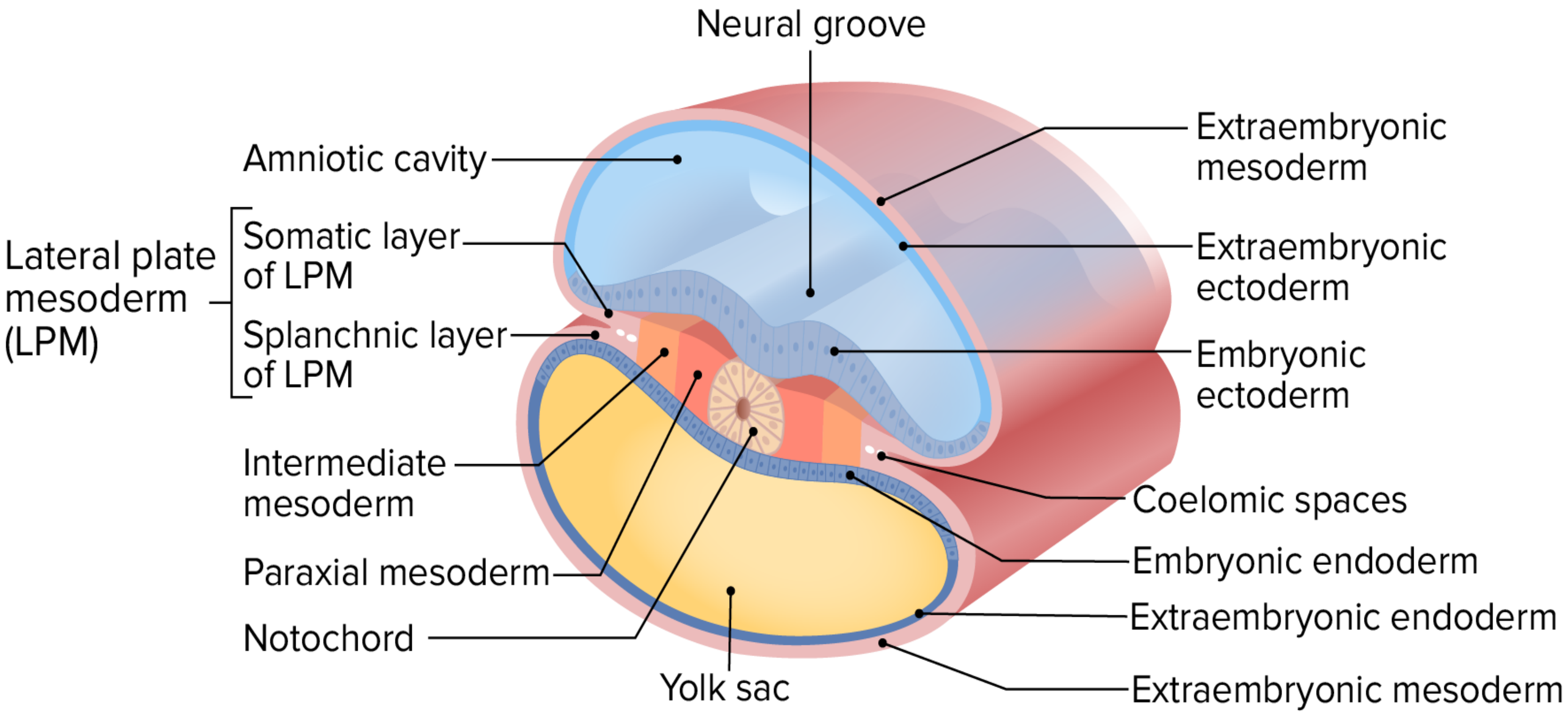
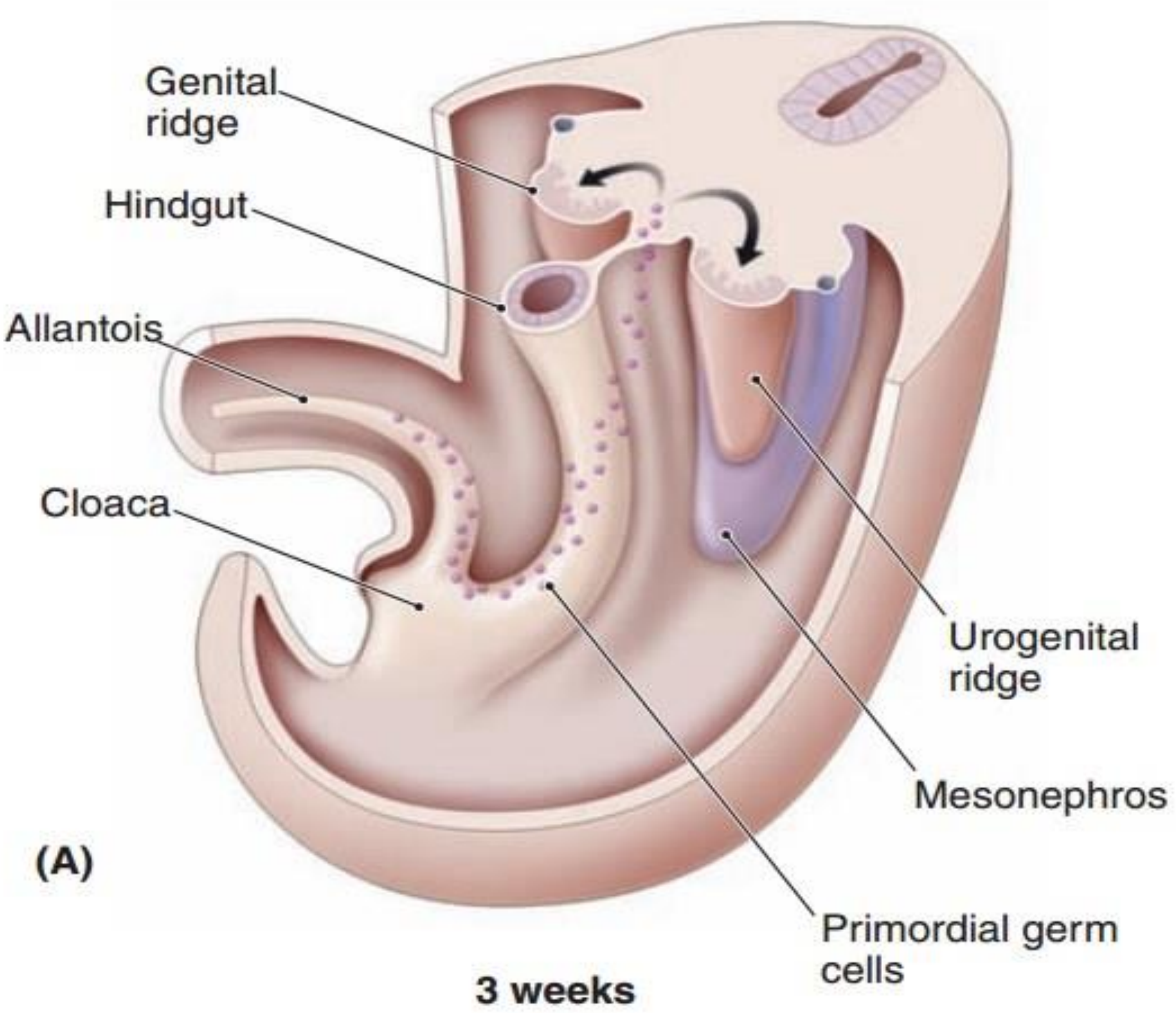
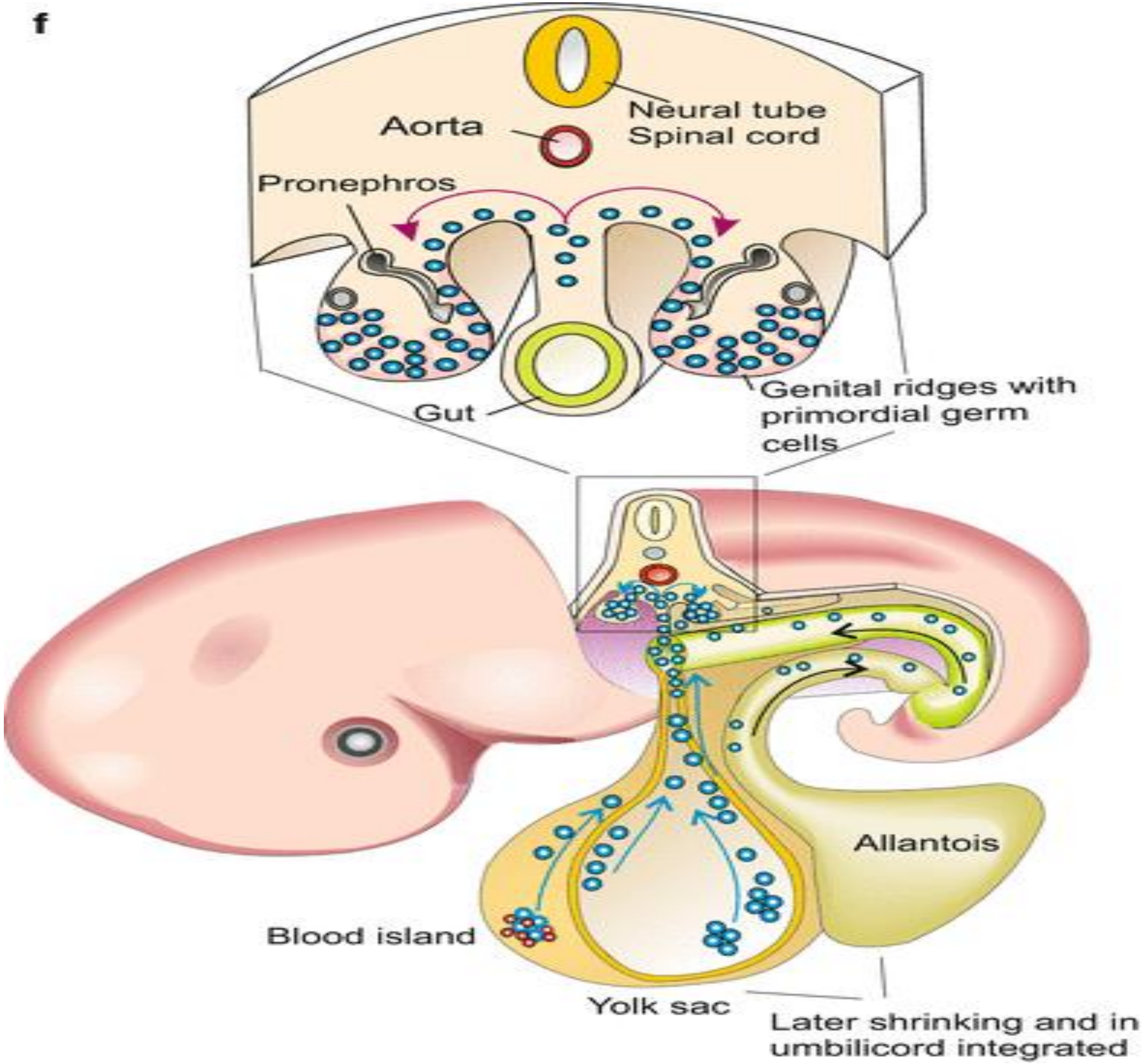

Neural groove
Amniotic cavity
Extraembryonic mesoderm
Extraembryonic ectoderm
Lateral plate mesoderm (LPM)
Somatic layer of LPM
Splanchnic layer of LPM
Embryonic ectoderm
Intermediate mesoderm
Coelomic spaces
Embryonic endoderm
Paraxial mesoderm
Extraembryonic endoderm
Notochord
Yolk sac
Extraembryonic mesoderm

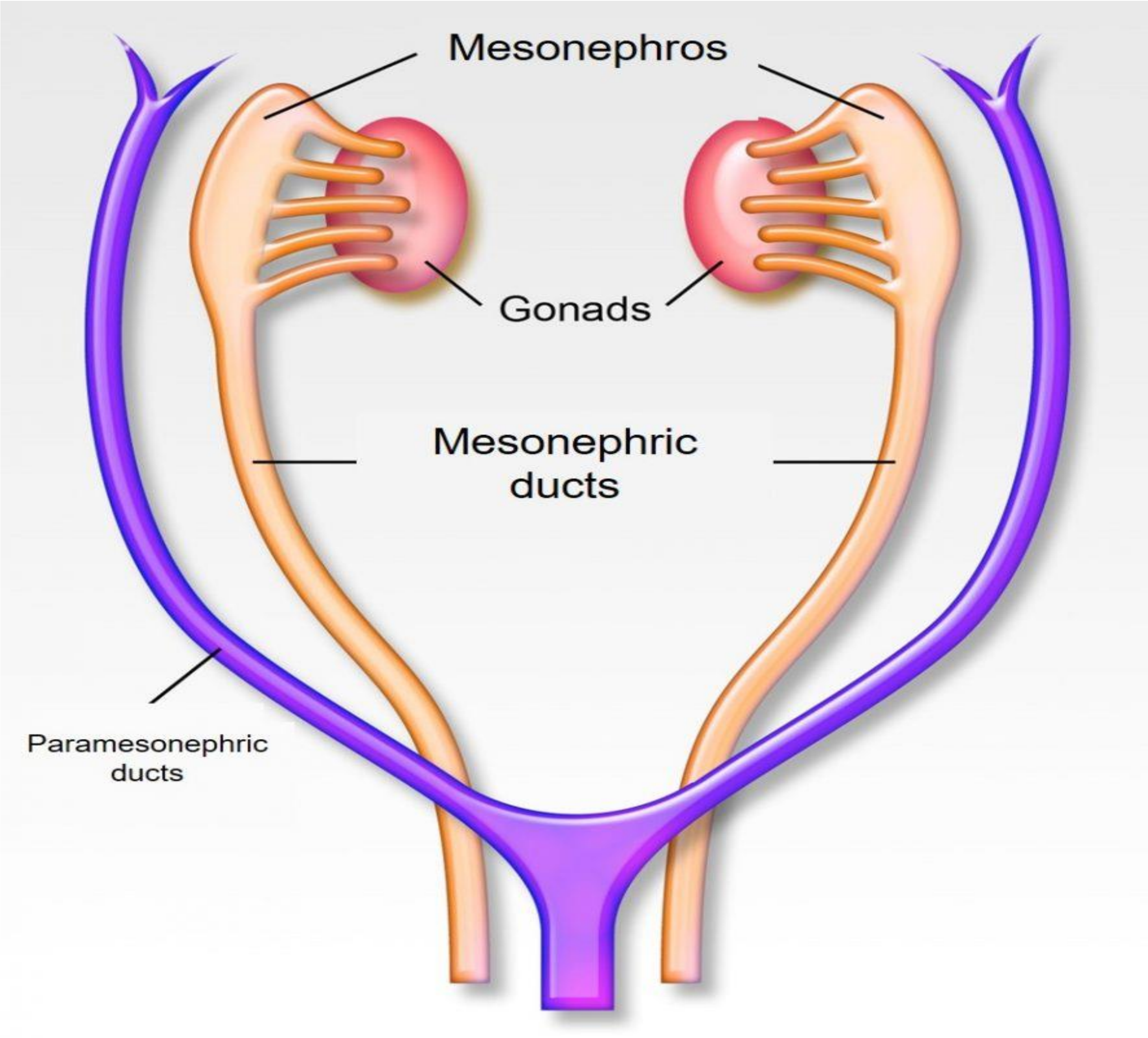


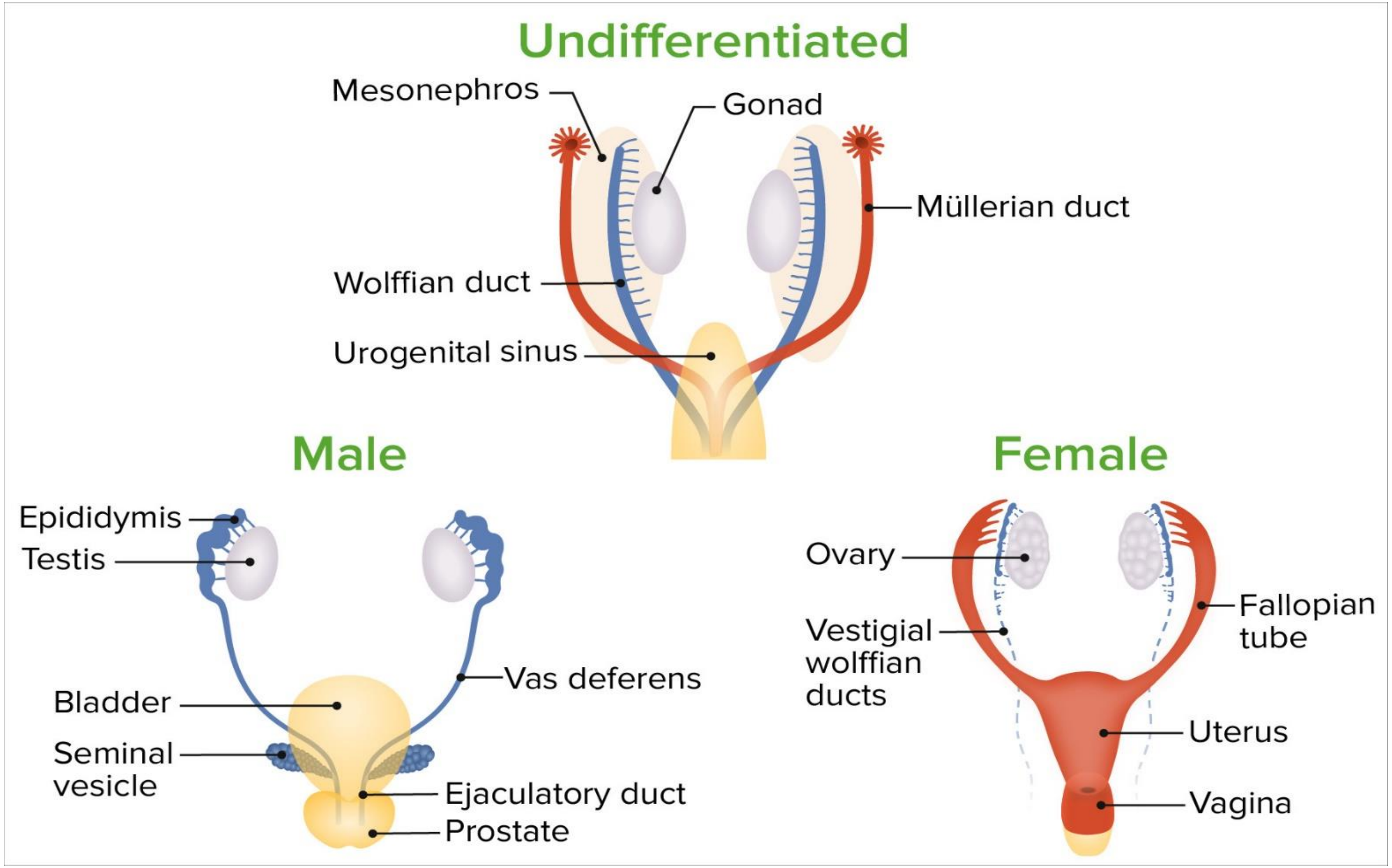
Genital ridge
Hindgut
Allantois
Cloaca
(A)
Urogenital ridge
Mesonephros
Primordial germ cells
3 weeks

f

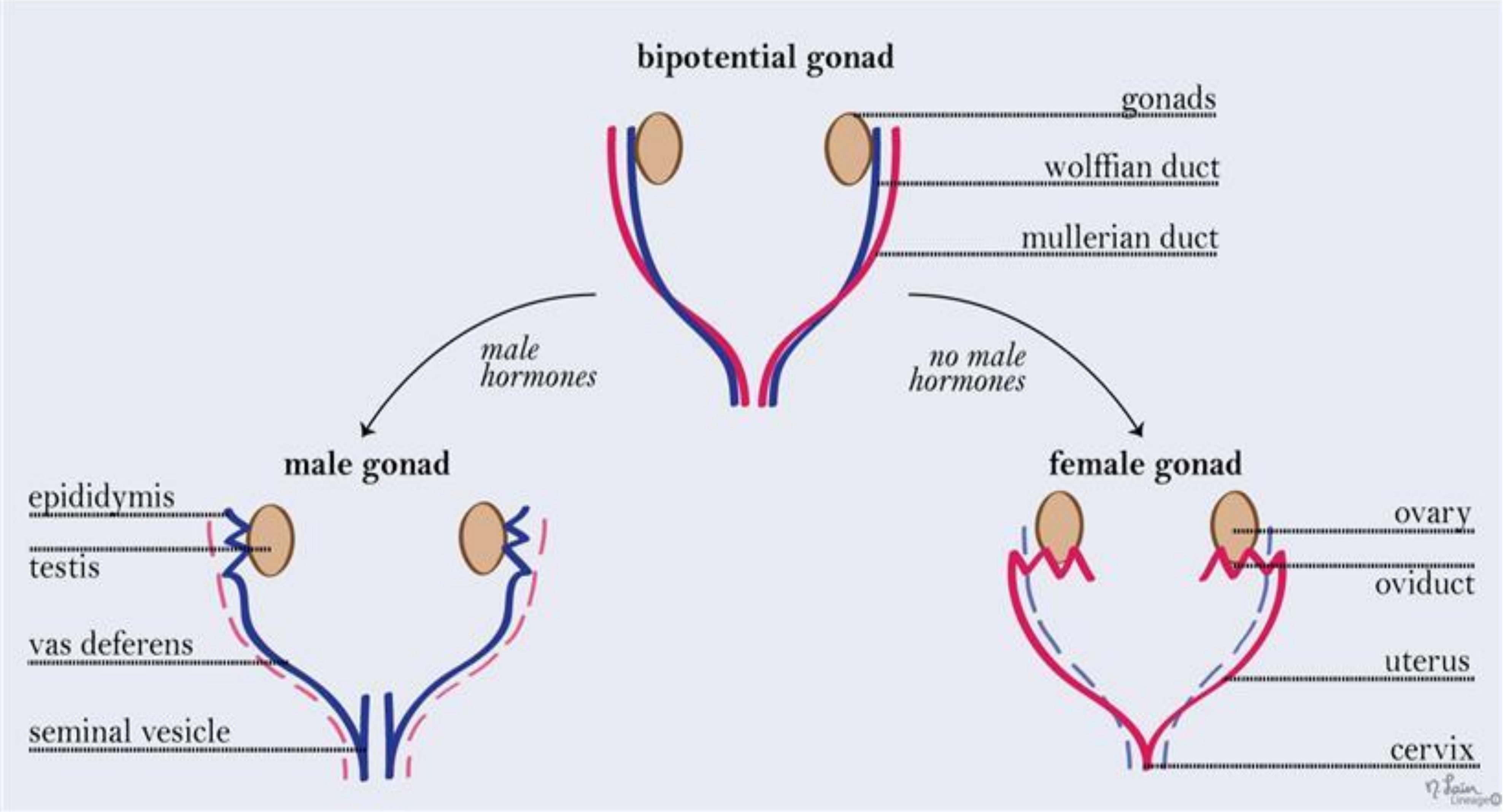


Neural tube
Spinal cord
Aorta
Pronephros
Genital ridges with primordial germ cells
Gut
Allantois
Blood island
Yolk sac
Later shrinking and in umbilicord integrated

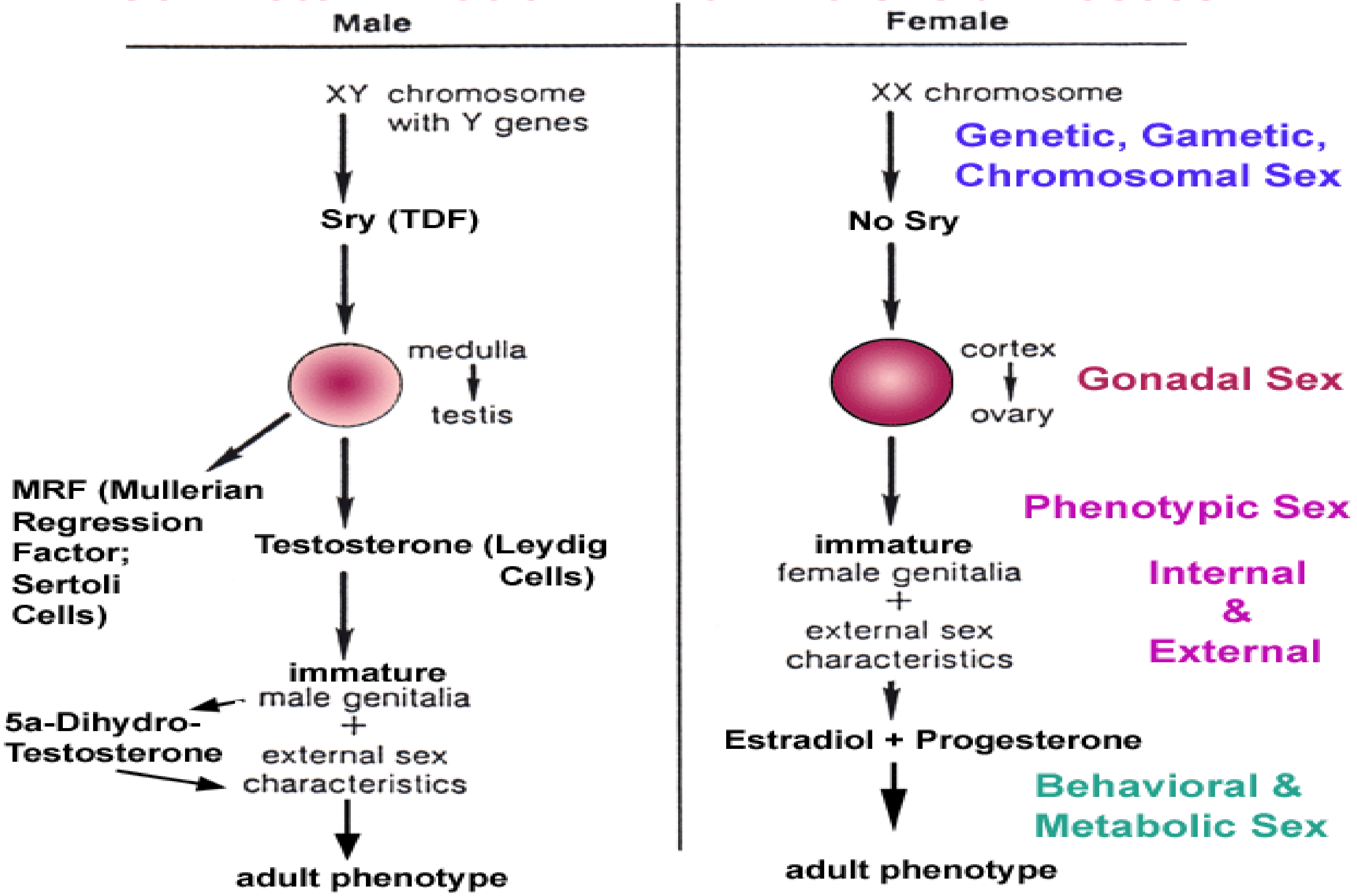

Mesonephros
Gonads
Mesonephric ducts
Paramesonephric ducts


Undifferentiated
Mesonephros
Gonad
Müllerian duct
Wolffian duct
Urogenital sinus
Male
Epididymis
Testis
Vas deferens
Bladder
Seminal vesicle
Ejaculatory duct
Prostate
Female
Ovary
Fallopian tube
Vestigial wolffian ducts
Uterus
Vagina

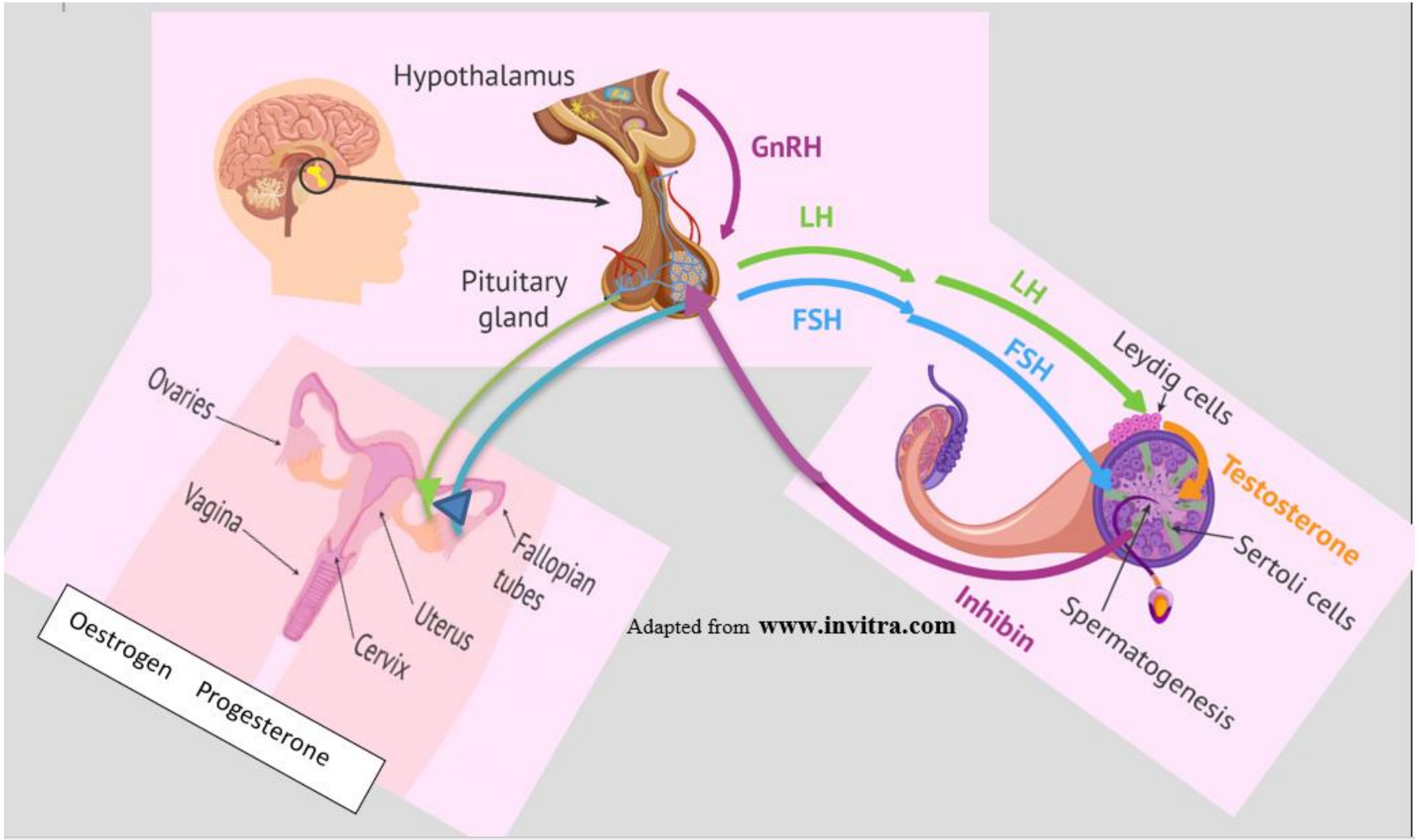
Male/Female Differentiation



Sex Determination in Mammals Is a Process

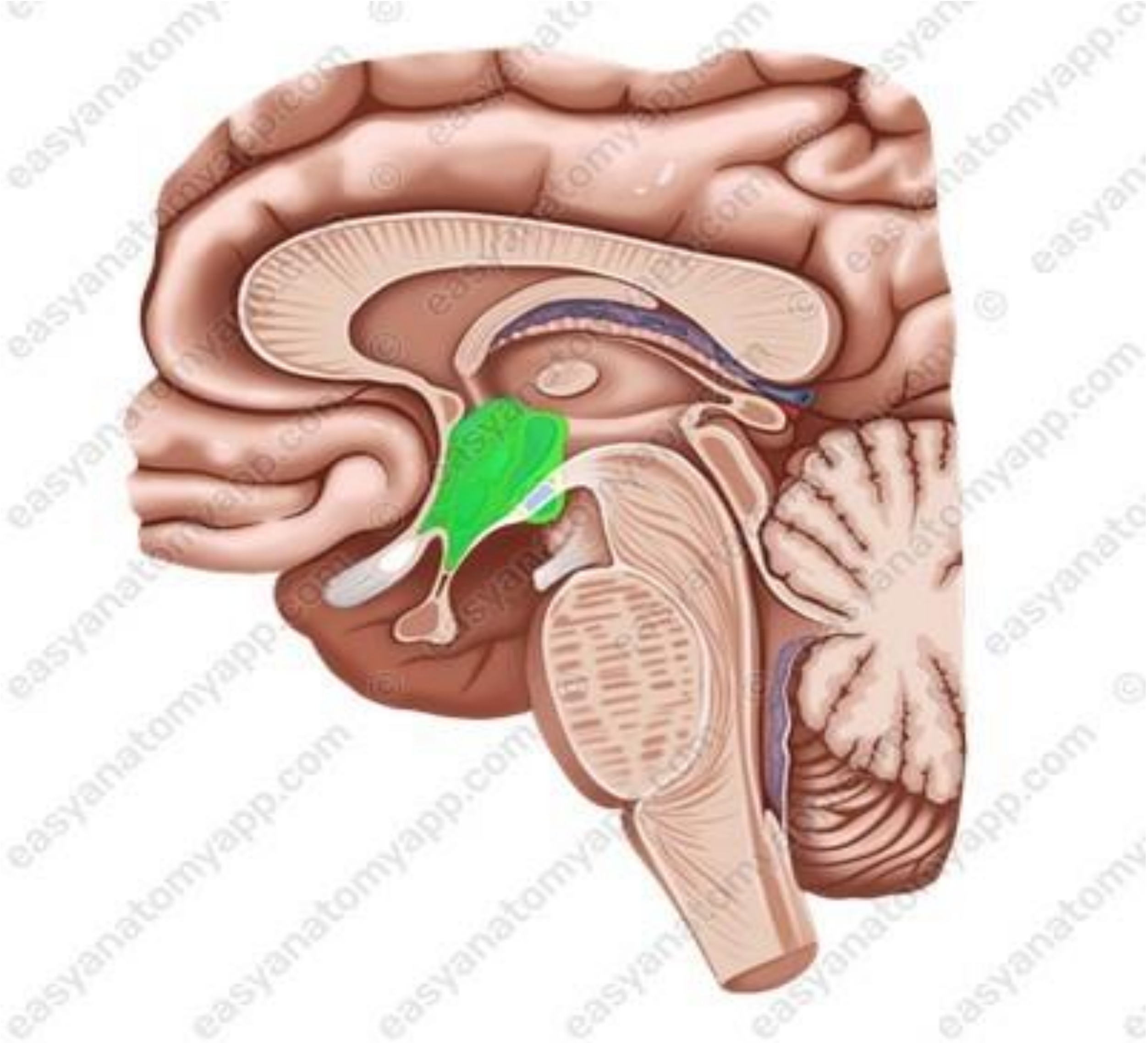


HPG axis



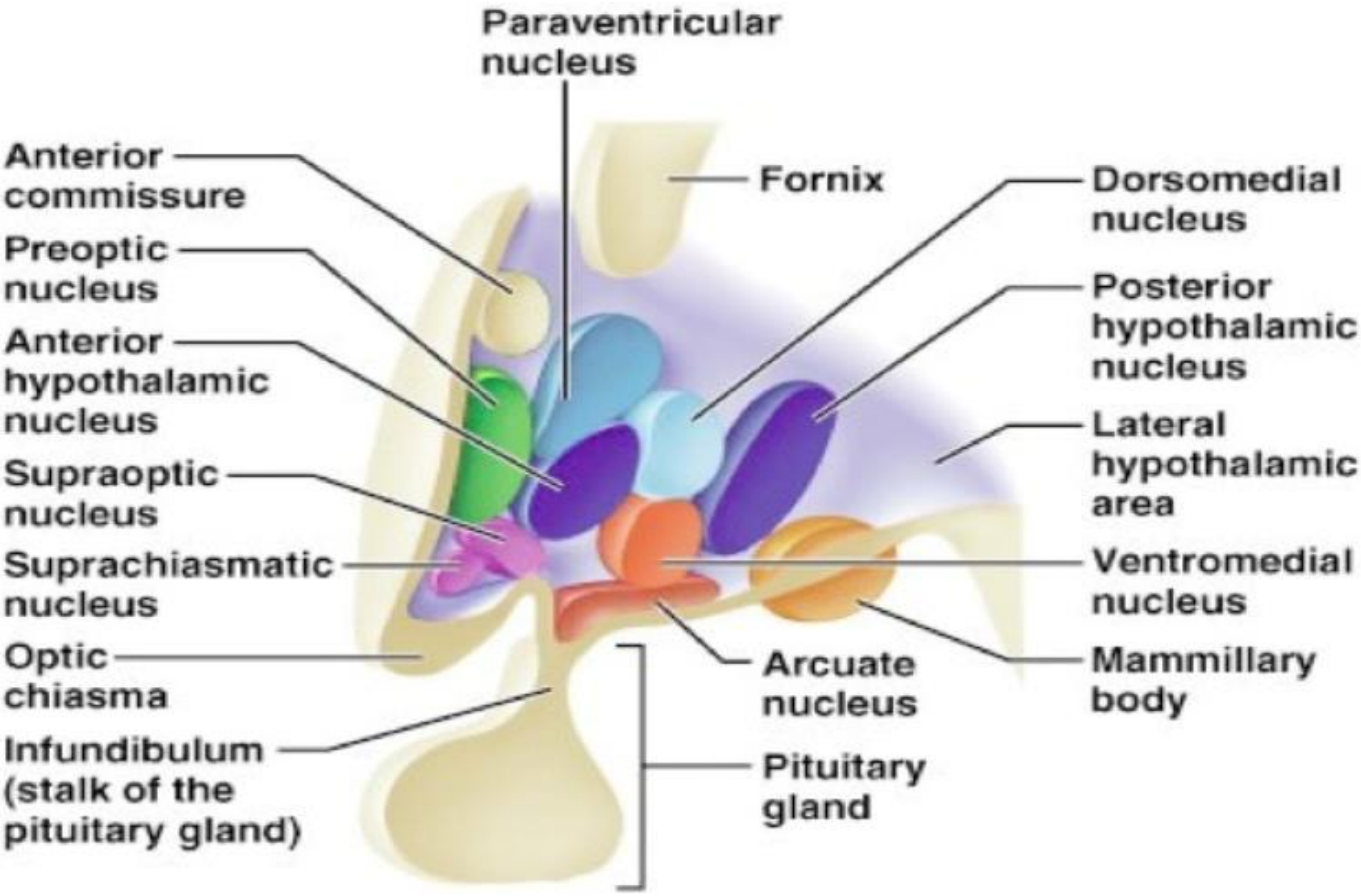
Adapted from www.invitra.com

Hypothalamus

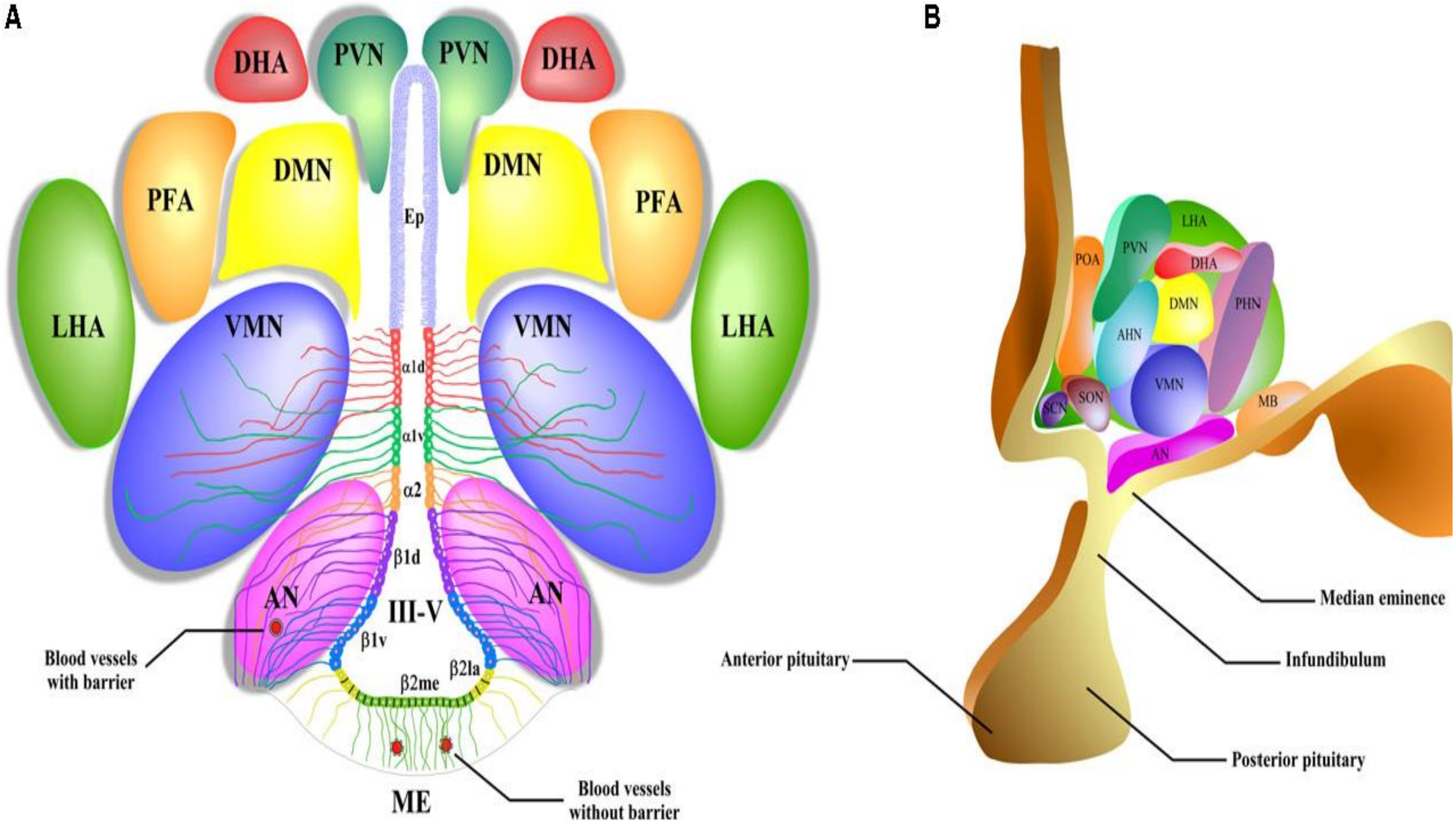


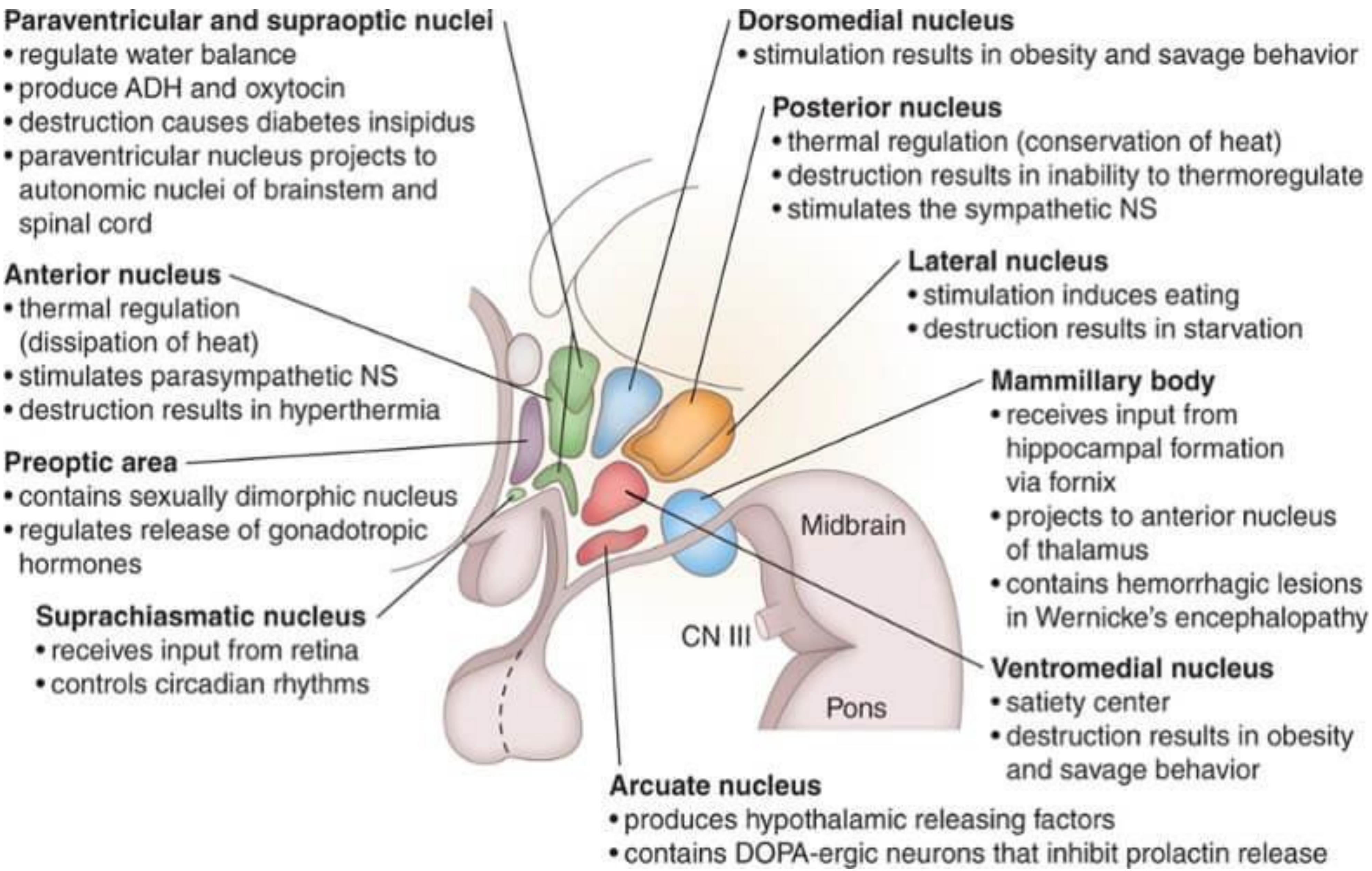
Functions of the Hypothalamus

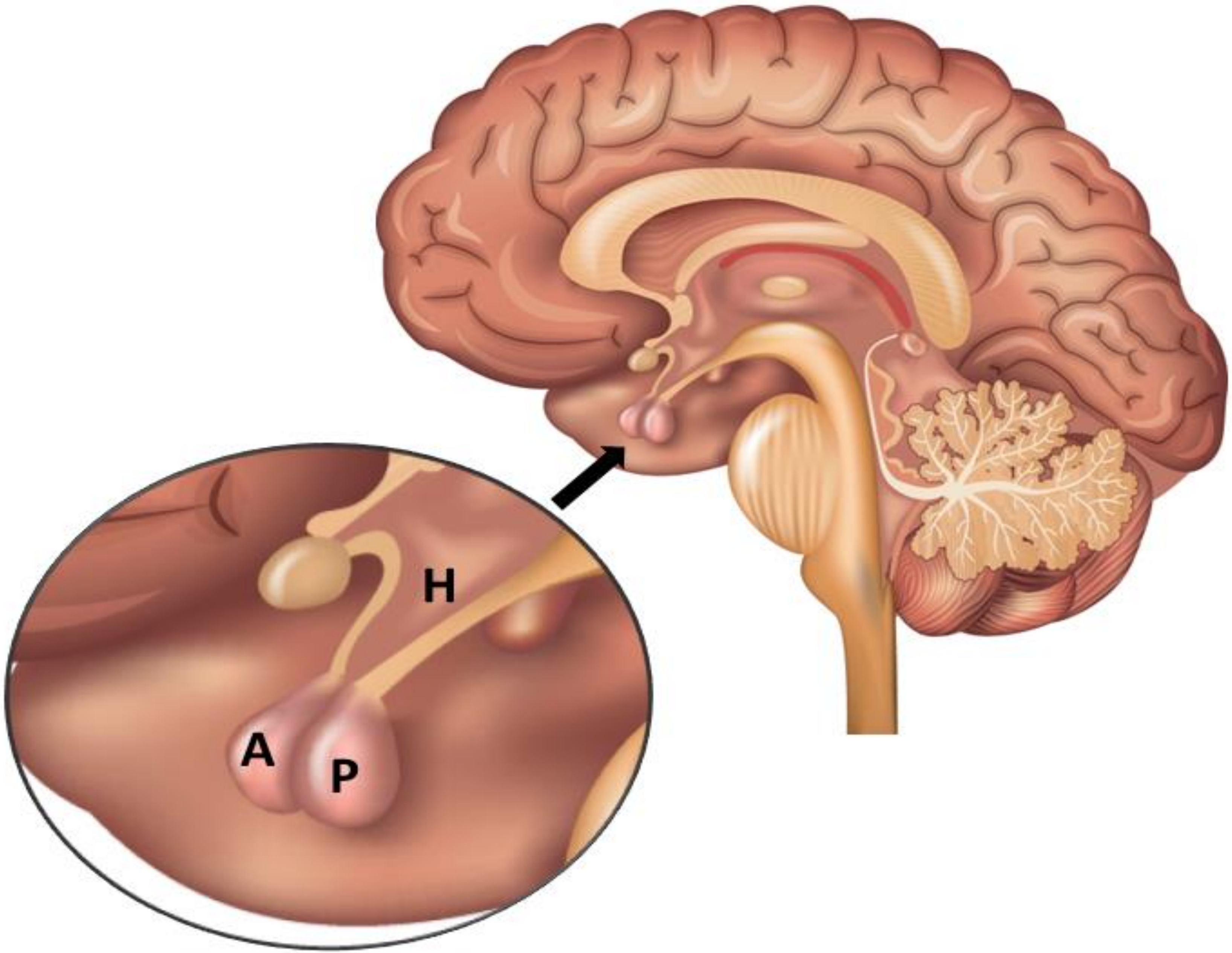
- ***Endocrine function(Control of Pituitary gland)***
- ***Autonomic function(Control of ANS)***
- ***Regulation of Body Temperature***
- ***Regulation of Food Intake***
- ***Regulation of Water Intake and Excretion***
- ***Relation to Emotions***
- ***Relation to Memory***
- ***Control of Circadian Rhythm***

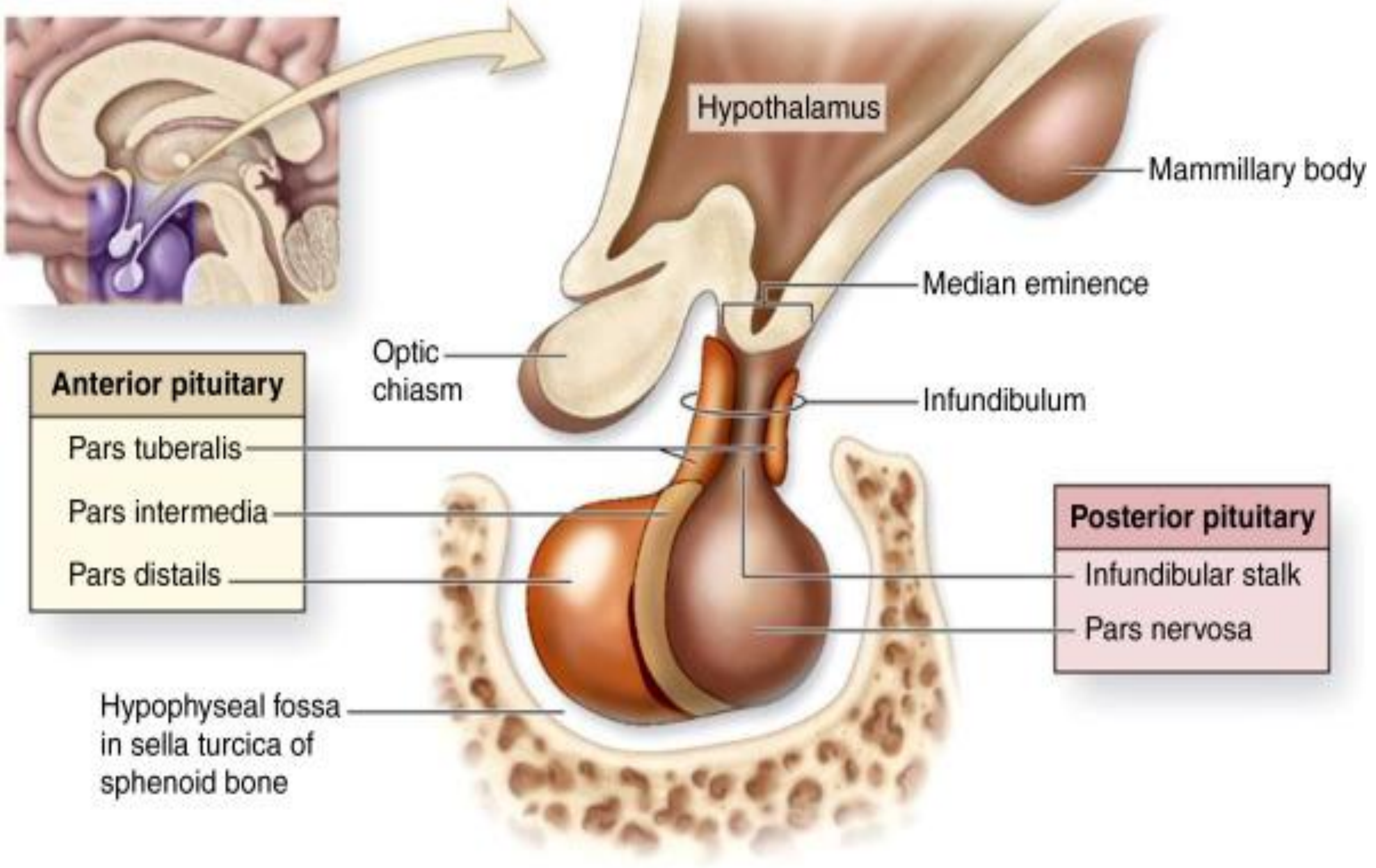


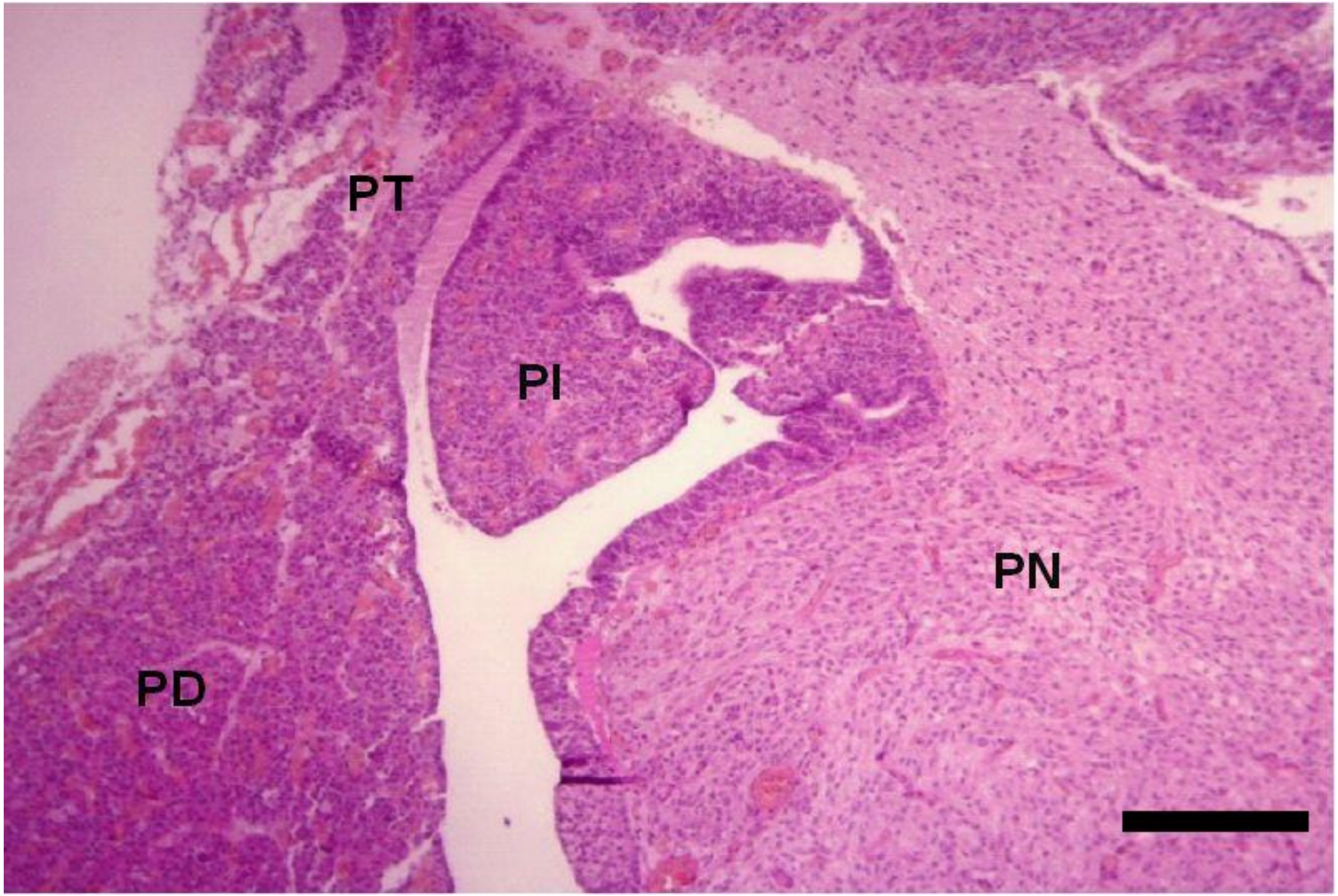
Paraventricular nucleus
Anterior commissure
Fornix
Dorsomedial nucleus
Preoptic nucleus
Posterior hypothalamic nucleus
Anterior hypothalamic nucleus
Lateral hypothalamic area
Supraoptic nucleus
Suprachiasmatic nucleus
Ventromedial nucleus
Optic chiasma
Arcuate nucleus
Mammillary body
Infundibulum (stalk of the pituitary gland)
Pituitary gland

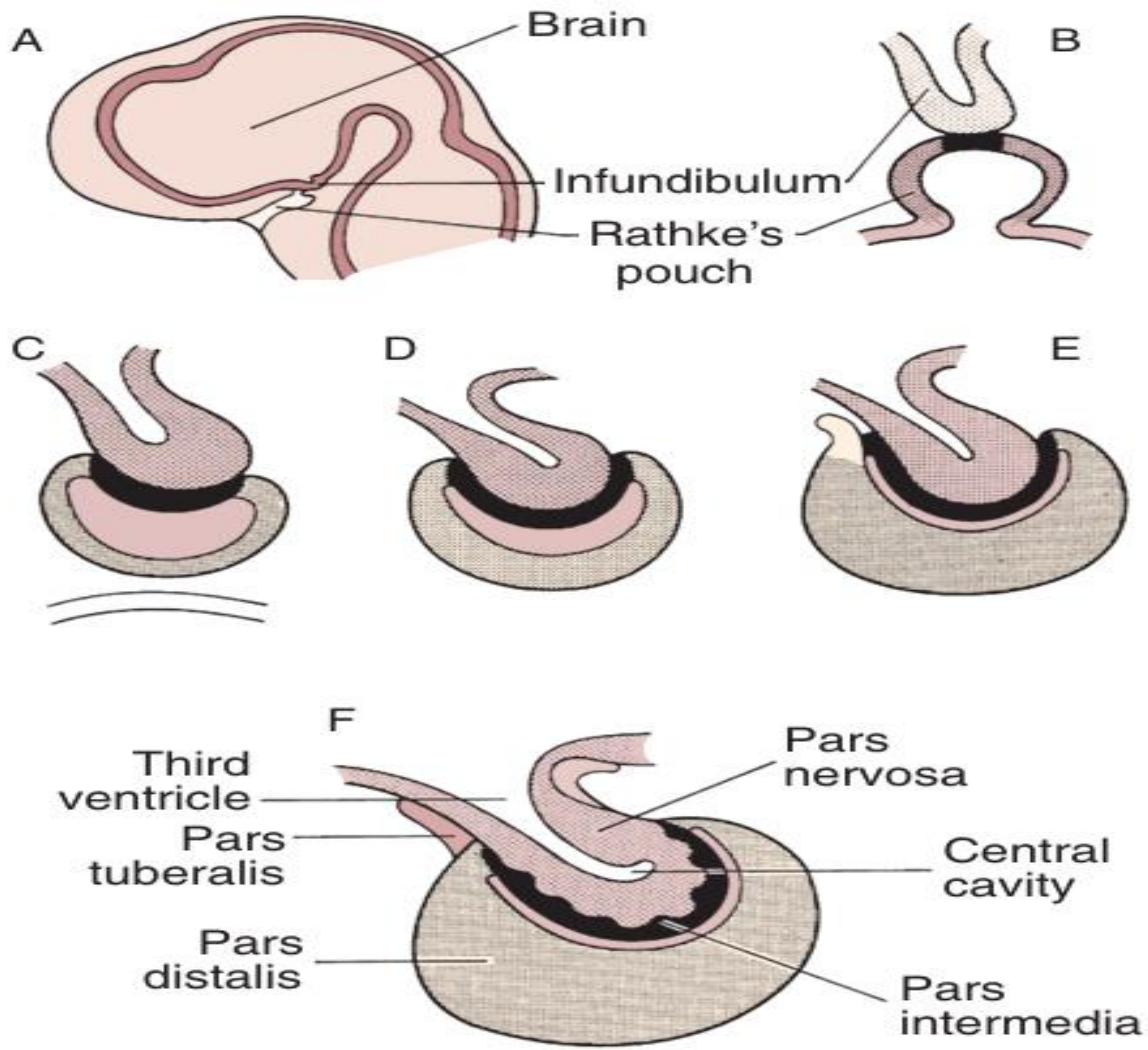

A
DHA
PVN
PVN
DHA
PFA
DMN
DMN
PFA
Ep
LHA
VMN
VMN
LHA
α1d
α1v
α2
β1d
AN
III-V
AN
β1v
β2me
β2la
Blood vessels with barrier
Blood vessels without barrier
ME
B
LHA
PVN
POA
DHA
DMN
PHN
AHN
VMN
SCN
SON
MB
AN
Median eminence
Infundibulum
Anterior pituitary
Posterior pituitary


Paraventricular and supraoptic nuclei
• regulate water balance
• produce ADH and oxytocin
• destruction causes diabetes insipidus
• paraventricular nucleus projects to autonomic nuclei of brainstem and spinal cord
Anterior nucleus
• thermal regulation (dissipation of heat)
• stimulates parasympathetic NS
• destruction results in hyperthermia
Preoptic area
• contains sexually dimorphic nucleus
• regulates release of gonadotropic hormones
Suprachiasmatic nucleus
• receives input from retina
• controls circadian rhythms
Dorsomedial nucleus
• stimulation results in obesity and savage behavior
Posterior nucleus
• thermal regulation (conservation of heat)
• destruction results in inability to thermoregulate
• stimulates the sympathetic NS
Lateral nucleus
• stimulation induces eating
• destruction results in starvation
Mammillary body
• receives input from hippocampal formation via fornix
• projects to anterior nucleus of thalamus
• contains hemorrhagic lesions in Wernicke's encephalopathy
Midbrain
CN III
Pons
Ventromedial nucleus
• satiety center
• destruction results in obesity and savage behavior
Arcuate nucleus
• produces hypothalamic releasing factors
• contains DOPA-ergic neurons that inhibit prolactin release

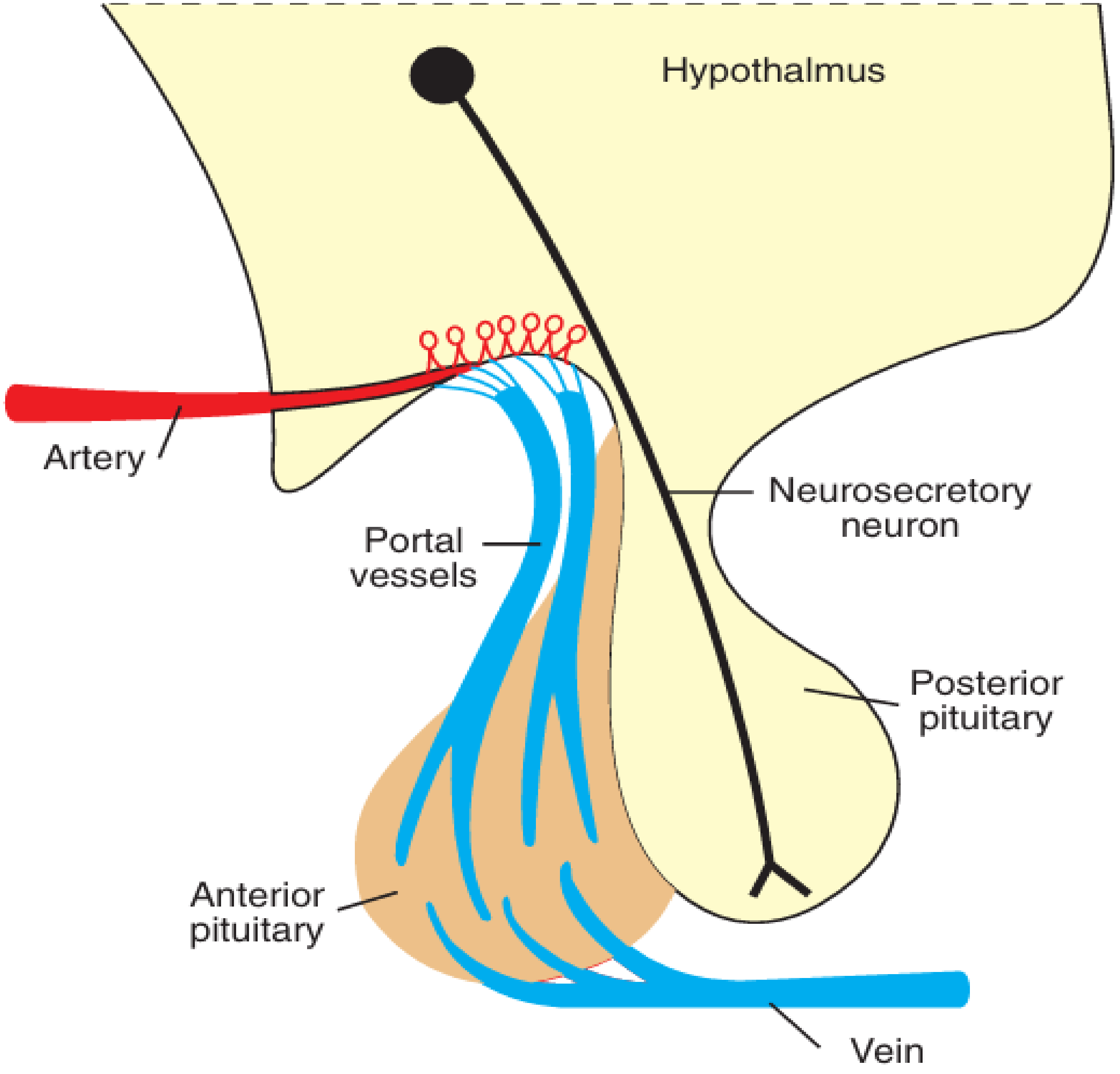

H
A
P


Hypothalamus
Mammillary body
Median eminence
Optic chiasm
Infundibulum
Anterior pituitary
Pars tuberalis
Pars intermedia
Pars distails
Posterior pituitary
Infundibular stalk
Pars nervosa
Hypophyseal fossa in sella turcica of sphenoid bone

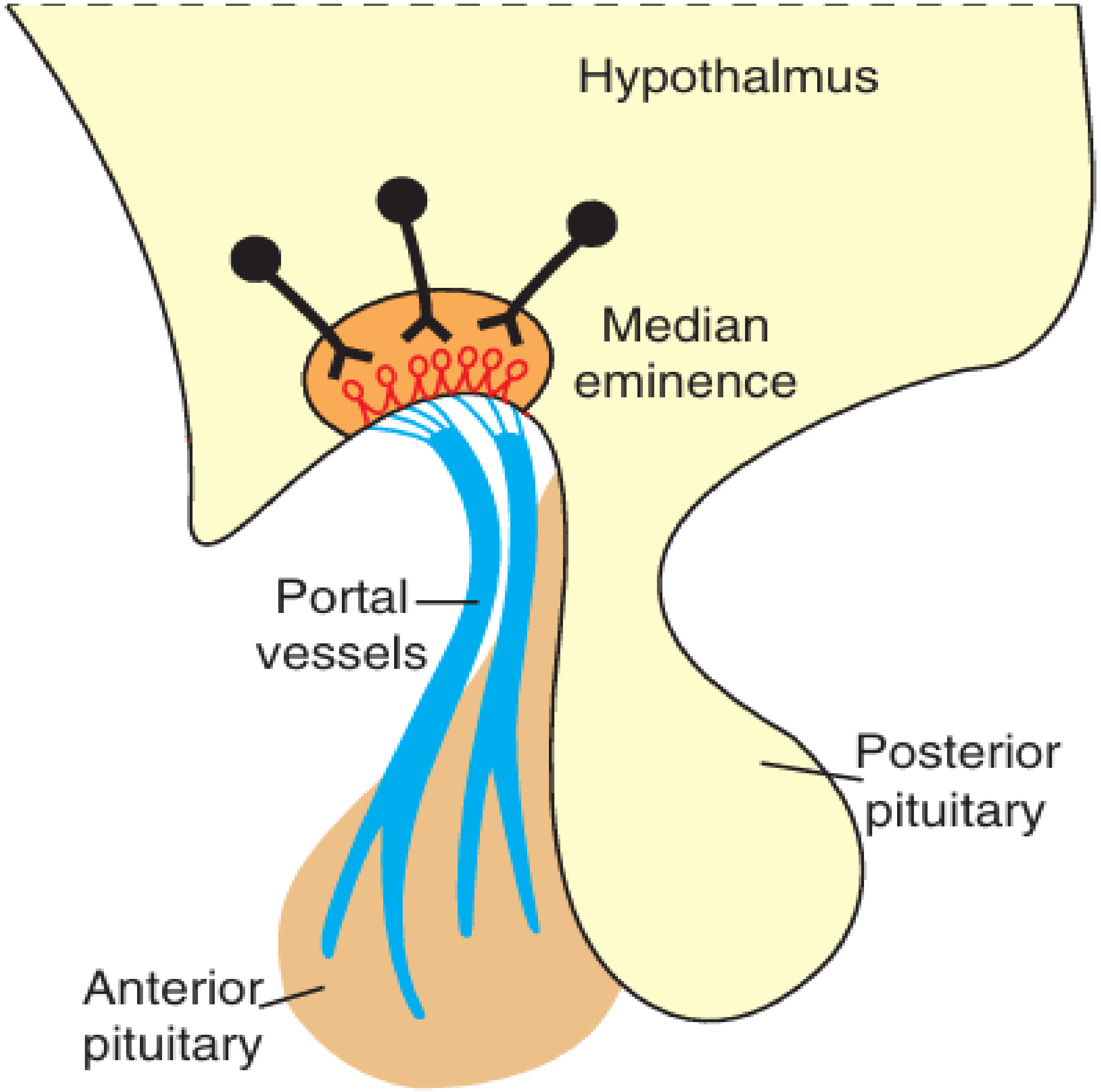

PT
PI
PN
PD

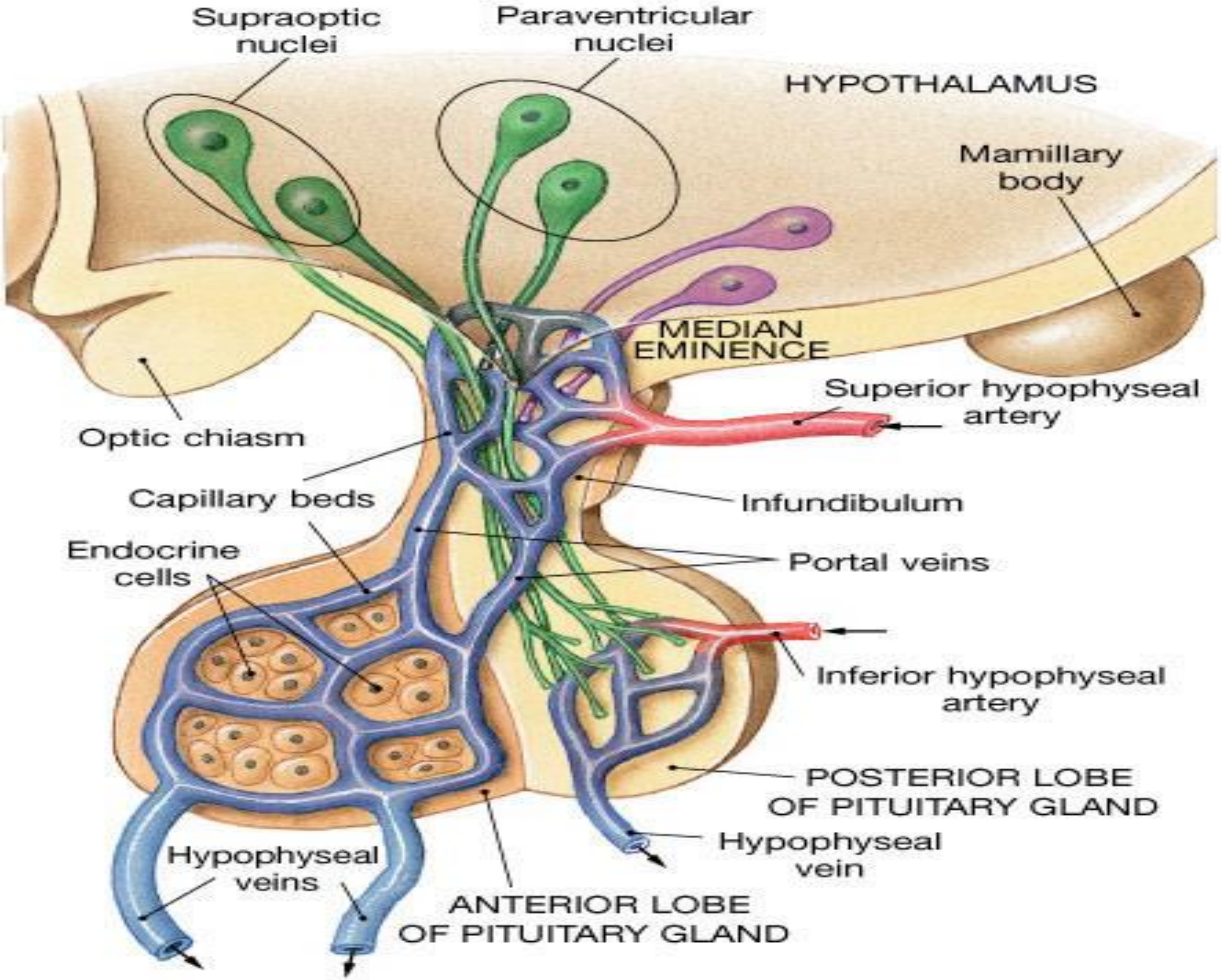


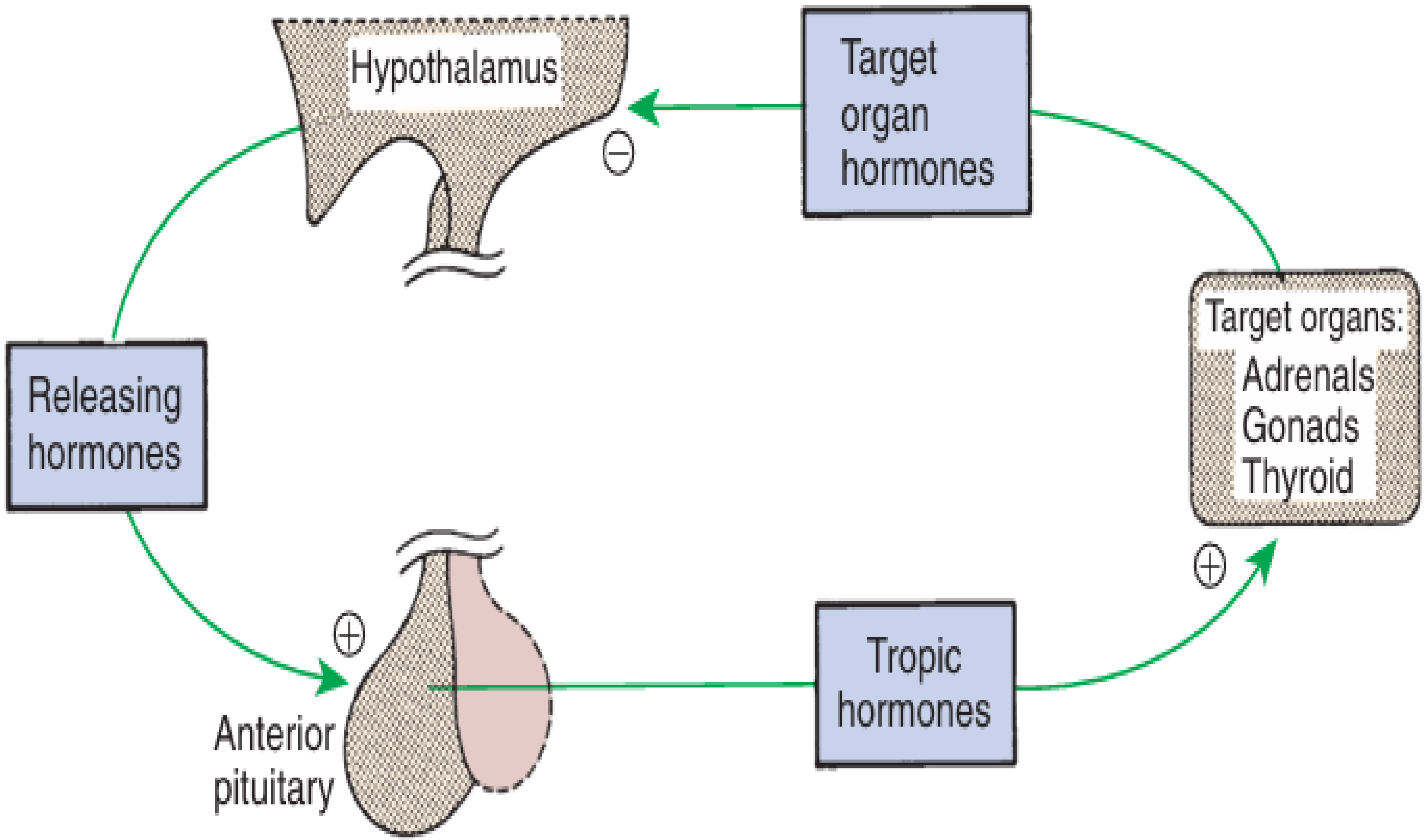
A
Brain
B
Infundibulum
Rathke's
pouch
C
D
E
F
Third
ventricle
Pars
tuberalis
Pars
distalis
Pars
nervosa
Central
cavity
Pars
intermedia

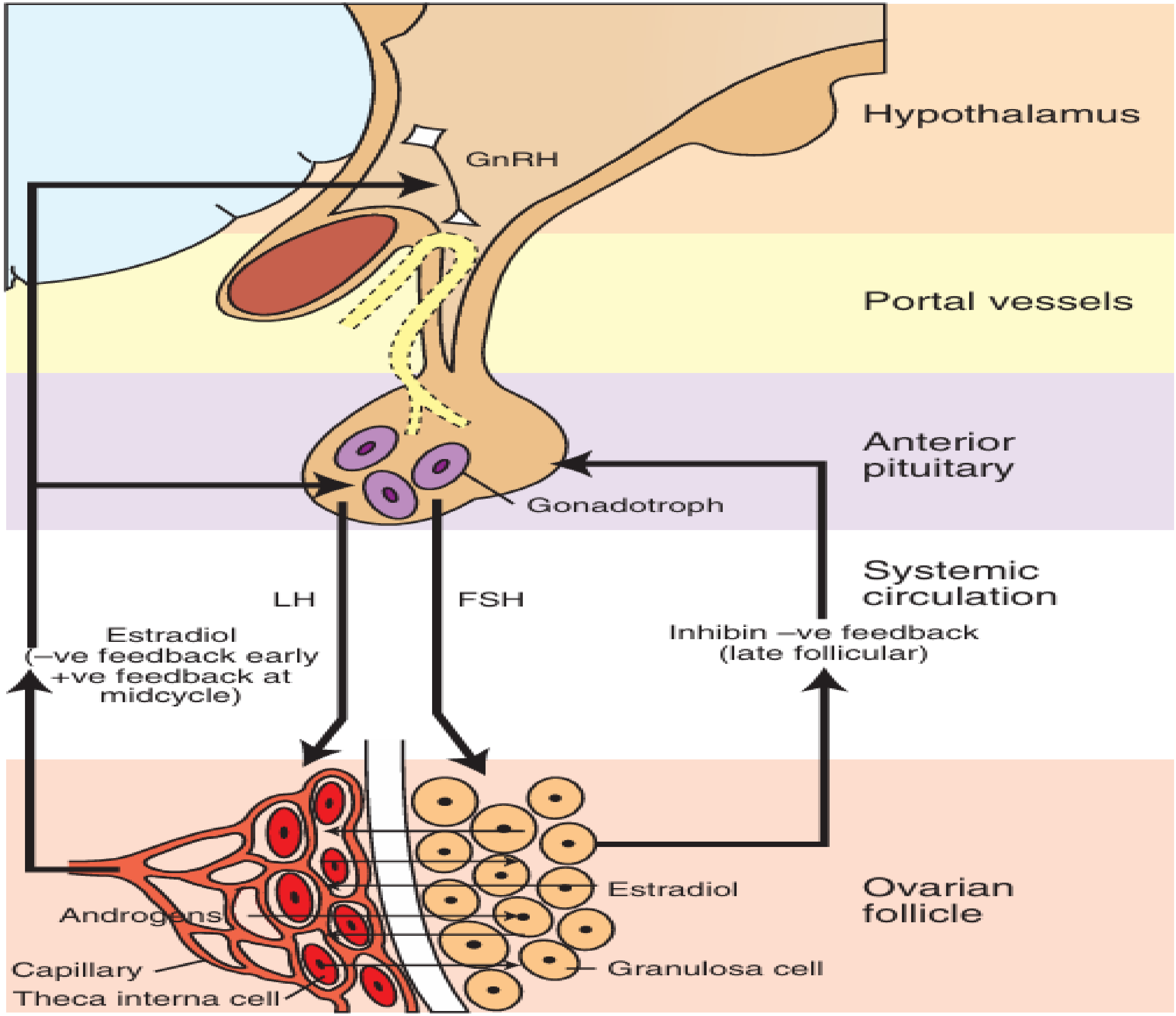


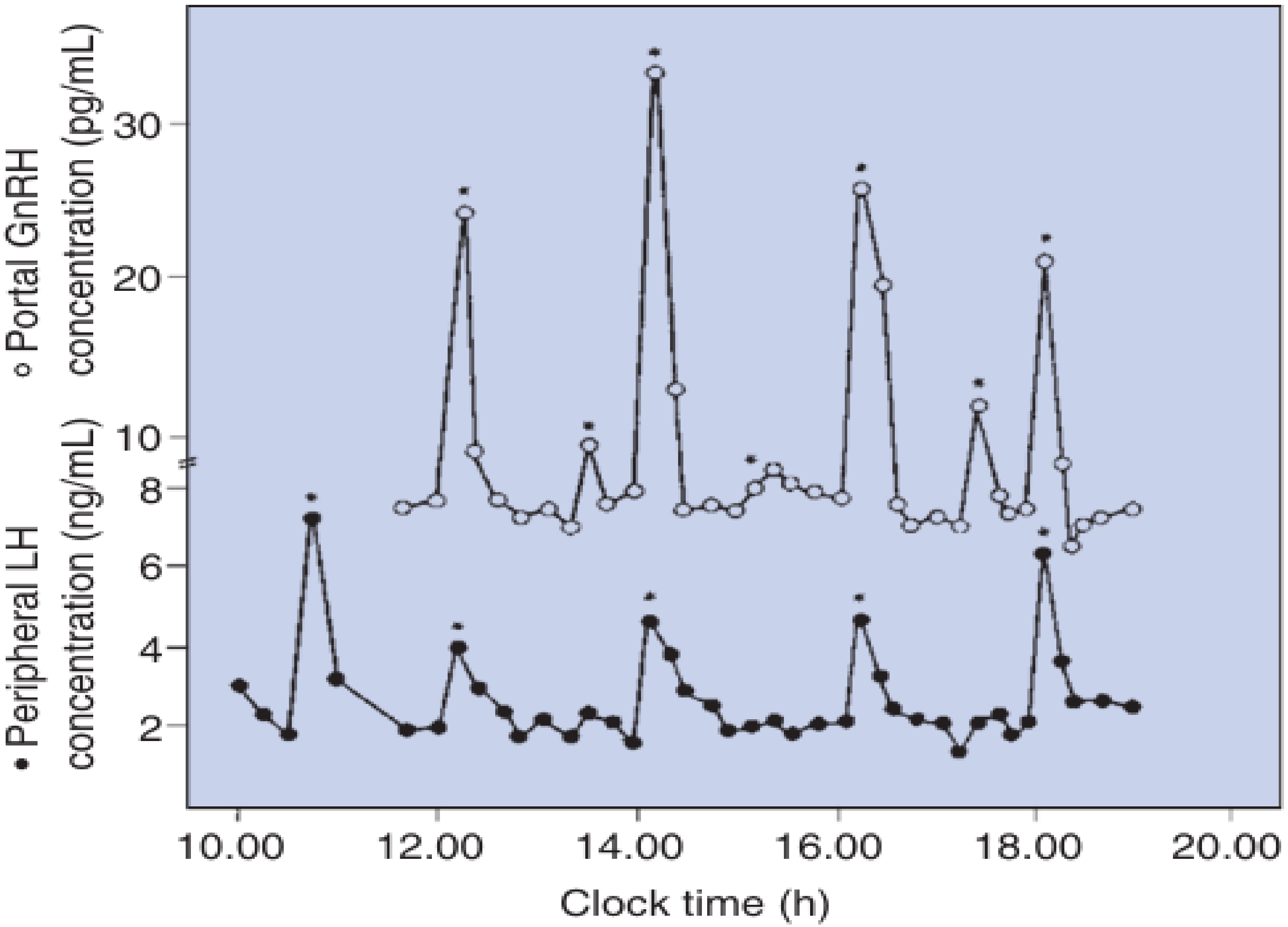
Hypothalmus
Artery
Neurosecretory
neuron
Portal
vessels
Posterior
pituitary
Anterior
pituitary
Vein


Hypothalmus
Median
eminence
Portal
vessels
Posterior
pituitary
Anterior
pituitary

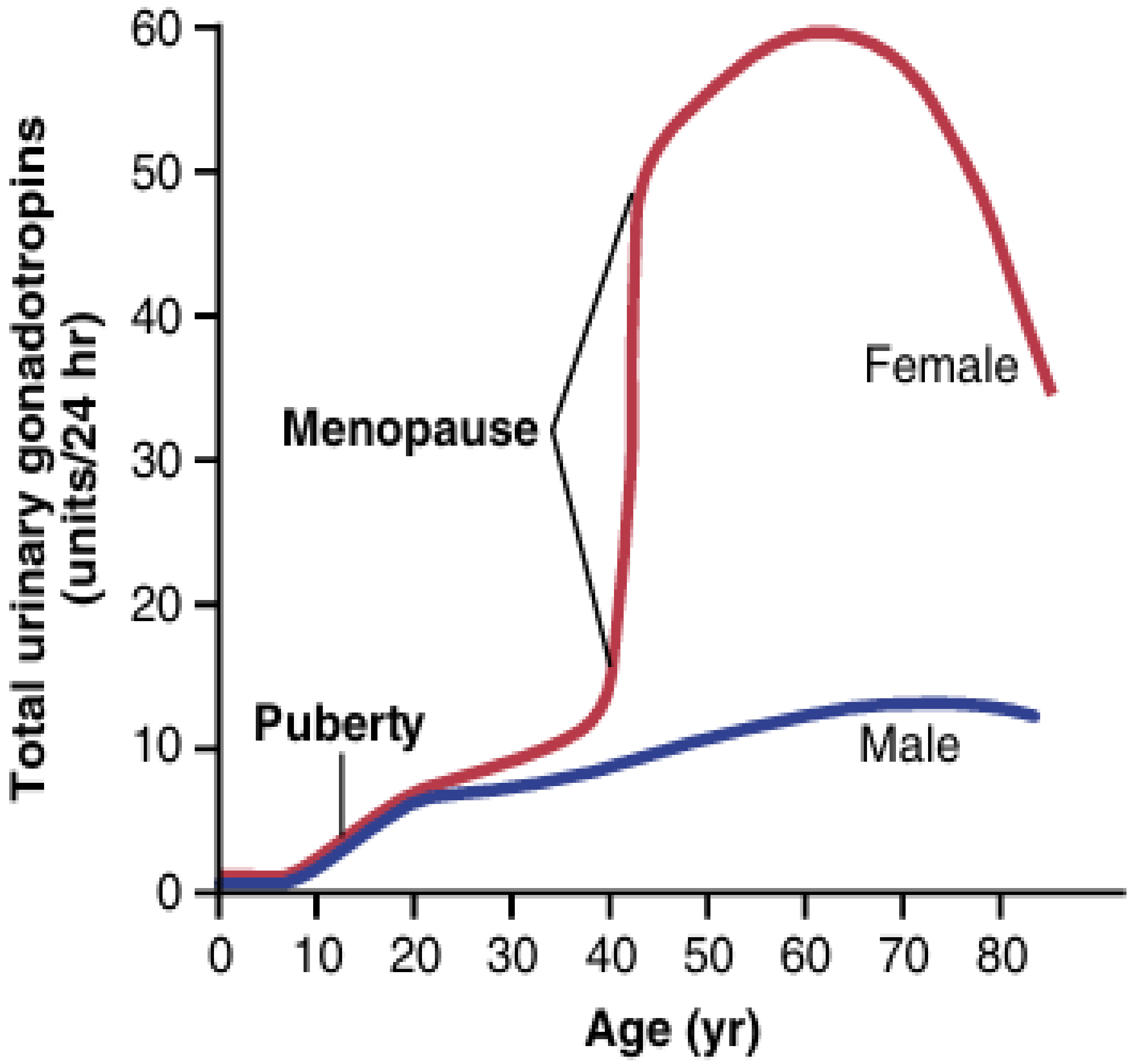

Supraoptic nuclei
Paraventricular nuclei
HYPOTHALAMUS
Mamillary body
MEDIAN EMINENCE
Superior hypophyseal artery
Optic chiasm
Capillary beds
Infundibulum
Endocrine cells
Portal veins
Inferior hypophyseal artery
POSTERIOR LOBE OF PITUITARY GLAND
Hypophyseal vein
Hypophyseal veins
ANTERIOR LOBE OF PITUITARY GLAND


Hypothalamus
Target organ hormones
Releasing hormones
Target organs:
Adrenals
Gonads
Thyroid
Anterior pituitary
Tropic hormones


Hypothalamus
GnRH
Portal vessels
Anterior pituitary
Gonadotroph
Systemic circulation
LH
FSH
Estradiol
(−ve feedback early
+ve feedback at
midcycle)
Inhibin −ve feedback
(late follicular)
Estradiol
Androgens
Capillary
Theca interna cell
Granulosa cell
Ovarian follicle

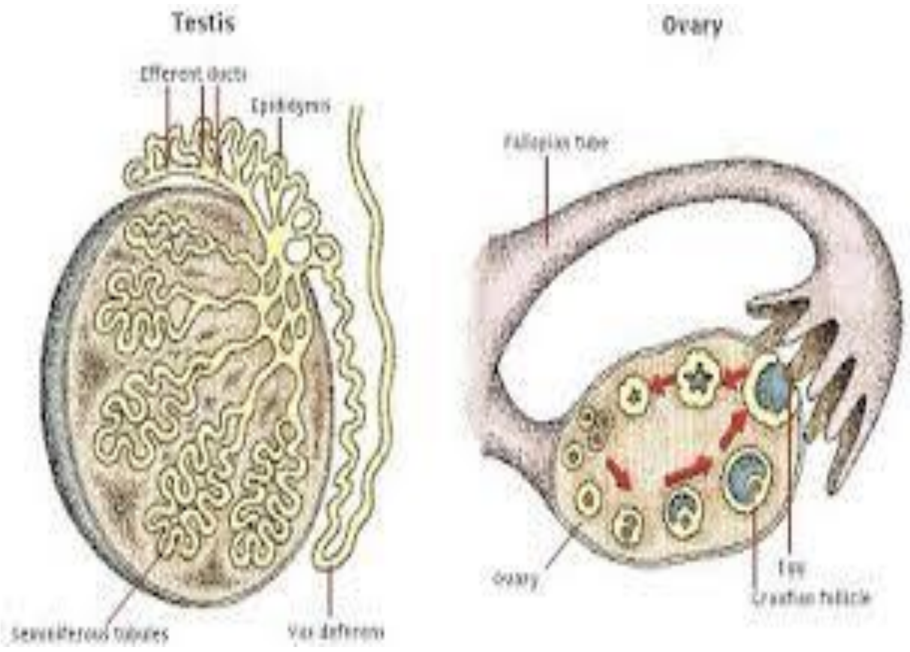


◦ Portal GnRH concentration (pg/mL)
• Peripheral LH concentration (ng/mL)
30
20
10
8
6
4
2
10.00
12.00
14.00
16.00
18.00
20.00
Clock time (h)

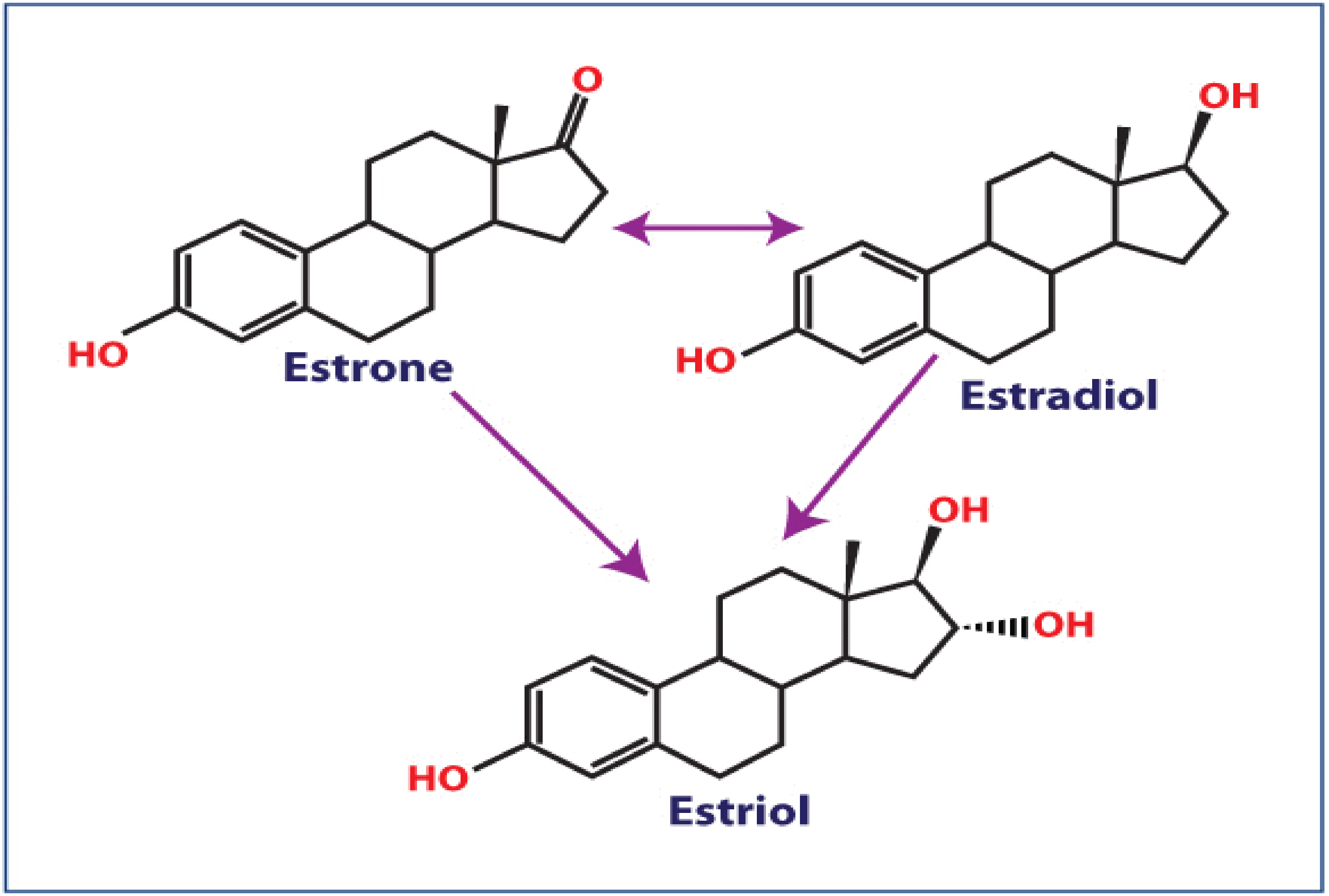

Total urinary gonadotropins
(units/24 hr)
60
50
40
30
20
10
0
Menopause
Puberty
Female
Male
0
10
20
30
40
50
60
70
80
Age (yr)

The gonads have two functions

- **production of gametes**
- **production of hormones**



Estrogens



Functions of Estrogens

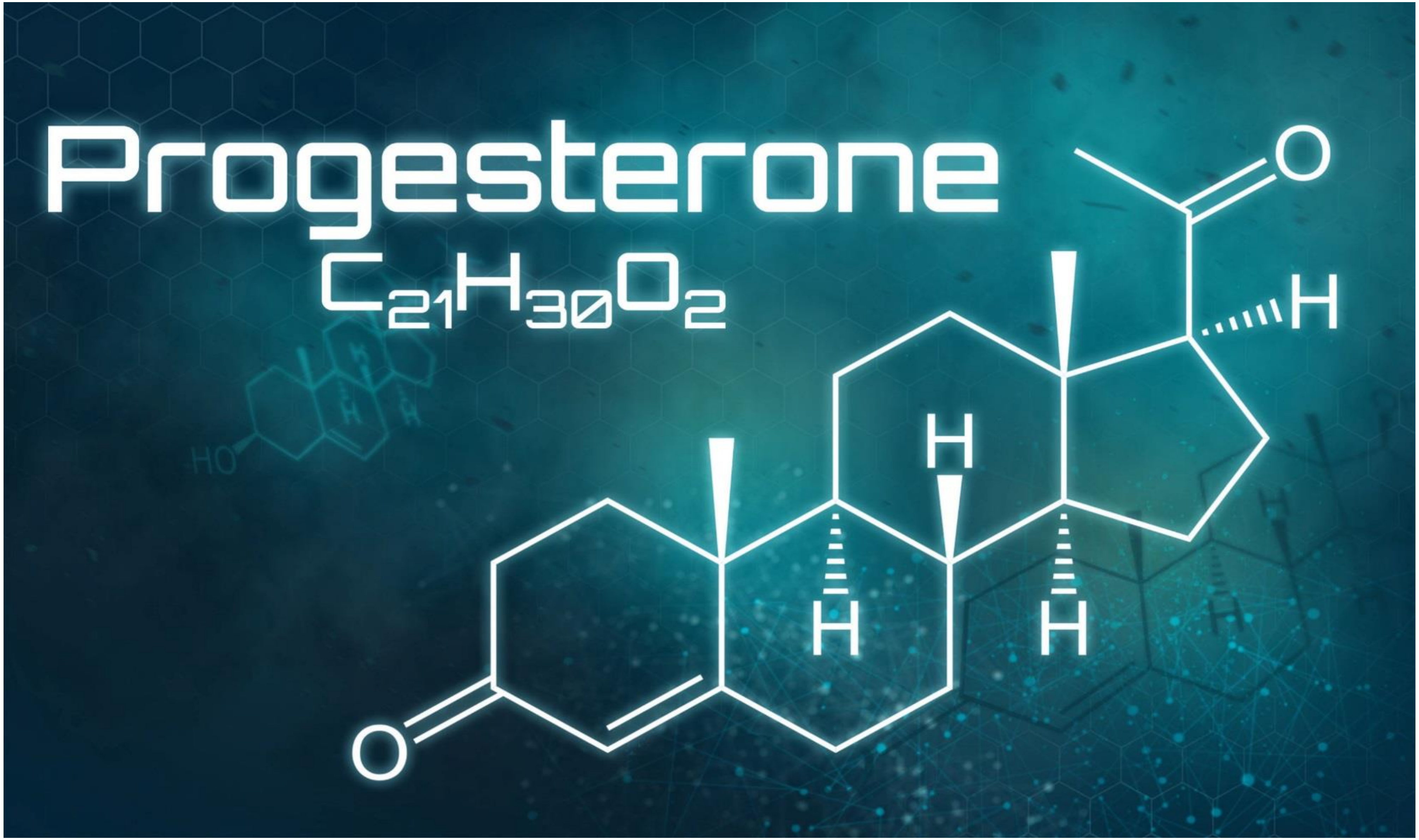
- **Cellular proliferation and growth of the tissues of reproductive organs and other tissues related to reproduction**
- **Estrogens cause proliferation of the endometrium and development of the endometrial glands**
- **Estrogens cause proliferation of the oviduct(fallopian tube) glandular mucosa and increase the number of ciliated epithelial cells**

Functions of Estrogens

- **Estrogens cause development of stromal tissue, growth of ductile system and deposition of fat in the mammillary glands**
- **Estrogens cause deposition of fat in subcutaneous tissues**
- **Estrogens cause sodium and water retention**
- **Estrogen deficiency leads to increased osteoclastic activity, decreased matrix and decreased deposition of calcium and phosphate in bone**

Functions of Estrogens

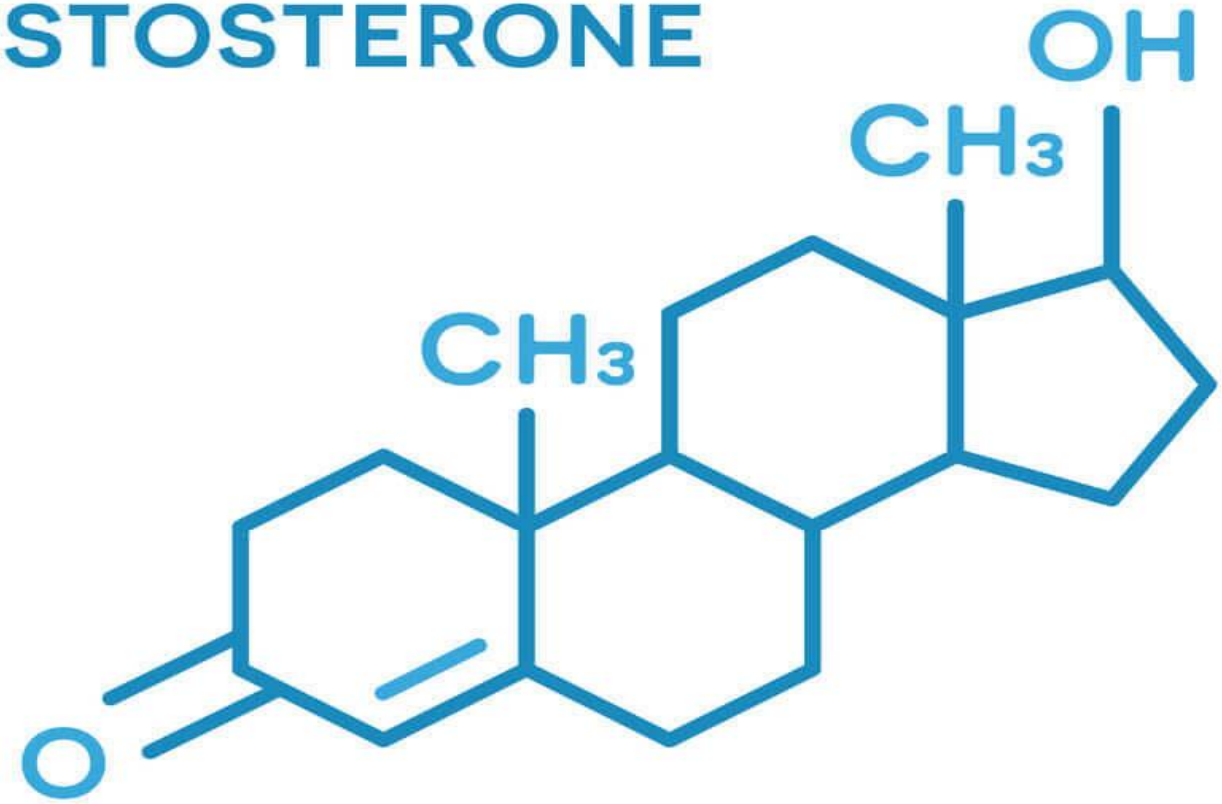
- **Estrogens increase uterine contractility**
- **Estrogen facilitate female sexual behavior**
- **During pregnancy, estrogens cause enlargement of uterus and mammillary glands and also relax the pelvic ligaments**


Progesterone
C21H30O2
O
H
H
H
H
O
HO

Functions of Progesterone

- **Progesterone promotes secretory changes in the uterus**
- **Progesterone decreases the frequency and intensity of uterine contractions**
- **Progesterone promotes secretion by the fallopian tubes**
- **Progesterone promotes development of the mammillary gland**

TESTOSTERONE



Functions of Testosterone

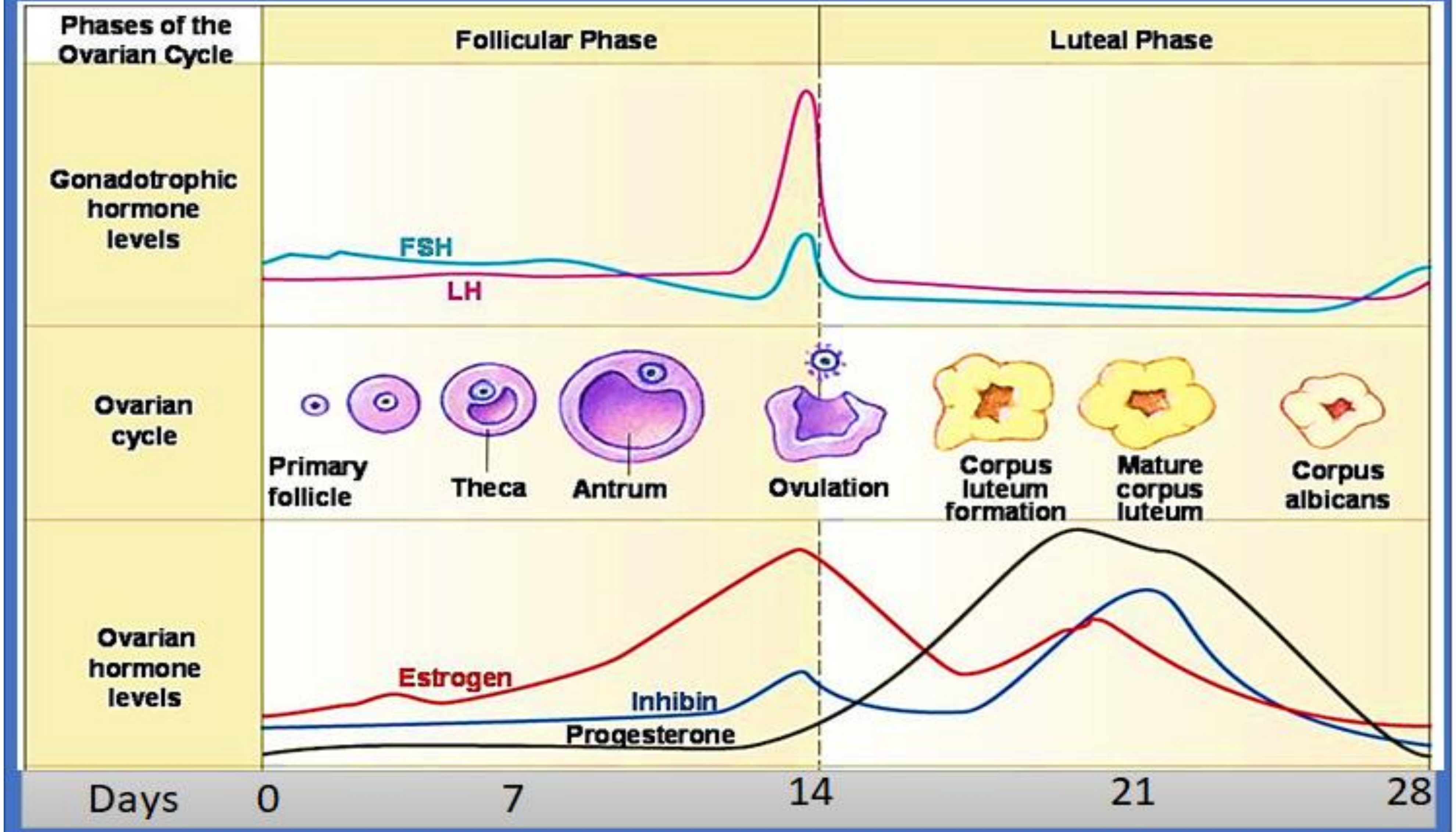
- **Effect of testosterone to cause descent of the testes**
- **Effect of testosterone on development adult primary and secondary characteristics(Distribution of body hair, male baldness, laryngeal enlargement)**
- **Testosterone increases thickness of the skin**
- **Testosterone increases protein formation and muscle development**
- **Testosterone increases bone matrix, basal metabolic rate and RBC**

Physiology of female reproductive system

- ***The Ovarian Cycle***
- ***The Estrous /Menstrual Cycle***

Follicular and Leuteal phases

Menstrual cycle



Ovulation

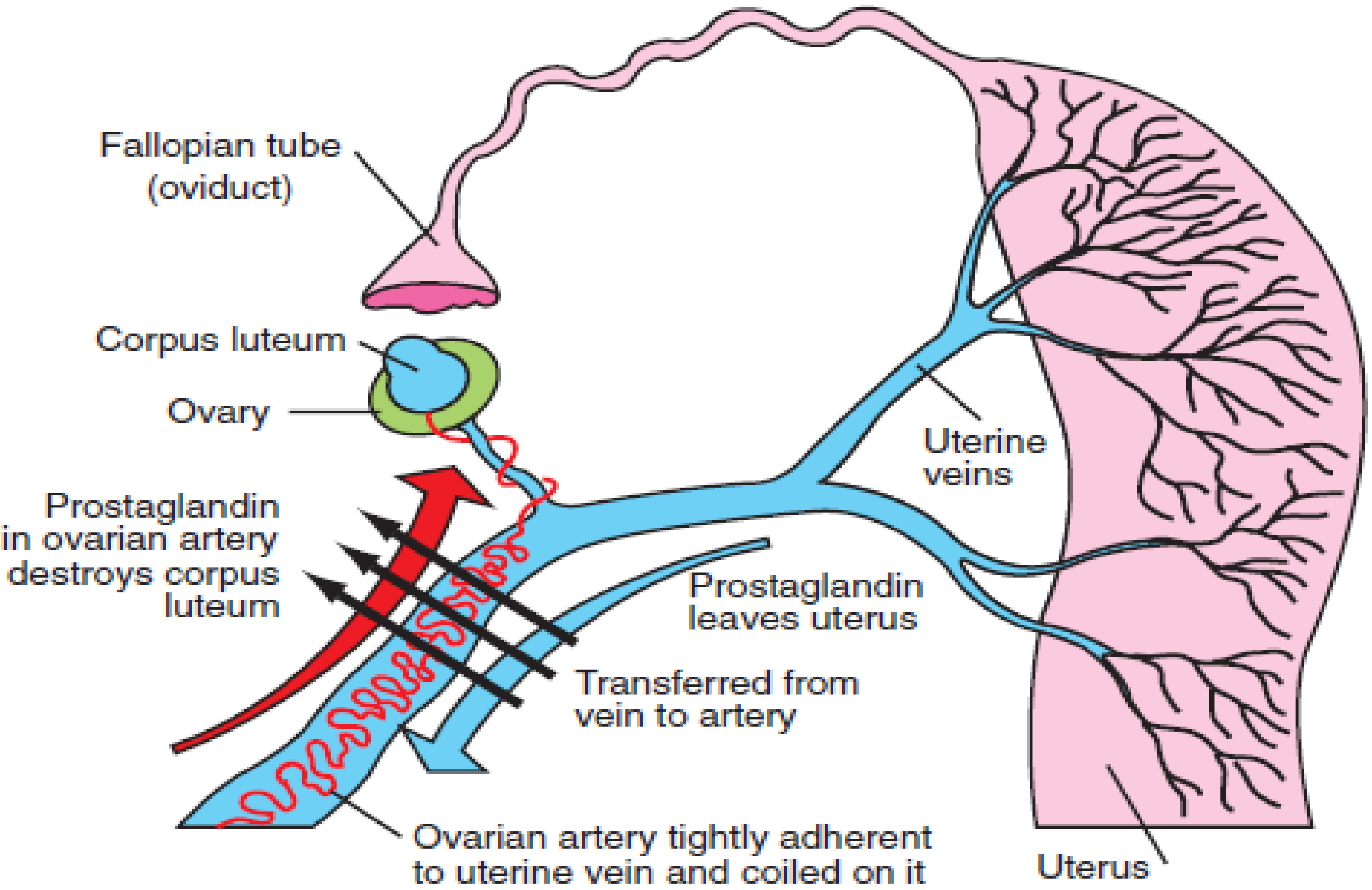
1. Ovulatory follicles are selected at the onset of luteolysis (in large domestic animals).
2. Ovulation is caused by an estrogen-induced preovulatory surge of gonadotropins.

Corpus Luteum

1. The corpus luteum secretes progesterone, which is essential for pregnancy.
2. Luteinizing hormone is important for the maintenance of the corpus luteum.
3. Regression of the corpus luteum in nonpregnant large domestic animals is controlled by uterine secretion of prostaglandin $F_{2\alpha}$.
4. Changes in luteal life span in large domestic animals occur because of changes in prostaglandin $F_{2\alpha}$ synthesis by the uterus.

Ovarian Cycles

1. In spontaneously ovulating animals, ovarian cycles have two phases: follicular and luteal; animals that require copulation for ovulation can have only a follicular phase.
2. The luteal phase is modified by copulation in some species.



Fallopian tube
(oviduct)
Corpus luteum
Ovary
Prostaglandin
in ovarian artery
destroys corpus
luteum
Uterine
veins
Prostaglandin
leaves uterus
Transferred from
vein to artery
Ovarian artery tightly adherent
to uterine vein and coiled on it
Uterus

Reproductive Cycles

1. The two types of reproductive cycles are estrual and menstrual.

Puberty and Reproductive Senescence

1. Puberty is the time when animals initially release mature germ cells.
2. Reproductive senescence in primates occurs because of ovarian inadequacy, not inadequacy of gonadotropin secretion.

Sexual Behavior

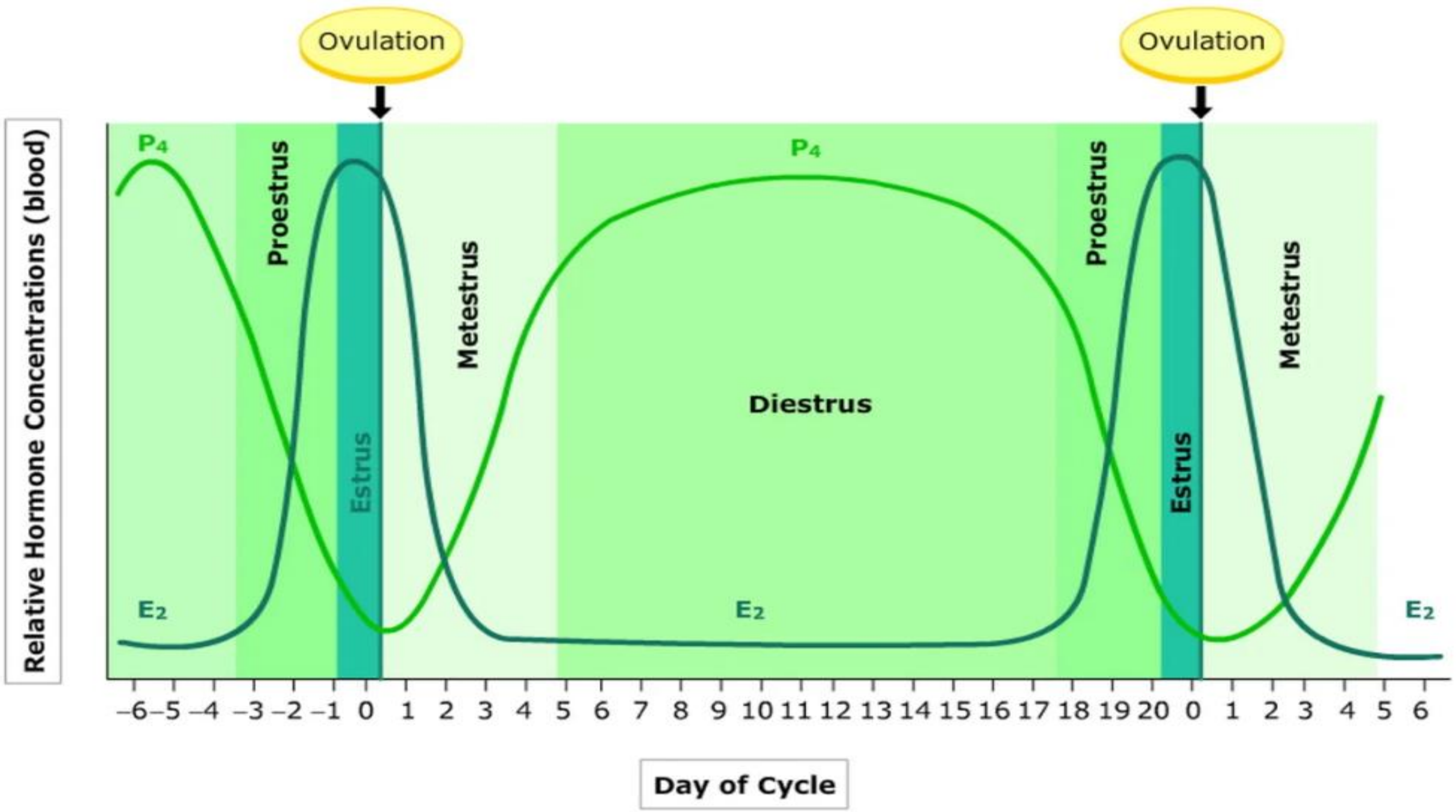
1. Sexual receptivity is keyed by the interaction of the hormones estrogen and progesterone via gonadotropin-releasing hormone in the female and testosterone in the male.

External Factors Controlling Reproductive Cycles

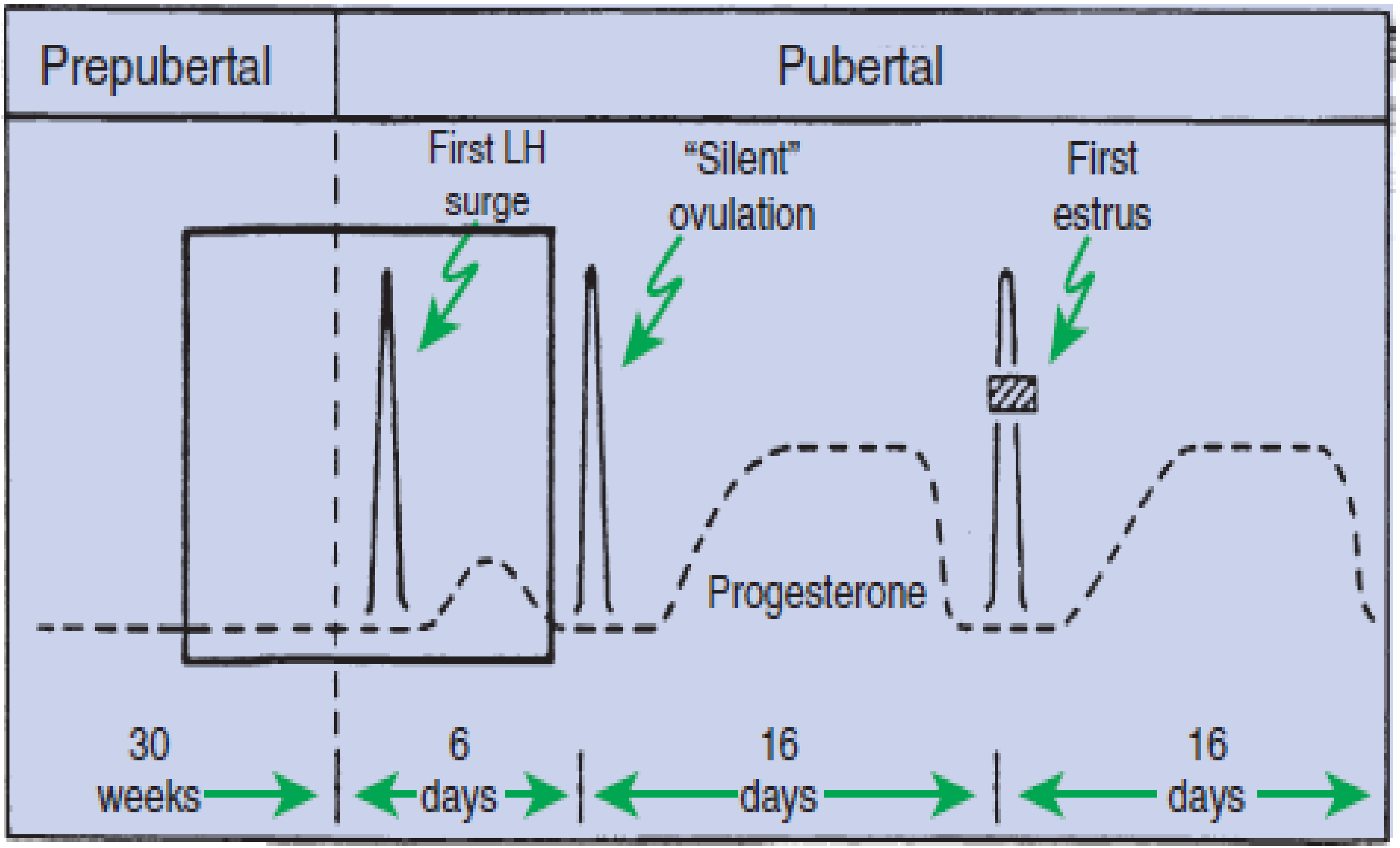
1. Photoperiod, lactation, nutrition, and animal interaction are important factors that affect reproduction.
2. Inadequate nutrition results in ovarian inactivity, especially in cattle.

STAGES OF ESTROUS CYCLE

- Four stages:
  - Proestrus
  - Estrus
  - Metestrus
  - Diestrus
    - Follicular phase = Proestrus + Estrus
    - Luteal phase = Metestrus + Diestrus

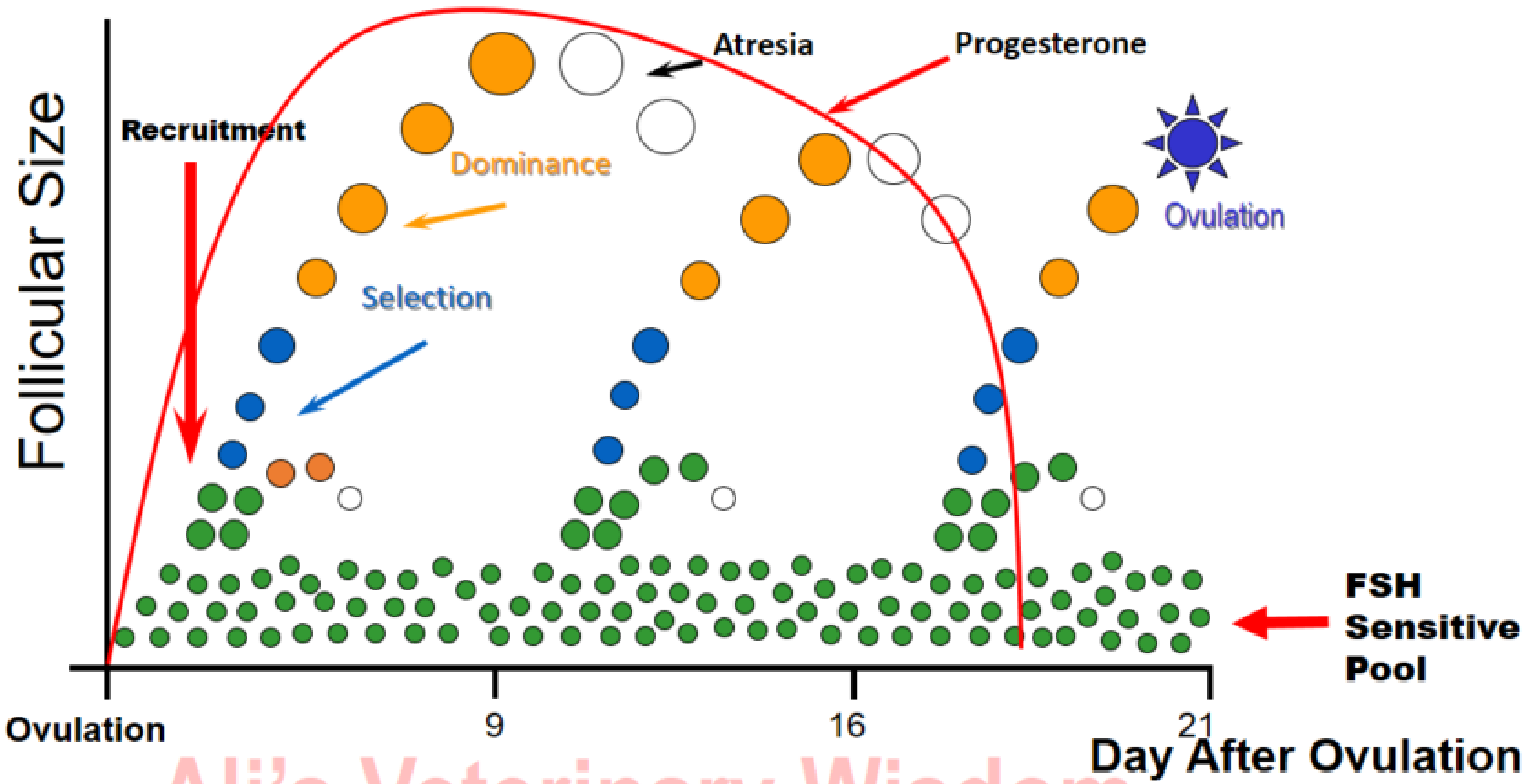


Proestrus	Estrus	Metestrus	Diestrus
Proestrus is characterised by a significant rise in Estradiol (E2) produced by developing follicles.	*When estradiol reaches a certain level, the female exhibits estrus and then ovulates.*	*Following ovulation, the cells of the follicle are transformed into luteal cells that form the corpus luteum (CL) during metestrus.*	*Diestrus is characterised by a fully functional CL and high progesterone (P4)*



Prepubertal
Pubertal
First LH surge
"Silent" ovulation
First estrus
Progesterone
30 weeks
6 days
16 days
16 days

Follicular Waves in Cattle



Estrous Cycle Intervals

- Polyestrous: animals that cycle continuously throughout the year if they are not pregnant (cattle and swine)
- Seasonally polyestrous: animals with seasonal variations in estrous cycles (horse, sheep, cat)
- Diestrous: animals with two cycles per year, usually spring and fall (dog)
- Monoestrous: animals with one cycle per year (fox and mink)

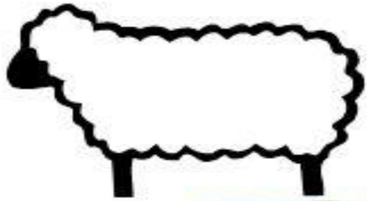
Reproductive Process

Estrous Cycle

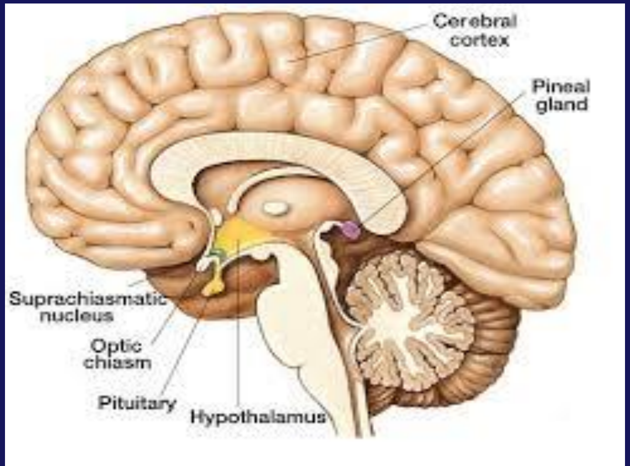
- **Is categorized by frequency of occurrence throughout the year**
  - *seasonally polyestrus*— **cycles occur only during certain times of the year**

Long-day breeders
→ **cycle when day length increases**

Short-day breeders
→ **cycle when day length decreases**



Pineal Gland



- The pineal gland secretes melatonin
- Melatonin secretion inhibited by light entering retina (lower in day than night)
- May regulate sleep and daily rhythms
- Melatonin regulates reproductive cycles in some vertebrates

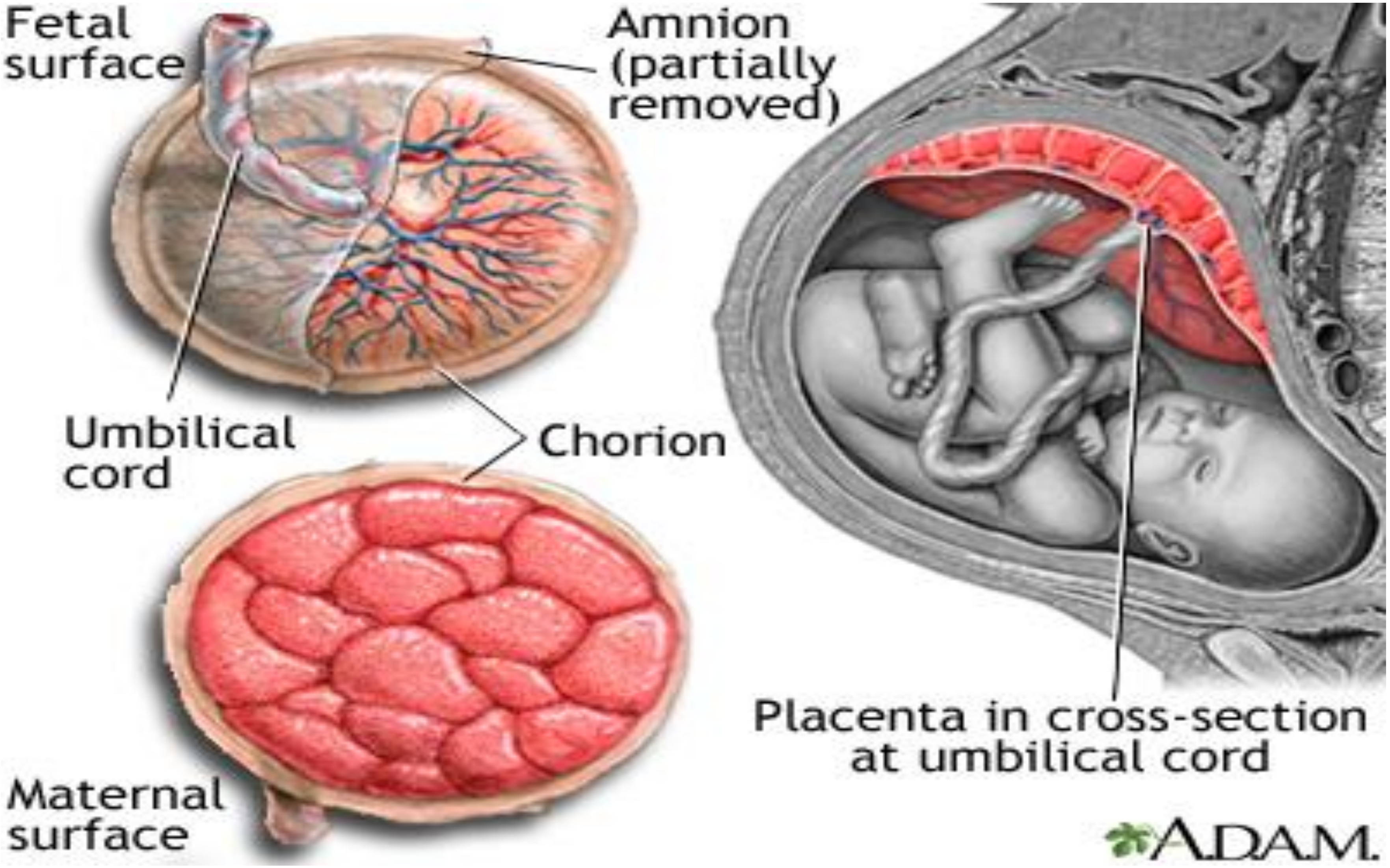
Average Reproductive Cycles

Species	Length of Estrous Cycle	Length of Estrus	Ovulation	Length of Pregnancy
cow	21 days polyestrus	18 hr	11 hr after end estrus	282 days
ewe	17 days seasonal (fall)	29 hr	near end estrus	148 days
sow	21 days polyestrus	48-72 hr	35-45 hr after start estrus	115 days
mare	21 days seasonal (spring) polyestrus	4-8 days	3-6 day of estrus (1-2 days before end of estrus)	335 days

Average Reproductive Cycles

Species	Length of Estrous Cycle	Length of Estrus	Ovulation	Length of Pregnancy
Bitch	6 months	9 days	4 - 24 days after start of estrus	63 days
Queen	17 days	9 days	Induced	63 days

Placenta


Fetal surface
Amnion (partially removed)
Umbilical cord
Chorion
Maternal surface
Placenta in cross-section at umbilical cord
A.D.A.M.

Functions of Placenta

- Transfer of nutrients and oxygen:

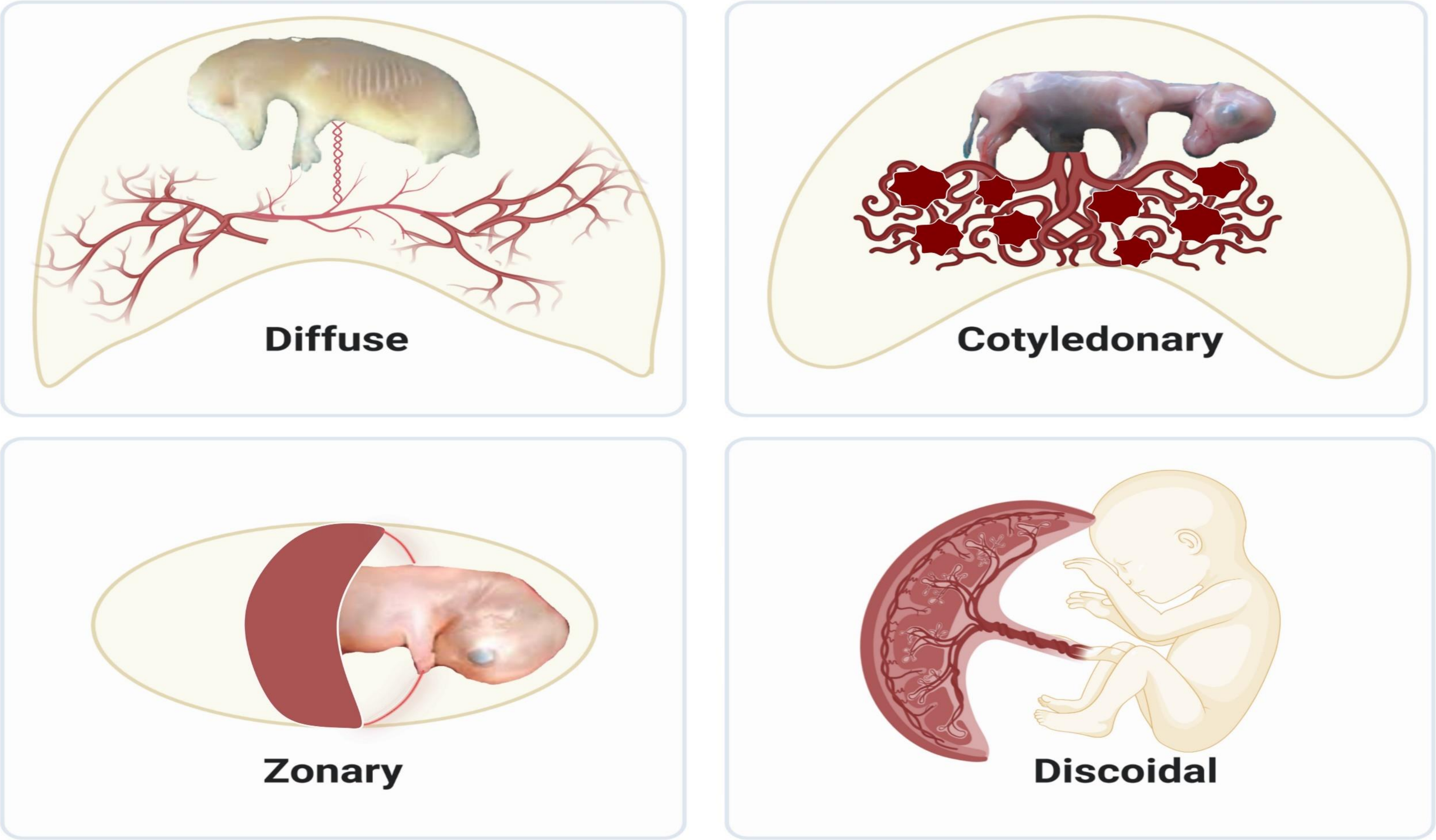
  Fetus derives nutrients and oxygen from placenta.
- Excretion:

  Waste products from fetus is excreted to maternal blood in placenta.
- Secretion:

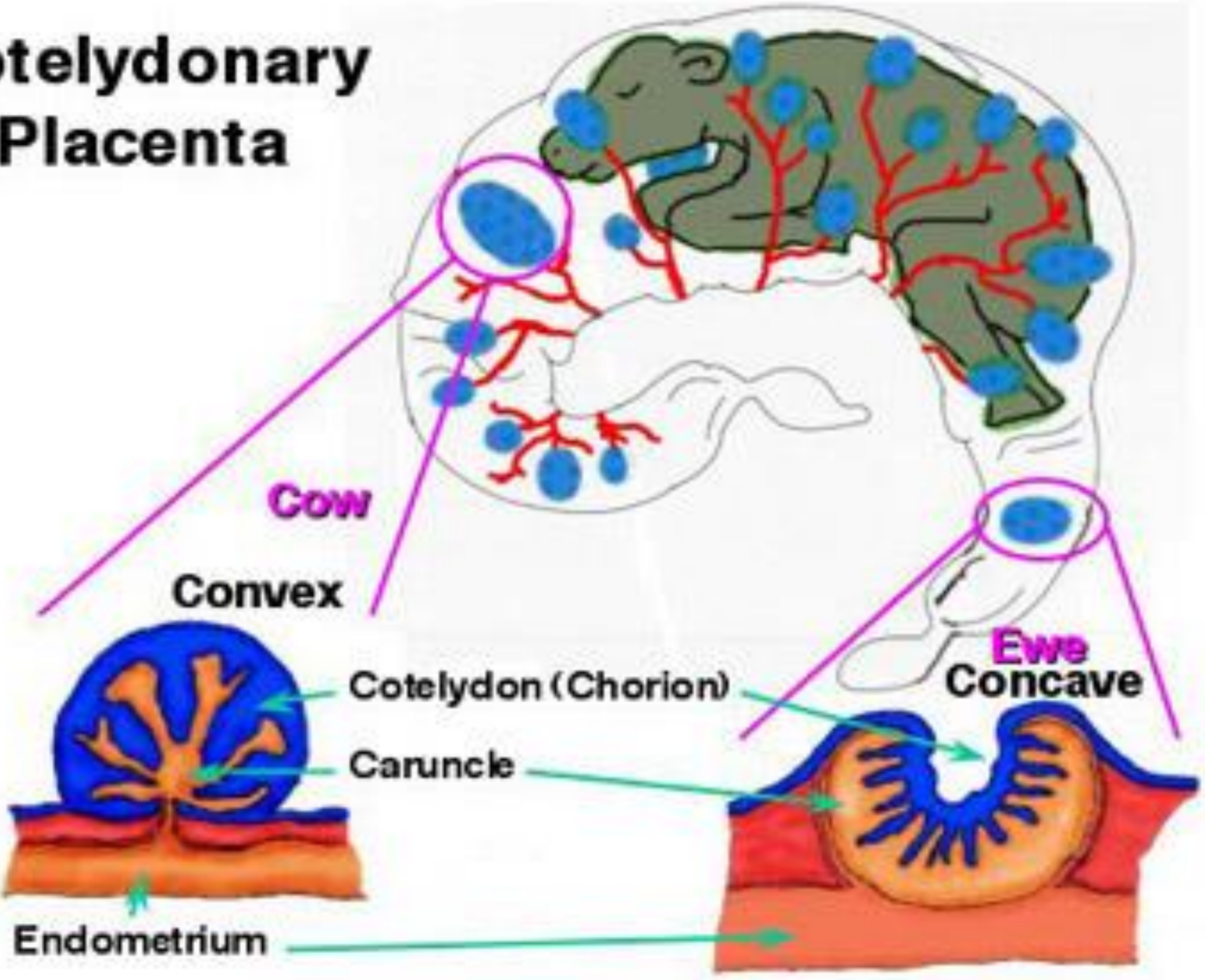
  Produces hormones such as HCG, progesterone etc and enzymes such as oxitocinase necessary to maintain pregnancy.
- Barrier:

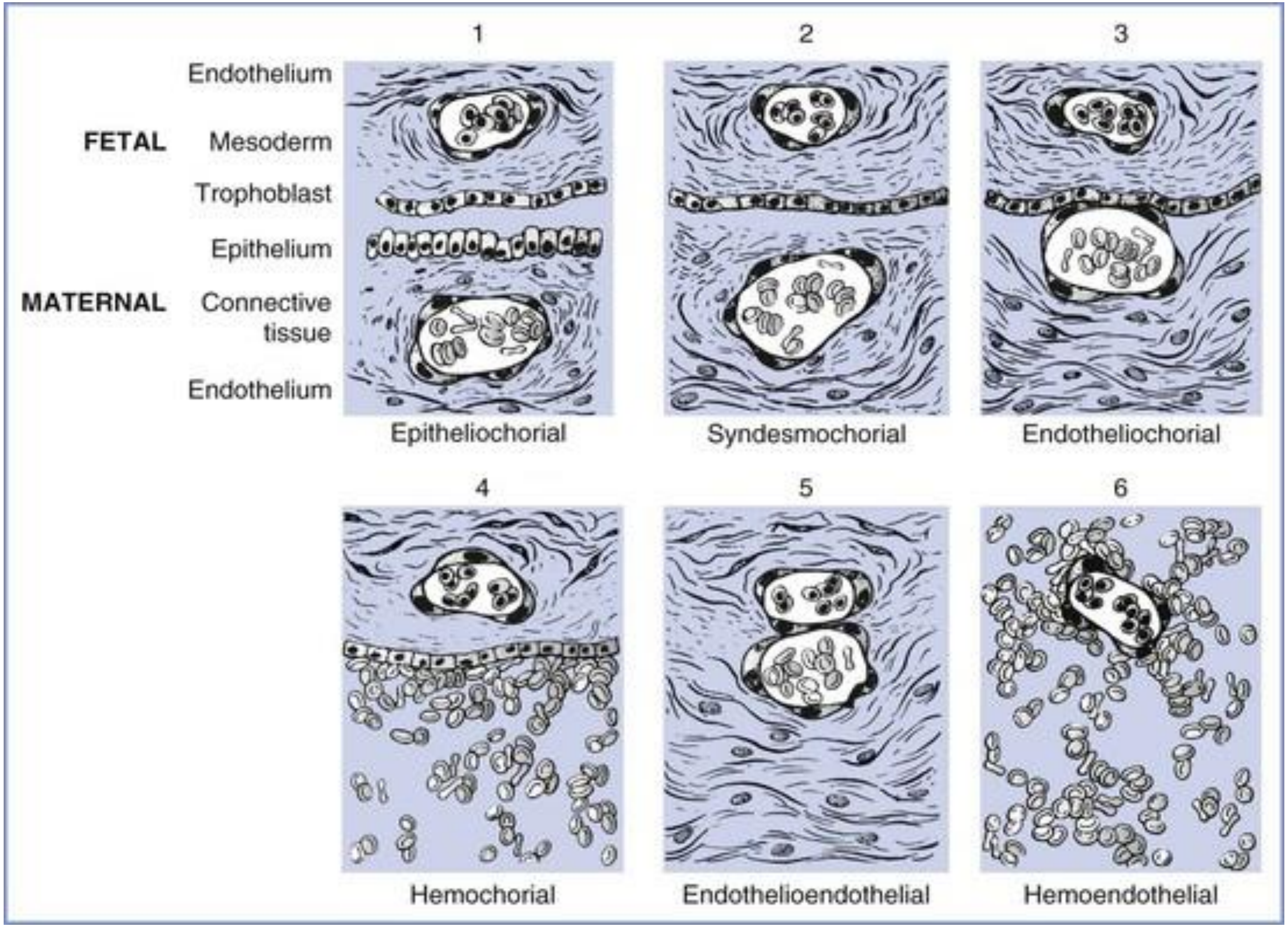
  Act as protective barrier to fetus against noxious agent.
- Immunological:

  Provides immunological protection to fetus.

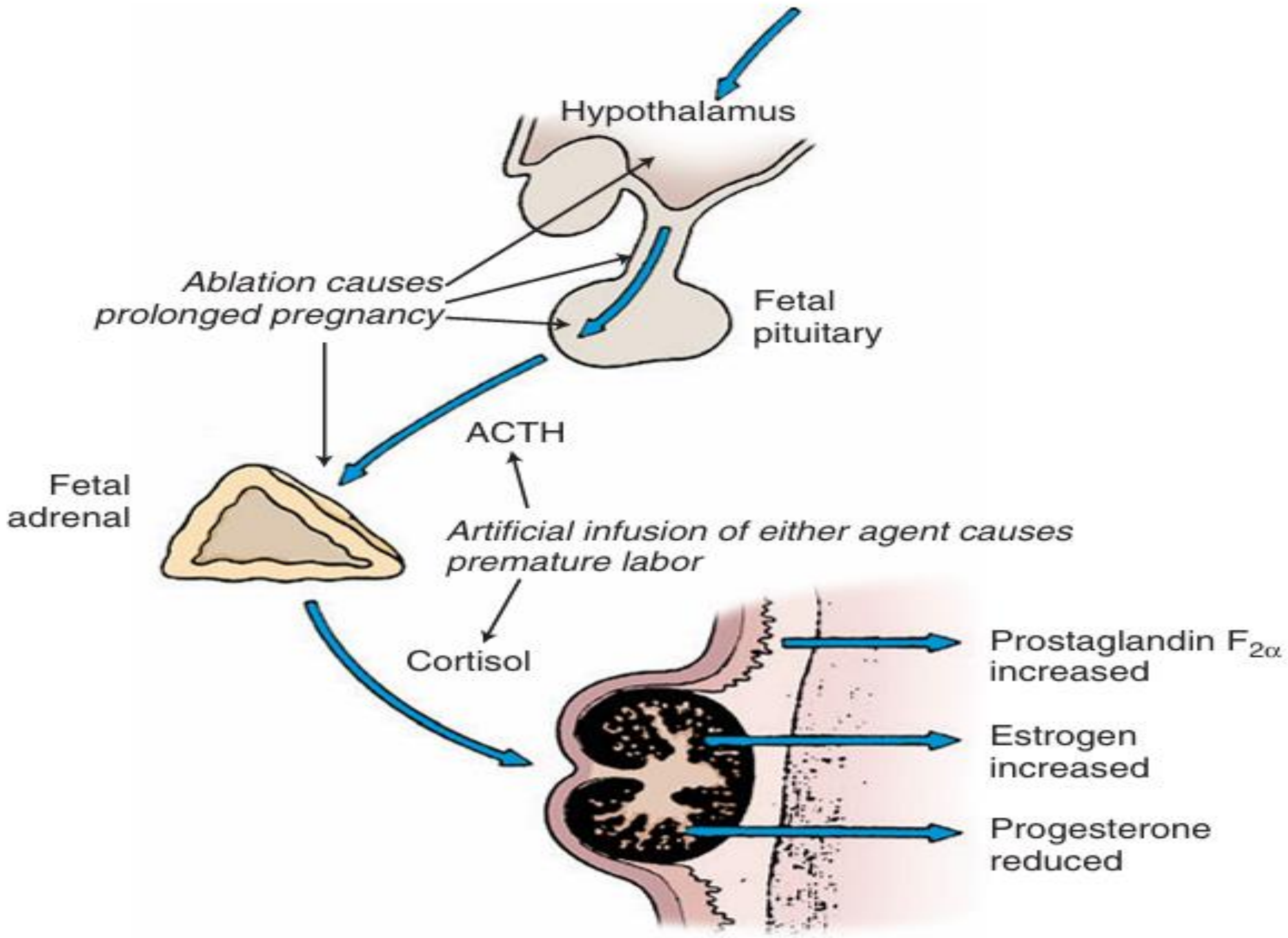

Diffuse
Cotyledonary
Zonary
Discoidal

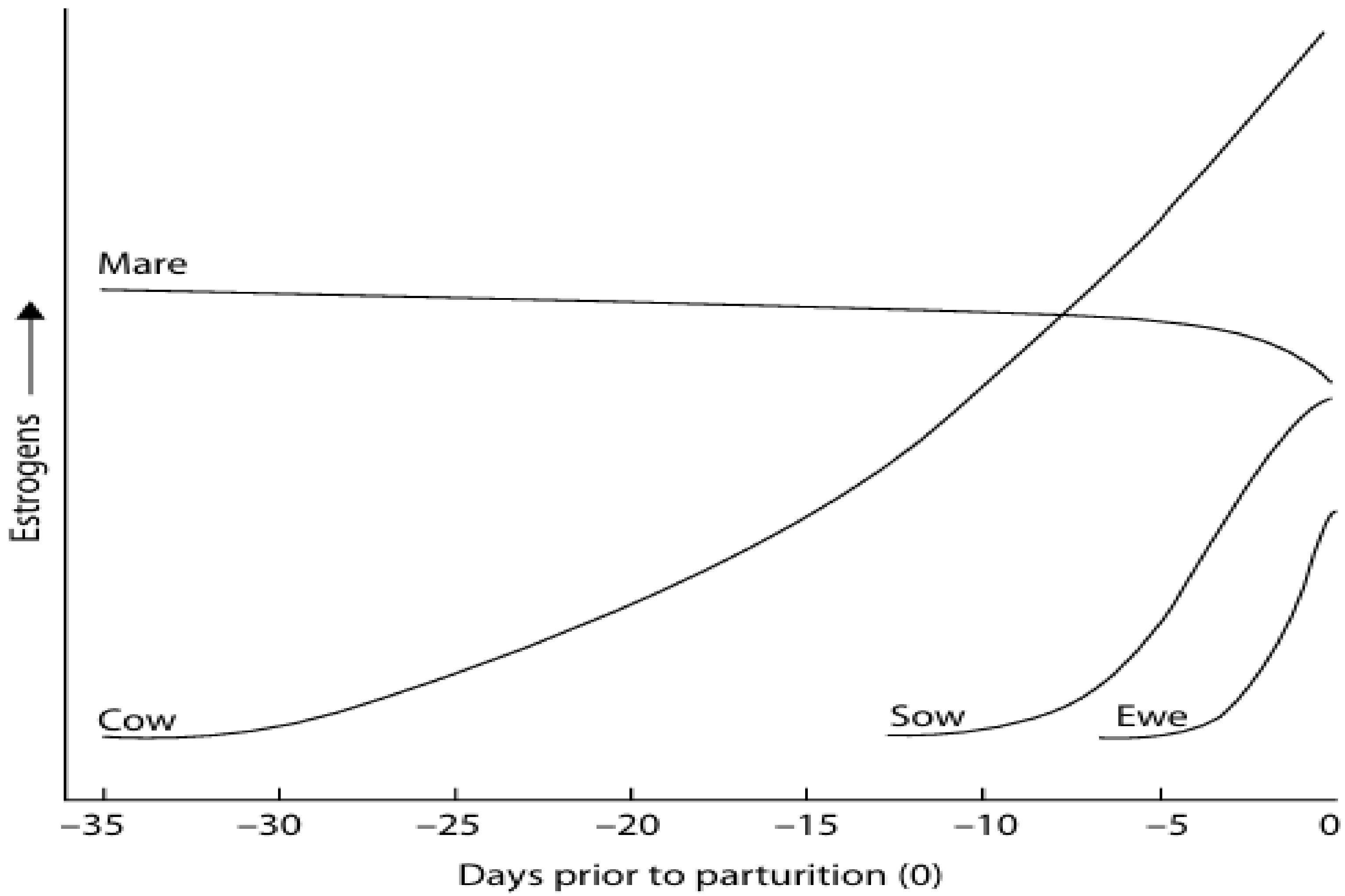
Cotelydonary Placenta

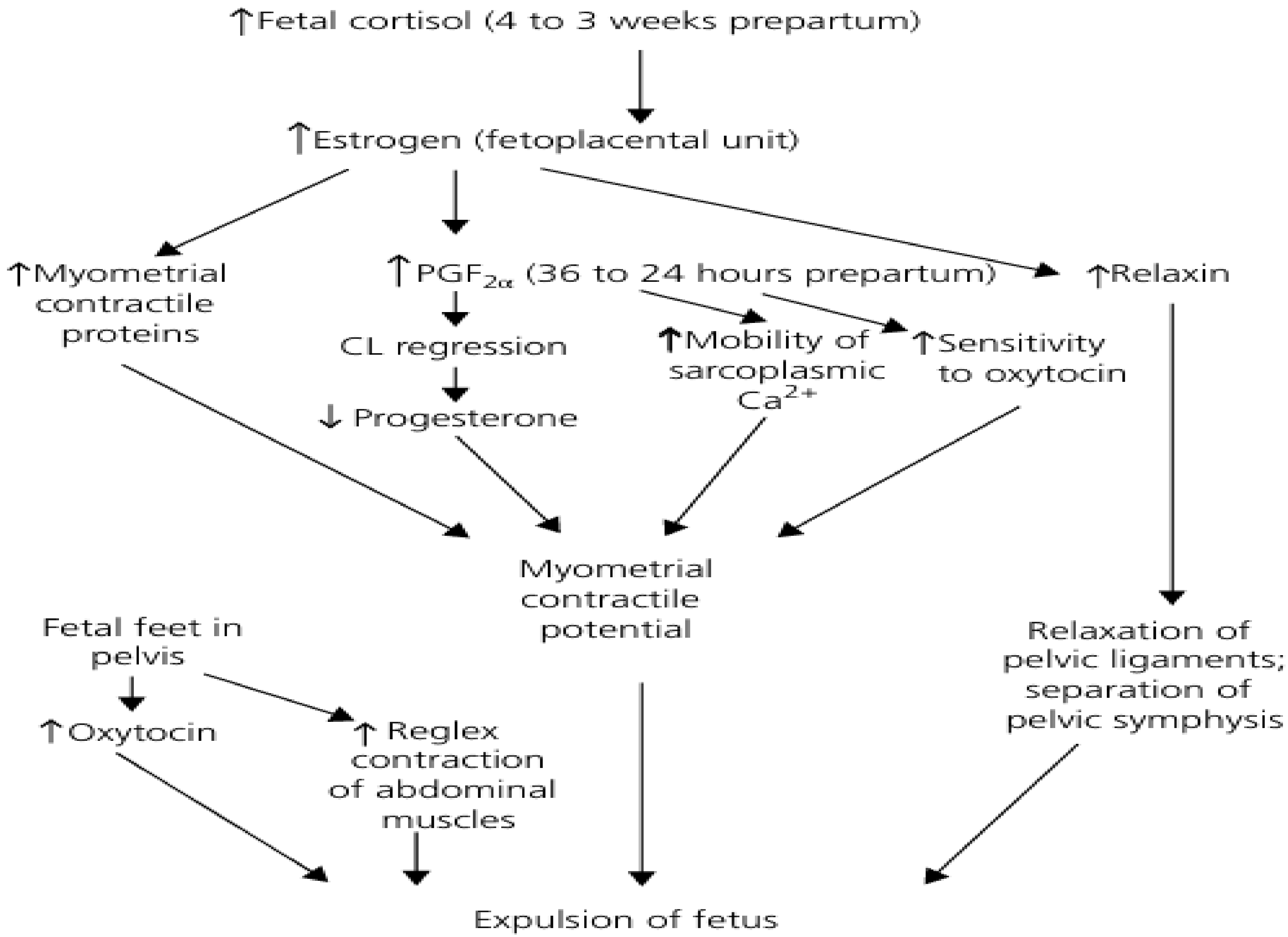



1
2
3
Endothelium
FETAL
Mesoderm
Trophoblast
Epithelium
MATERNAL
Connective tissue
Endothelium
Epitheliochorial
Syndesmochorial
Endotheliochorial
4
5
6
Hemochorial
Endothelioendothelial
Hemoendothelial

Fetal Cortisol

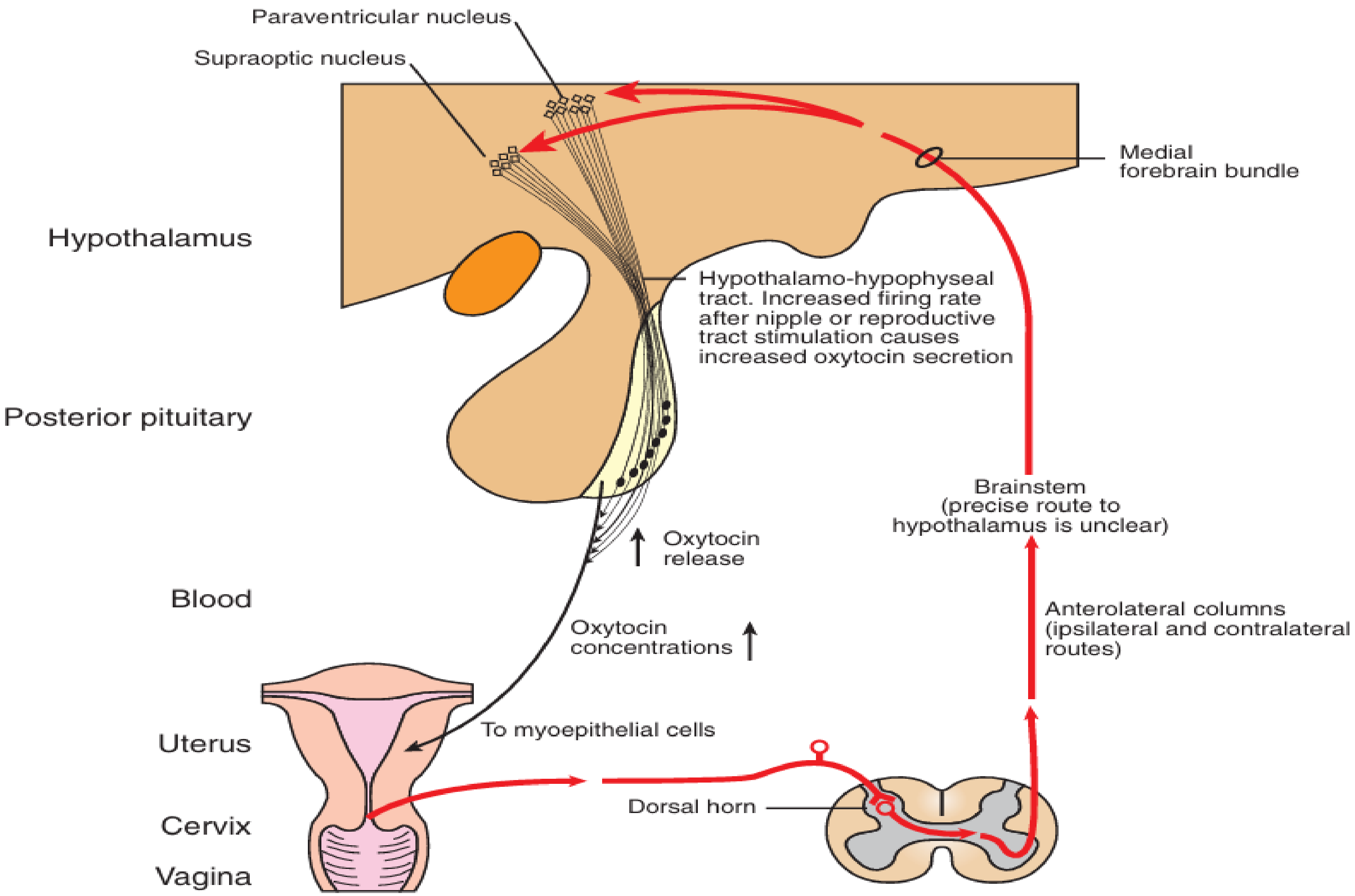



Mare
Cow
Sow
Ewe
Estrogens
−35
−30
−25
−20
−15
−10
−5
0
Days prior to parturition (0)



↑Fetal cortisol (4 to 3 weeks prepartum)
↑Estrogen (fetoplacental unit)
↑Myometrial contractile proteins
↑$PGF_{2\alpha}$ (36 to 24 hours prepartum)
↑Relaxin
CL regression
↓ Progesterone
↑Mobility of sarcoplasmic Ca^{2+}
↑Sensitivity to oxytocin
Myometrial contractile potential
Fetal feet in pelvis
↑Oxytocin
↑ Reglex contraction of abdominal muscles
Relaxation of pelvic ligaments; separation of pelvic symphysis
Expulsion of fetus

Neuroendocrine Reflex of Parturition



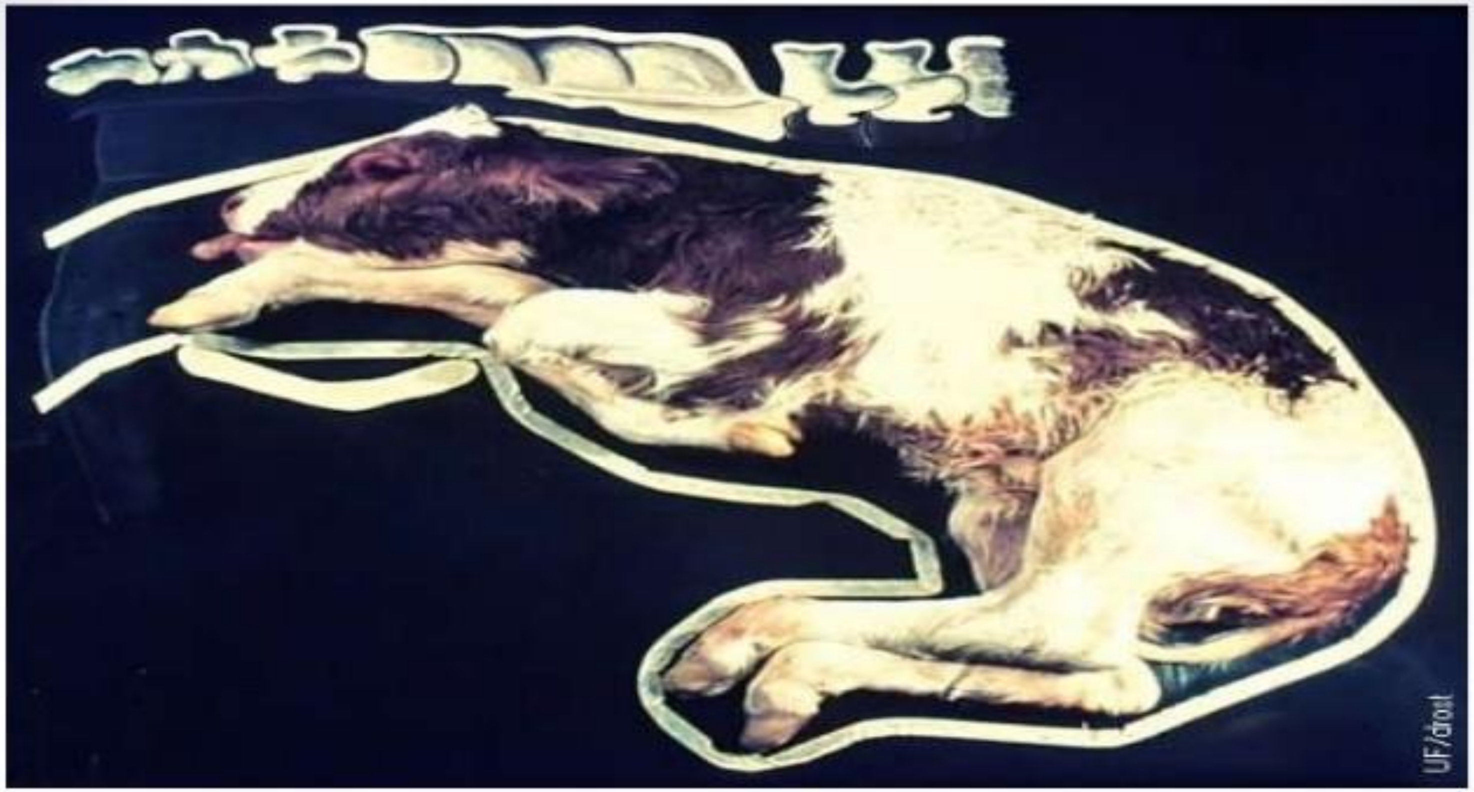
Normal P.P.P

If you have time:

Presentation: Anterior longitudinal

Position: Dorsal (Dorso-sacral)

Posture: Complete extension of head & fore limbs



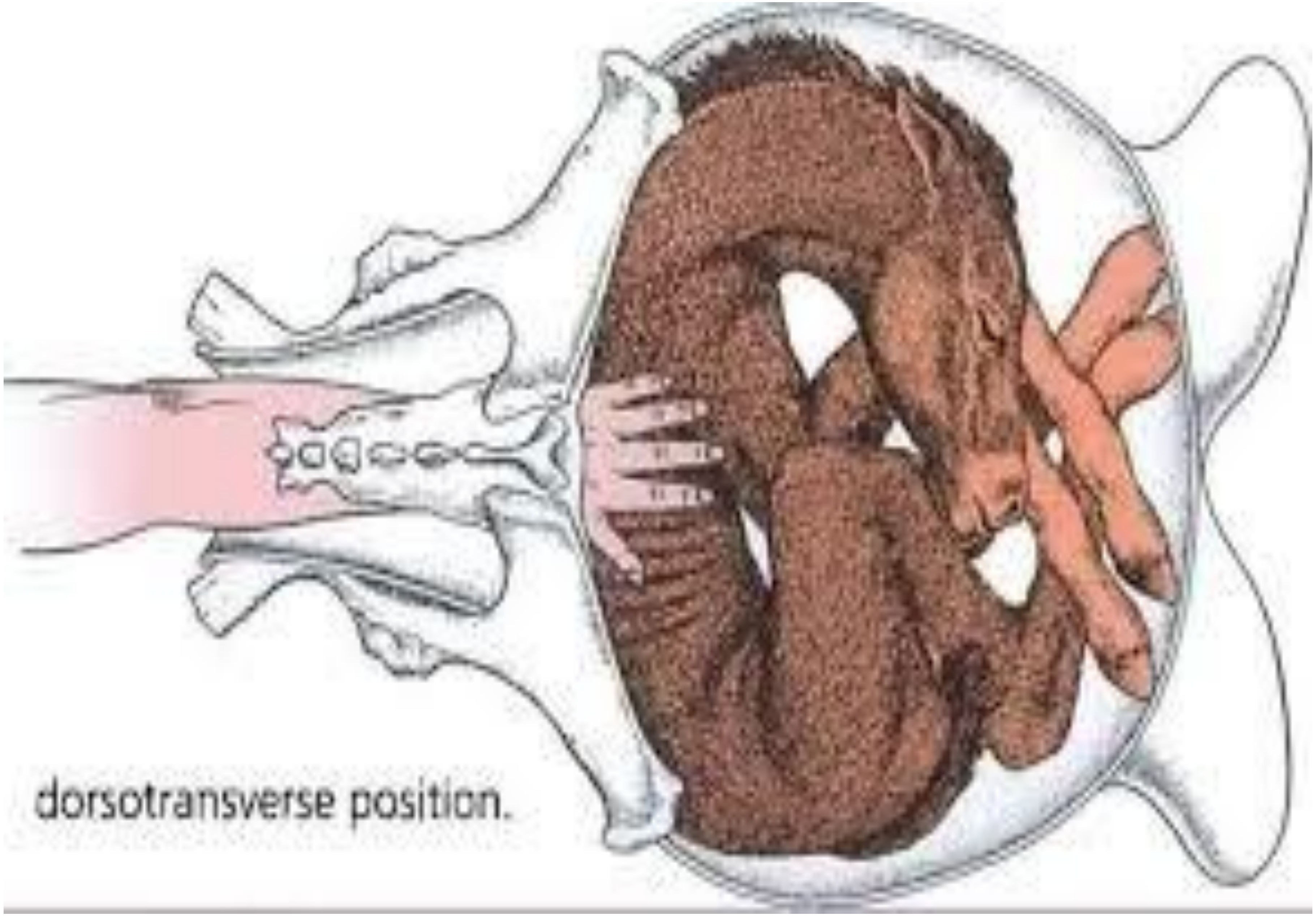
Left Carpal Flexion (N.B. Left according to fetus NOT Dam)

If you have time:

Presentation: Anterior Longitudinal

Position: Dorsal (Dorso-Sacral)

Posture: Left Carpal Flexion

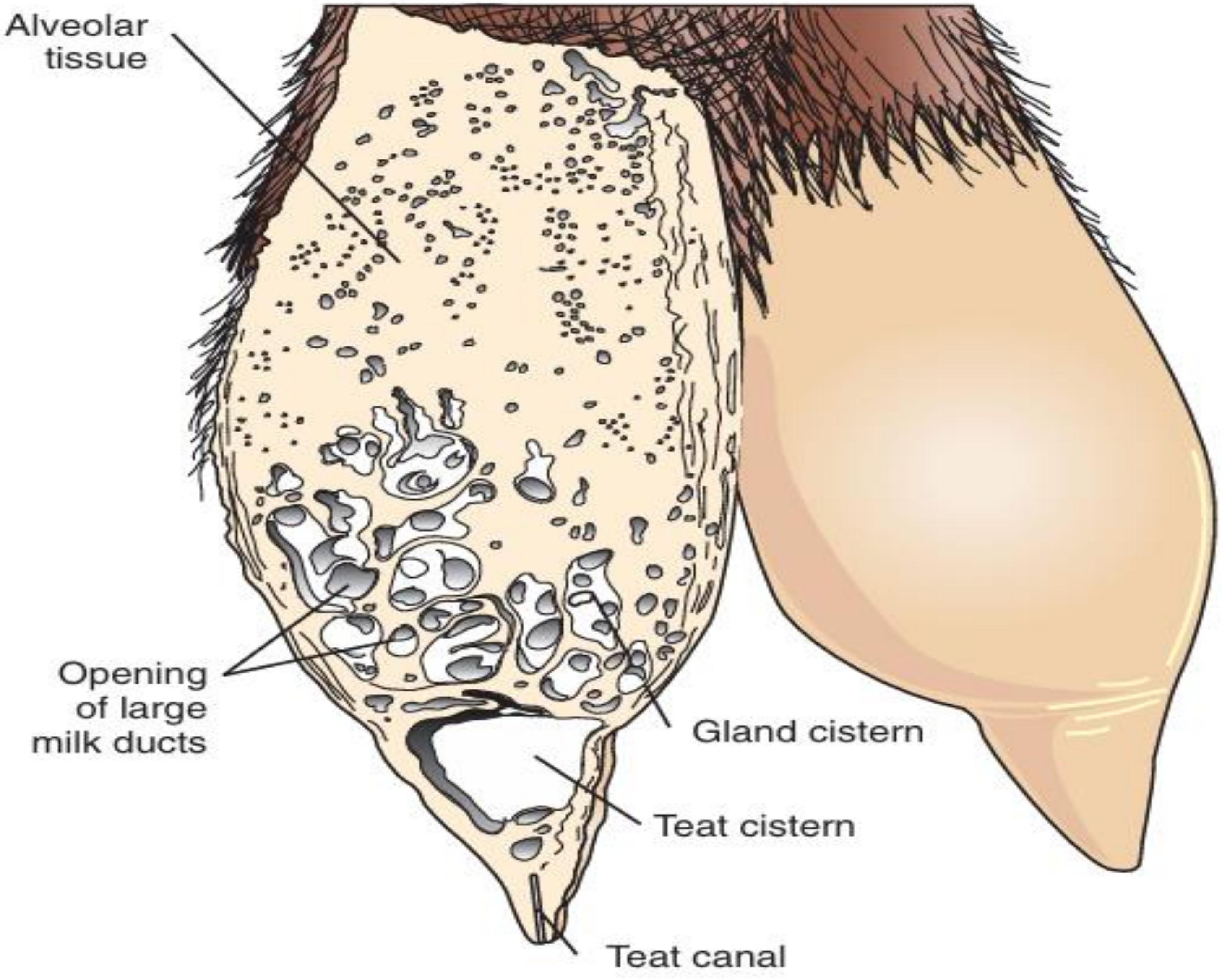


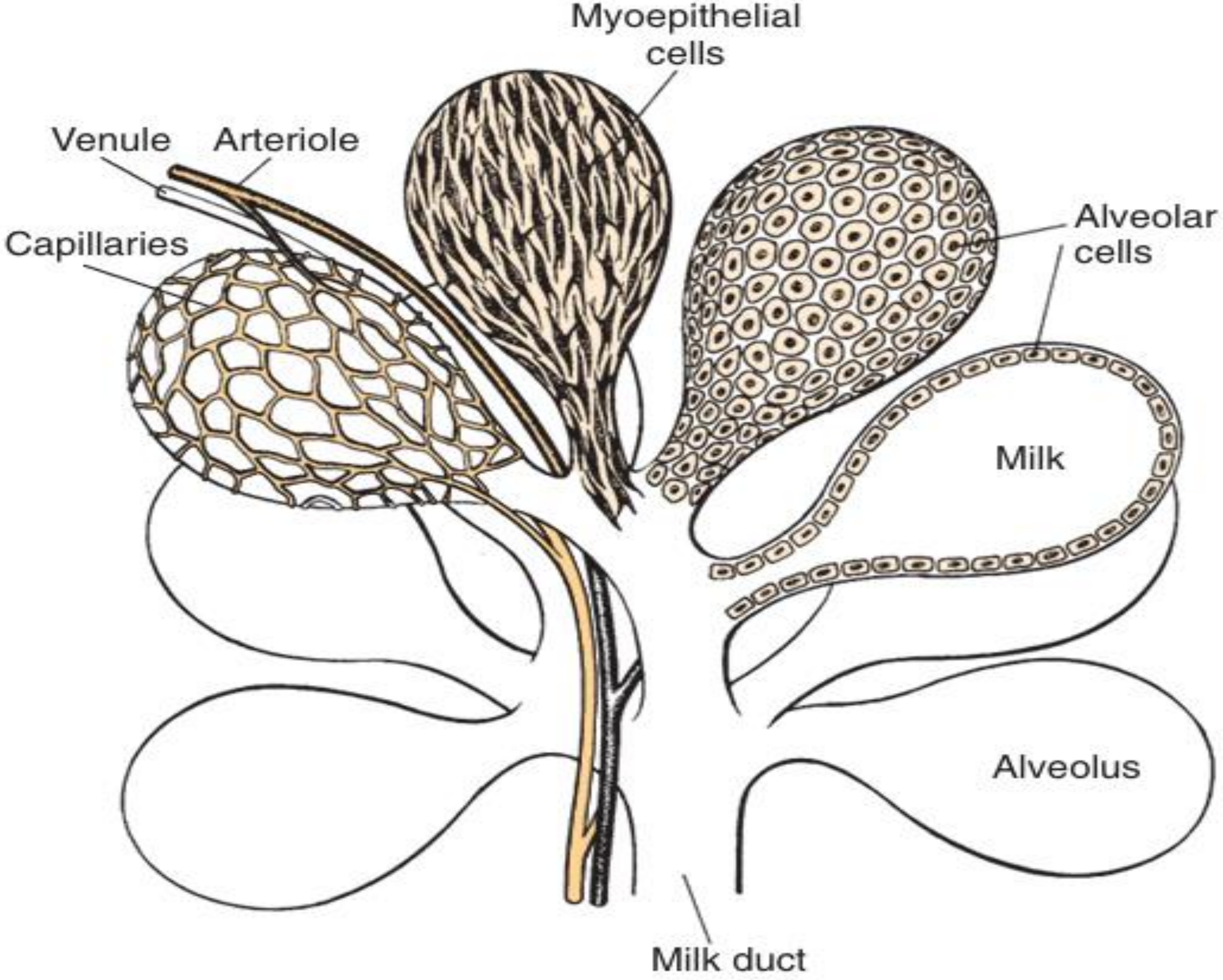
dorsotransverse position.

The Mammary gland and Lactation

Anatomical Aspects of the Mammary Gland

1. The milk-secreting cells of the mammary gland develop through the proliferation of epithelium into hollow structures called alveoli.
2. Most of the milk that accumulates before suckling or milking is stored in the alveoli, even though animals have enlarged milk-storage areas called cisterns.
3. A suspensory system involving the udder of the cow allows the animal to carry a large amount of milk.


Alveolar tissue
Opening of large milk ducts
Gland cistern
Teat cistern
Teat canal


Myoepithelial cells
Venule
Arteriole
Capillaries
Alveolar cells
Milk
Alveolus
Milk duct

The Mammary gland and Lactation

Control of Mammogenesis

1. Initial development of the mammary gland is programmed by embryonic mesenchyme.
2. Proliferation of the mammary duct system begins at puberty, with ducts under the control of estrogen, growth hormone, and adrenal steroids, and the alveoli under the control of progesterone and prolactin.

The Mammary gland and Lactation

Colostrum

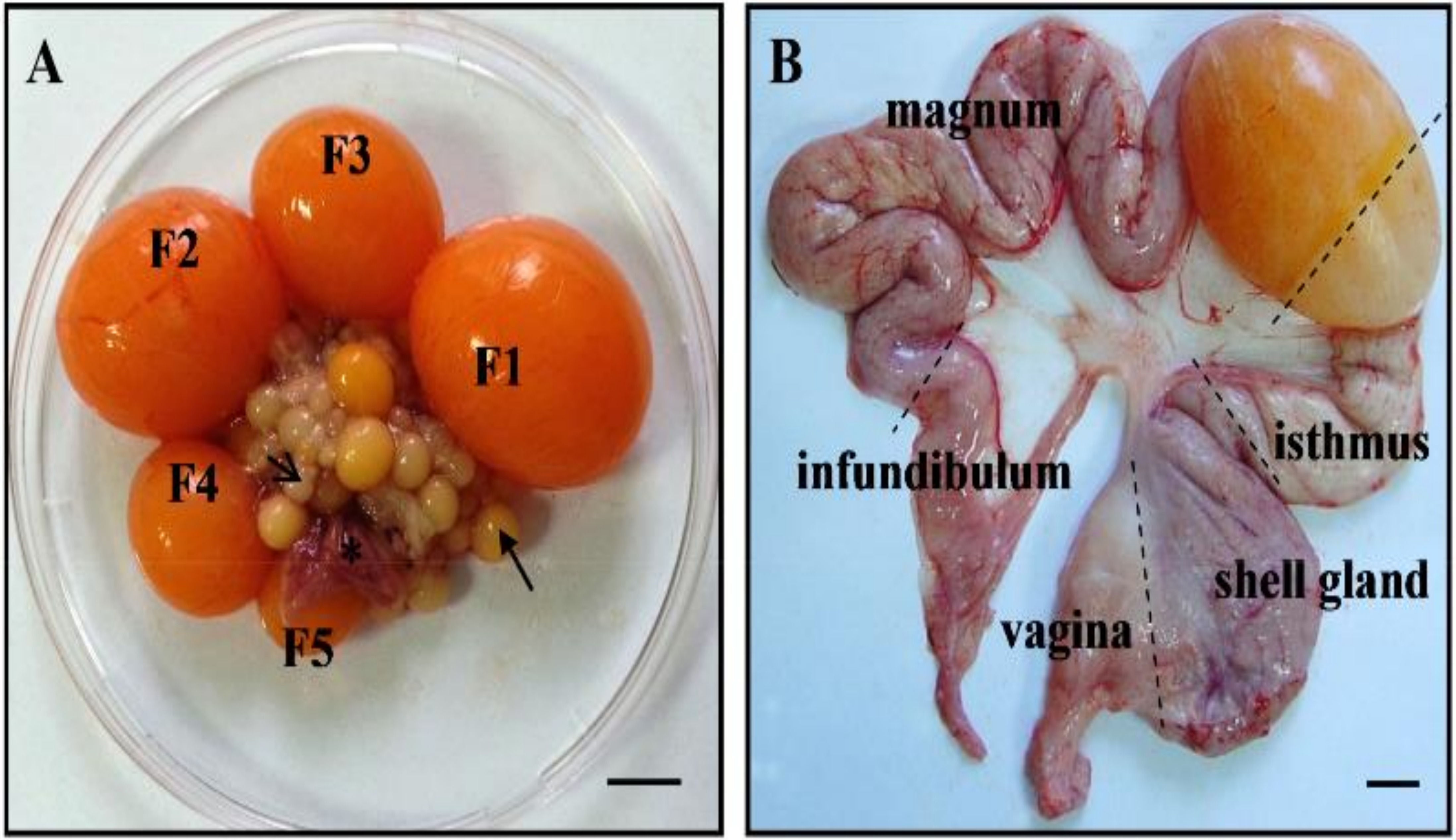
1. Prepartum milk production (without removal) results in the formation of colostrum.
2. The ingestion of colostrum is important because of the passive immunity it confers through the presence of high concentrations of immunoglobulins.
3. The time immunoglobulins can be absorbed through the neonatal gut is limited to the first 24 to 36 hours of life.
4. Lipids (particularly vitamin A) and proteins (caseins and albumins) are high in concentration in colostrum; carbohydrates (lactose) are low.

The Mammary gland and Lactation

Lactogenesis

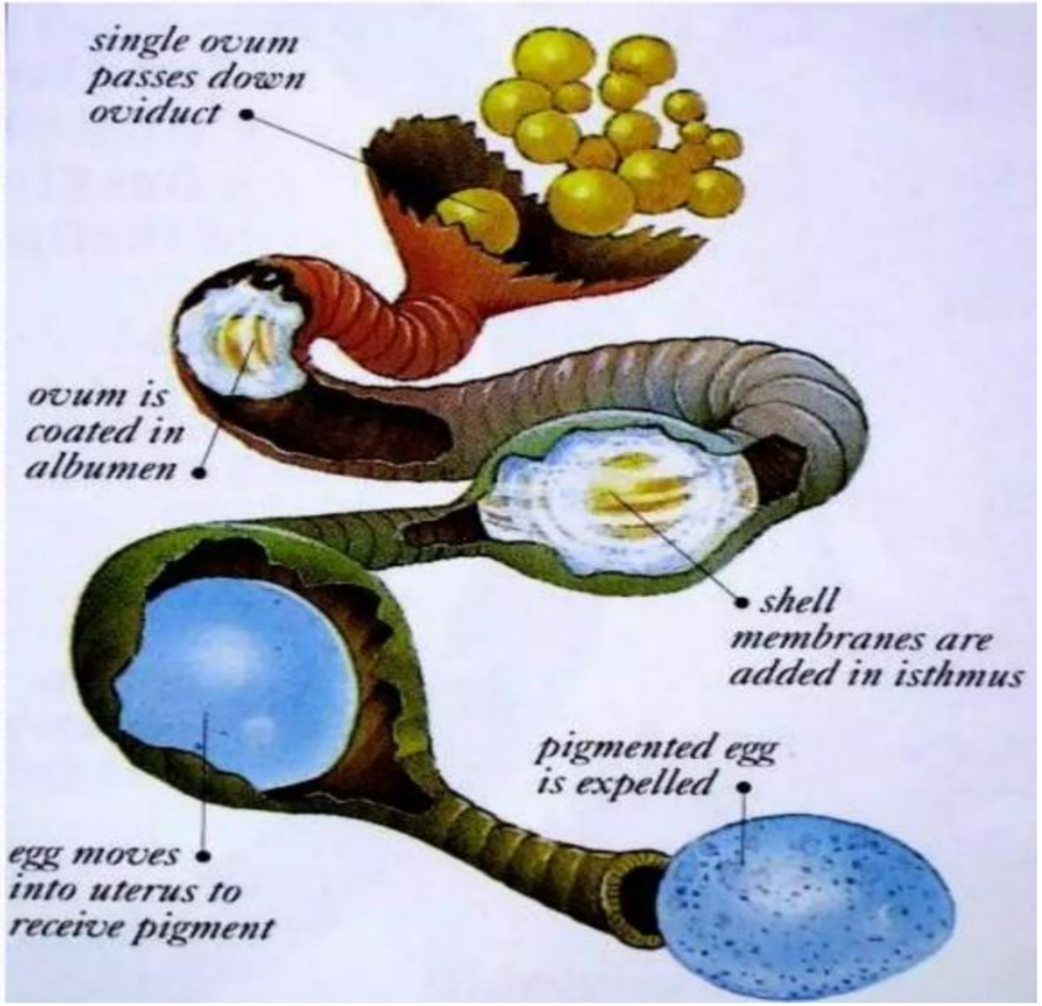
1. Prolactin, inhibited by dopamine and stimulated by vasoactive intestinal peptide, is the most important hormone involved in the process of milk synthesis, or lactogenesis; growth hormone is also important for lactogenesis.
2. The release of fat into milk from the alveolar cell involves constriction of the plasma membrane around the fat droplet; fats are dispersed in milk in droplet form.
3. Milk proteins and lactose are released from alveolar cells by the process of exocytosis.

Female Avian Reproductive System


A
F3
F2
F1
F4
*
F5
B
magnum
infundibulum
isthmus
shell gland
vagina

Female Reproductive Tract

- **Ovary**
- **Infundibulum** - site of fertilization
- **Magnum** - albumin addition
- **Isthmus** - membranes
- **Uterus** - shell gland
- **Vagina** - transport to exterior
- Sperm storage occurs at various sites in tract in some species

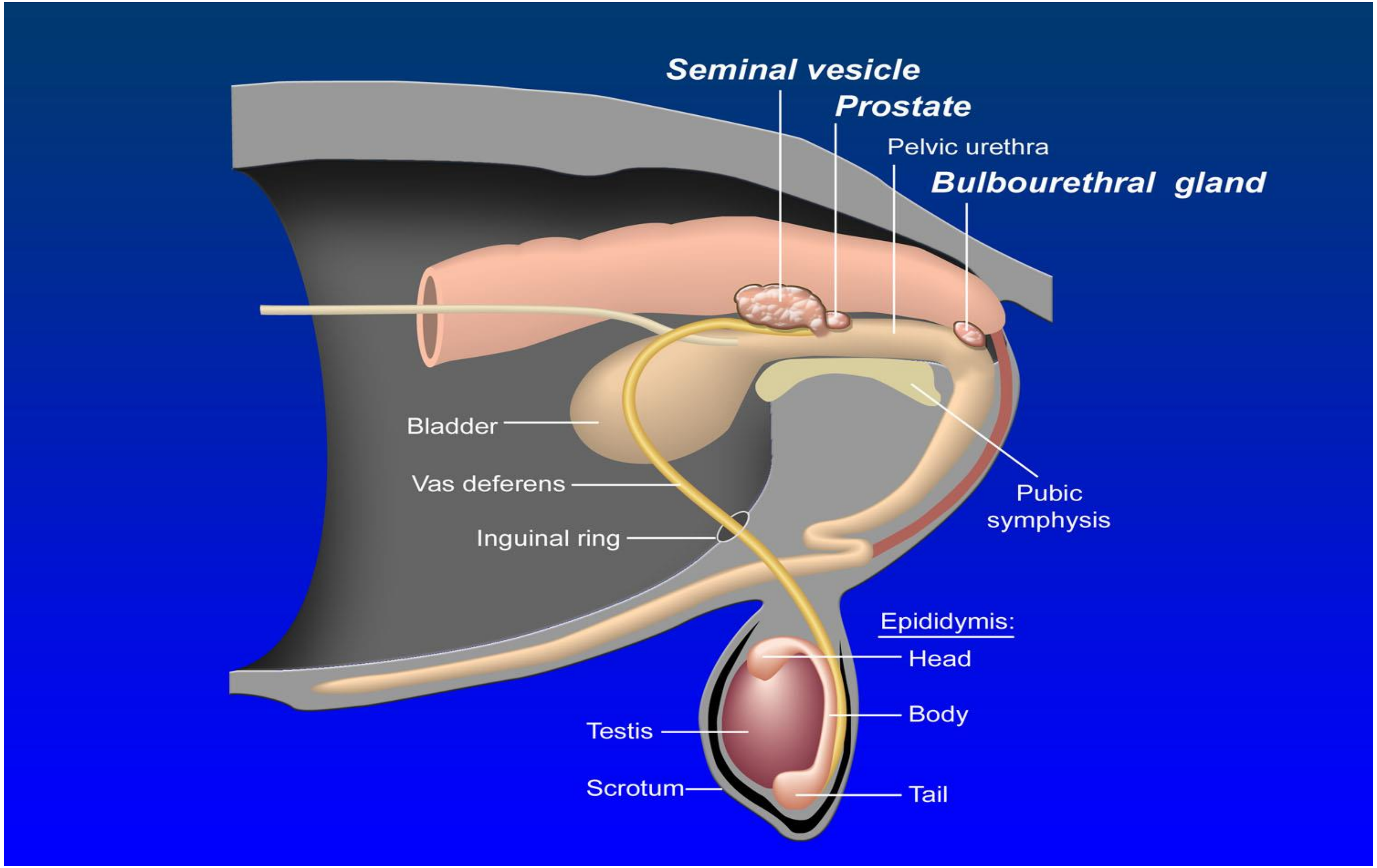


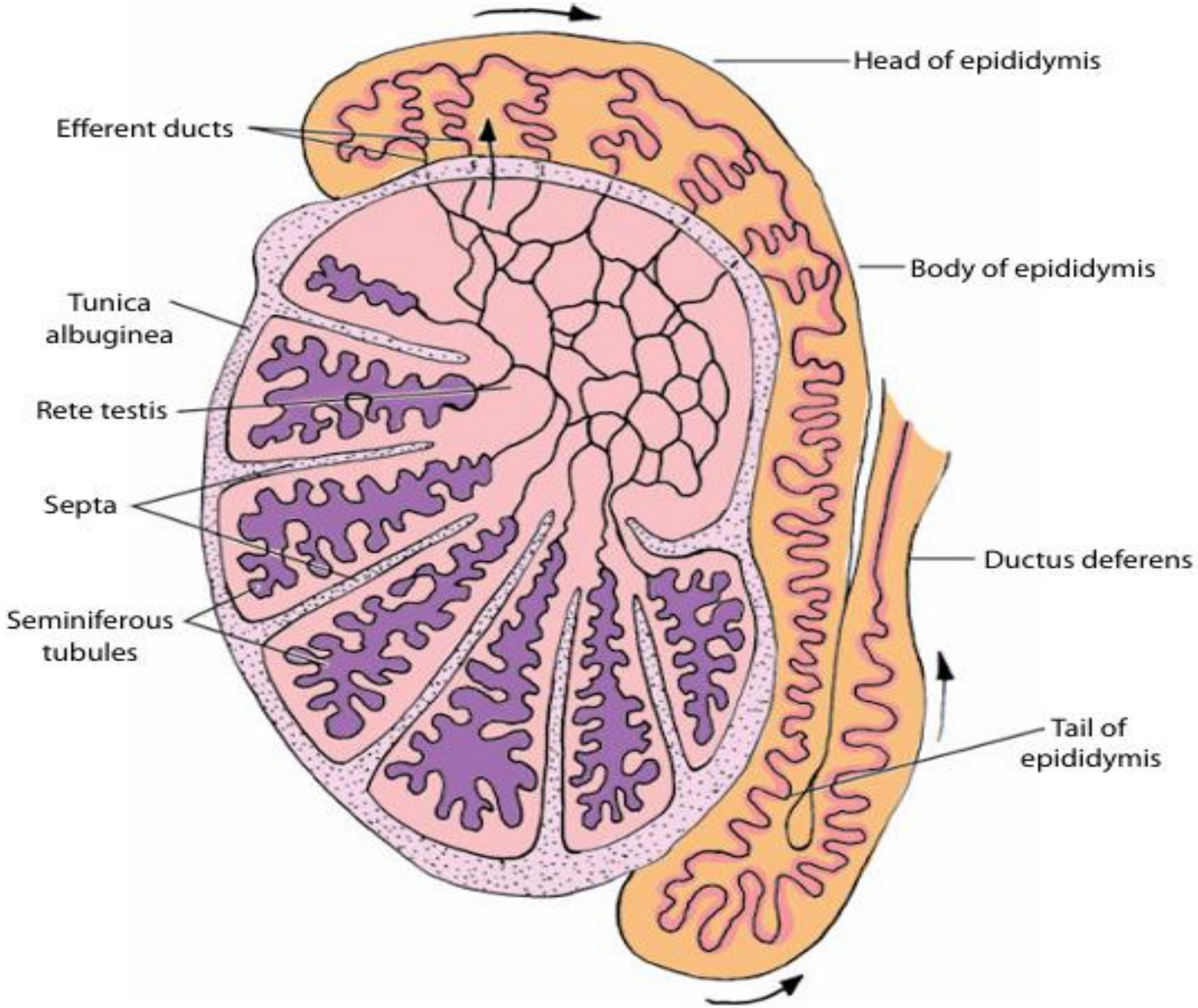
Male Reproductive System

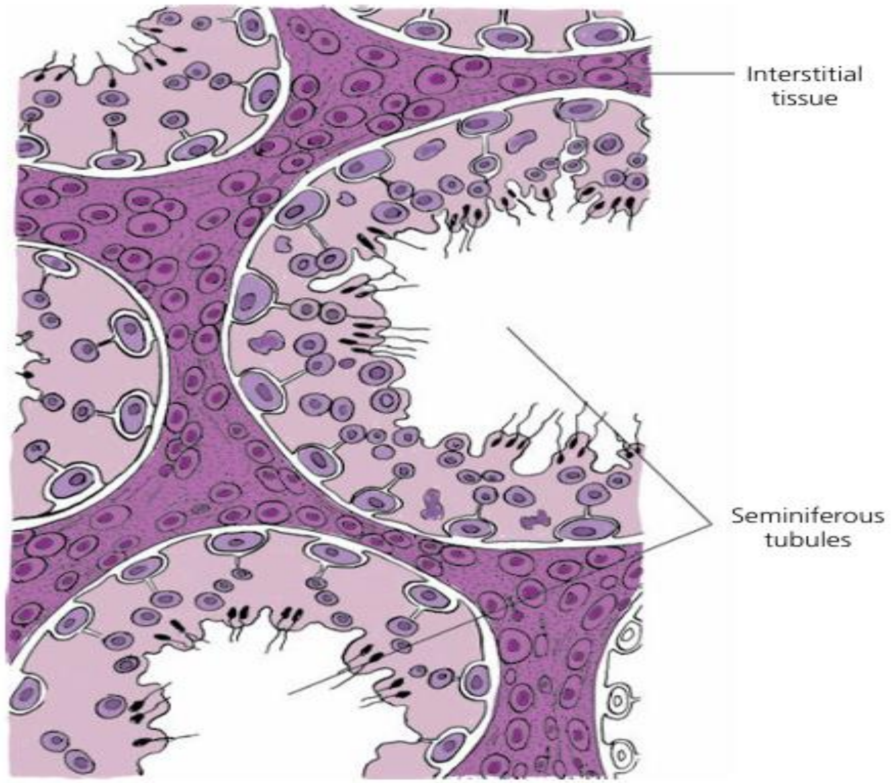
Functional Anatomy

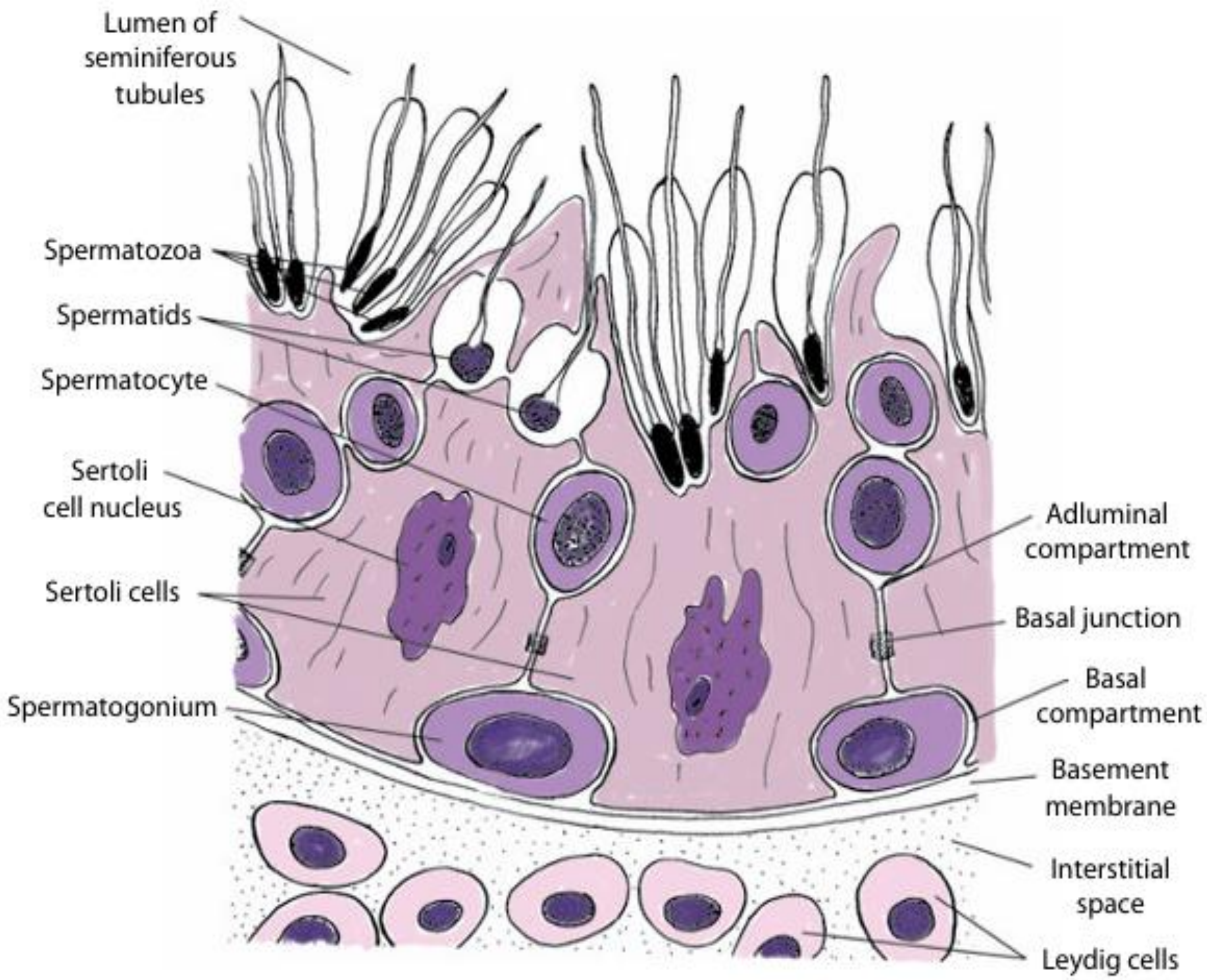
1. The male reproductive system consists of many individual organs acting in concert to produce spermatozoa and deliver them to the female's reproductive tract.
2. Normal spermatogenesis requires maintenance of uniform testicular temperature 2°C to 6°C lower than core body temperature.
3. Emission is the release of spermatozoa and accessory gland fluids into the pelvic urethra, whereas ejaculation is the forceful expulsion of semen from the urethra.

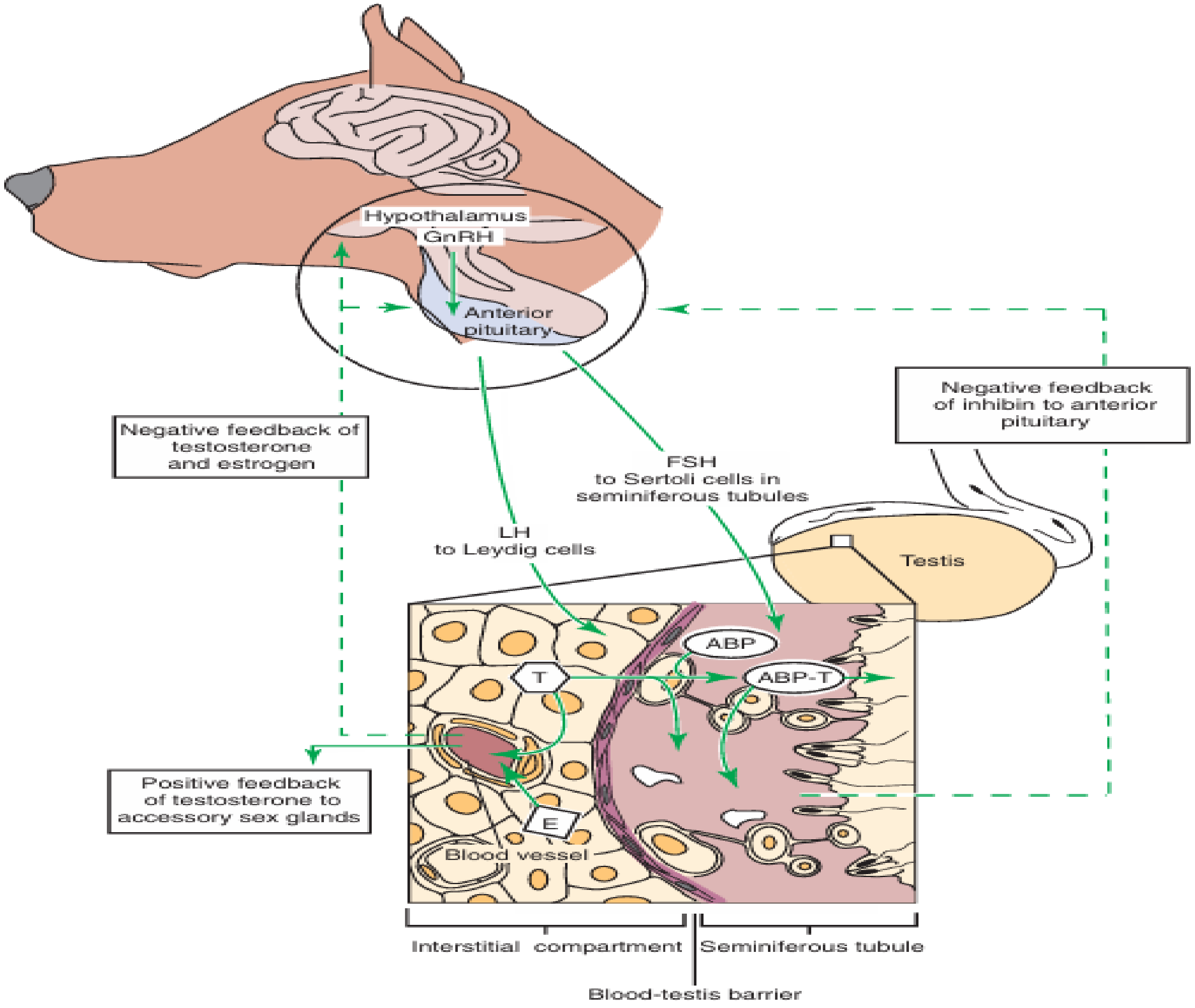
Male Bovine Reproductive System




Head of epididymis
Efferent ducts
Body of epididymis
Tunica
albuginea
Rete testis
Septa
Ductus deferens
Seminiferous
tubules
Tail of
epididymis


Interstitial tissue
Seminiferous tubules


Lumen of seminiferous tubules
Spermatozoa
Spermatids
Spermatocyte
Sertoli cell nucleus
Sertoli cells
Spermatogonium
Adluminal compartment
Basal junction
Basal compartment
Basement membrane
Interstitial space
Leydig cells



Hypothalamus
GnRH
Anterior pituitary
Negative feedback of testosterone and estrogen
Negative feedback of inhibin to anterior pituitary
FSH to Sertoli cells in seminiferous tubules
LH to Leydig cells
Testis
ABP
T
ABP-T
E
Blood vessel
Positive feedback of testosterone to accessory sex glands
Interstitial compartment
Seminiferous tubule
Blood-testis barrier

Accessory reproductive glands

- Seminal vesicles
  - Yellowish viscous fluid high in fructose
  - Energy source for sperm motility
  - Produce most fluid found in semen
- Prostate gland
  - Porduce thin, watery slightly acidic fluid
  - The enzyme fibrinolysin liquefies the semen after ejaculation.
- Bulbourethral glands
  - Produce clear, viscid, mucus-like secretion during erotic stimulation
  - As lubricant for thr penile urethra.

The Endocrine System

Hormones Are Chemicals Produced by Specific Tissues That Are Transported by the Vascular System to Affect Other Tissues at Low Concentrations

The Endocrine System

The Endocrine and Nervous Systems Are Integrated in Their Control of Physiological Processes

Chemical nature of hormones

1- Protein and polypeptide hormones:
Hypothalamic, pituitary, pancreatic and parathroid hormones.

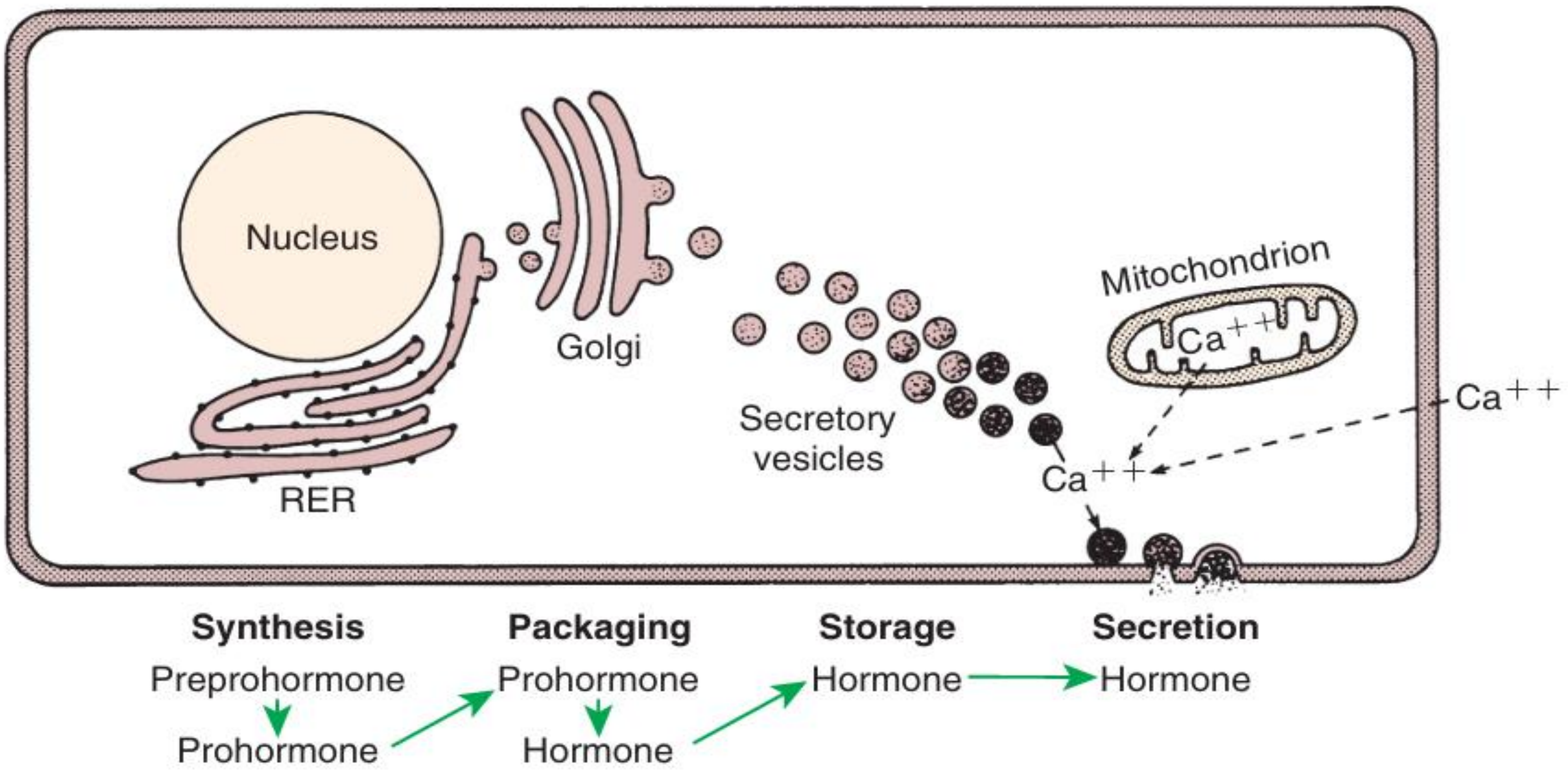
2- Steroid hormones:
Adrenocortical and gonadal hormones

3- Hormones derived from simple amino acids:
Thyroid and adrenal medullary hormones.

Synthesis of Hormones

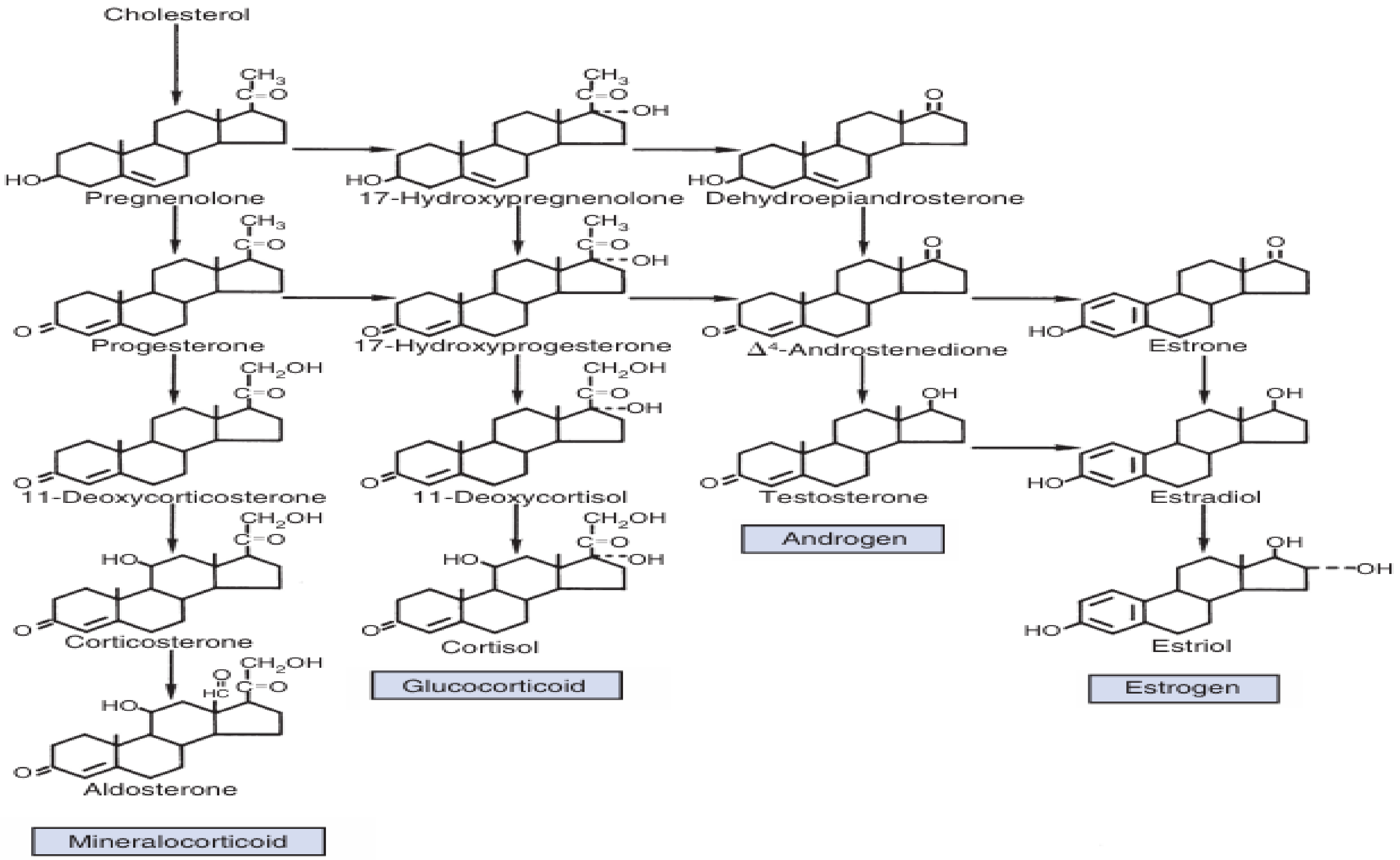
Protein Hormones Are Initially Synthesized as Preprohormones and Then Cleaved in the Rough Endoplasmic Reticulum to Form Prohormones, and in the Golgi Apparatus to Form the Active Hormones, Which Are Stored in Granules Before Being Released by Exocytosis

Synthesis of Hormones



Synthesis of Hormones

Steroids Are Synthesized from Cholesterol, Which Is Synthesized by the Liver; Steroids Are Not Stored but Are Released as They Are Synthesized



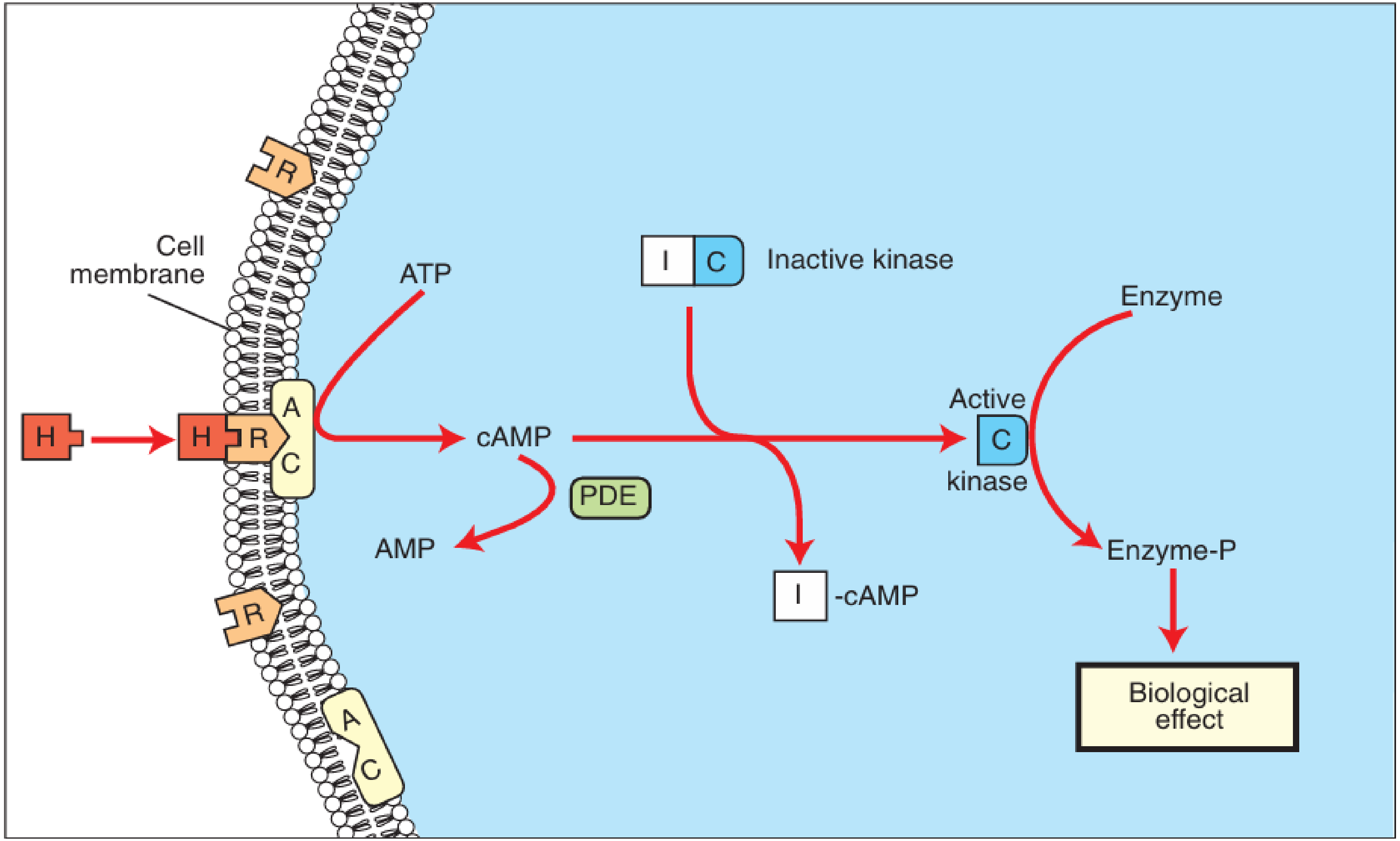
Cholesterol
Pregnenolone
17-Hydroxypregnenolone
Dehydroepiandrosterone
Progesterone
17-Hydroxyprogesterone
Δ4-Androstenedione
Estrone
11-Deoxycorticosterone
11-Deoxycortisol
Testosterone
Estradiol
Androgen
Corticosterone
Cortisol
Estriol
Glucocorticoid
Estrogen
Aldosterone
Mineralocorticoid

Hormone-Cell Interaction

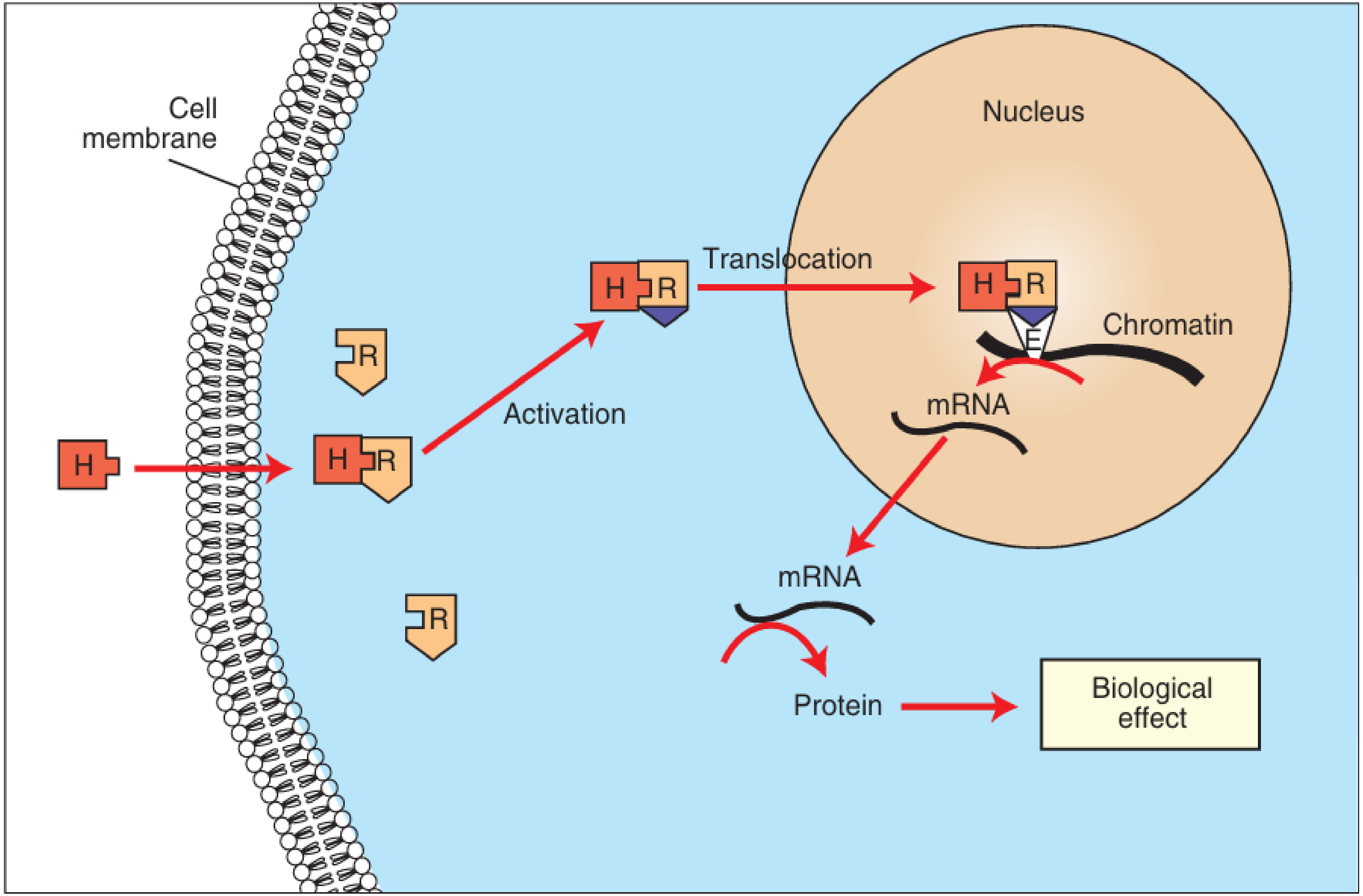
Protein Hormones Have Specific Receptors on Target Tissue Plasma Membranes, Whereas Steroids Have Specific Receptors Within the Cytoplasm or Nucleus

Postreceptor Cell Responses

Steroids Interact Directly With the Cell Nucleus Through the Formation of a Complex With Their Cytosolic or Nuclear Receptors, Whereas Protein Hormones Need a Messenger Because They Cannot Enter the Cell



Cell membrane
H
H
R
R
R
A
C
A
C
ATP
cAMP
PDE
AMP
I
C
Inactive kinase
I
-cAMP
Active
C
kinase
Enzyme
Enzyme-P
Biological effect

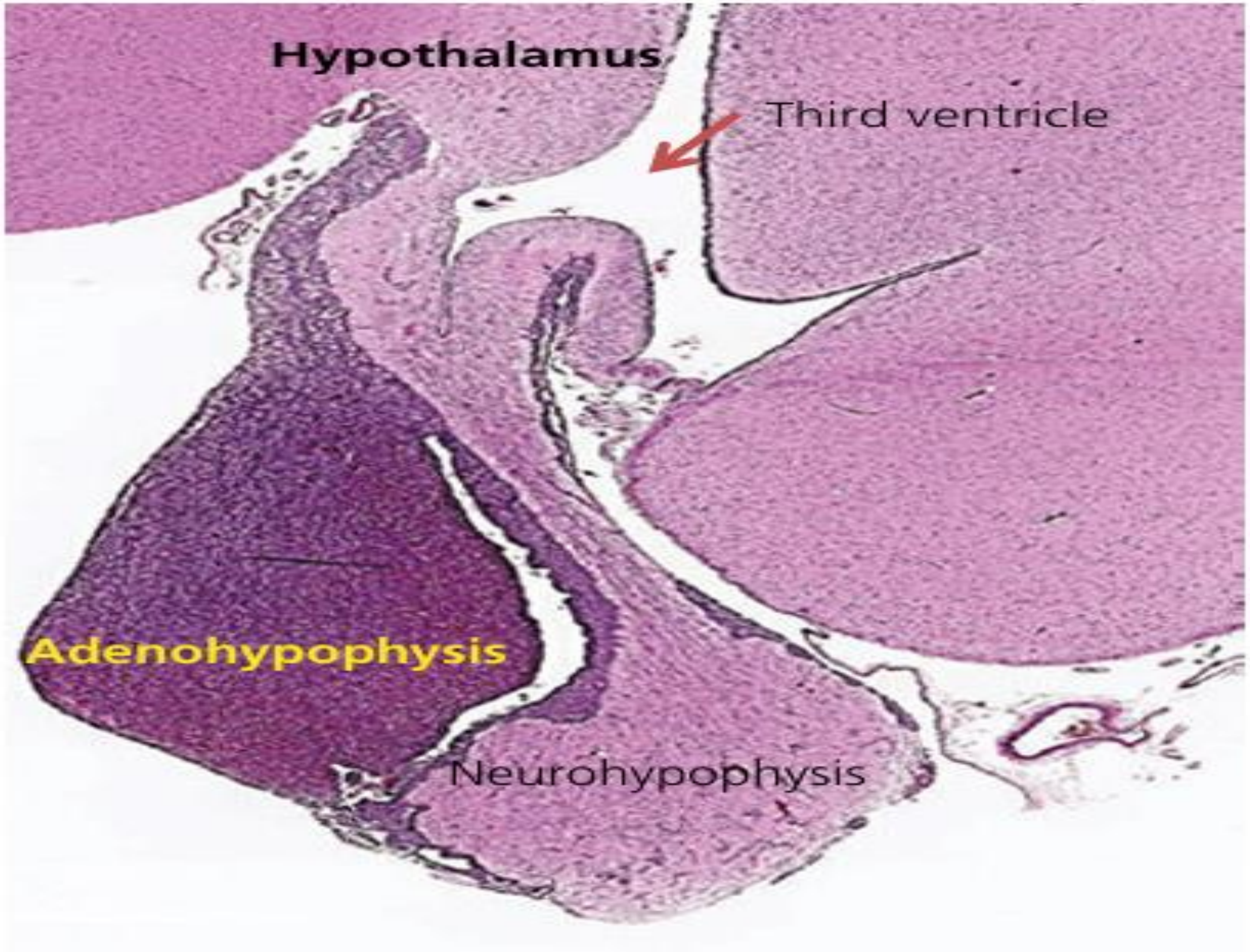

Cell
membrane
Nucleus
Translocation
H
R
Chromatin
E
mRNA
Activation
mRNA
Protein
Biological
effect

Transport of Hormones in the Blood

Protein Hormones Are Hydrophilic and Carried in the Plasma in Dissolved Form

Steroids and Thyroid Hormones Are Lipophilic and Carried in Plasma in Association With Both Specific and Nonspecific Binding Proteins; the Amount of Unbound, Active Hormone Is Relatively Small

Pituitary Gland



Pituitary Gland

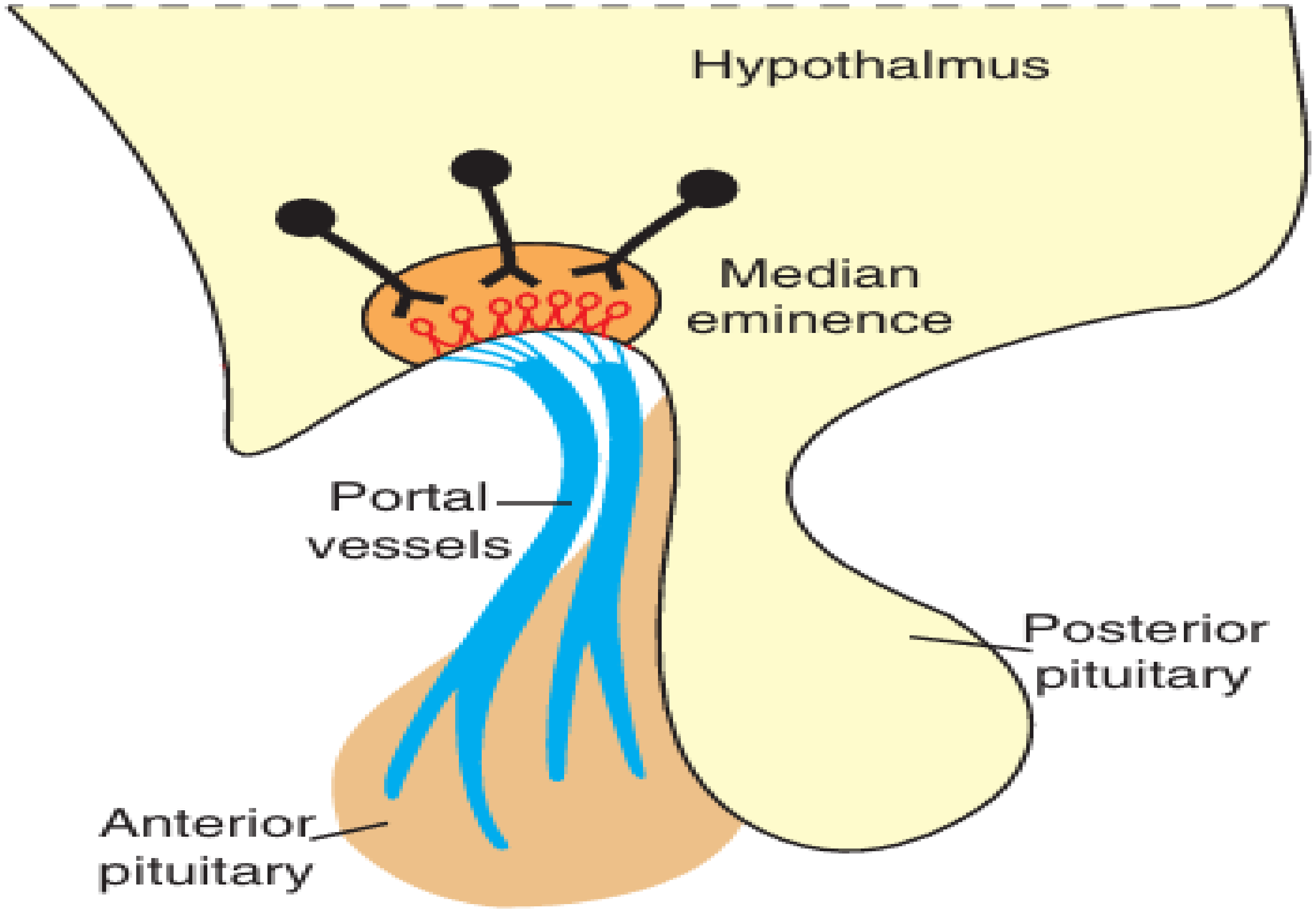


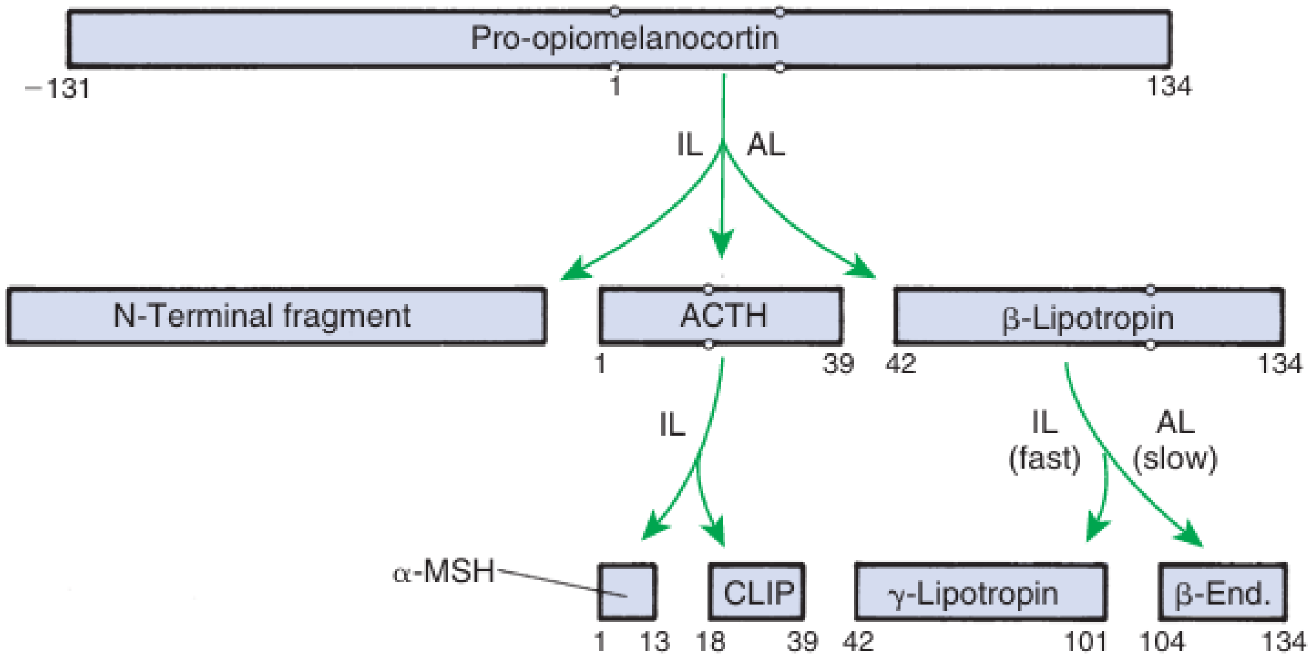
TABLE 33.2 Major Hypophysiotrophic Hormones

Hormone	Abbreviation	Site of Origin
Thyrotropin-releasing hormone	TRH	Paraventricular nucleus
Gonadotropin-releasing hormone	GnRH	Preoptic area of hypothalamus
Growth hormone–inhibiting hormone (somatostatin)	GHIH	Anterior hypothalamic area
Growth hormone–releasing hormone	GHRH	Arcuate nucleus
Corticotropin-releasing hormone	CRH	Paraventricular nucleus
Prolactin-releasing factor	PRF	Unknown
Prolactin-inhibiting hormone (or dopamine)	PIH	Arcuate nucleus

TABLE 33.1 Six Major Hormones Secreted by the Anterior Pituitary Gland

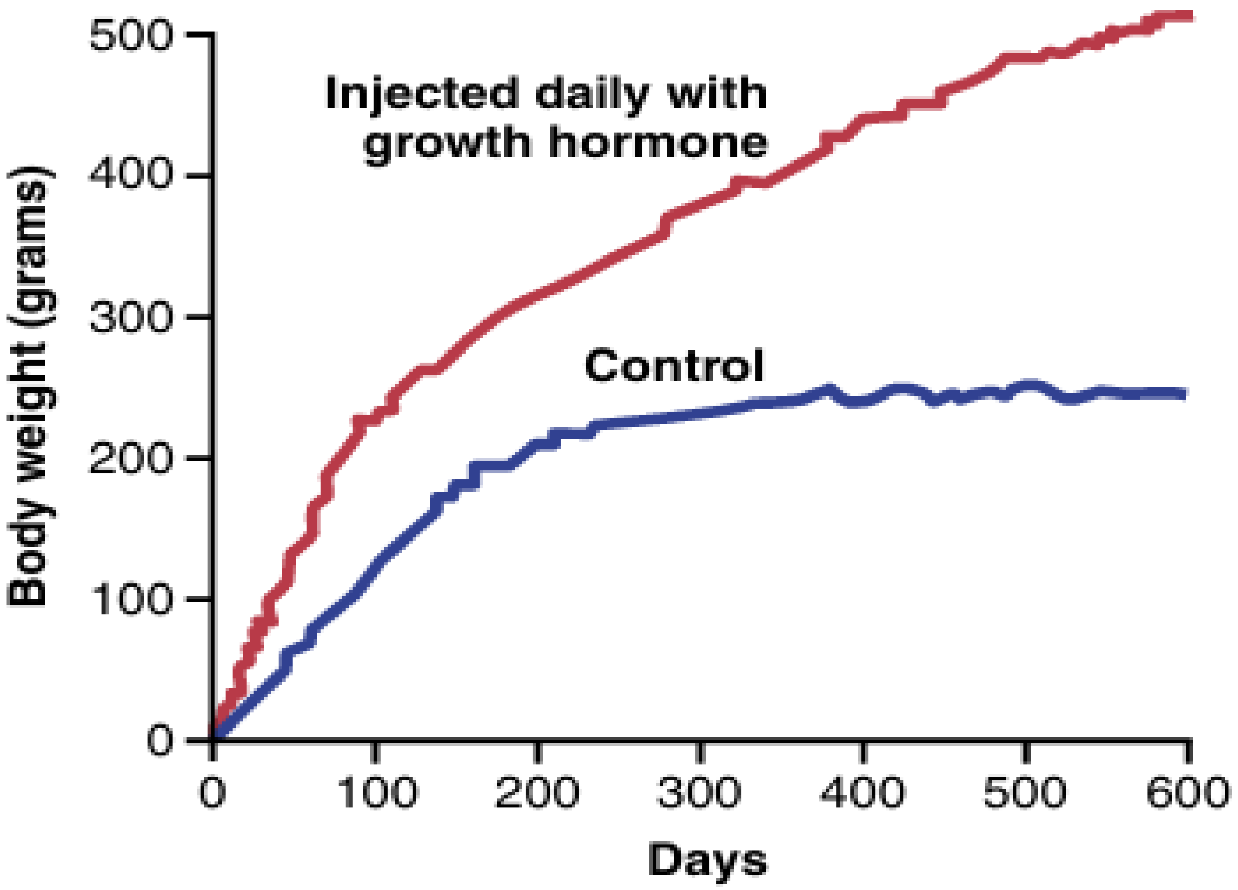
Hormone	Abbreviations
Glycoproteins	
Follicle-stimulating hormone	FSH
Luteinizing hormone (interstitial cell–stimulating hormone)	LH (ICSH)
Thyroid-stimulating hormone (thyrotropin)	TSH
Somatotropins	
Growth hormone (somatotropin)	GH
Prolactin	PRL
Proopiomelanocortin	
Corticotropin (adrenocorticotropic hormone)	ACTH

POMC

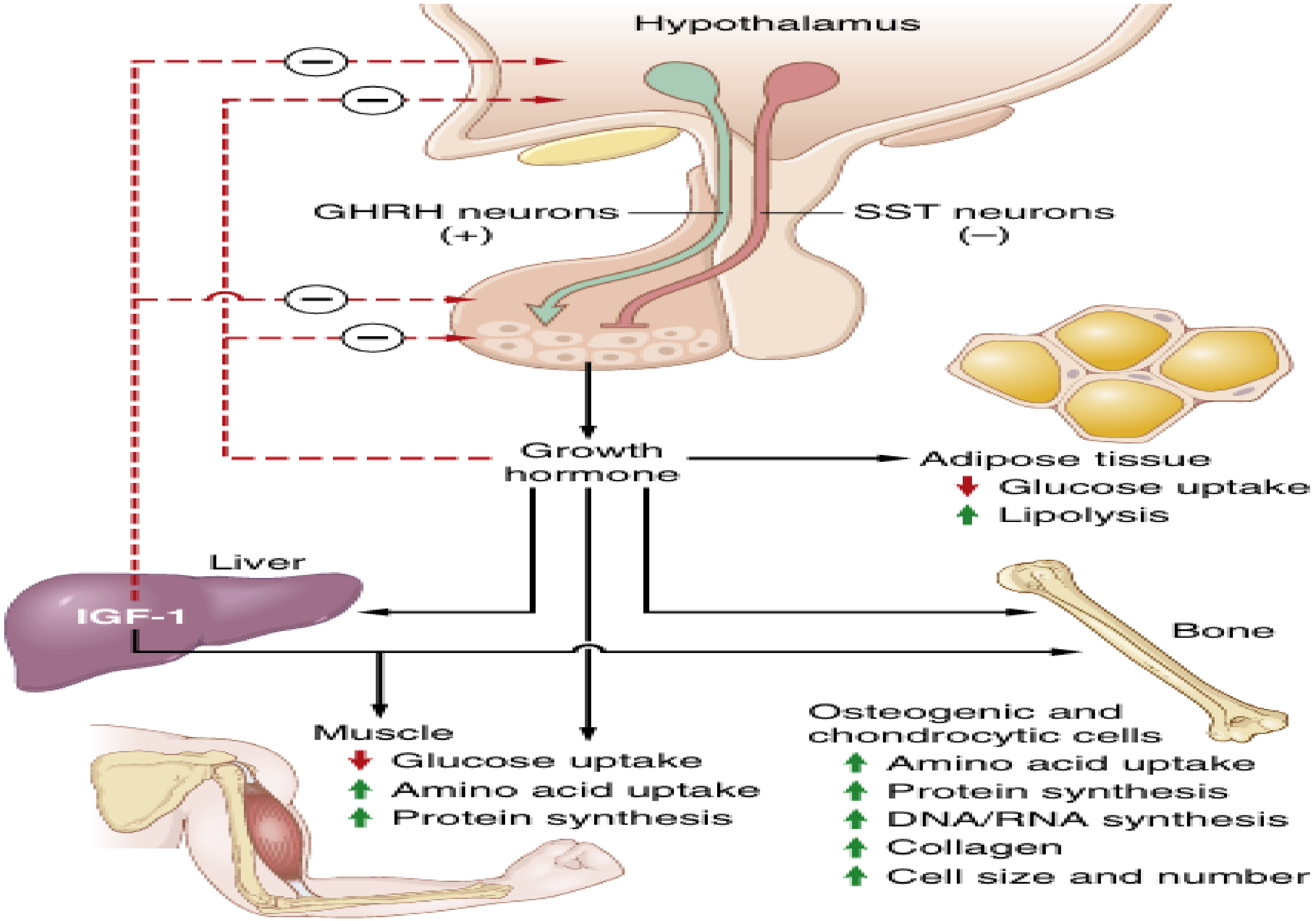


• **Fig. 33.15** Cleavage of proopiomelanocortin to yield ACTH and related peptides. By convention, the numbering of the amino acids begins with the first one of ACTH and then increases positively toward the carboxy terminal and negatively toward the amino terminal. Cleavage occurs at pairs of basic amino acids indicated by the circles. *ACTH,* Adrenocorticotropic hormone; *AL,* anterior lobe; *α-MSH,* alpha-melanocyte–stimulating hormone; *β-End,* beta-endorphin; *CLIP,* corticotropin-like intermediate lobe peptide; *IL,* intermediate lobe. (From Hedge GA, Colby HD, Goodman RL. *Clinical Endocrine Physiology*. Philadelphia: Saunders; 1987.)

GH(Somatotrop)



GH(Somatotrop)



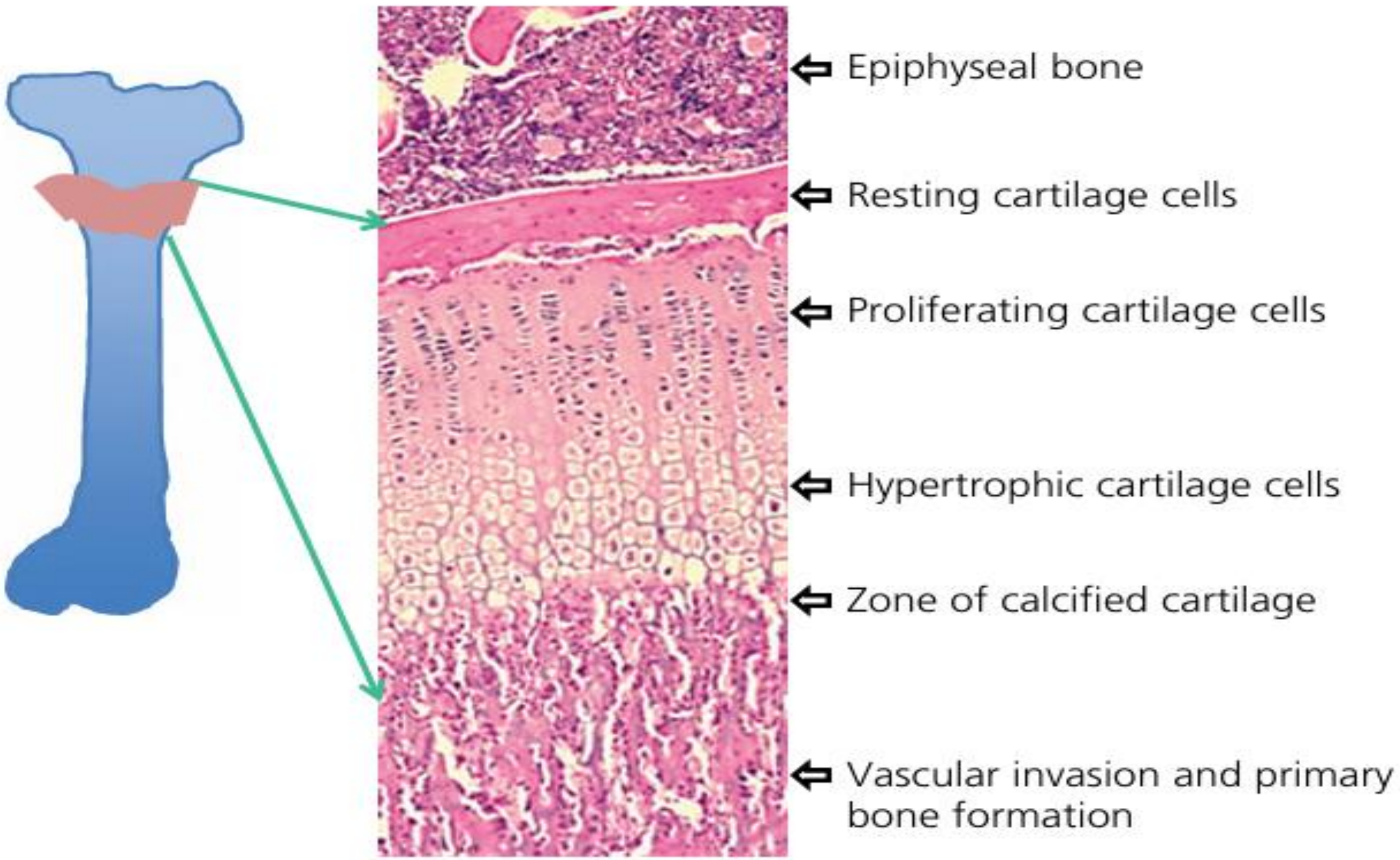
Metabolic Effects of GH

Growth Hormone Promotes Protein Deposition in Tissues

Growth Hormone Decreases Carbohydrate Utilization

Growth Hormone Enhances Fat Utilization for Energy

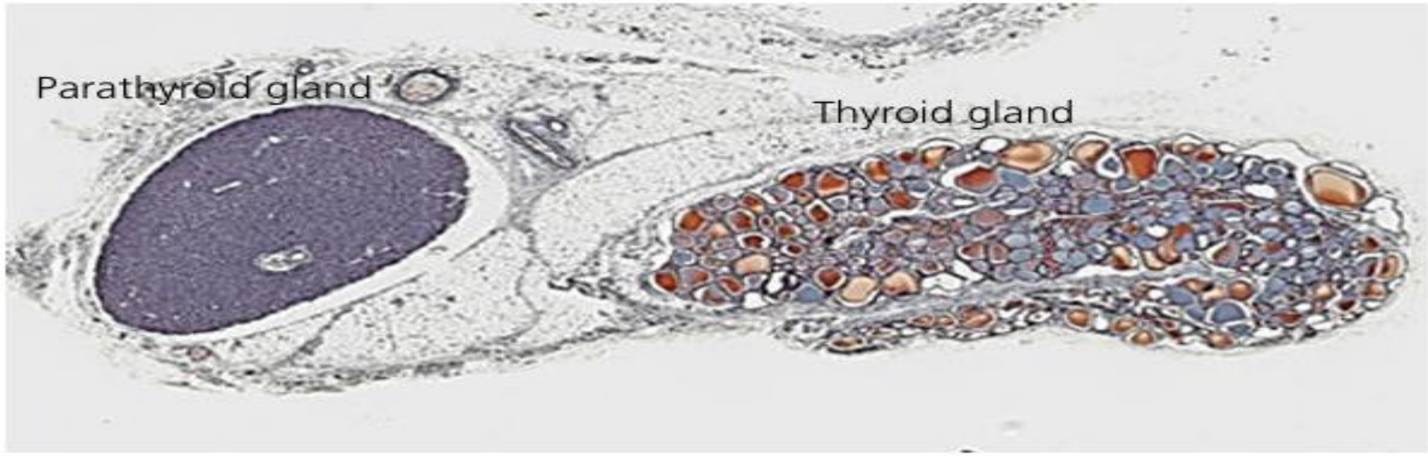
GH(Somatotrop)



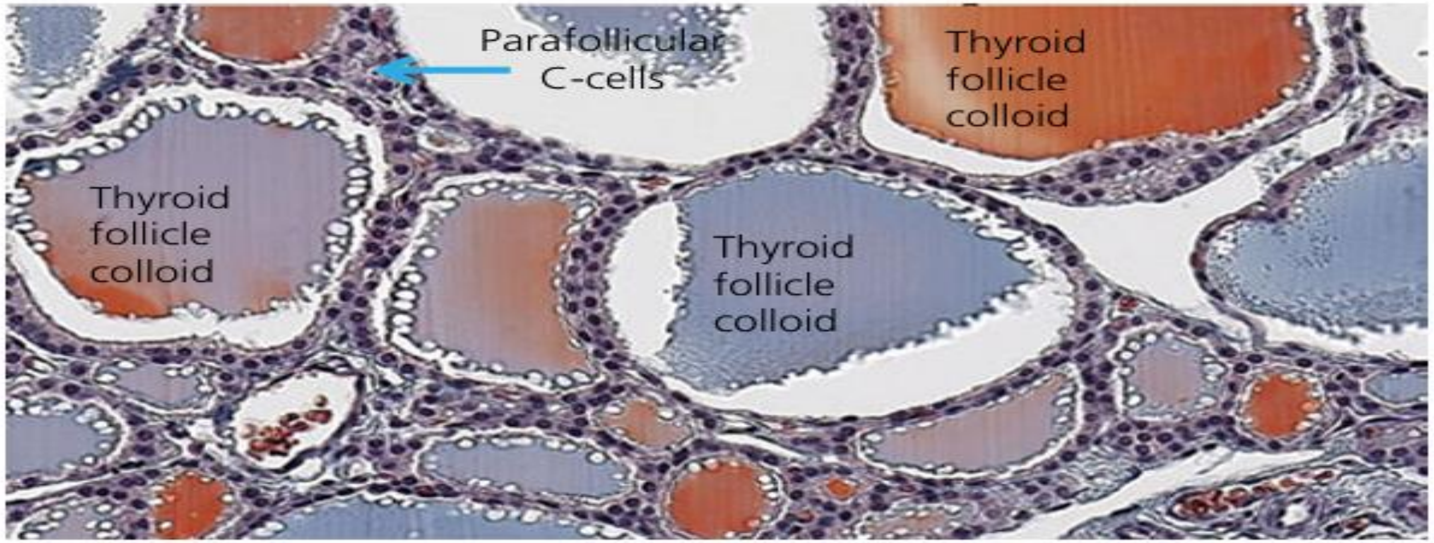
Regulation of GH Secretion

Stimulate Growth Hormone Secretion	Inhibit Growth Hormone Secretion
Decreased blood glucose level	Increased blood glucose level
Decreased blood free fatty acid levels	Increased blood free fatty acid levels
Increased blood amino acid levels (arginine)	Aging
Starvation or fasting, protein deficiency	Obesity
Trauma, stress, excitement	Growth hormone inhibitory hormone (somatostatin)
Exercise	Growth hormone (exogenous)
Testosterone, estrogen	Insulin-like growth factors (somatomedins)
Deep sleep (stages 2 and 4)	
Growth hormone–releasing hormone	

Thyroid Gland

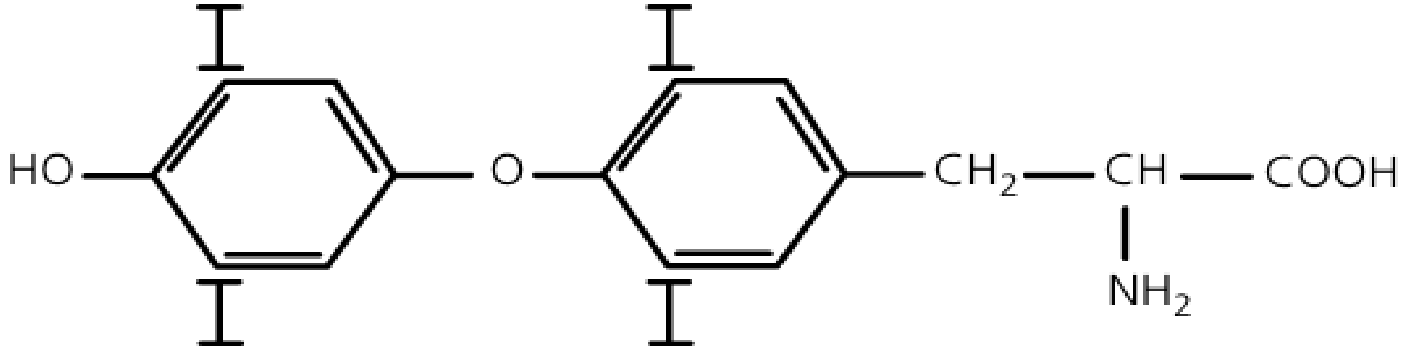


(A)

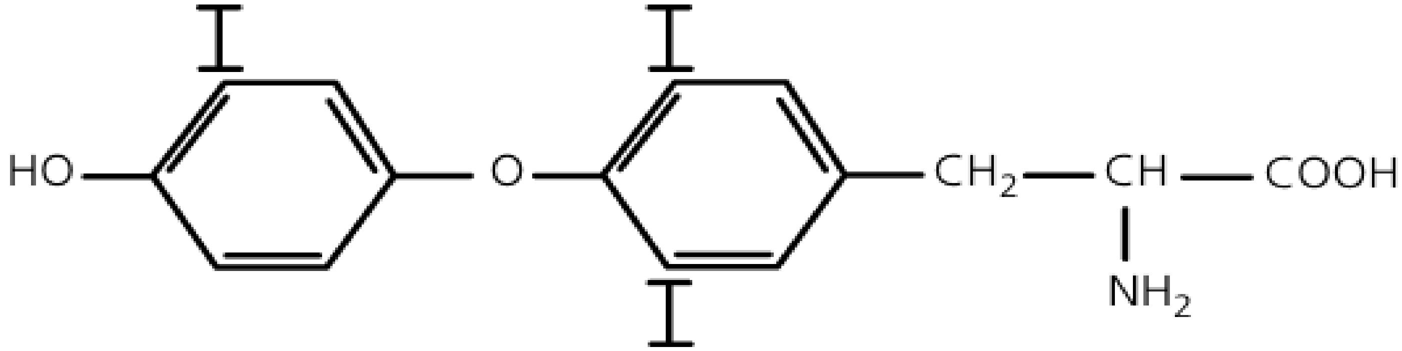


(B)

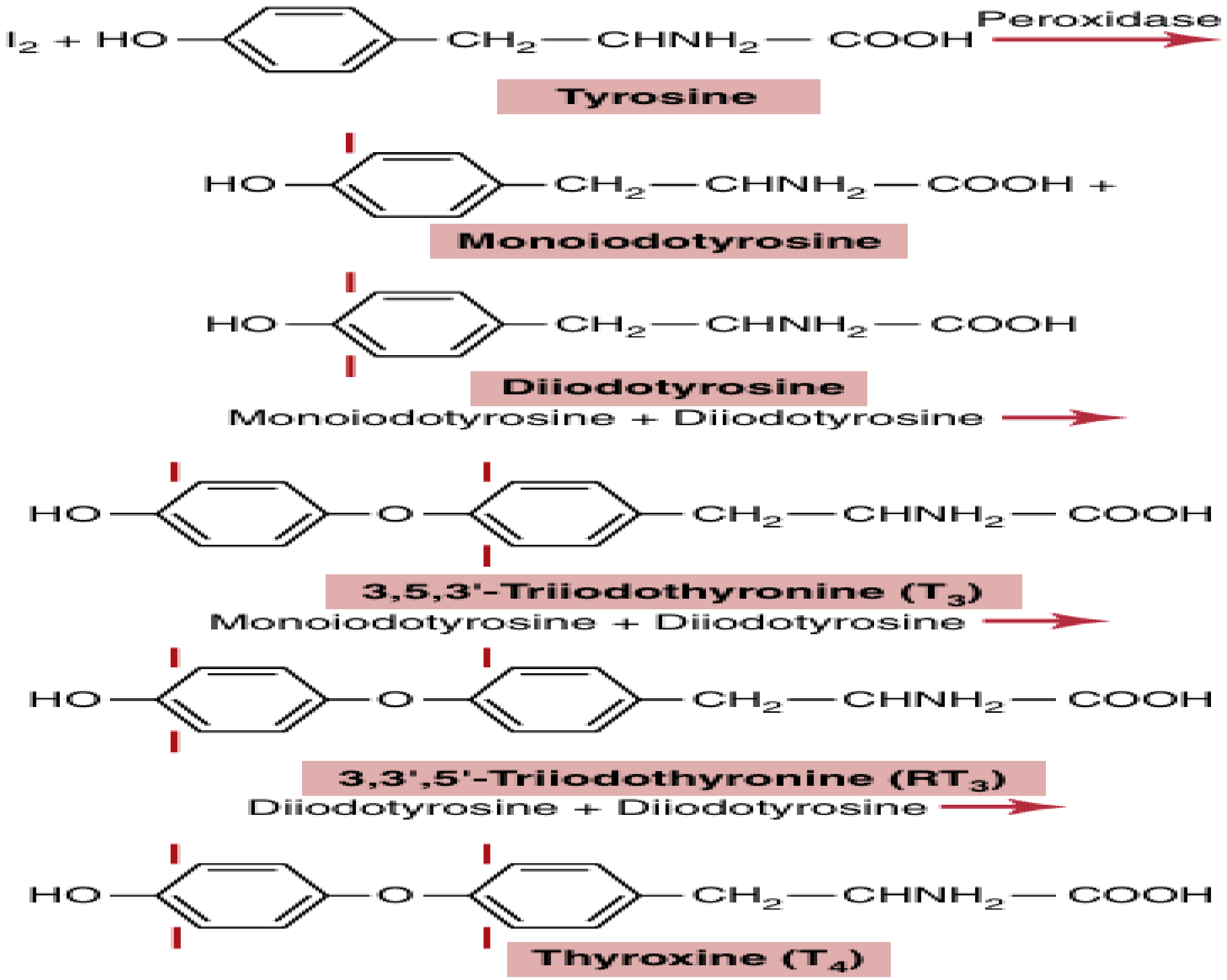
Thyroid Hormones



3,5,3′,5′ - Tetraiodothyronine
(Thyroxine)

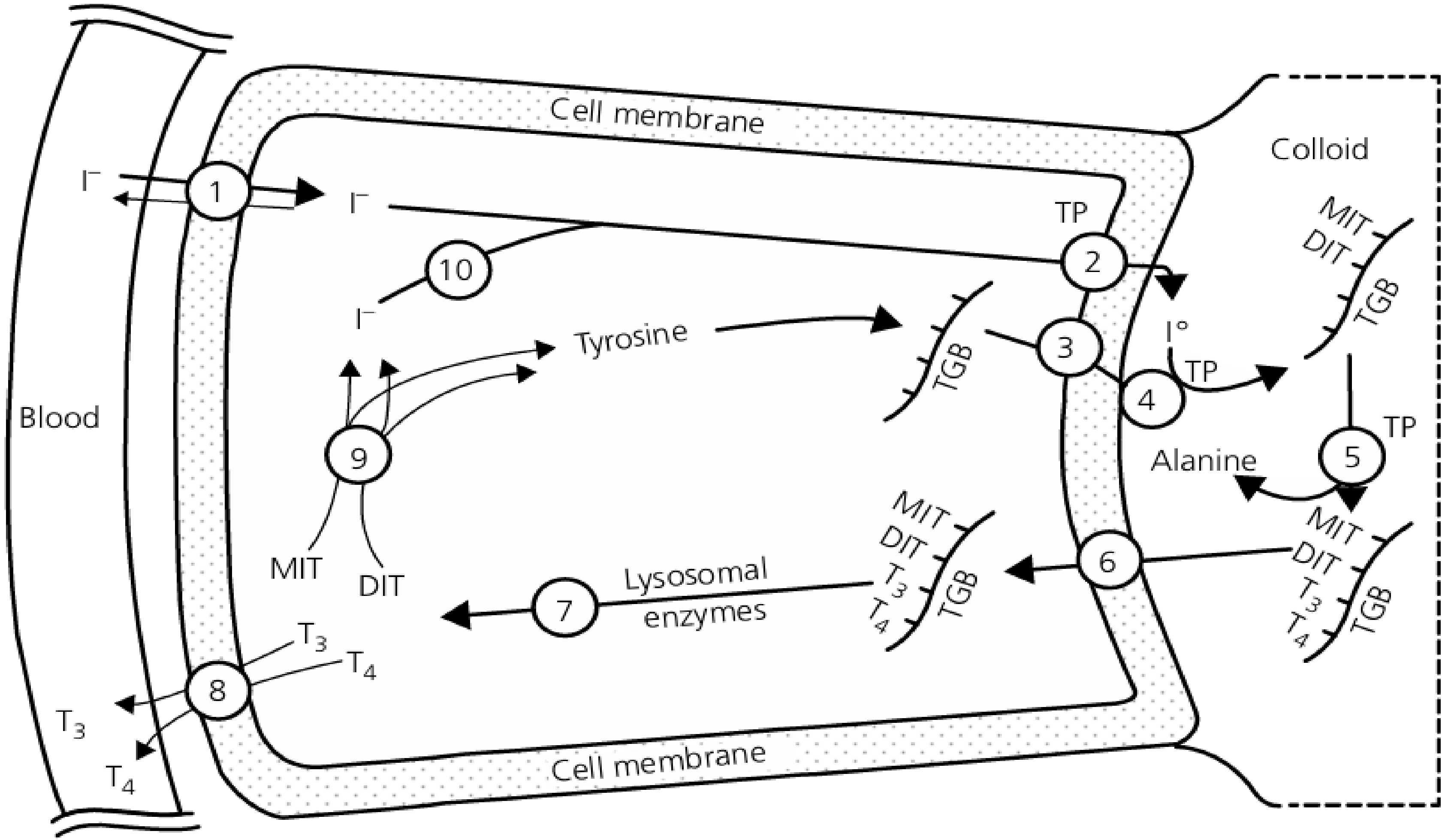


3,5,3′ - Triiodothyronine



I_2 + HO—C₆H₄—CH_2—$CHNH_2$—COOH
Peroxidase
Tyrosine
Monoiodotyrosine
Diiodotyrosine
Monoiodotyrosine + Diiodotyrosine
3,5,3'-Triiodothyronine (T_3)
Monoiodotyrosine + Diiodotyrosine
3,3',5'-Triiodothyronine (RT_3)
Diiodotyrosine + Diiodotyrosine
Thyroxine (T_4)

Thyroid Hormones

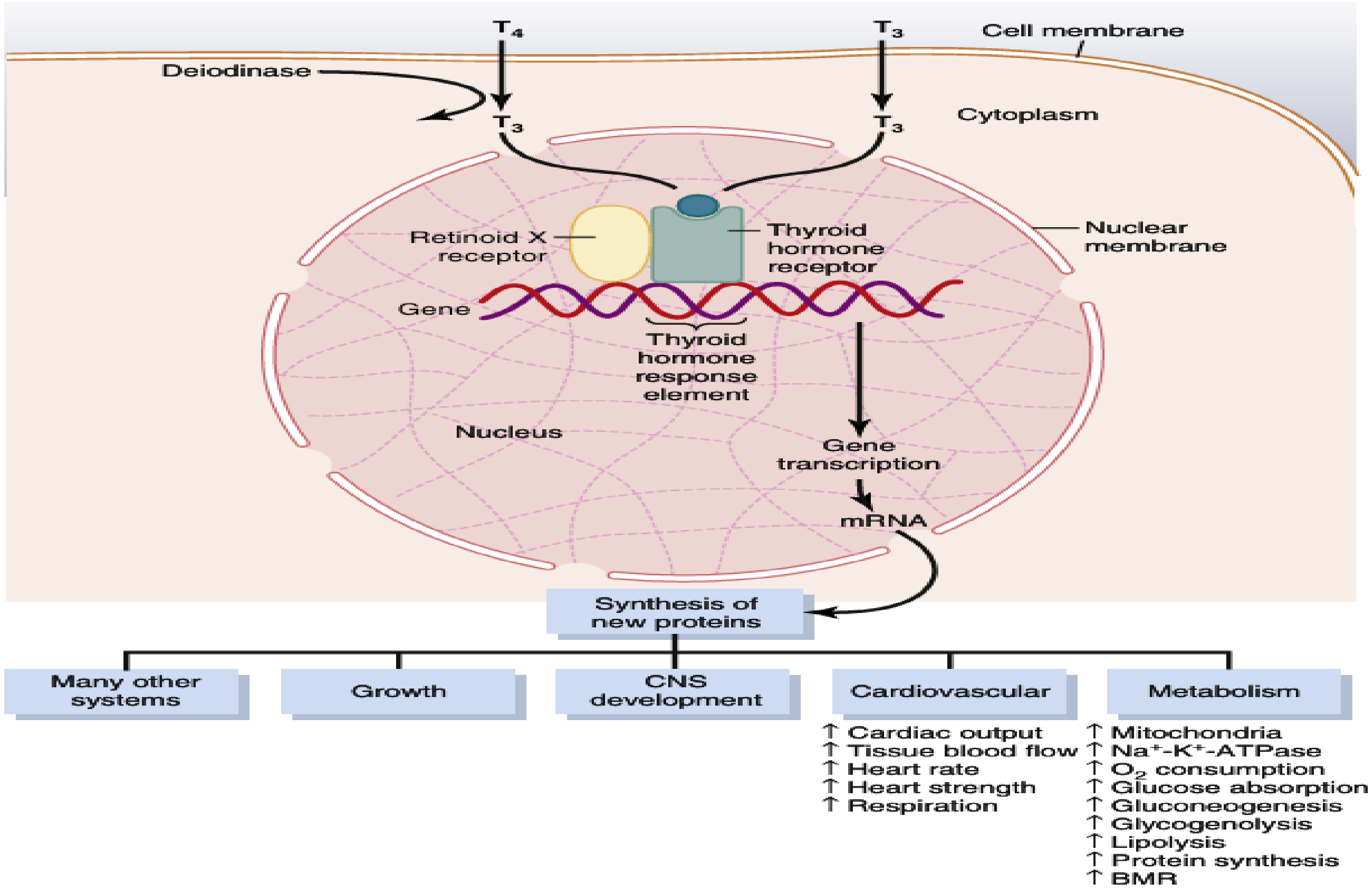


Thyroid Hormones

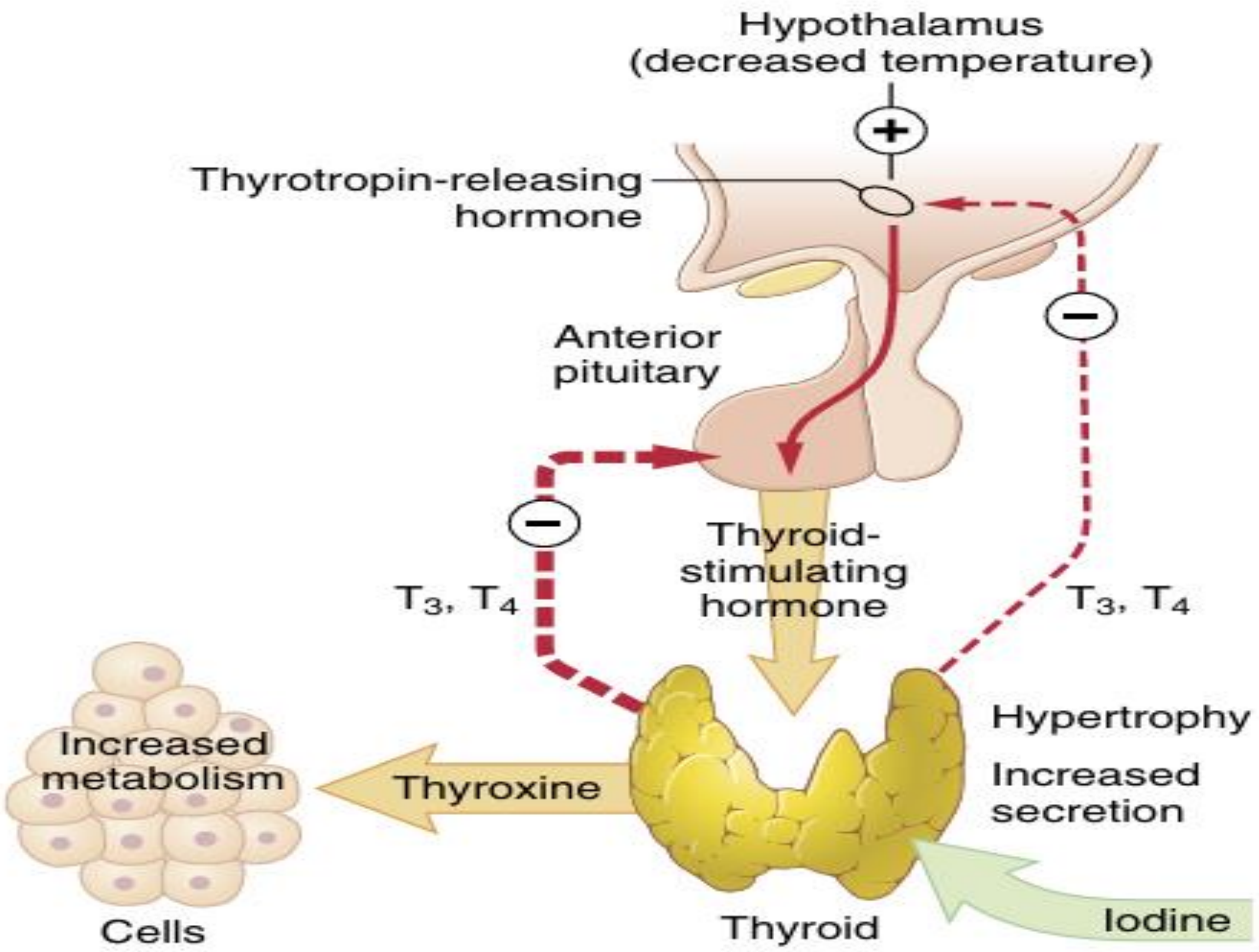
The Thyroid Gland

1. The thyroid hormones are synthesized from two connected tyrosine molecules that contain three or four iodine molecules.
2. Thyroid hormones are stored outside the cell and attached to thyroglobulin in colloid.
3. The release of thyroid hormones involves transport of thyroglobulin with attached thyroid hormones into the cell, cleavage of the thyroid hormones from thyroglobulin, and release of hormones into the interstitial tissues.
4. Thyroid hormones are transported in the plasma attached to plasma proteins.
5. The main routes of metabolism of thyroid hormones are through deiodination or the formation of glucuronides and sulfates via hepatic mechanisms.
6. Thyroid hormones are the primary factors for the control of basal metabolism.
7. The ingestion of compounds that inhibit the uptake or organic binding of iodine blocks the thyroid's ability to secrete thyroid hormones and causes goiter.

Functions of Thyroid Hormones

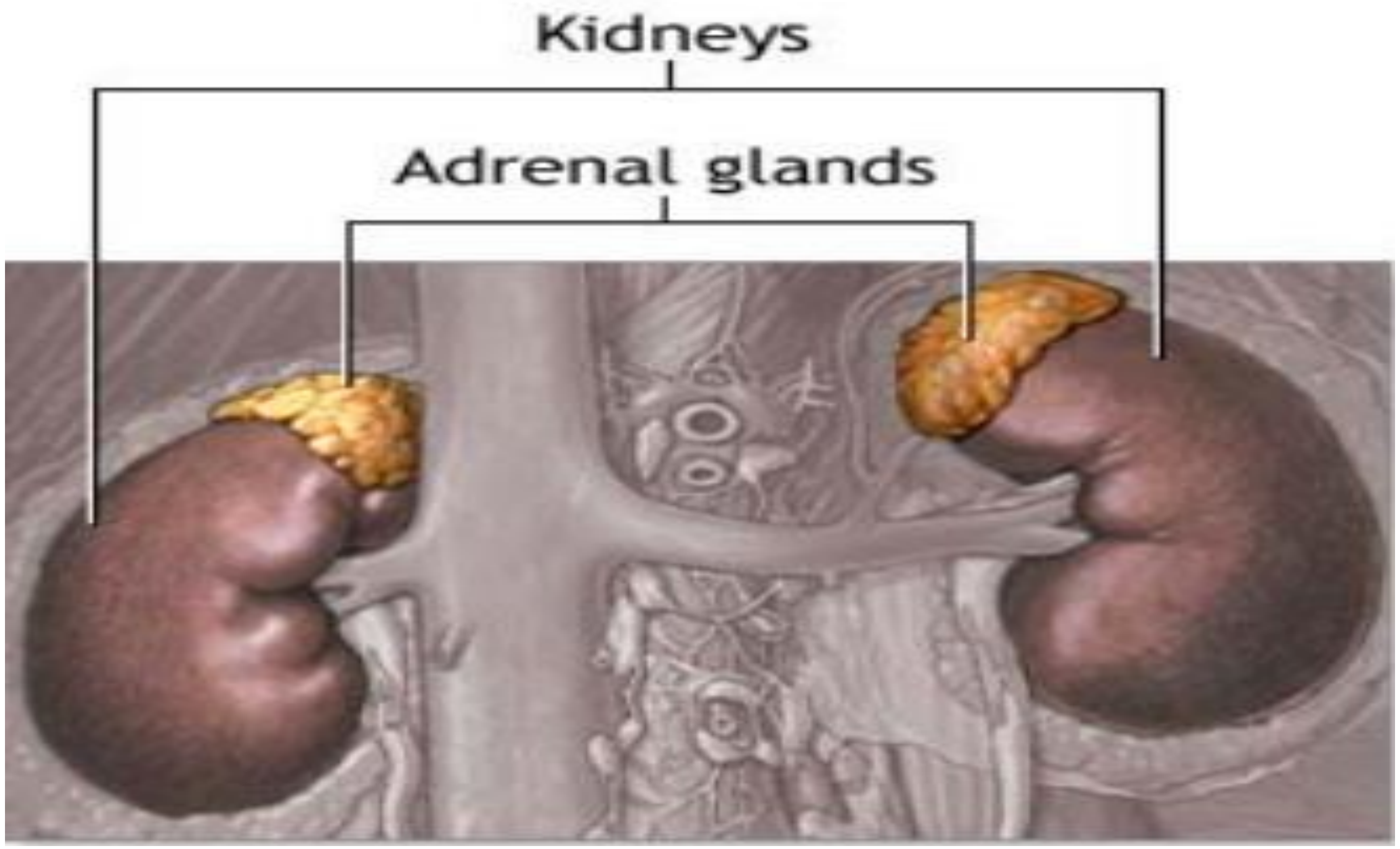


Regulation of Thyroid Hormones Secretion



The Adrenal Glands

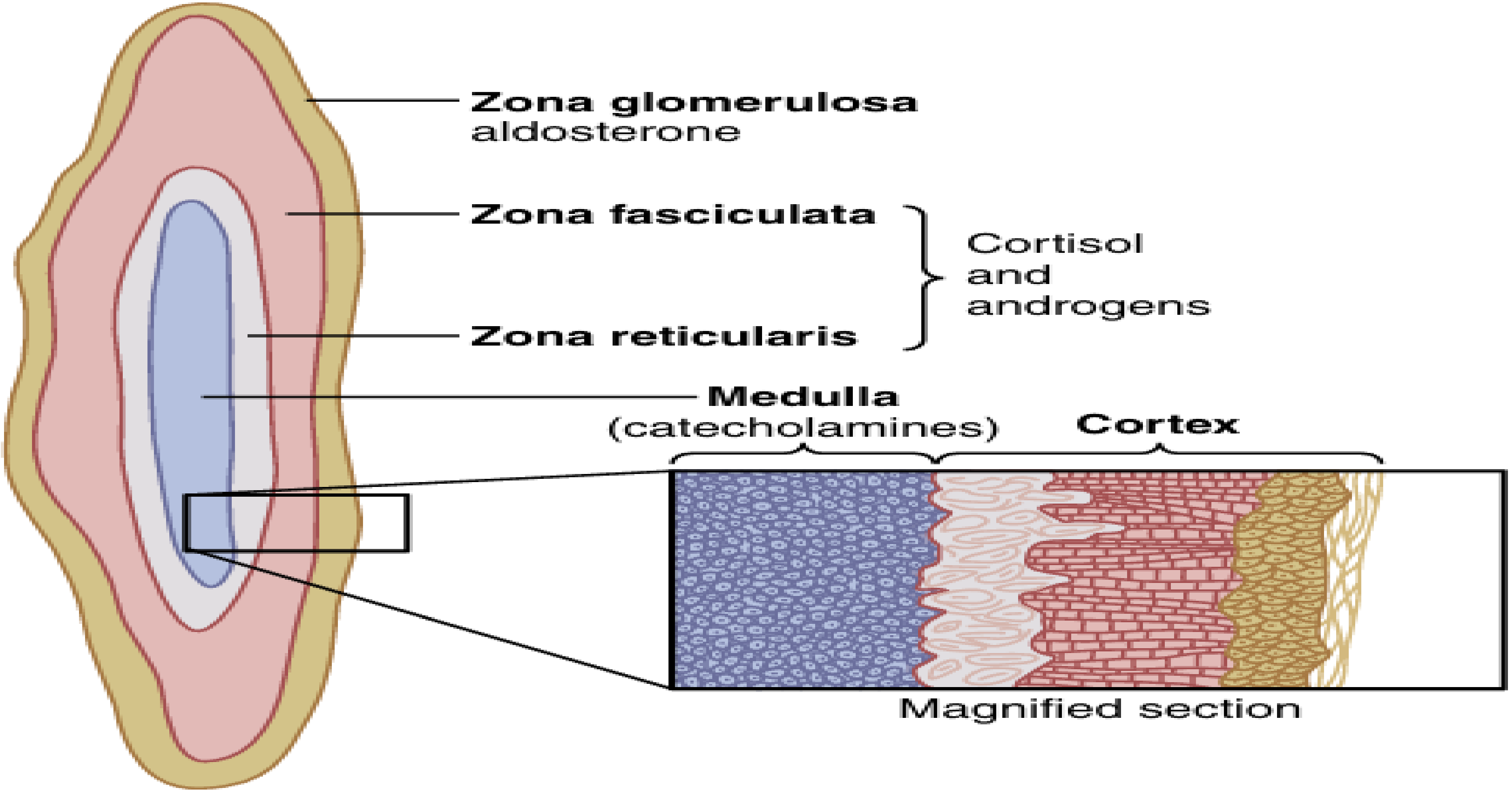
The Adrenal Glands Are Composed of Two Organs: the Outer Gland (Cortex) and the Inner Gland (Medulla)



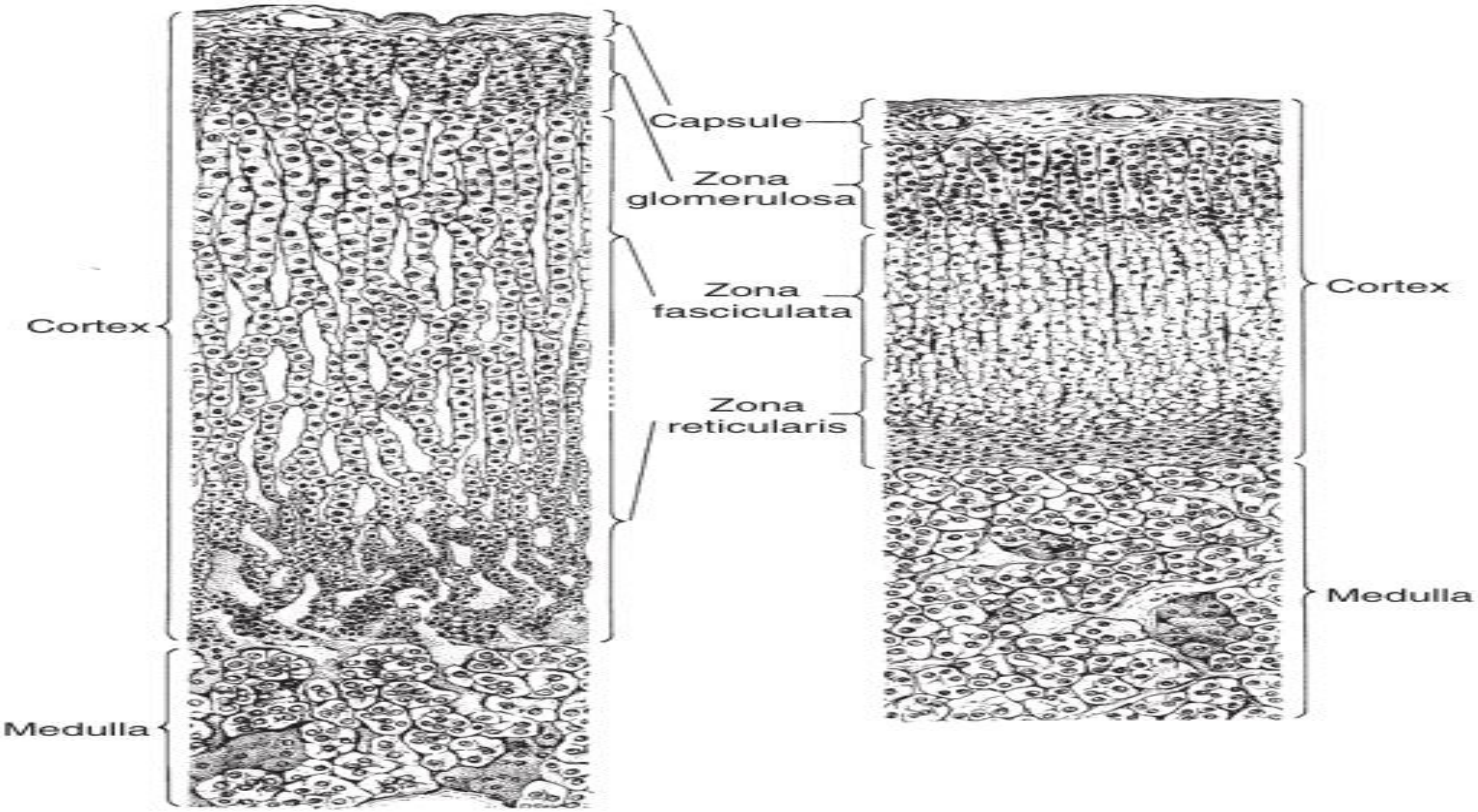
The Adrenal Cortex

The Adrenal Cortex Has Three Zones: the Zona Glomerulosa, Which Secretes Mineralocorticoids, and the Zona Fasciculata and the Zona Reticularis, Which Secrete Glucocorticoids and Sex Steroids

The Adrenal Glands



The Adrenal Gland of Normal and Hypophysectomized Rats



Mineralocorticoids

TABLE 34.4 Mineralocorticoid Effects and Target Tissues

Effect	Site of Action
Stimulates Na^+ reabsorption	Kidney, salivary glands, sweat glands
Stimulates K^+ excretion	Kidney, salivary glands, sweat glands
Stimulates H^+ excretion	Kidney

From Hedge GA, Colby HD, Goodman RL. *Clinical Endocrine Physiology.* Philadelphia: Saunders; 1987.

Mineralocorticoids

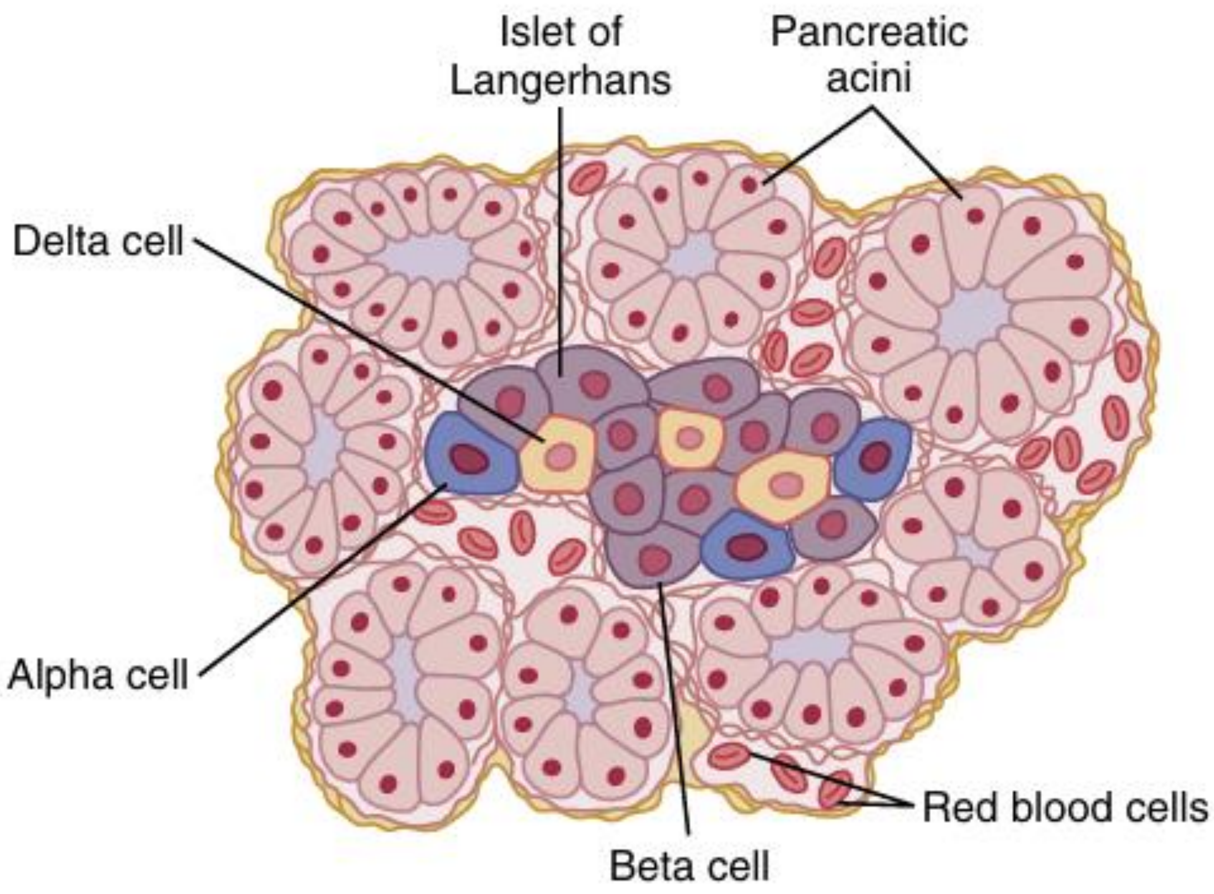
1. Increased potassium ion concentration in the extracellular fluid greatly *increases* aldosterone secretion.
2. Increased angiotensin II concentration in the extracellular fluid also greatly *increases* aldosterone secretion.
3. Increased sodium ion concentration in the extracellular fluid *slightly decreases* aldosterone secretion.
4. Increased atrial natriuretic peptide (ANP), a hormone secreted by the heart when specific cells of the cardiac atria are stretched (see Chapter 28), *decreases* aldosterone secretion.
5. ACTH from the anterior pituitary gland is necessary for aldosterone secretion but has little effect in controlling the rate of secretion in most physiological conditions.

Glucocorticoids

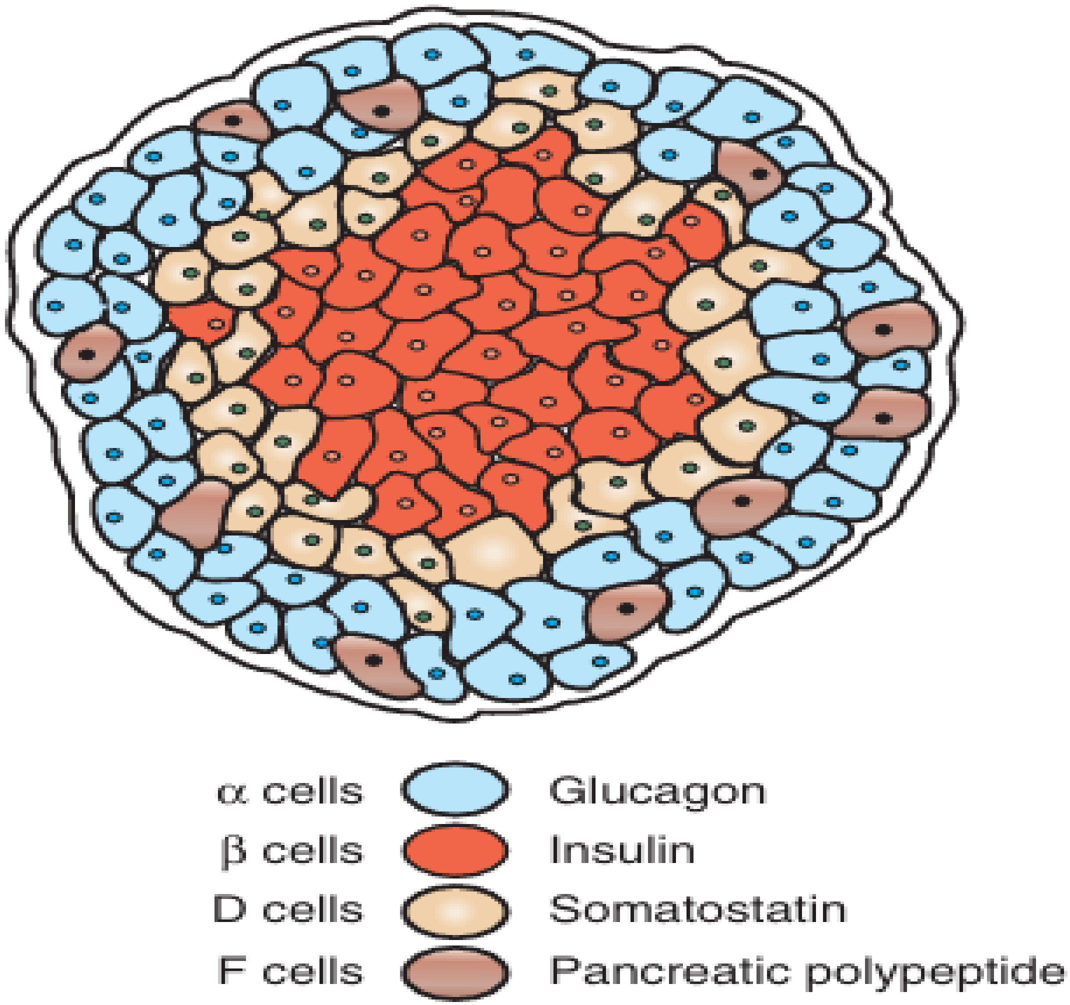
TABLE 34.3 Glucocorticoid Effects and Target Tissues

Effect	Site of Action
Stimulates gluconeogenesis	Liver
Increases hepatic glycogen	Liver
Increases blood glucose	Liver
Facilitates lipolysis	Adipose tissue
Is catabolic (negative nitrogen balance)	Muscle, liver
Inhibits ACTH secretion	Hypothalamus, anterior pituitary gland
Facilitates water excretion	Kidney
Blocks inflammatory response	Multiple sites
Suppresses immune system	Macrophages, lymphocytes
Stimulates gastric acid secretion	Stomach

Hormones of the Pancreas



Hormones of the Pancreas



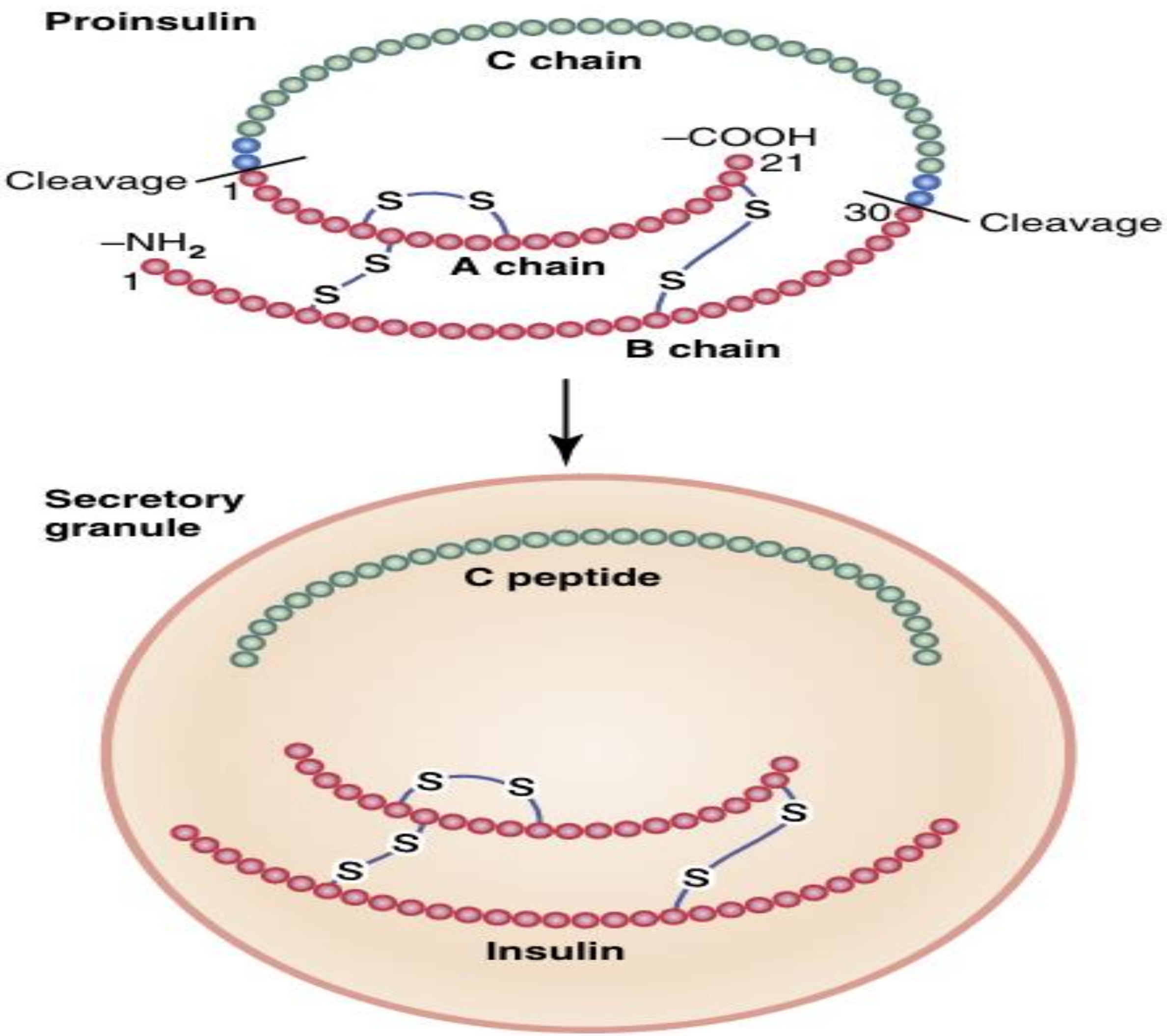
Insulin

TABLE 34.6 Sites of Action and Effects of Insulin on Carbohydrate, Lipid, and Protein Metabolism

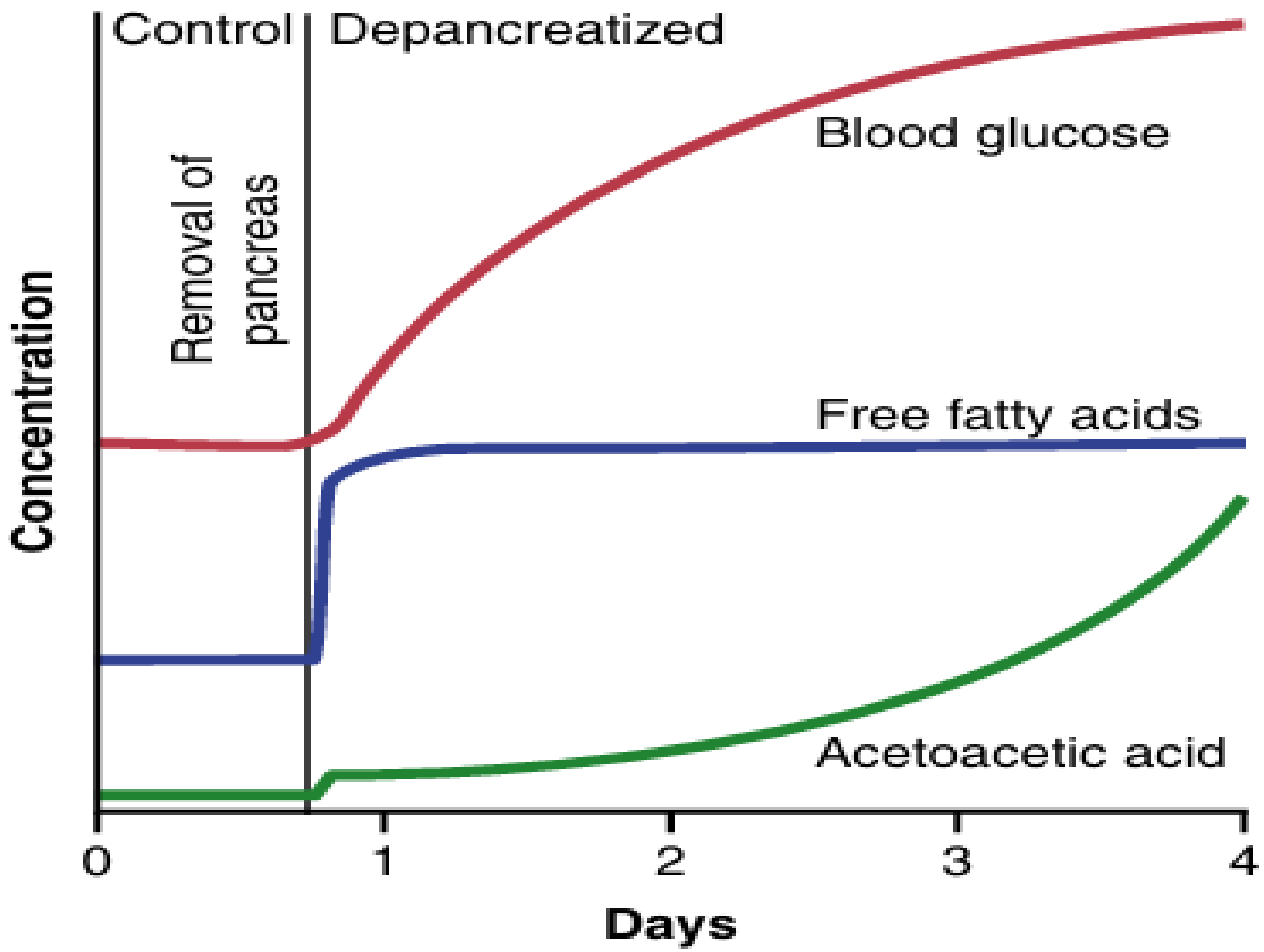
	SITE OF ACTION		
Process Affected	Liver	Muscle	Adipose
Carbohydrate Metabolism			
↑Glucose transport		X	X
↑Glycogen synthesis	X	X	X
↓Glycogenolysis	X	X	X
↓Gluconeogenesis	X		
Lipid Metabolism			
↑Lipogenesis	X		X
↓Lipolysis	X		X
Protein Metabolism			
↑Amino acid uptake		X	
↑Protein synthesis		X	
↓Protein degradation		X	
↓Gluconeogenesis	X		

From Hedge GA, Colby HD, Goodman RL. *Clinical Endocrine Physiology.* Philadelphia: Saunders; 1987.

Insulin

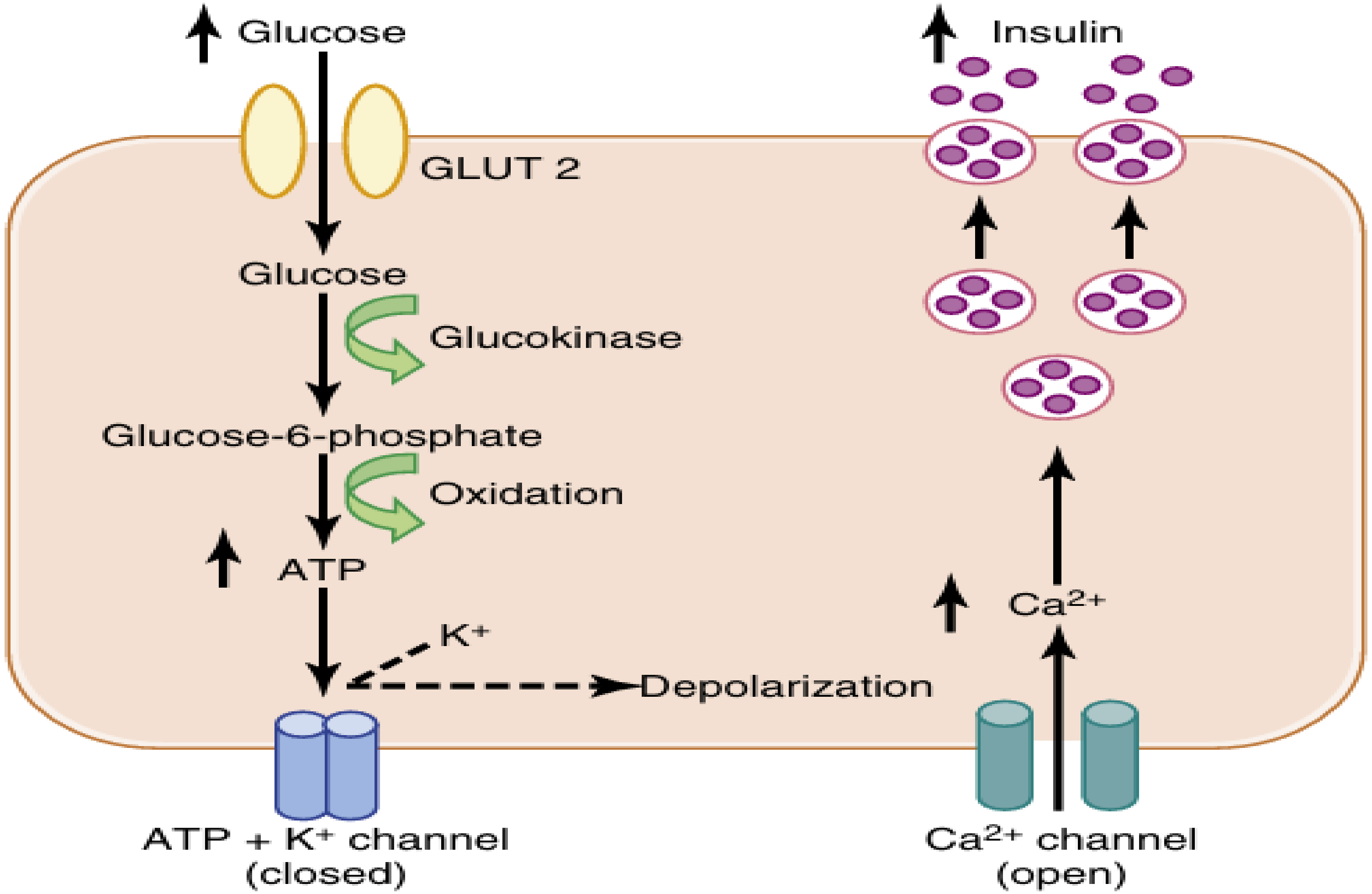

Proinsulin
C chain
–COOH
21
Cleavage
1
S
S
S
30
Cleavage
–NH2
S
A chain
1
S
S
B chain
Secretory
granule
C peptide
S
S
S
S
S
S
Insulin

Insulin



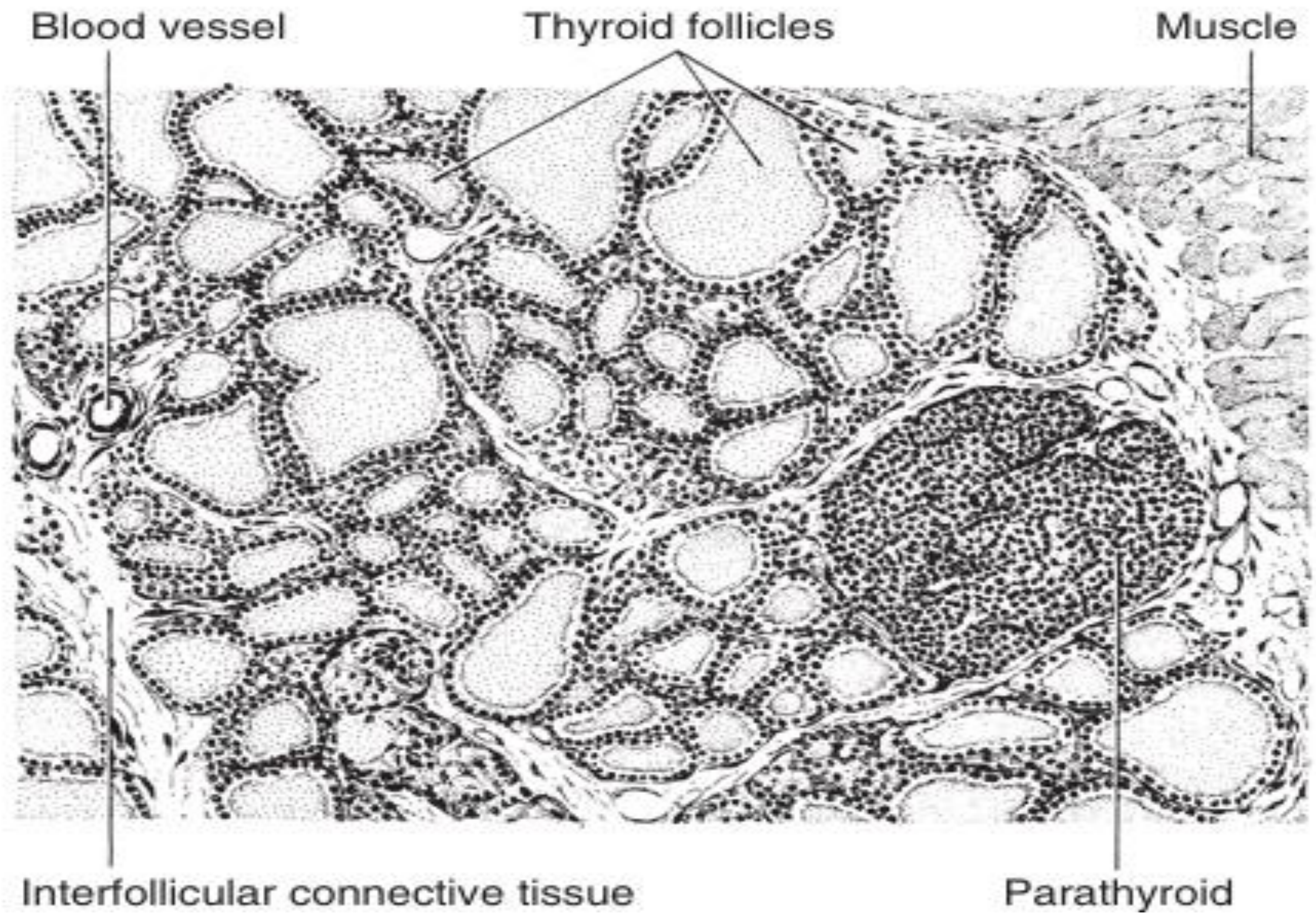
Control
Depancreatized
Removal of pancreas
Blood glucose
Free fatty acids
Acetoacetic acid
Concentration
0
1
2
3
4
Days

Insulin

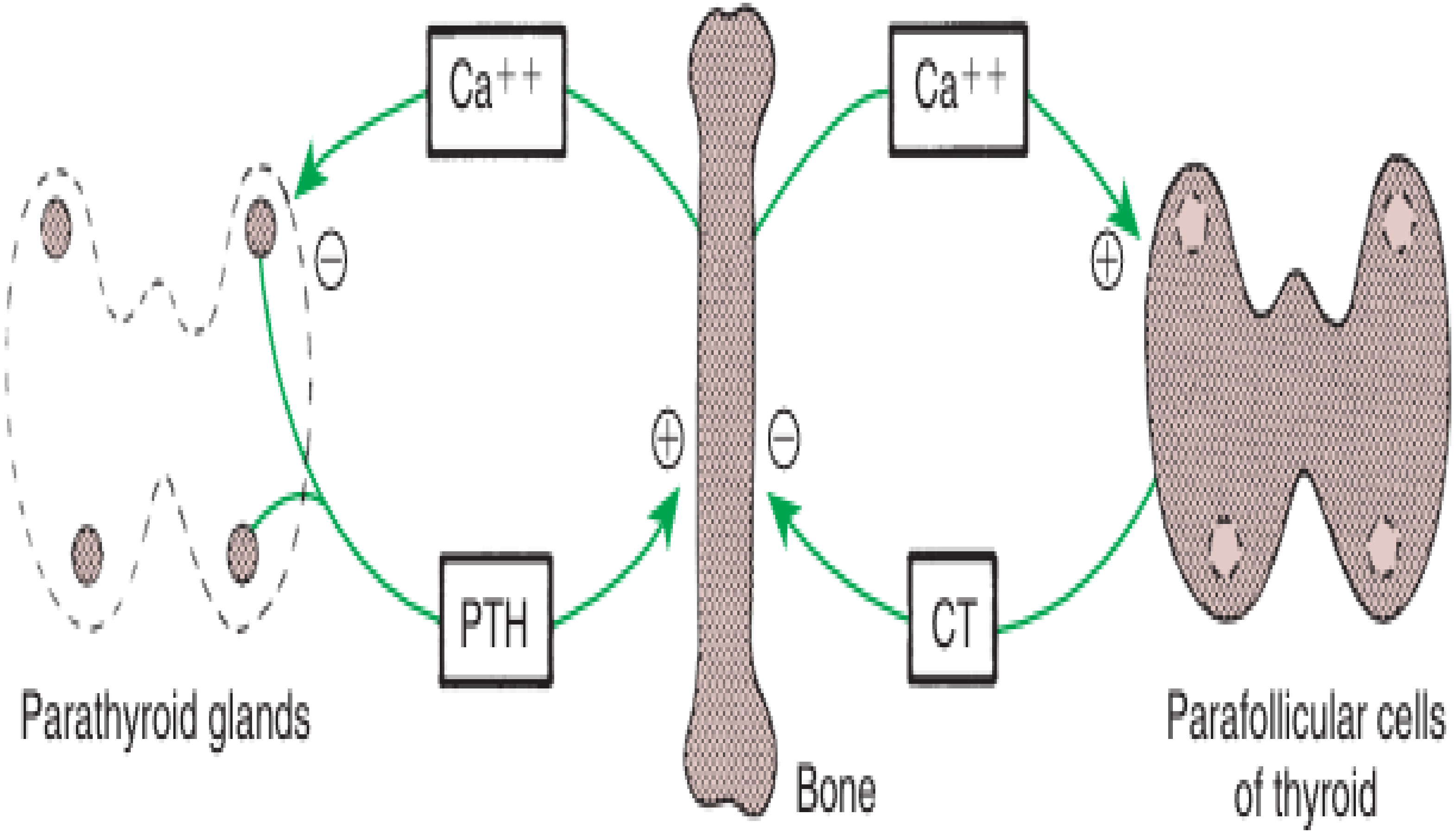


Glucose
GLUT 2
Glucose
Glucokinase
Glucose-6-phosphate
Oxidation
ATP
K+
Depolarization
ATP + K+ channel
(closed)
Insulin
Ca2+
Ca2+ channel
(open)

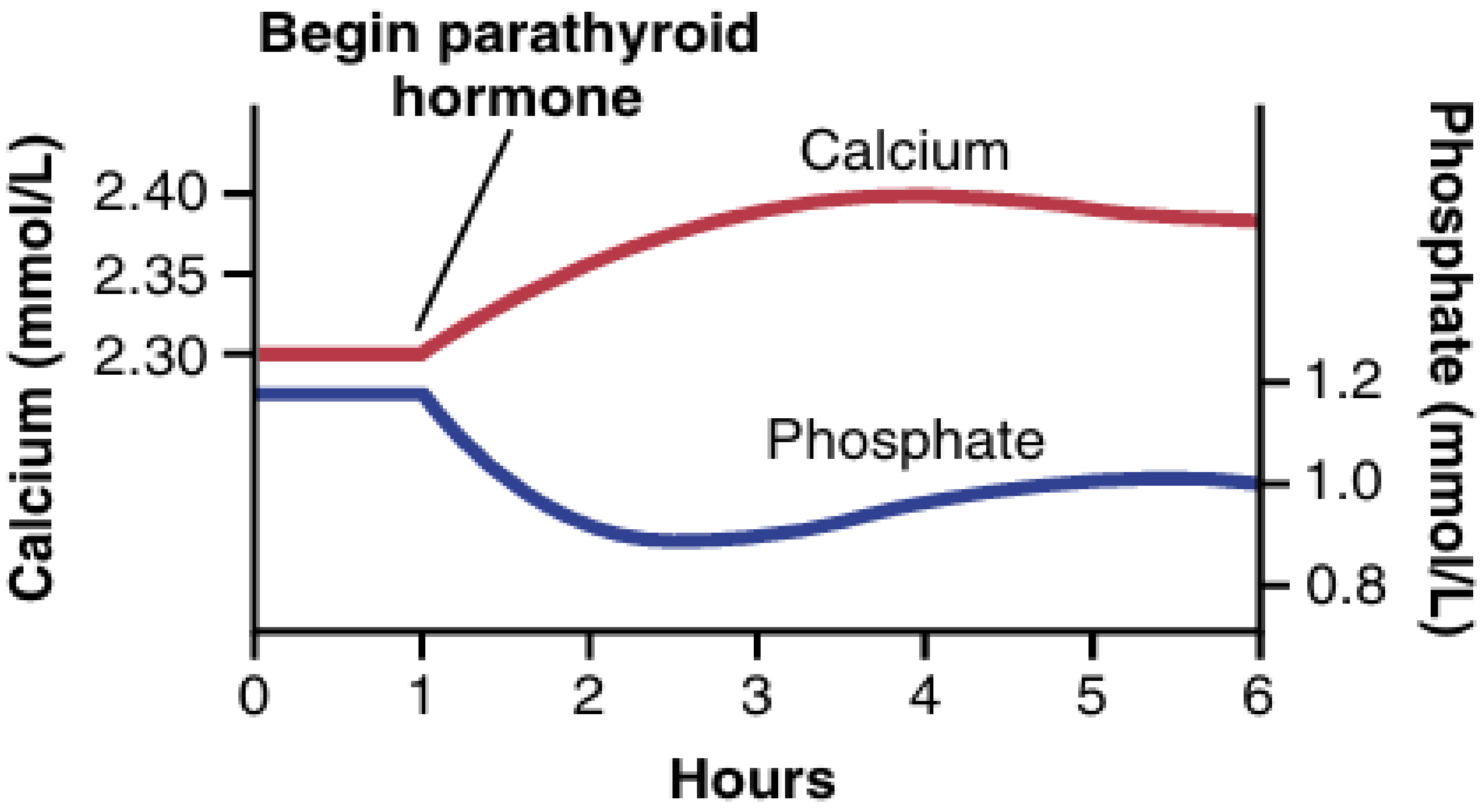
Parathyroid Hormone(PTH)



Parathyroid Hormone(PTH)



Parathyroid Hormone(PTH)



Parathyroid Hormone(PTH)