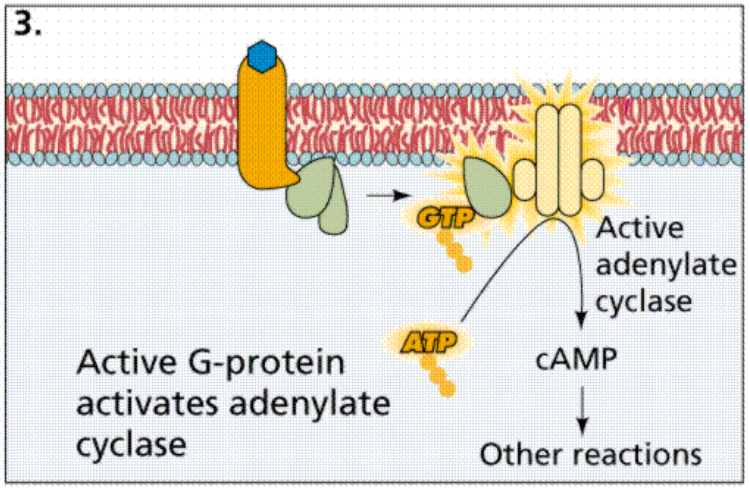
- e.g. proteins, peptides, amines, etc.
- typically combine w/ receptors in the target cell's **PLASMA MEMBRANE**



- the receptor changes shape and a sequence of molecular events (enzymes activated via phosphorylation, etc.) that results in the target cell responding to the hormone.

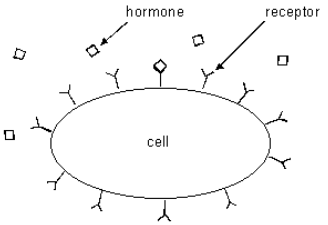

1.
Hormone
Plasma membrane
Outside of cell
Receptor molecule
Inside of cell
Inactive G-protein


2.
Receptor binds hormone
GTP
Hormone–receptor complex activates G-protein
Inactive adenylate cyclase


3.
GTP
Active adenylate cyclase
ATP
Active G-protein activates adenylate cyclase
cAMP
Other reactions

NONSTEROID HORMONES

- Examples of cellular responses to nonsteroid hormones:



-change in membrane permeability

-enzymes activated

-promotion of syn. of specific proteins

-cell movement

-secretion of cell products (hormones, enz.)

-stimulate/inhibit certain chemical pathways

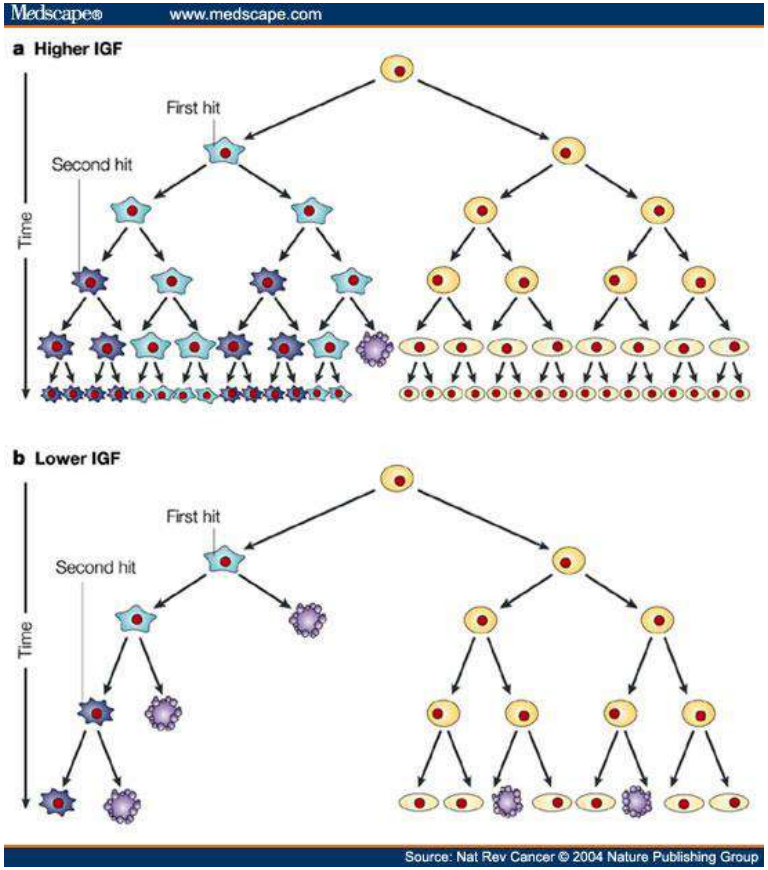
LOCAL REGULATORS

LOCAL REGULATORS: affect nearby ("local") cells

- **Growth Factors**:

-peptides and proteins that function as local regulators

-stimulate cells to grow, divide & develop normally

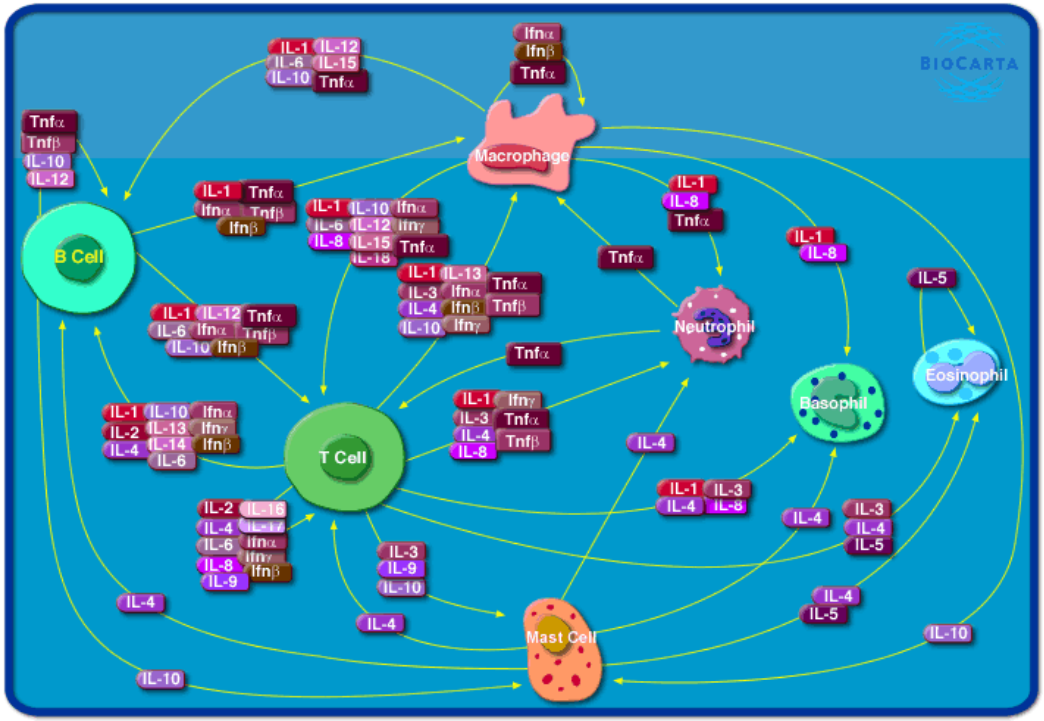


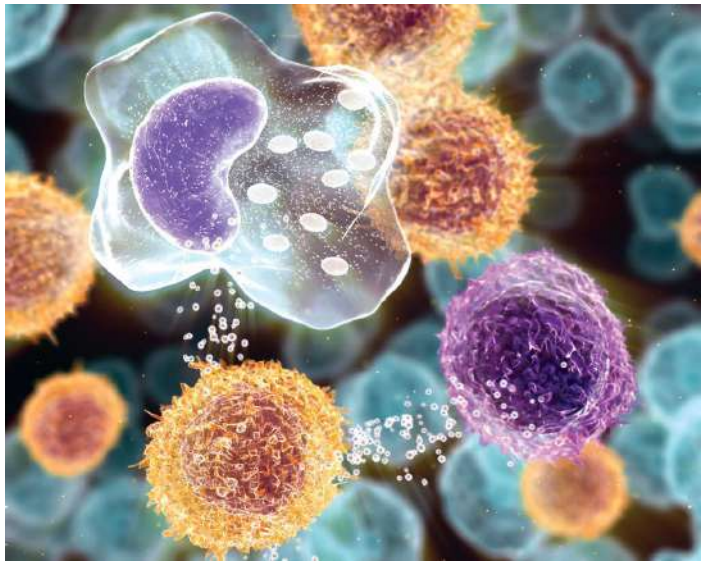
LOCAL REGULATORS

- **Cytokines**:

-produced by immune cells;

-stimulate other immune cells





LOCAL REGULATORS

- **Prostaglandins (PGs):**

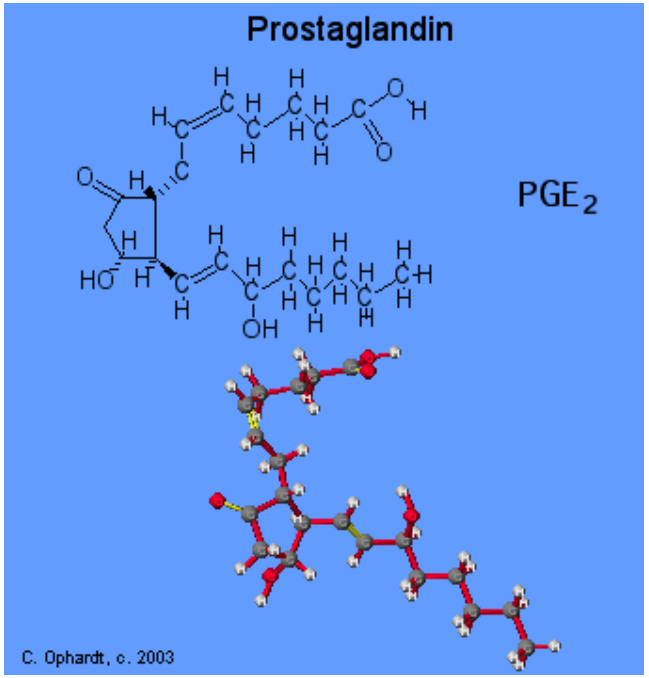
-modified fatty acids

-synthesized just before release (not stored)

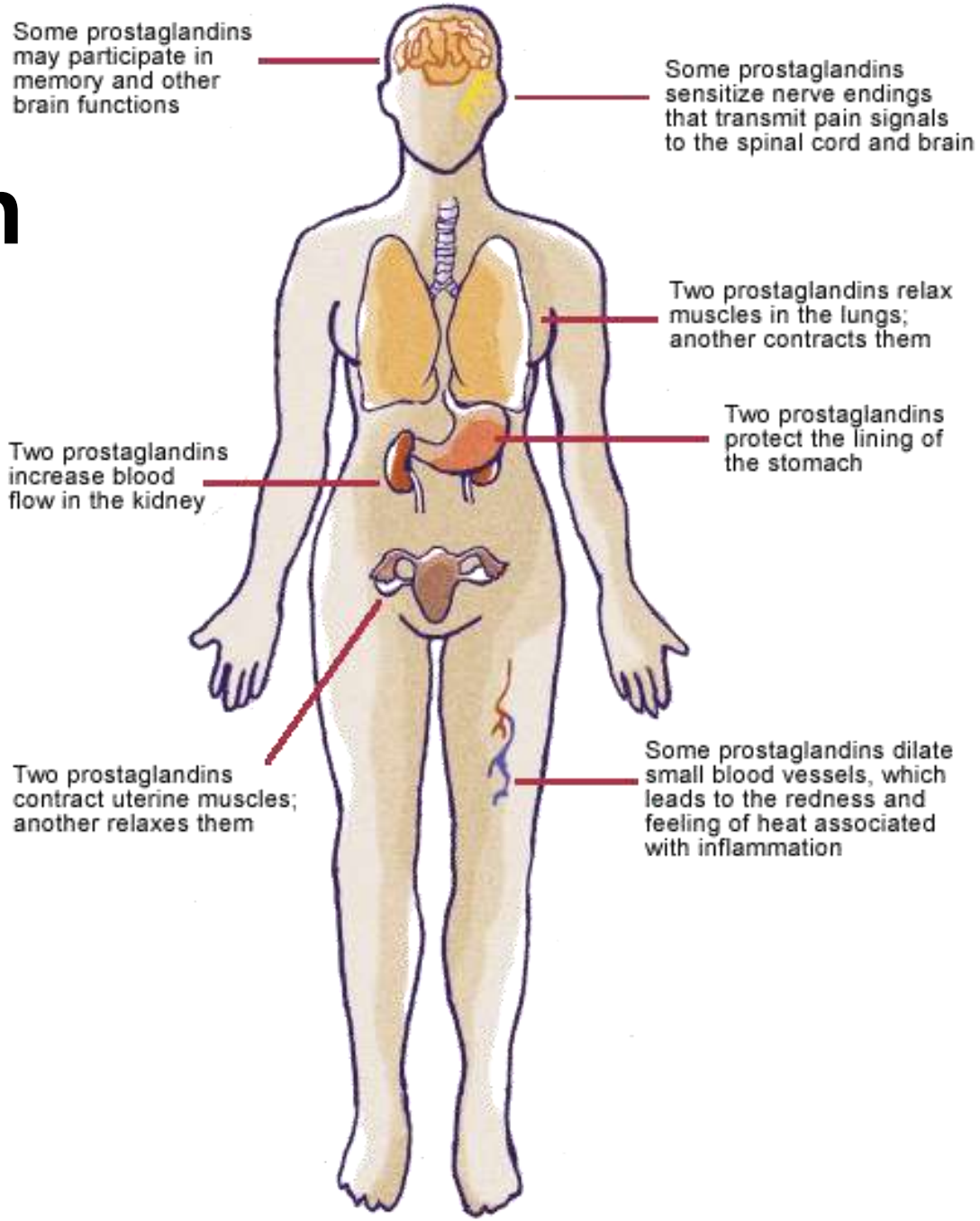
-in semen, stimulate contraction of the smooth muscles of the wall of the uterus; helps sperm reach the egg

-in placenta, stimulates uterus muscles to contract in labor

-in immune system, help to induce fever, inflammation, intensify pain

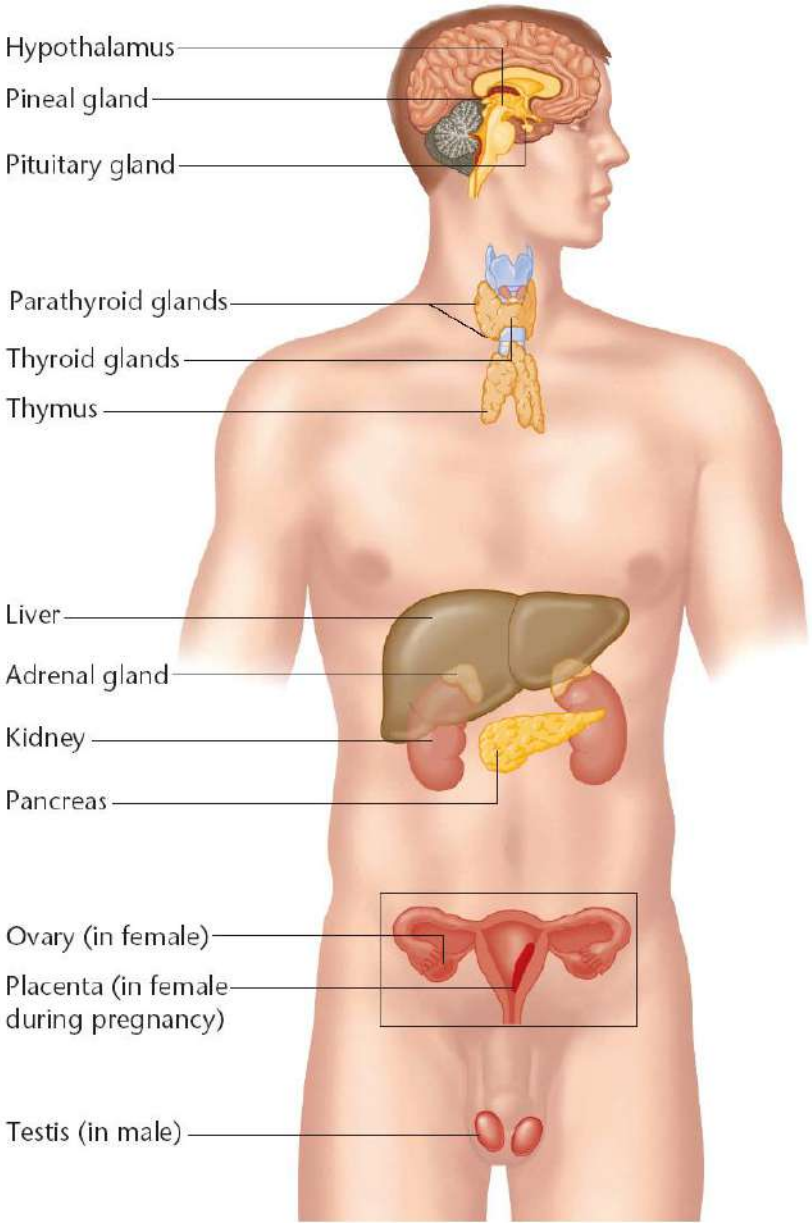


Prostaglandin actions!



ENDOCRINE SYSTEM

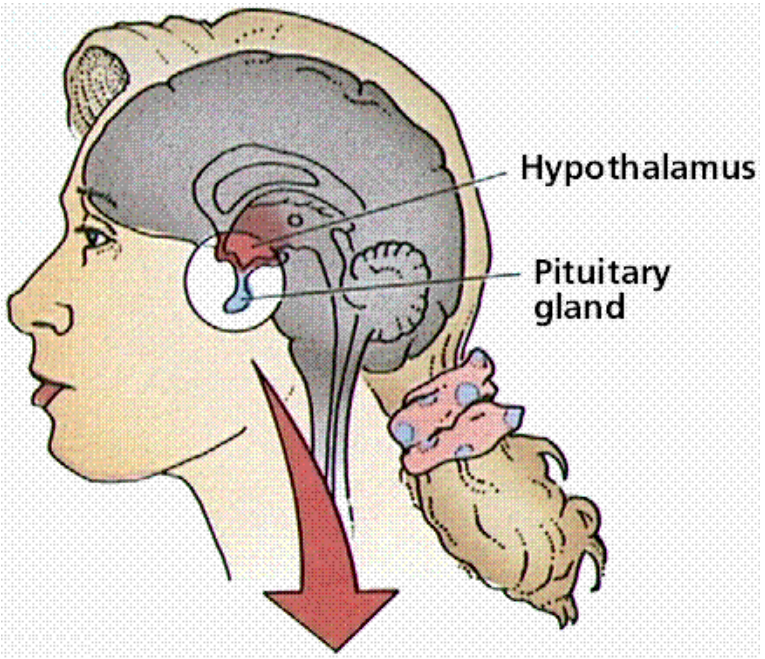
***see fig. 45.4 (p. 976): human endocrine glands**

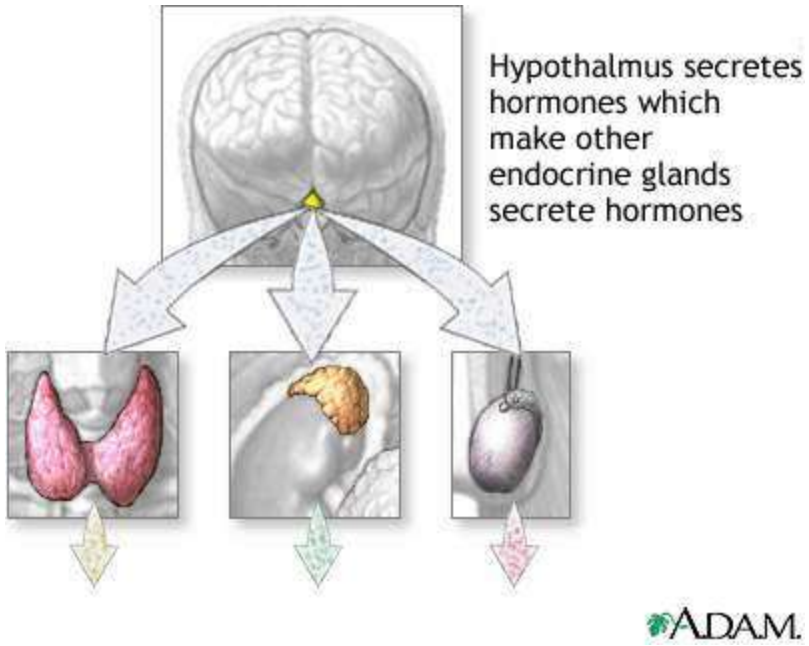


HYPOTHALAMUS:

-region of lower brain

-neurosecretory cells secrete hormones

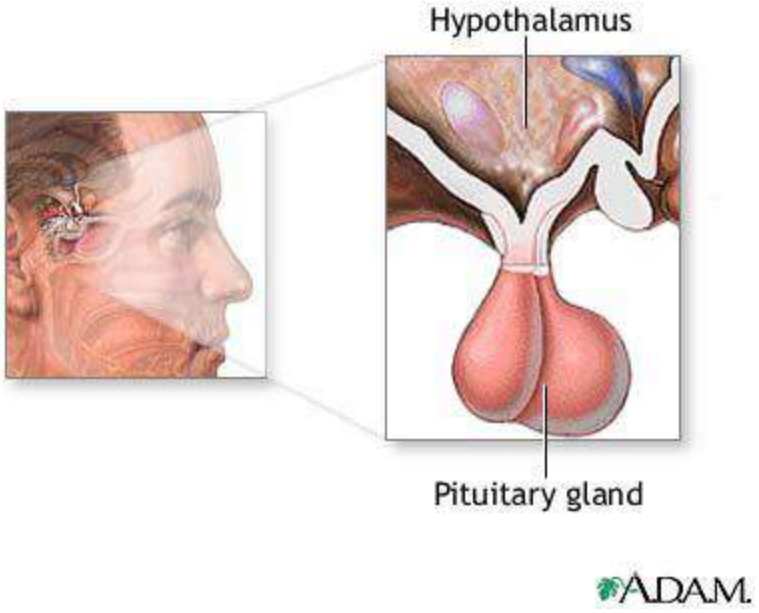


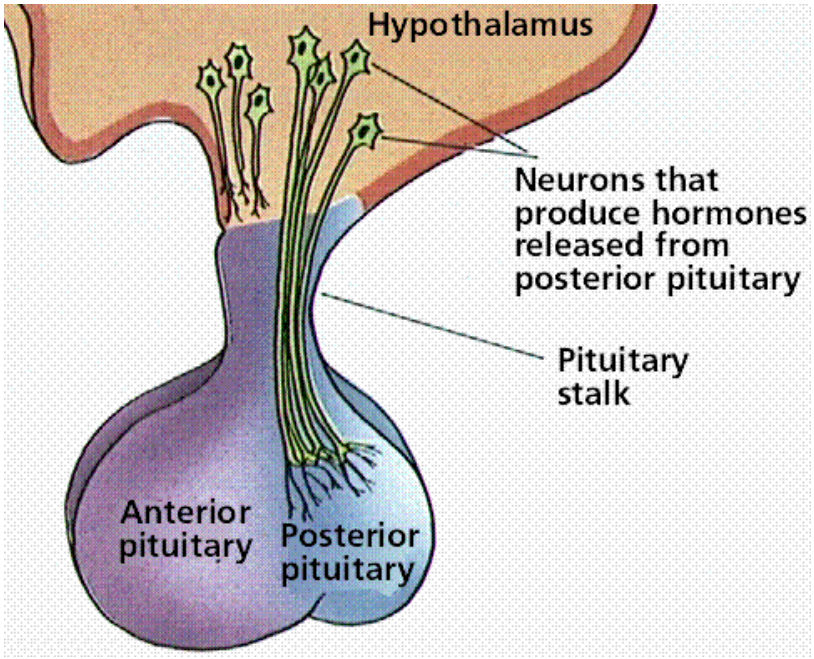


PITUITARY GLAND:

-stores secretions from the hypothalamus

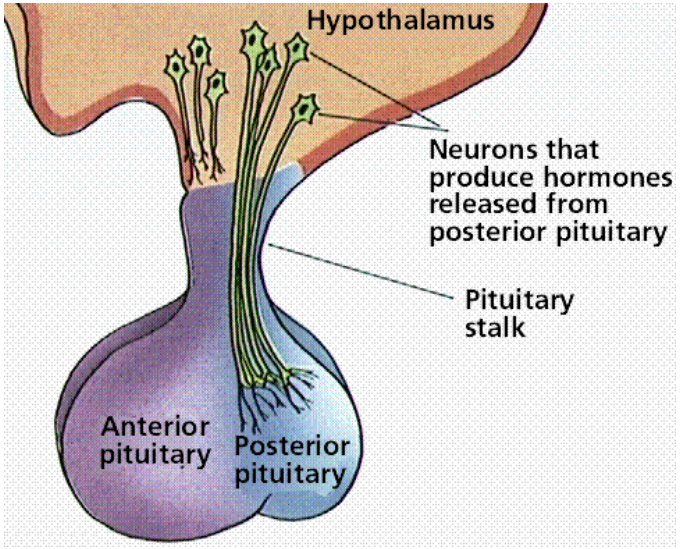
-located at base of hypothalamus



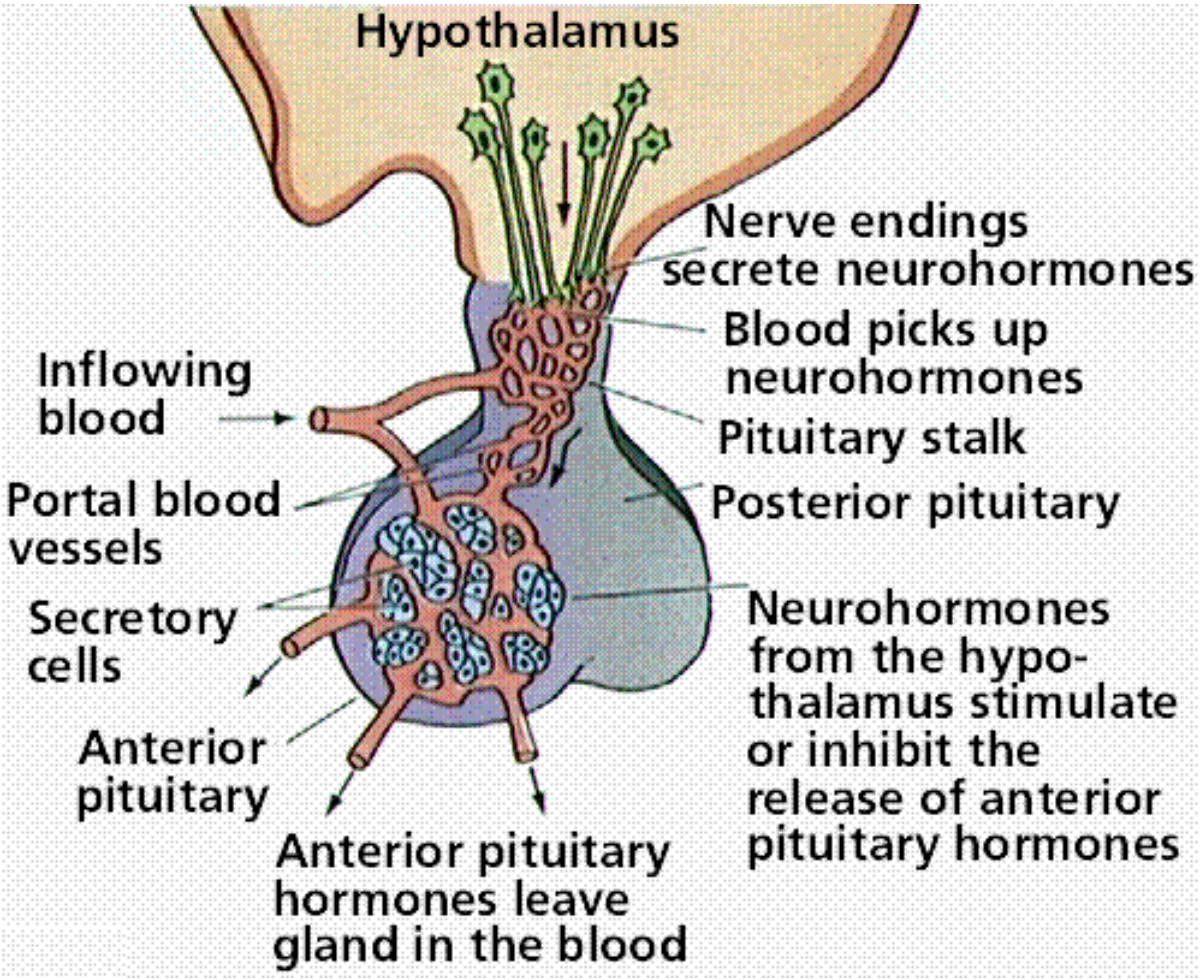


PITUITARY GLAND

- **POSTERIOR PITUITARY**: under direct control of neurosecretory cells from the hypothalamus



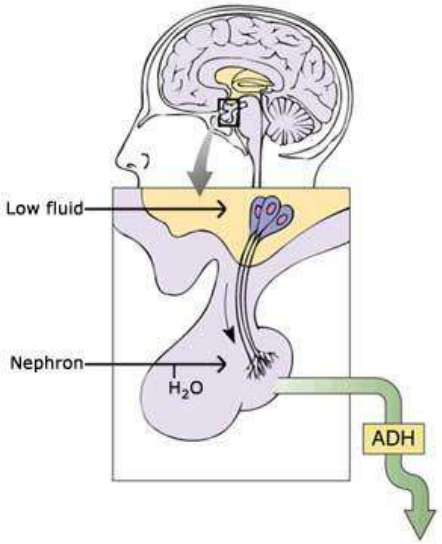
- **ANTERIOR PITUITARY**: responds to ***RELEASING HORMONES*** from the hypothalamus (these travel through the portal veins and to the anterior pituitary)

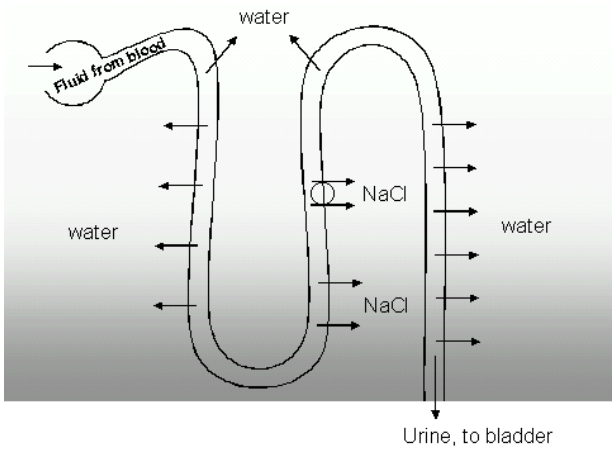


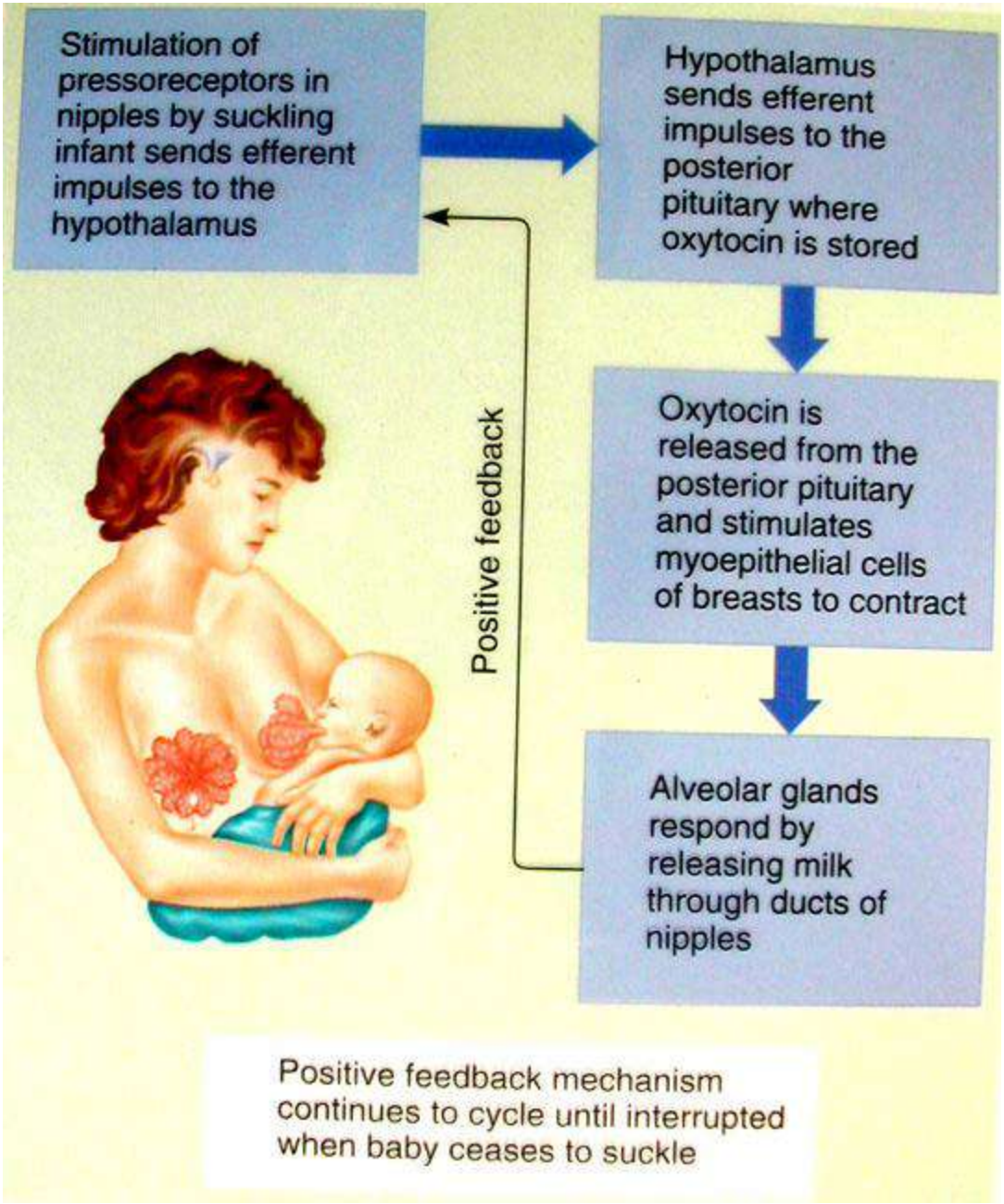
Anterior pituitary	Posterior pituitary
Hormones produced and released:	**Hormones released:**
Thyrotropin Adrenocorticotropin Luteinizing hormone Follicle-stimulating hormone	Oxytocin Vasopressin
Growth hormone Prolactin Melanocyte-stimulating hormone Endorphins Enkephalins	

Posterior Pituitary Hormones:

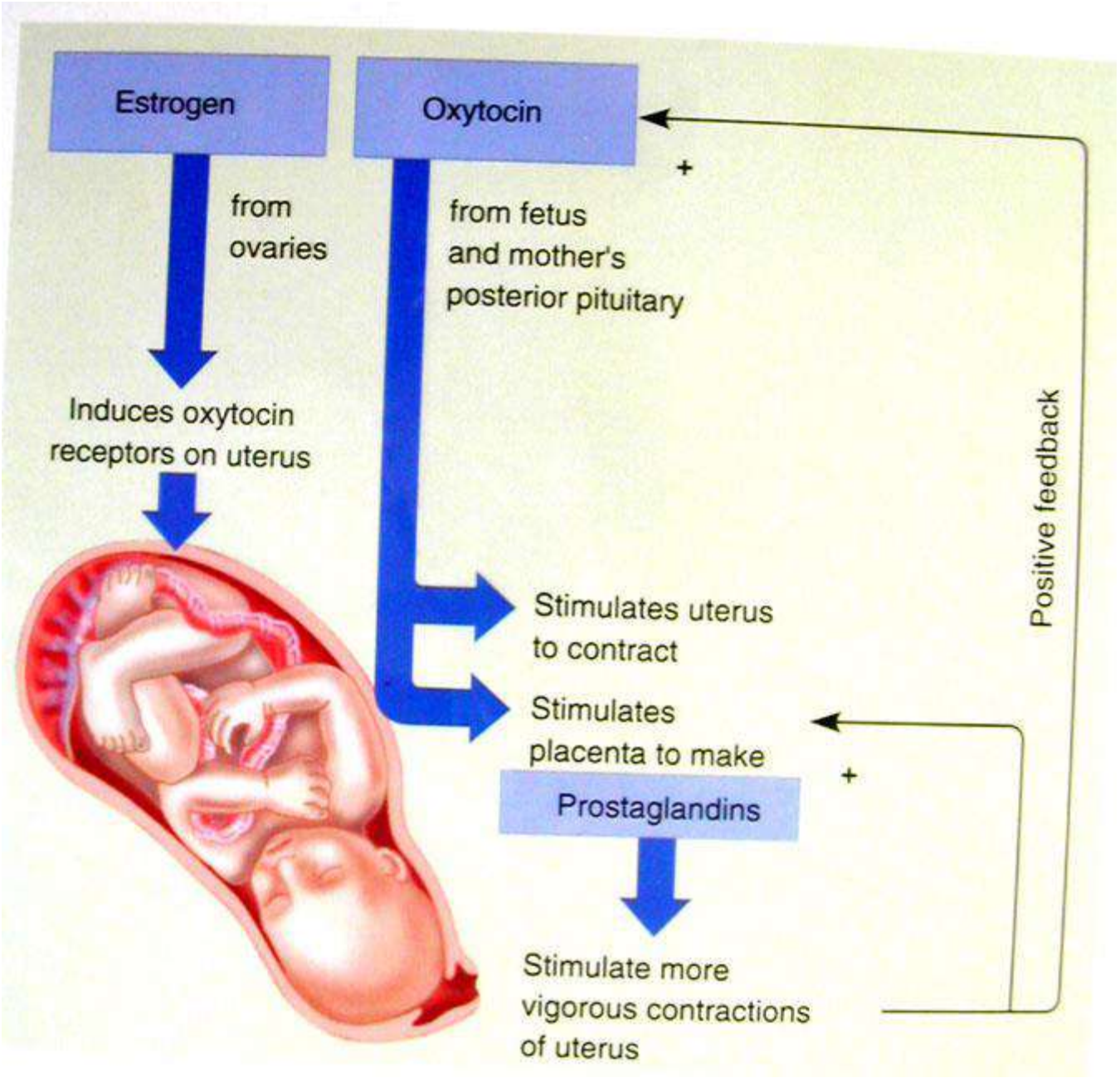
1) **OXYTOCIN**: induces contractions of uterine muscles; triggers mammary glands to eject milk
2) **ANTIDIURETIC HORMONE (ADH):** causes water retention in the kidneys; decreases urine volume





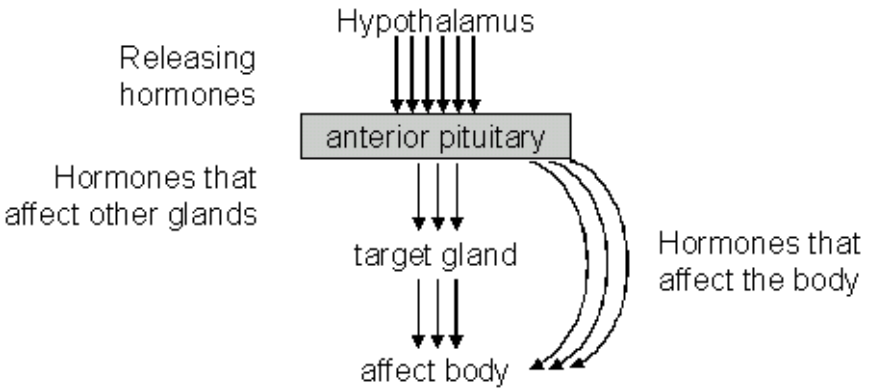


Positive feedback mechanism continues to cycle until interrupted when baby ceases to suckle


Estrogen
Oxytocin
+
from ovaries
from fetus and mother's posterior pituitary
Induces oxytocin receptors on uterus
Stimulates uterus to contract
Stimulates placenta to make
Prostaglandins
+
Stimulate more vigorous contractions of uterus
Positive feedback

Anterior Pituitary Hormones:

1) **Growth hormone (GH)**
2) **Prolactin (PRL)**



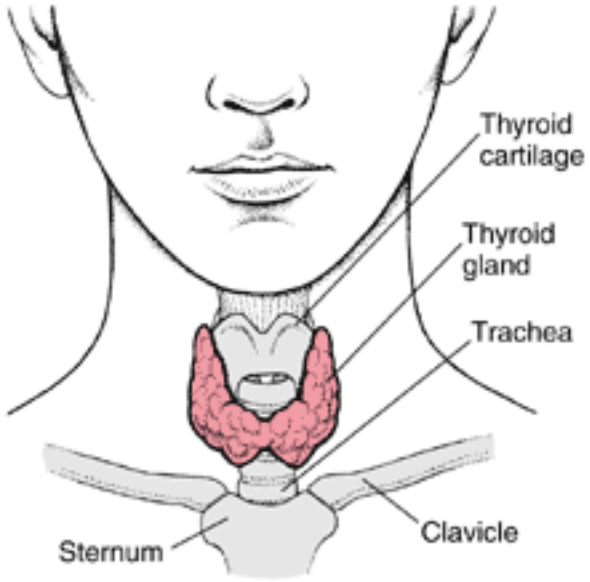
TROPIC HORMONES (stimulate synthesis & release of hormones from OTHER endocrine glands)

3) **Thyroid-stimulating hormone (TSH)**
4) **Adrenicorticotropic hormone (ACTH)**
5) **Follicle-stimulating hormone (FSH)**
6) **Luteinizing hormone (LH)**

THYROID GLAND

- Just below the larynx on either side and in front of the trachea

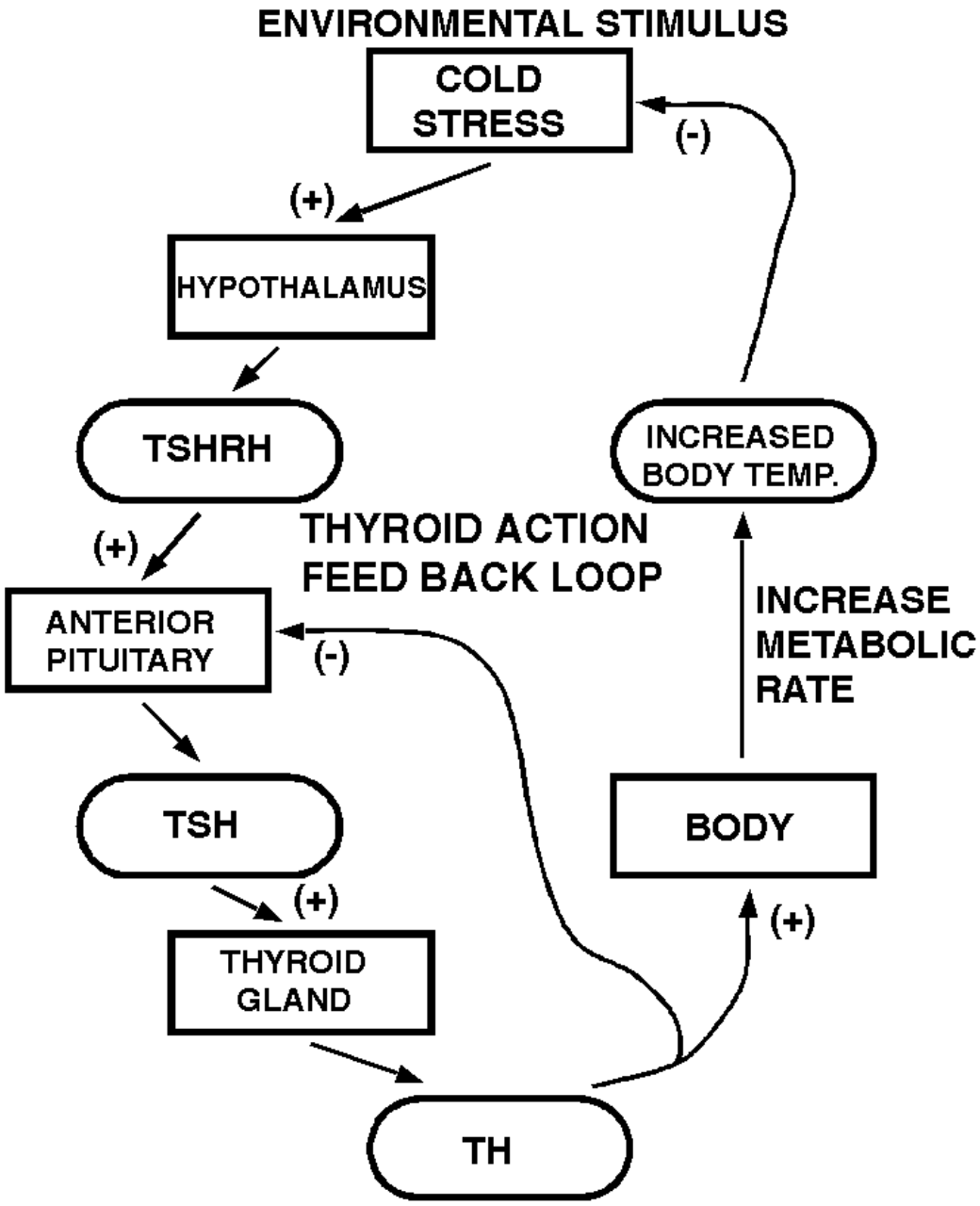
- Thyroid hormones:
  1) Thyroxine (T4)
  2) Triiodothyronine (T3)
  3) Calcitonin



Functions of Thyroid Hormones:

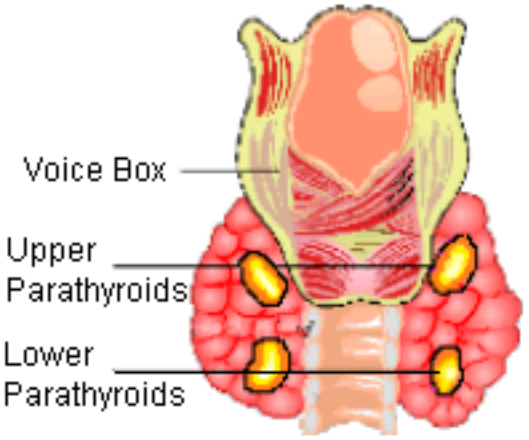
- **THYROXINE** and **TRIIODOTHYRONINE**: increase rate of energy release from carbs; increase rate of protein syn.; accelerates growth

- **CALCITONIN**: lowers blood calcium and phosphate ions


ENVIRONMENTAL STIMULUS
COLD STRESS
(-)
(+)
HYPOTHALAMUS
TSHRH
INCREASED BODY TEMP.
THYROID ACTION FEED BACK LOOP
(+)
ANTERIOR PITUITARY
(-)
INCREASE METABOLIC RATE
TSH
BODY
(+)
(+)
THYROID GLAND
TH

PARATHYROID GLANDS

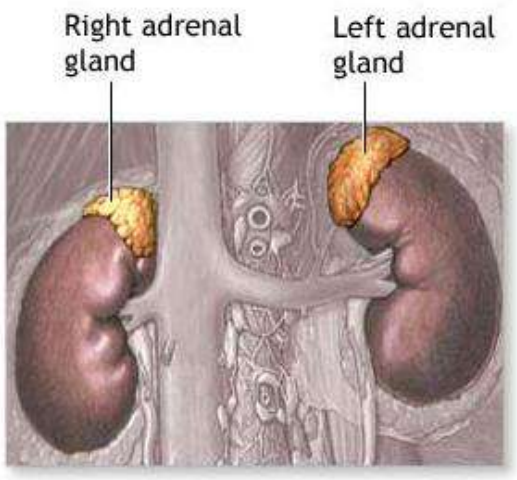
- on the posterior surface of the thyroid gland
- **PARATHYROID HORMONE (PTH):** increases blood calcium conc. & decreases phosphate ion conc.



in summary, calcitonin and PTH work together to maintain stable blood calcium concentration

ADRENAL GLANDS

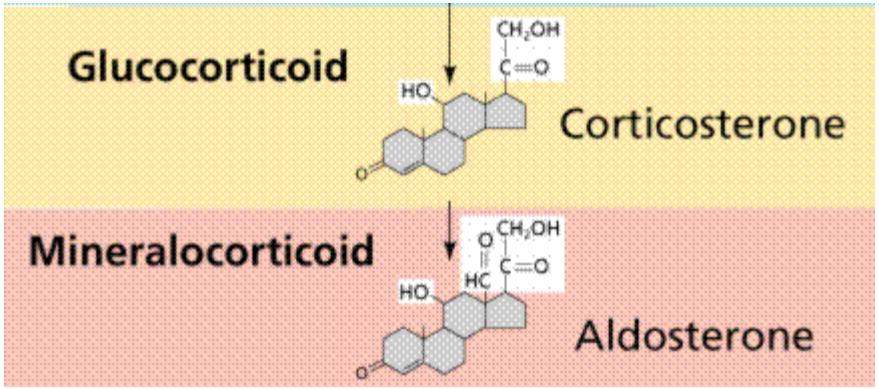
ADRENAL GLANDS: adjacent to the kidneys; made up of 2 parts:



- **Adrenal cortex (outer portion):**

  -**CORTISOL (glucocorticoid)**: glucose metabolism

  -**ALDOSTERONE (mineralocorticoid)**: salt & water balance



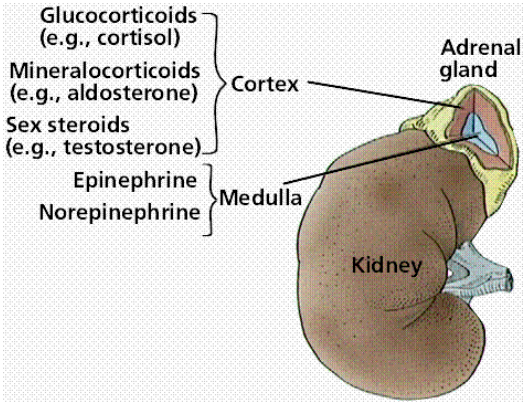
ADRENAL GLANDS

- **ADRENAL MEDULLA (inner portion):**
- Hormones include:

  -epinephrine (adrenalin)

  -norepinephrine (noradrenalin)

  -stimulates the “fight or flight” response to stress

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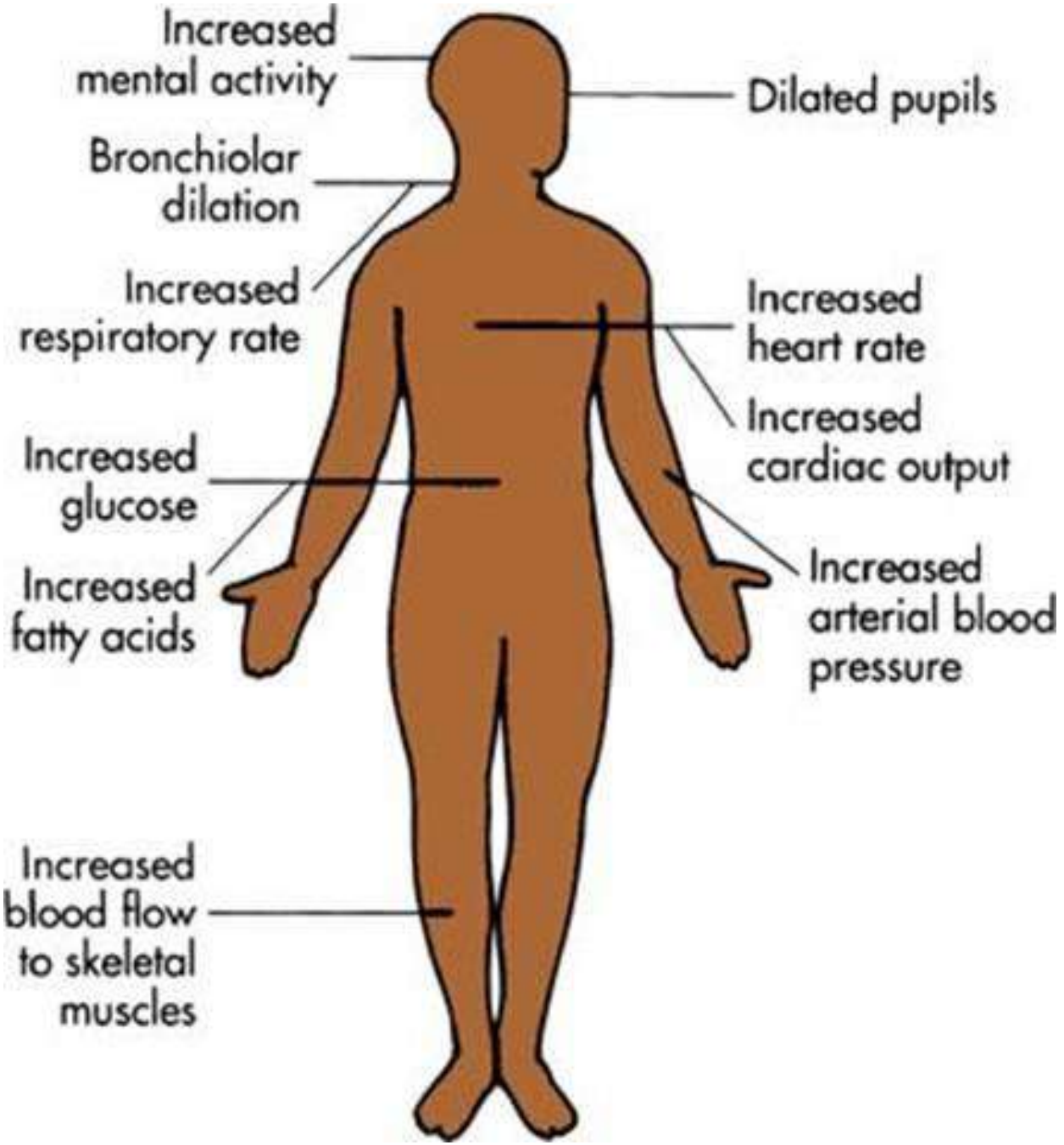
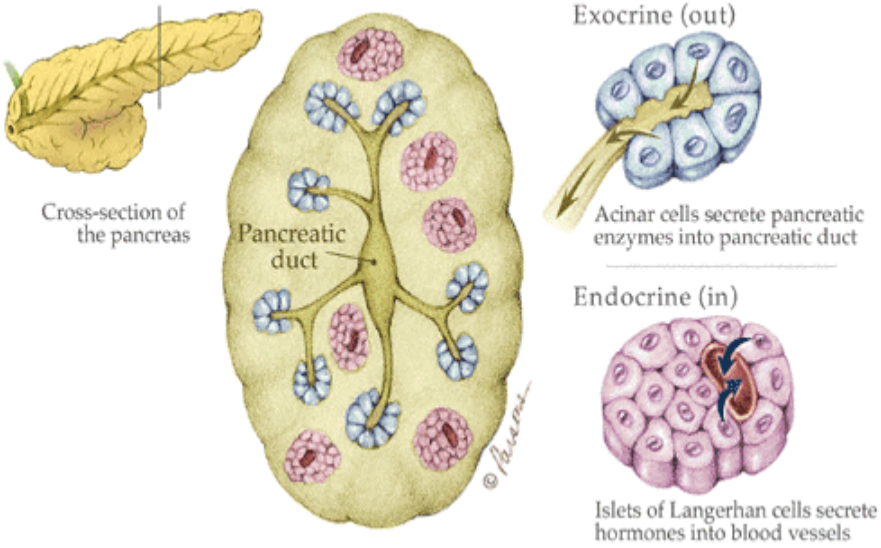
“Fight or Flight” Response:

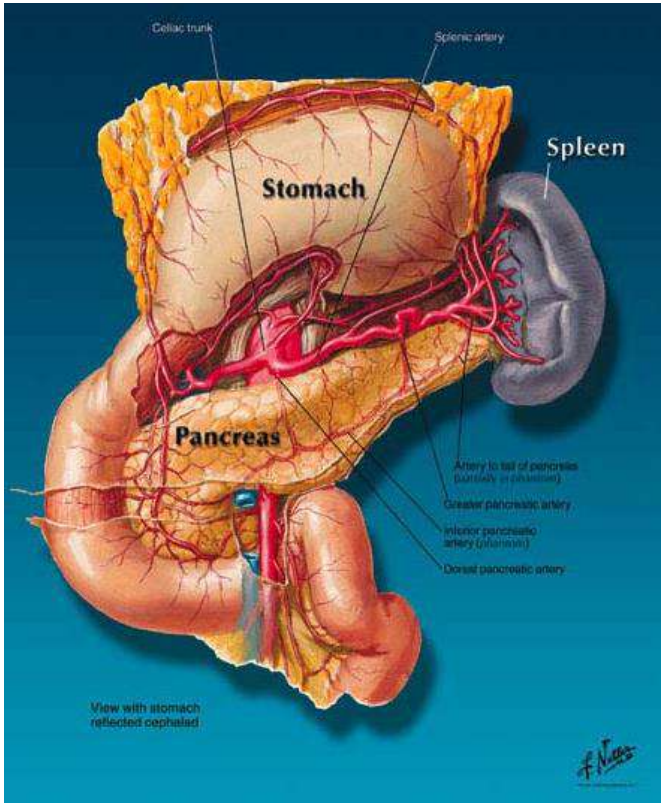
1) Glucose released from liver and muscles;
2) Fatty-acid release from fat cells;
3) Increase rate and stroke vol. of heartbeat;
4) Bronchioles of lungs become dilated (increase rate of oxygen delivery to cells);
5) Blood diverted away from skin, digestive organs and kidneys to the heart, brain & skeletal muscles (increase alertness and readiness)


Increased mental activity
Dilated pupils
Bronchiolar dilation
Increased respiratory rate
Increased heart rate
Increased cardiac output
Increased glucose
Increased fatty acids
Increased arterial blood pressure
Increased blood flow to skeletal muscles

PANCREAS

- **PANCREAS**: contains **endocrine** and **exocrine** cells (exocrine cells secrete digestive enz & bicarbonate into ducts)



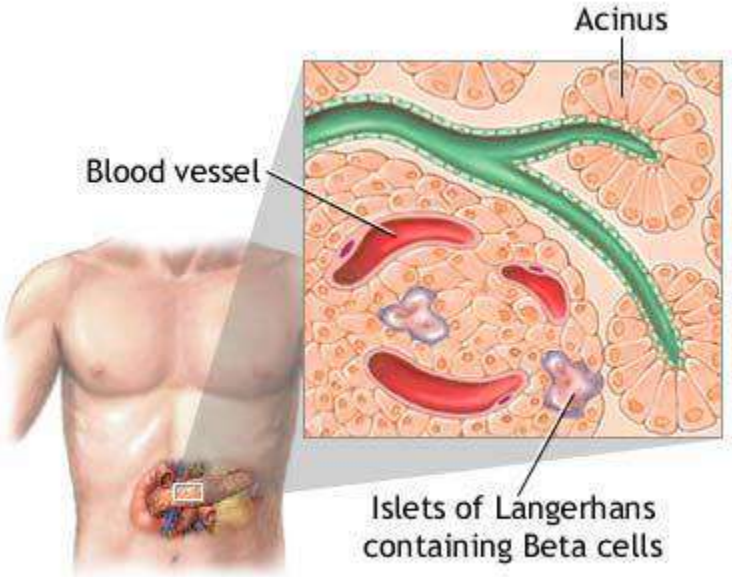


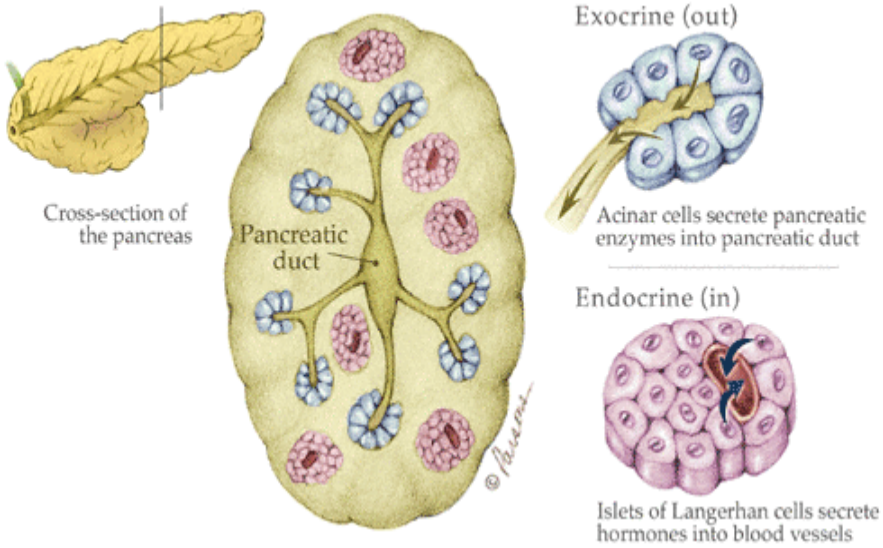
PANCREAS

-the endocrine cells are called the ***"ISLETS OF LANGERHANS"*** ☺…*it's #8!*

-**alpha cells**: secrete glucagon

-**beta cells**: secrete insulin





ISLETS OF LANGERHANS!

***word #8 on my list!!!...let's see, so far we have:*

1) Okazaki fragments

2) plasmodesmata

3) ???

4) ???

5) ???

6) rubisco

7) oxaloacetate

8) islets of Langerhans ☺

9) Batesian mimicry

10) ???

Feedback cycle to control blood glucose levels:

Beta cells secrete insulin

body cells & liver cells take up glucose

blood glucose level drops

Blood Glucose Level (90 mg/100 mL)

Low glucose level

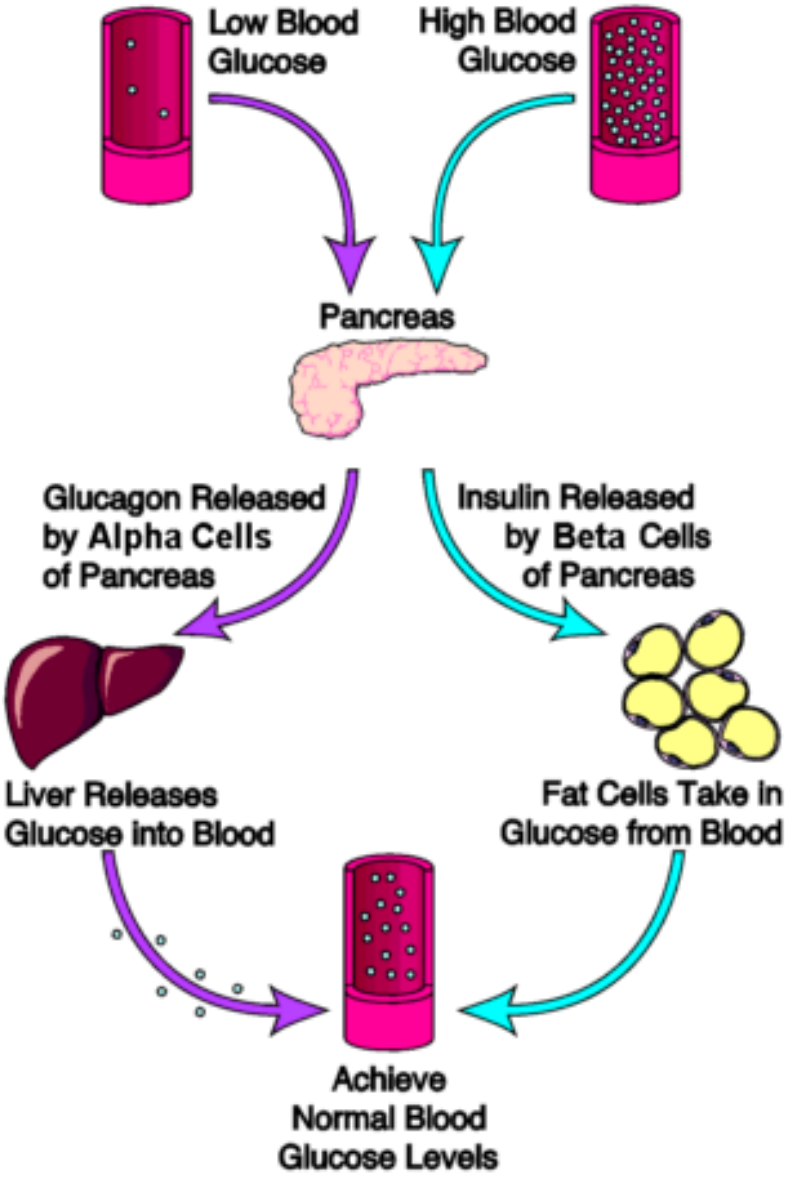
Alpha cells secrete glucagon

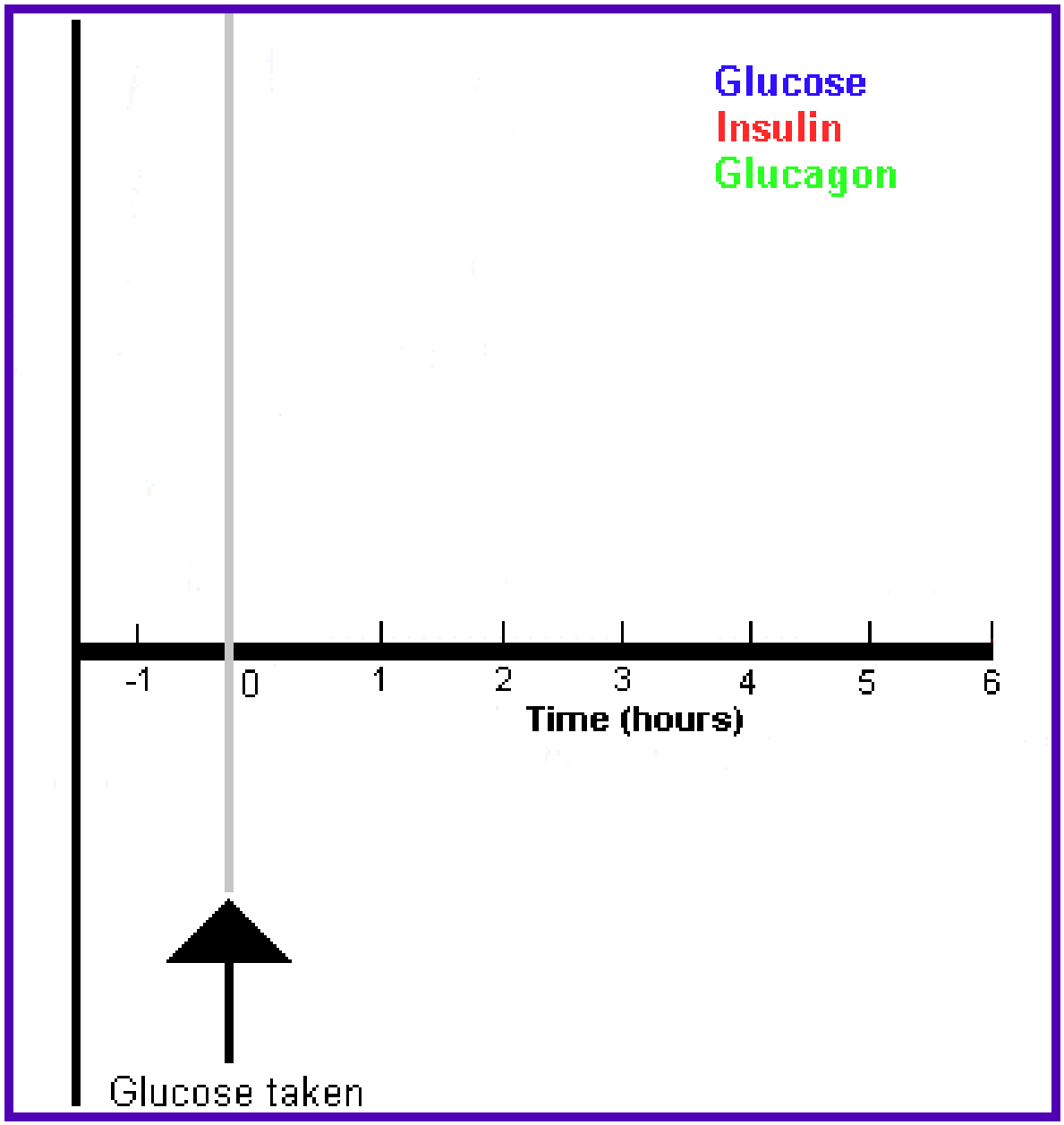
liver cells break down glycogen & release glucose

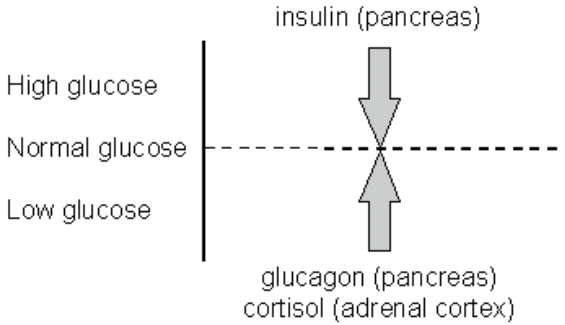
blood glucose level rises

High glucose level

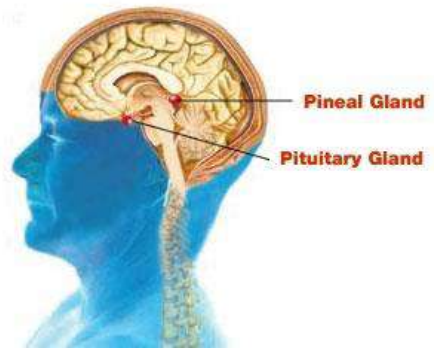
Feedback cycle to control blood glucose levels:




Glucose
Insulin
Glucagon
-1
0
1
2
3
4
5
6
Time (hours)
Glucose taken


insulin (pancreas)
High glucose
Normal glucose
Low glucose
glucagon (pancreas)
cortisol (adrenal cortex)

PINEAL GLAND



- located deep between the cerebral hemispheres (brain)
- secretes the hormone **MELATONIN** in response to light conditions

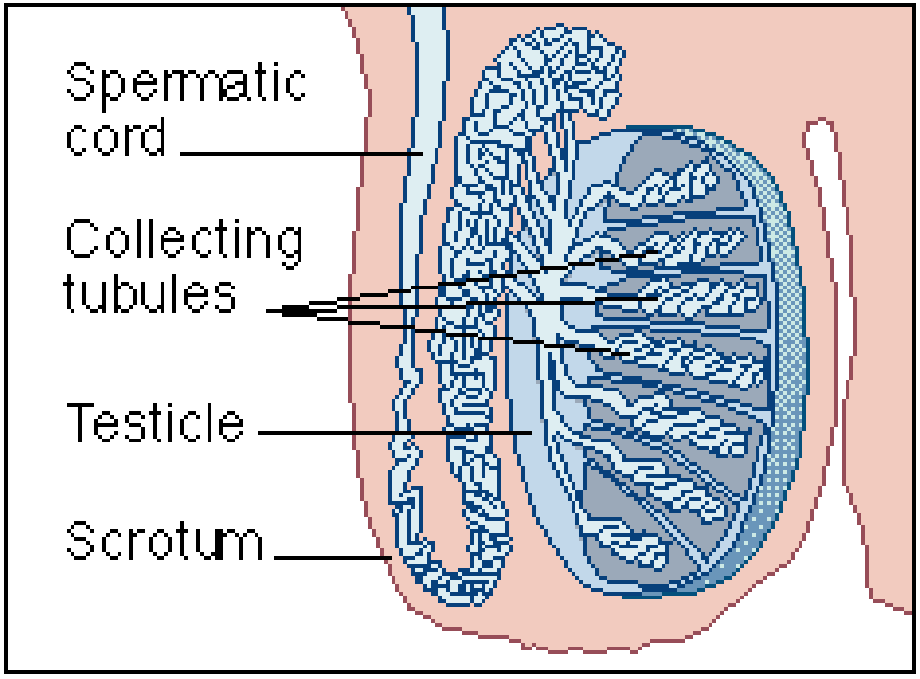
  -in the dark, nerve impulses from the retina to the brain decrease, and melatonin secretion increases

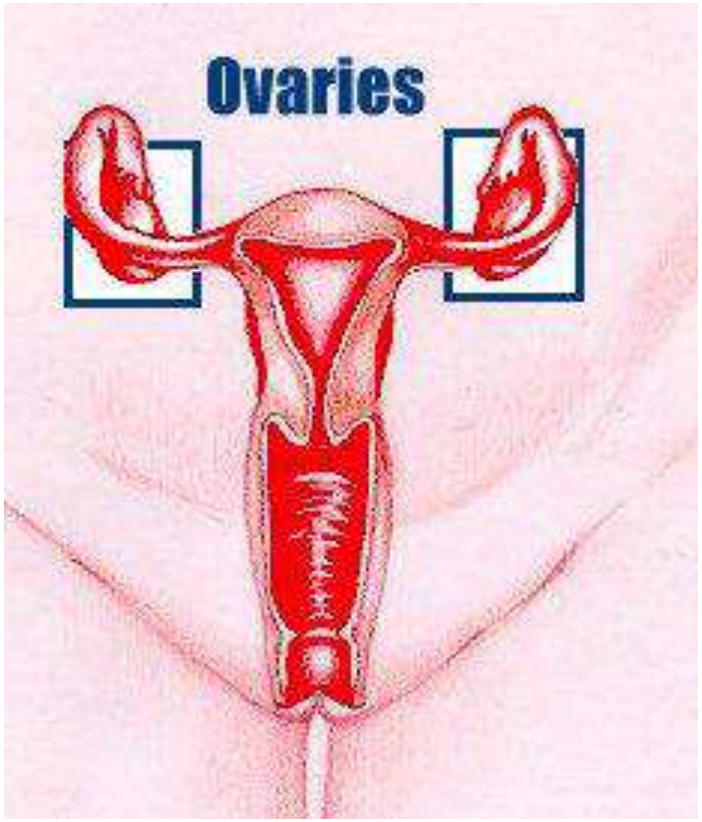
  -works with the brain to regulate "**CIRCADIAN RHYTHMS**"

  -may help regulate the female menstrual cycle, as well as the onset of puberty

GONADS

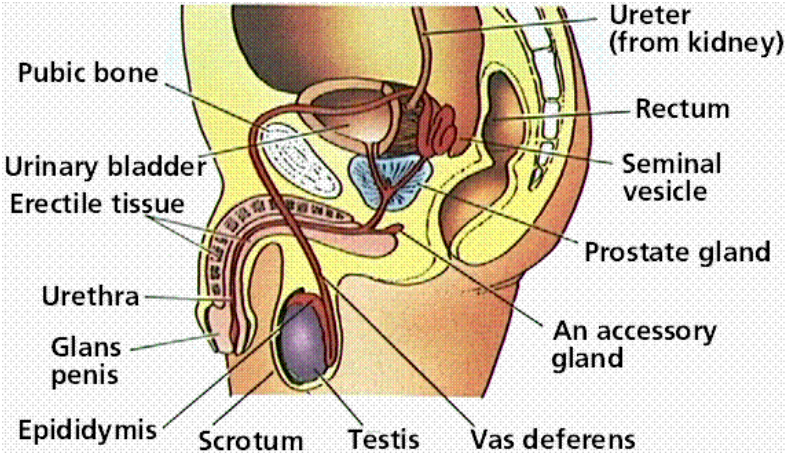
- **GONADS**: (testes in males, ovaries in females)



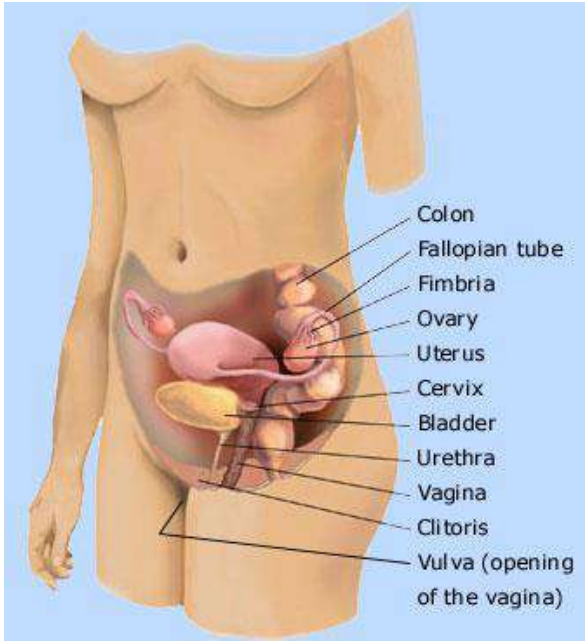


HORMONES PRODUCED BY THE GONADS:

1) Androgens: stimulate development & maintenance of male reproductive system; (e.g. testosterone)



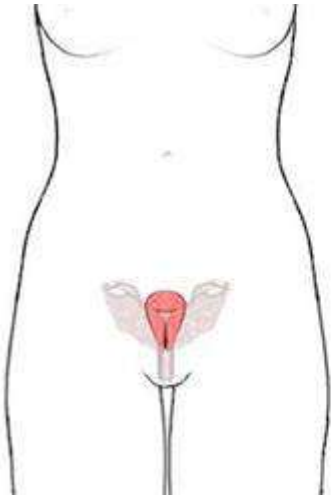
2) Estrogens: maintenance of female reproductive system; (e.g. estradiol)



HORMONES PRODUCED BY THE GONADS:

3) Progestins: preparing and maintaining uterus to support growth and development of embryo;

(e.g. progesterone)



all 3 hormones are found in males and females, but in different proportions