

# ANSC 630: REPRODUCTIVE BIOLOGY 1

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# ANSC 630: INFORMATION CARD

- NAME
- MAJOR
- ADVISOR
- RESEARCH INTERESTS
- PREVIOUS COURSES:
  - Reproductive Biology
  - Biochemistry
  - Physiology
  - Histology
  - Embryology

# OVERVIEW OF FUNCTIONAL REPRODUCTIVE ANATOMY: THE MAJOR COMPONENTS

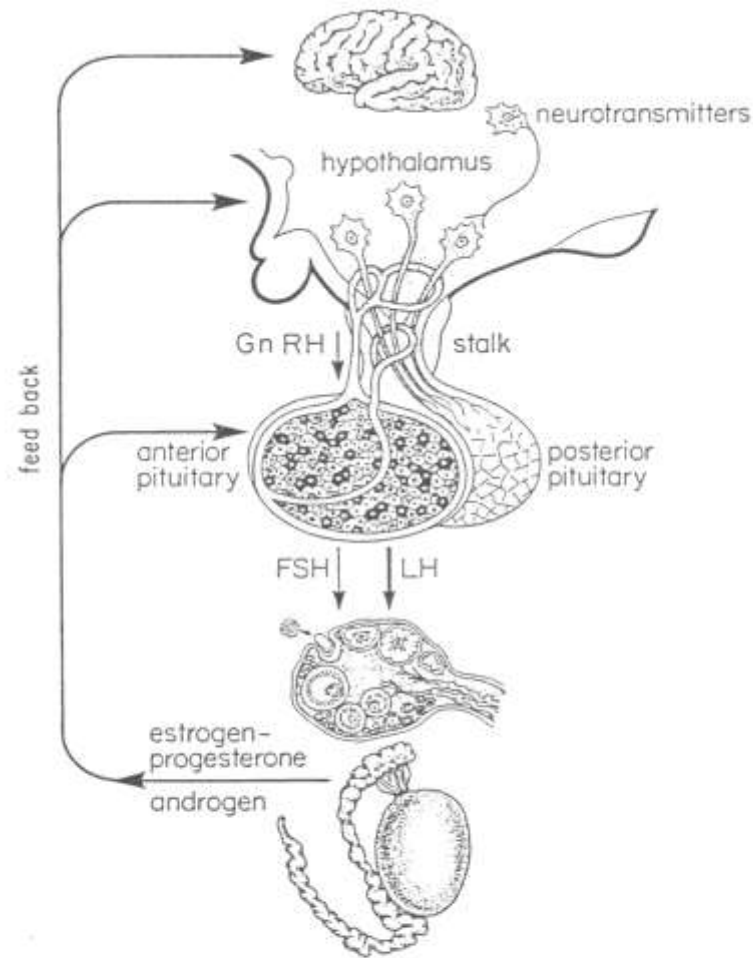
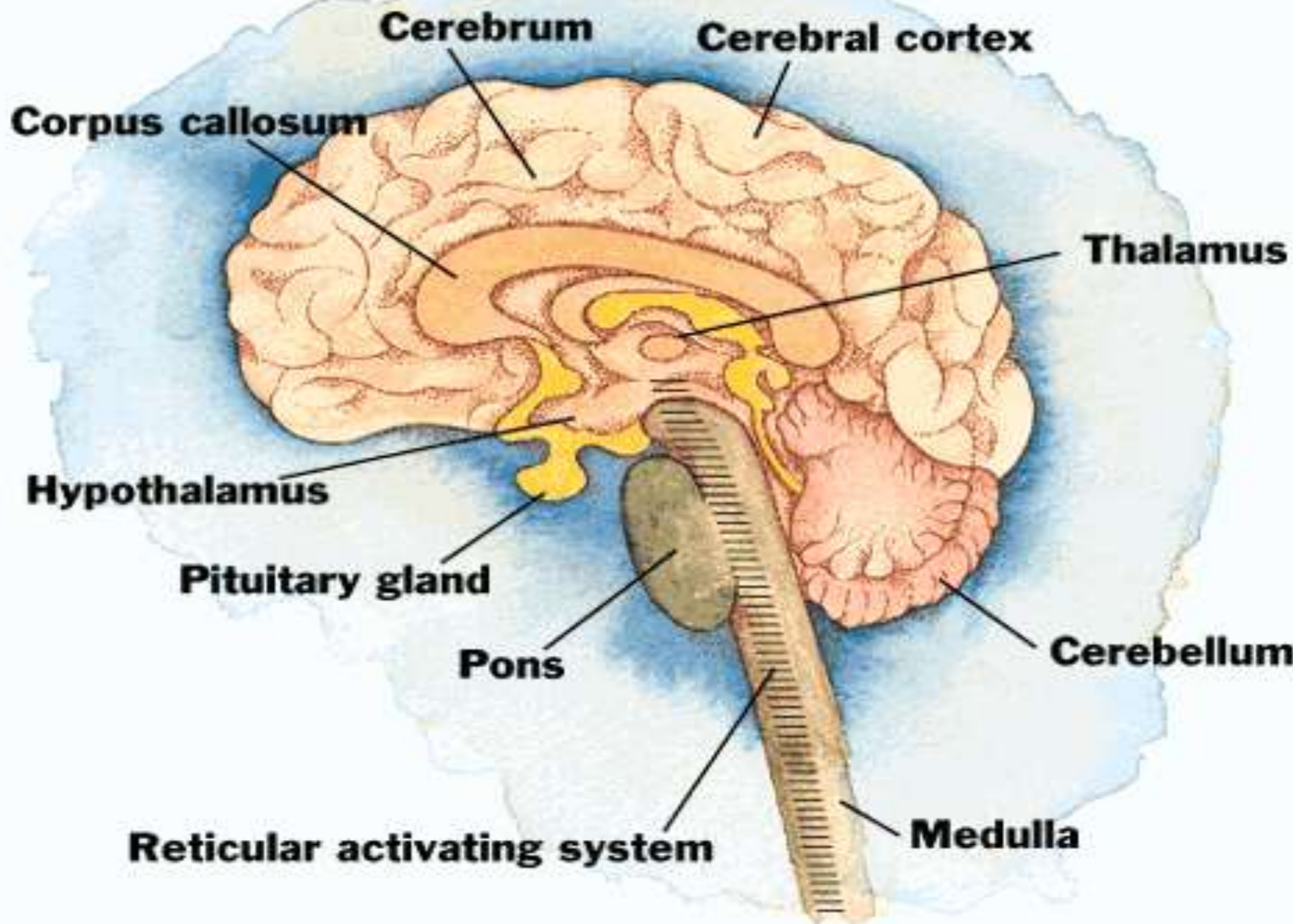
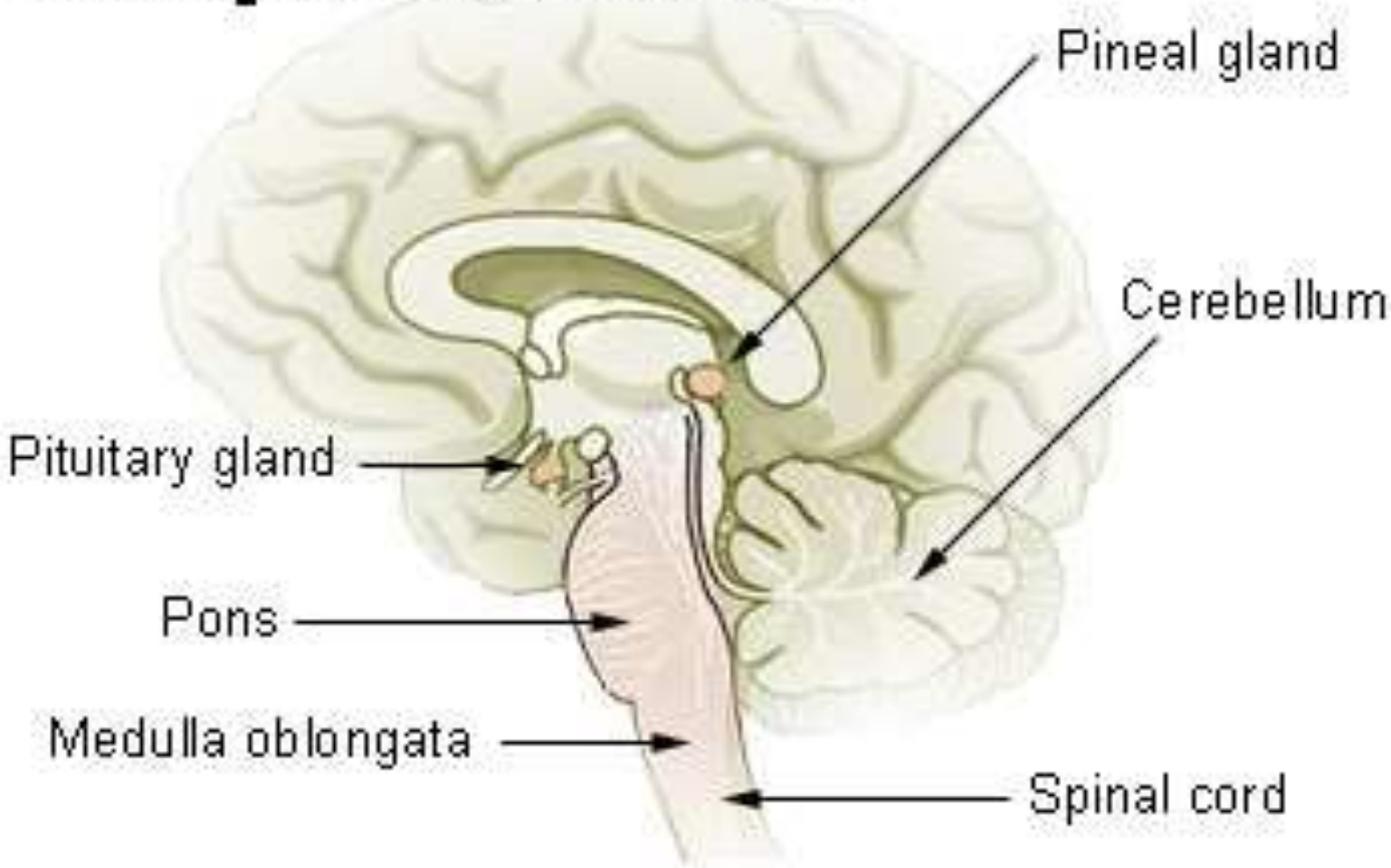


FIGURE 3-14. Endocrine-neuroendocrine relationship among hypothalamus, pituitary gland, and gonad (ovary-testis). Hypothalamic neurosecretory materials (GnRH) are transported by the portal blood capillaries to the cells of the anterior pituitary. FSH and LH stimulate the gonads. Estrogens and androgens secreted by the gonads exert a feedback.



# Pituitary and Pineal Glands





<b>Anterior pituitary</b>	
Pars tuberalis	_____
Pars intermedia	_____
Pars distalis	_____

<b>Posterior pituitary</b>	
Infundibular stalk	_____
Pars nervosa	_____

Optic chiasm \_\_\_\_\_

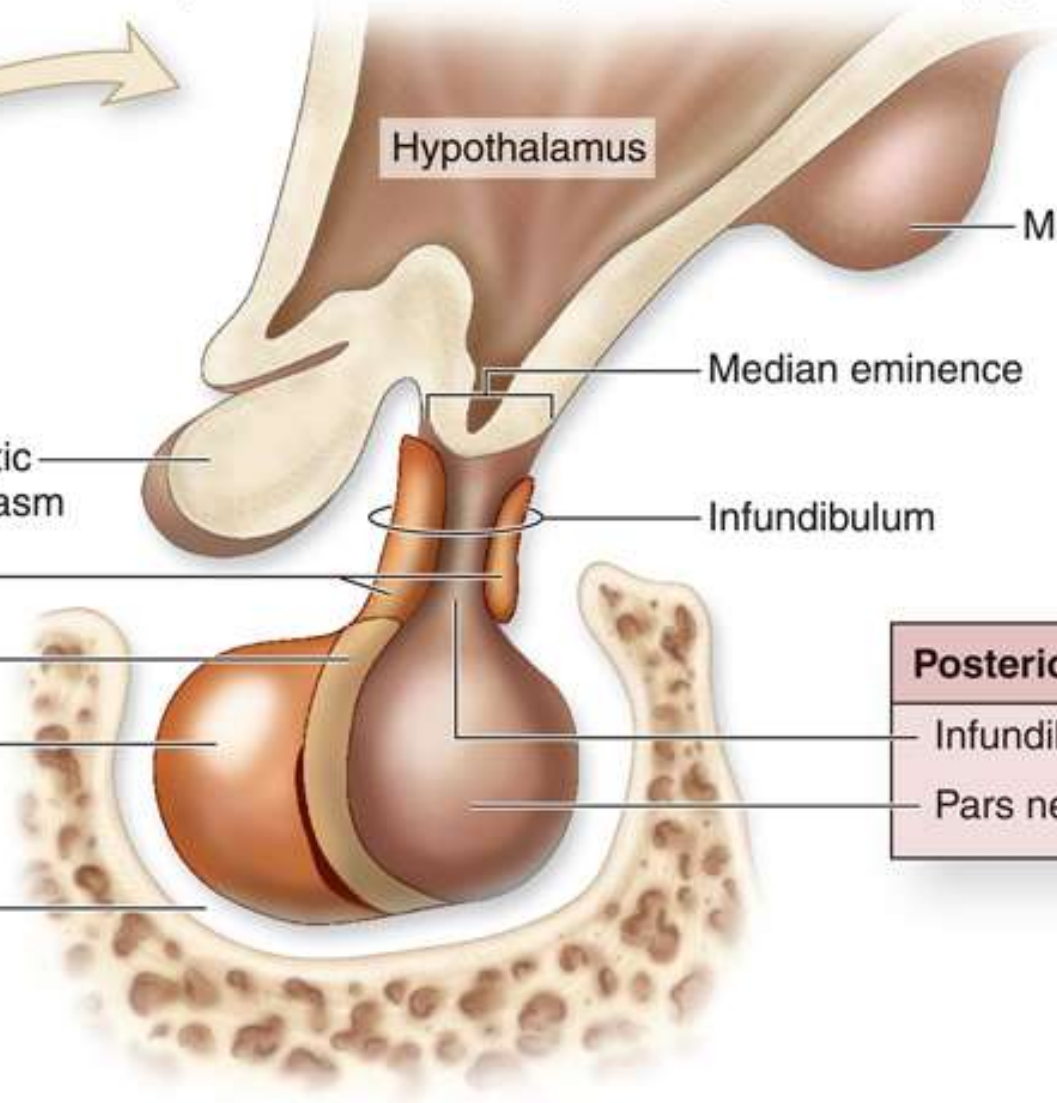
Hypothalamus \_\_\_\_\_

Mammillary body \_\_\_\_\_

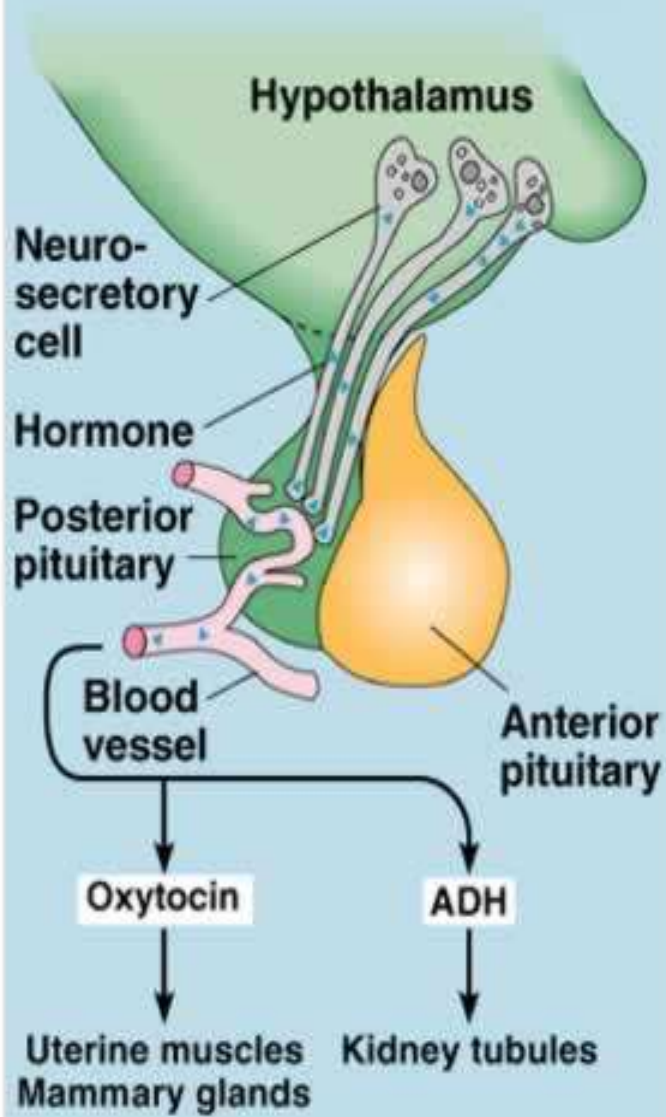
Median eminence \_\_\_\_\_

Infundibulum \_\_\_\_\_

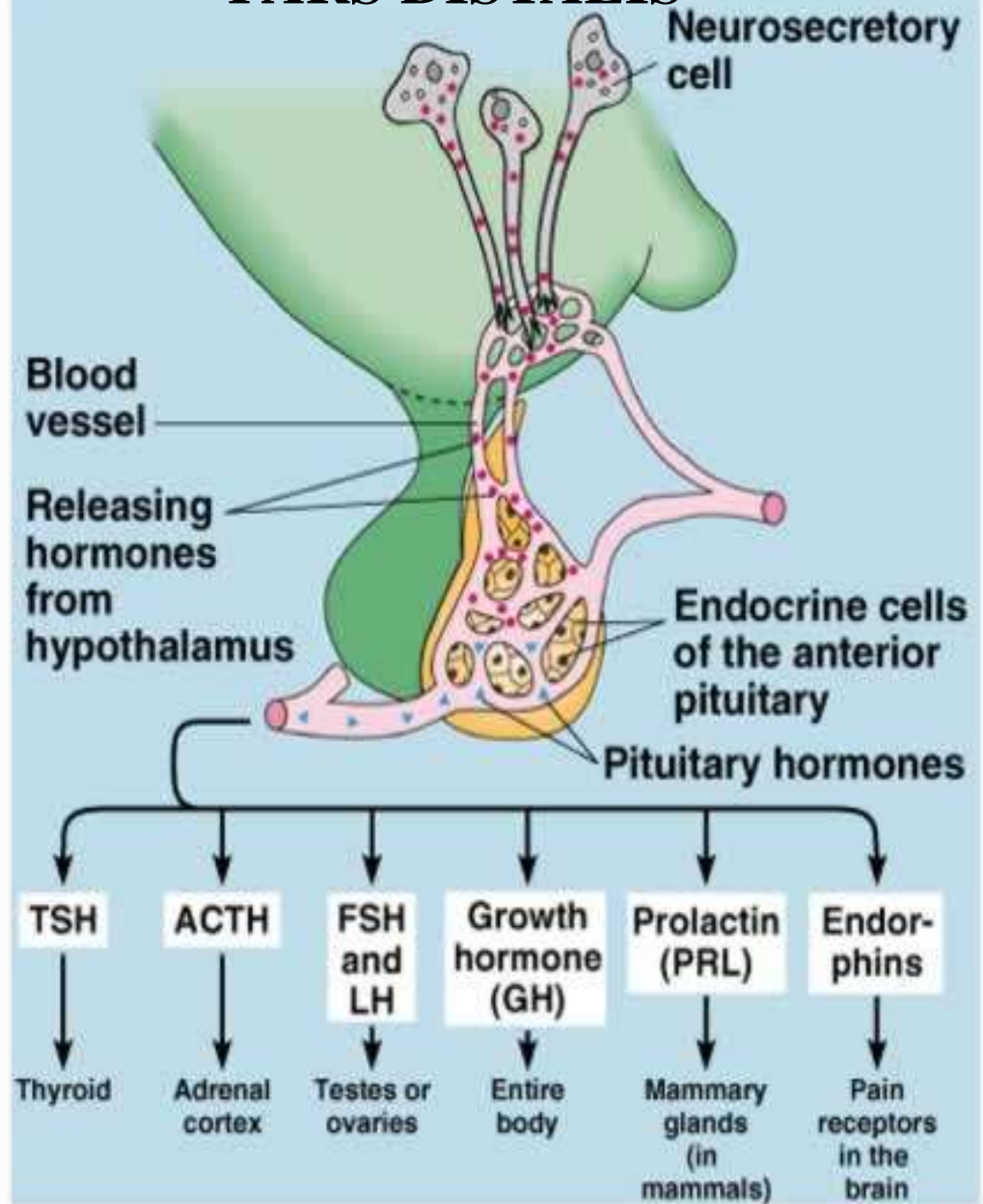
Hypophyseal fossa in sella turcica of sphenoid bone \_\_\_\_\_



# PARS NERVOSA



# PARS DISTALIS



**Hypothalamic Neurons**

Supraoptic  
Paraventricular



Axons

**POSTERIOR PITUITARY  
(PARS NERVOSA)**

Oxytocin - Neurophysin  
Vasopressin-Neurophysin

**Hypothalamic Neurons**

Melanocyte  
Stimulating Hormone Releasing  
Factor



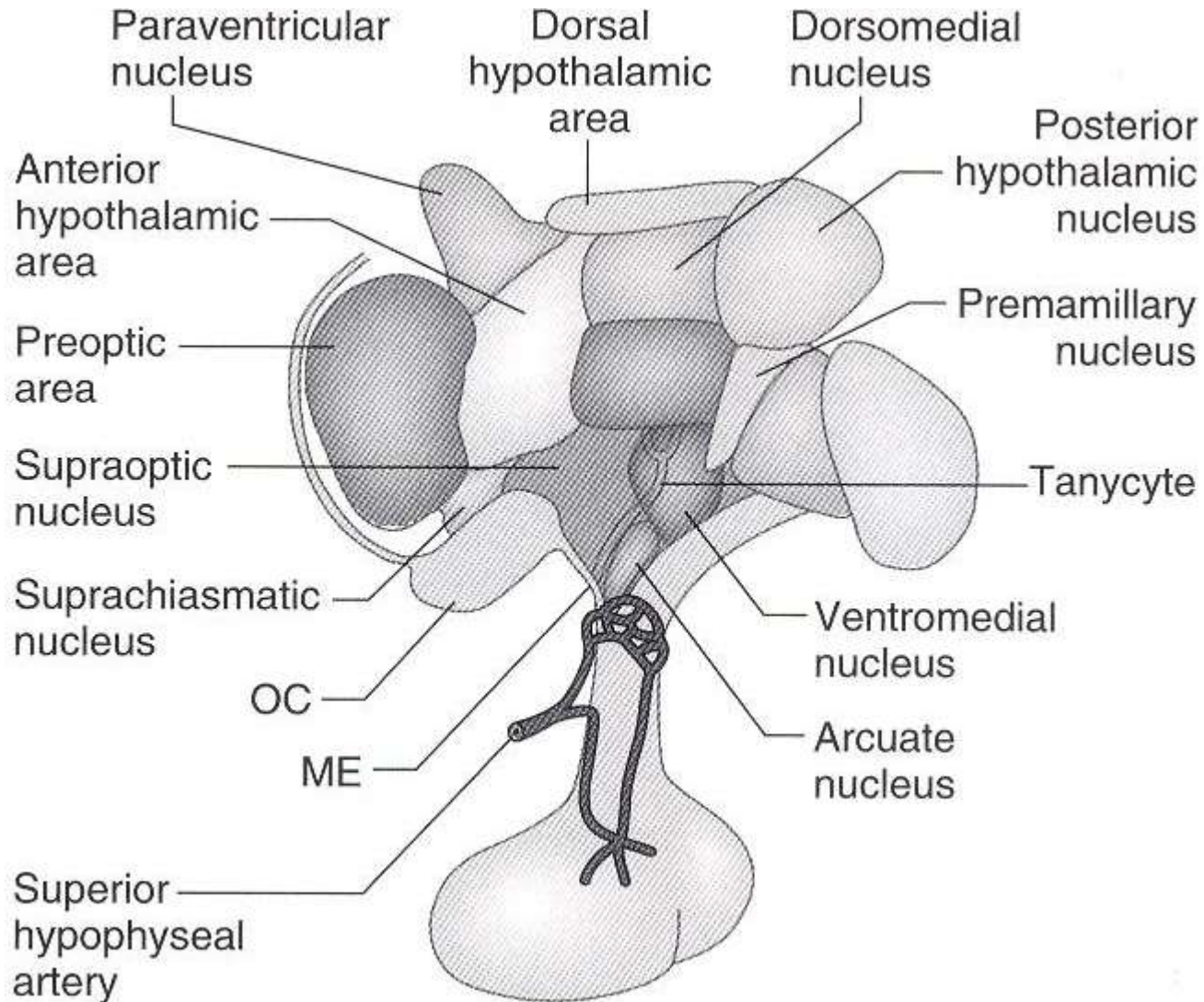
Nerve Tracts

**INTERMEDIATE LOBE OF  
PITUITARY**

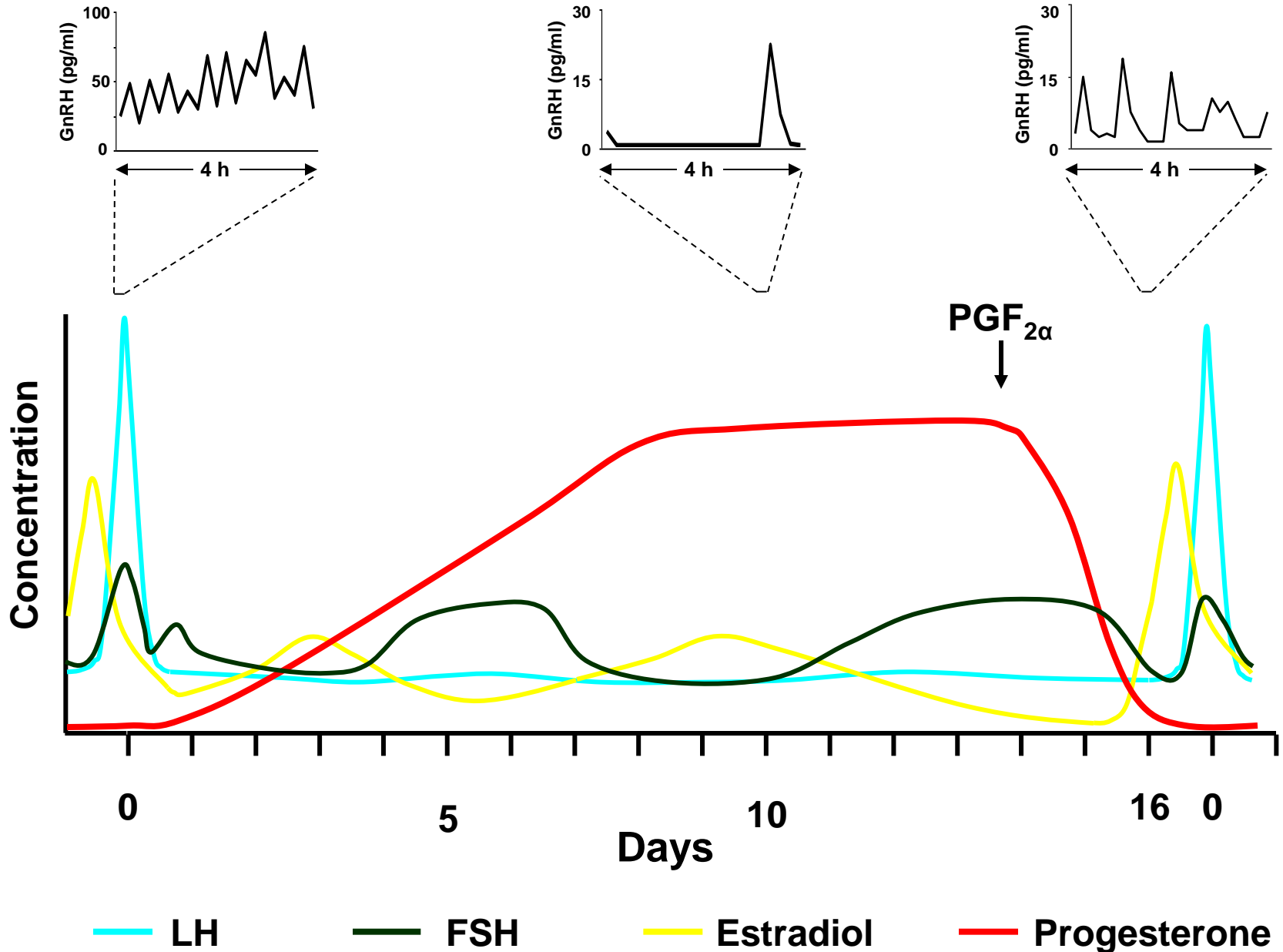
Melanocyte Stimulating  
Hormone (MSH)



# Hypothalamic Divisions



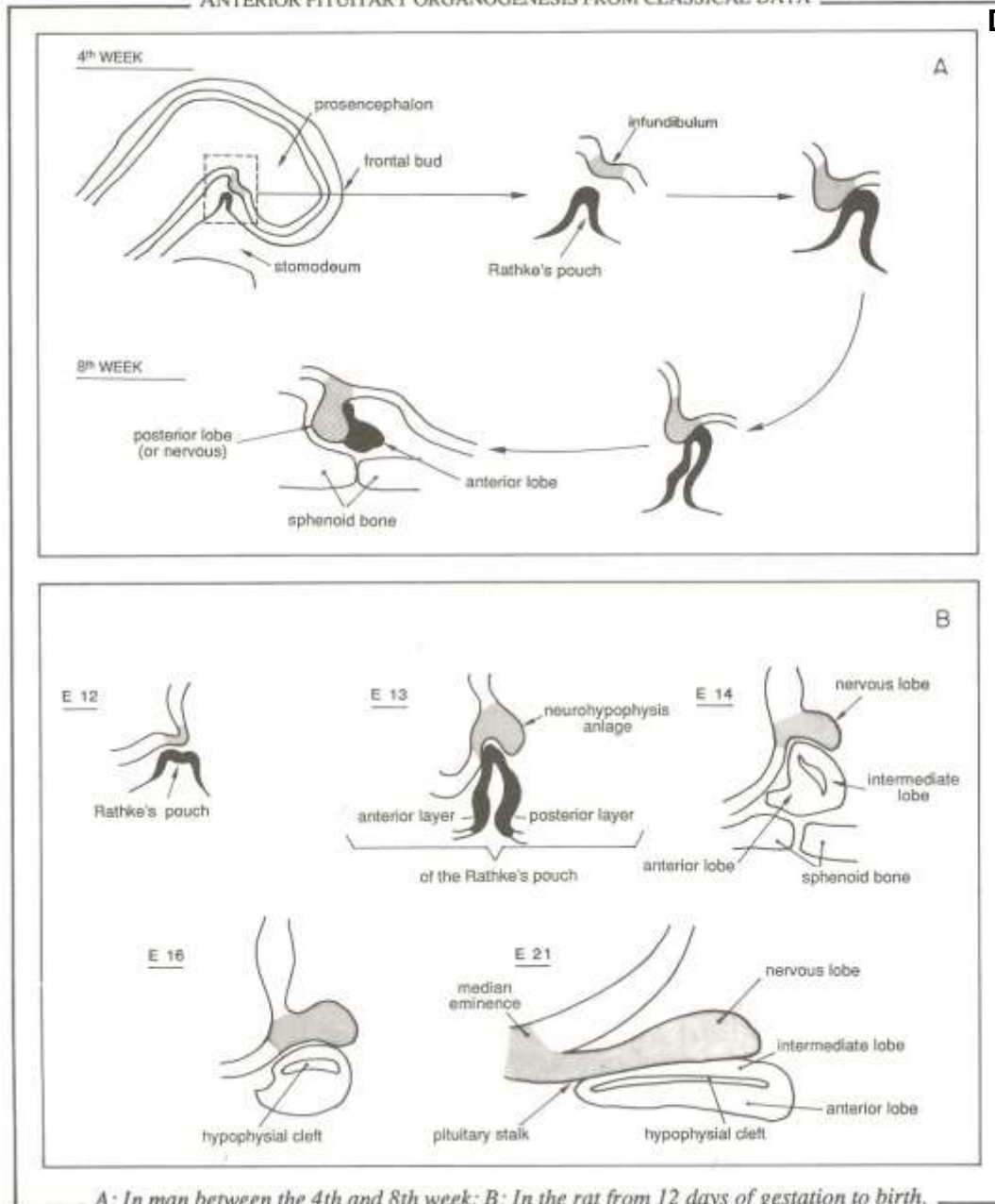
# Hormone Profile of the Estrous Cycle in the Ewe



# Development of the Hypophysis

ANTERIOR PITUITARY ORGANOGENESIS FROM CLASSICAL DATA

Dubois 1993 *Reprod Mamm Man* 17-50



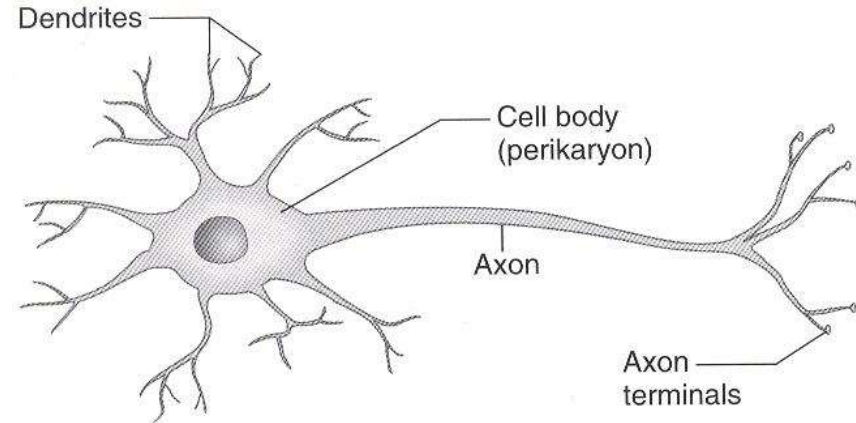
# Neurons

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- **Cell body (soma; perikaryon) – Synthesis of neuropeptides**

- **Cellular processes**

- **Dendrites**
- **Axon - Transport**
- **Terminals – Storage and Secretion**



Yen 2004 *Reprod Endocrinol* 3-73

- **Peptide neurotransmitter synthesis**

- **Transcription – Gene transcribes mRNA**
- **Translation – mRNA translated for protein synthesis**
- **Maturation – post-translational processing**
- **Storage in vesicles - Hormone secreted from vesicles**

# Hypothalamus

- Mid-central base of brain
  - Optic chiasma
  - 3rd ventricle
  - Mammillary body
- Nuclei
  - Clusters of neurons
    - Different functions & stimuli for hormone secretion
  - Secrete peptide hormones
    - Control pituitary activity
    - Vascular connections
    - Neural connections

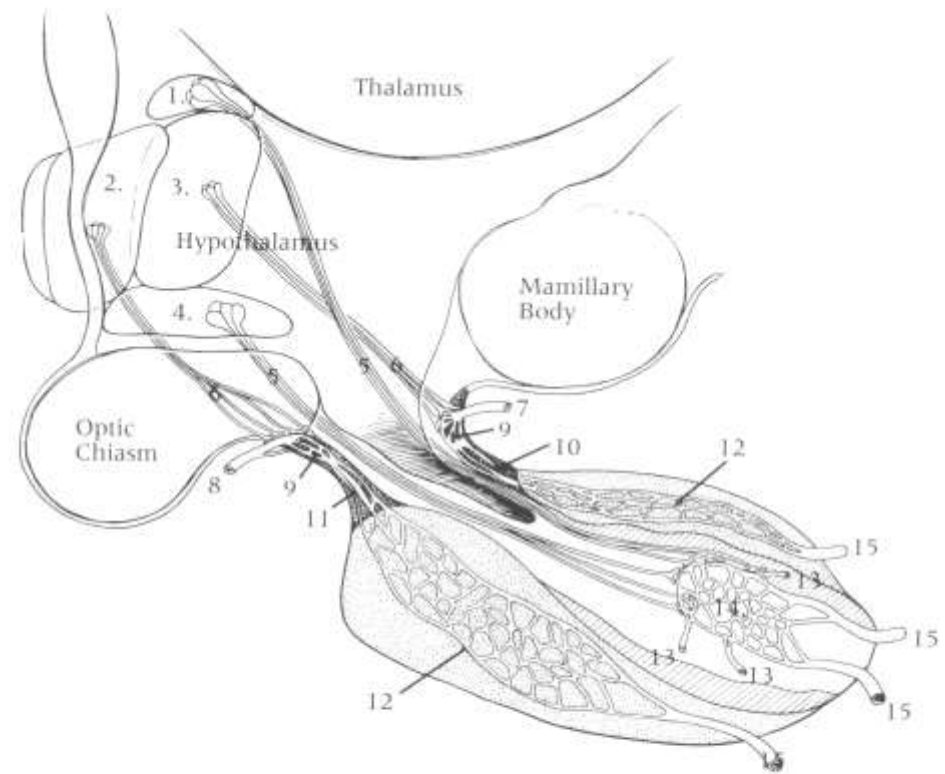
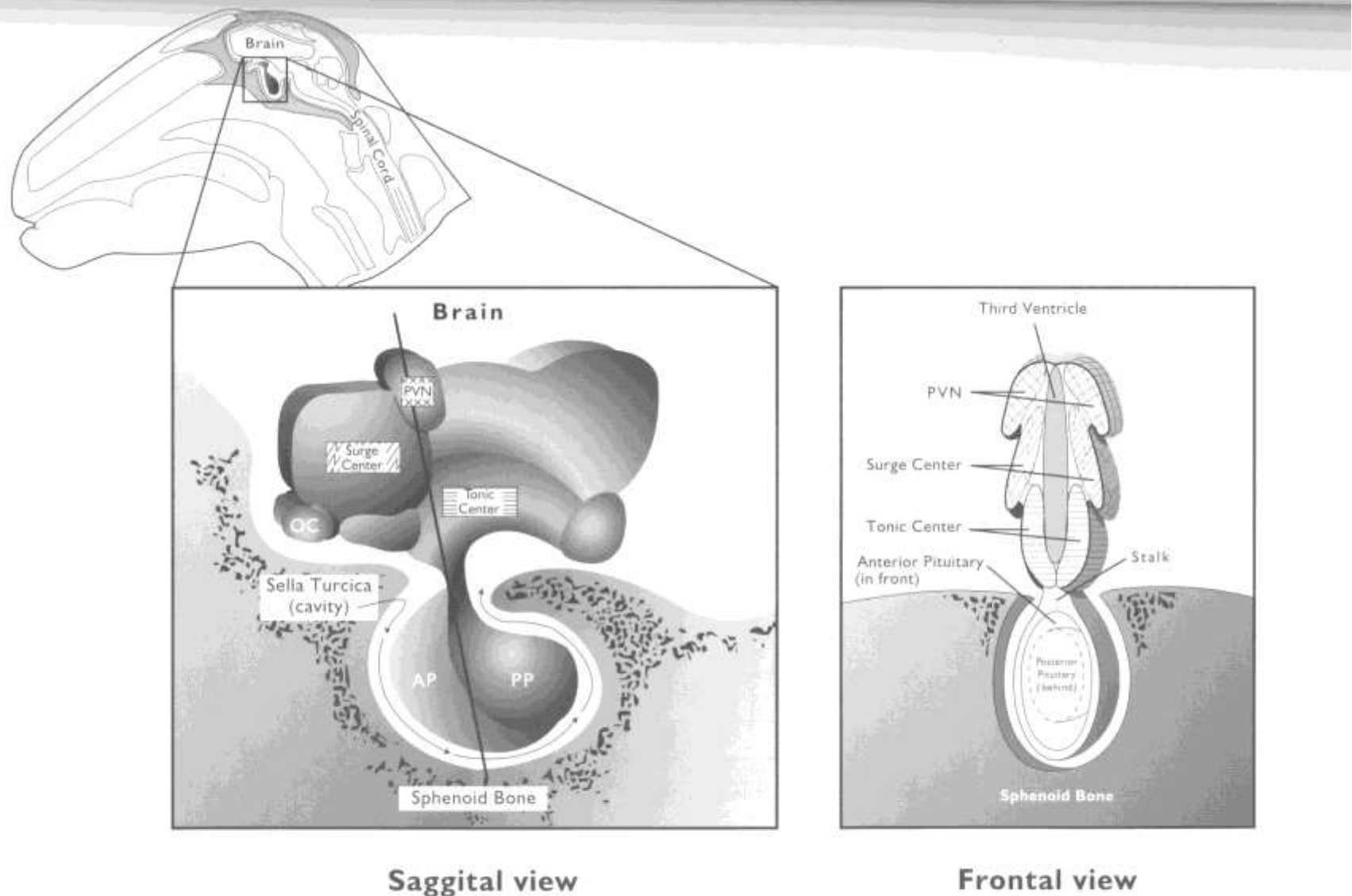


FIG. 1–3. Hypothalamo-hypophysial relationships. 1, Paraventricular nucleus; 2, preoptic nucleus; 3, rostral hypothalamic nucleus; 4, supraoptic nucleus; 5, processes of magnocellular neurosecretory cells; 6, processes of parvocellular neurosecretory cells; 7, branch of rostro-dorsal hypophysial (infundibular) artery; 8, branch of rostroventral hypophysial (infundibular) artery; 9, primary capillary plexus within median eminence; 10, dorsal group of hypophysial portal vessels; 11, ventral group of hypophysial portal vessels; 12, sinusoidal capillary network within pars distalis; 13, branches of caudal hypophysial arteries; 14, capillaries of neural lobe; 15, hypophysial veins. (Adapted in part from Vitums, A.: Observations on the equine hypophysial portal system. *Anat. Histol. Embryol.*, 4:49–161, 1975; and Krieger, D.T.: The hypothalamus and neuroendocrinology. *In* Neuroendocrinology. Edited by D.T. Krieger and J.C. Hughes. Sunderland, Sinauer Associates, 1980, pp. 3–12.)



**Figure 5-3.** The anatomy of the typical mammalian hypothalamus and pituitary. The hypothalamus is a specialized ventral portion of the brain consisting of groups of nerve cell bodies called hypothalamic nuclei, which appear as lobules in the figure. The surge center, the tonic center and the paraventricular nucleus (PVN) have direct influence on reproduction. The anterior and posterior pituitary are positioned in a depression of the sphenoid bone called the sella turcica. The right panel (frontal view) illustrates the relationship of the paraventricular nucleus (PVN), the surge center and the tonic center to the third ventricle and pituitary. The vertical line in the left panel (sagittal view) represents the plane of section shown in the right panel. Notice that the third ventricle, a brain cavity, separates the lateral portions of the hypothalamus. AP = Anterior Pituitary, PP = Posterior Pituitary, OC = Optic Chiasm. (Graphic by Sonja Oei.)

- Vascular connection to Anterior Pituitary
  - Hypothalamo-hypophyseal portal system
    - Axons to capillaries in pituitary stalk where GnRH and Dopamine is released
    - Blood to AP
      - Superior Hypophyseal Artery (SHA)
      - Primary Portal Plexus (PPP)
      - Secondary Portal Plexus (SPP)
  - GnRH – releases LH and FSH
  - Dopamine – Prolactin Inhibiting Factor

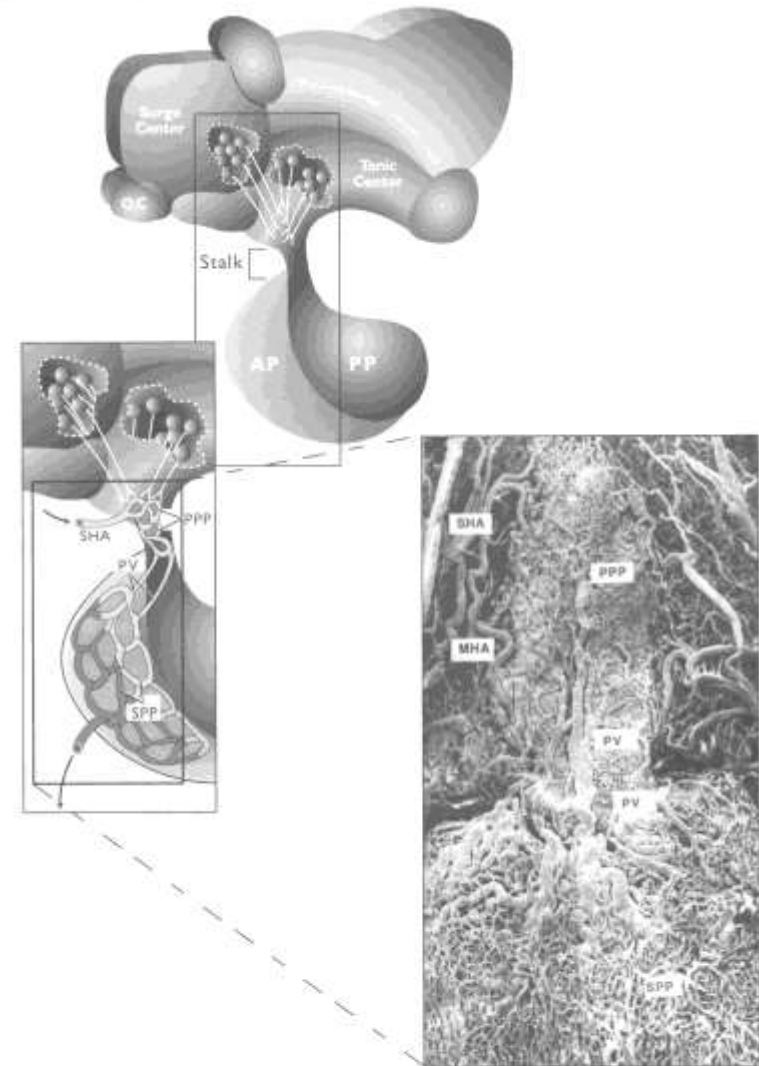
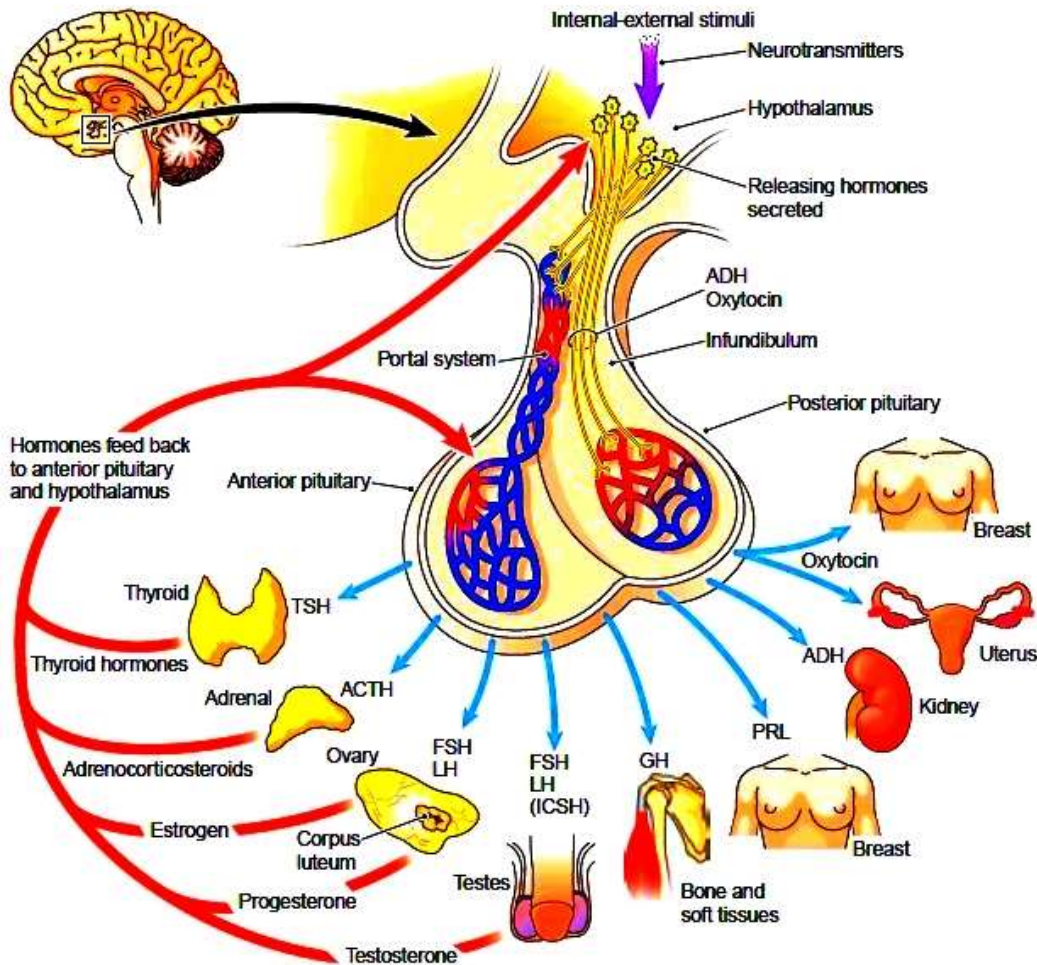


Figure 3-4. Axons from neurons in the surge center and the tonic center extend to the stalk region where their endings terminate upon blood vessels of the hypothalamo-hypophyseal portal system. This portal system consists of: the superior hypophyseal artery (SHA); the primary portal plexus (PPP), where the surge center and tonic center neurons terminate; the medial hypophyseal artery (MHA) which supplies part of the anterior pituitary; the portal vessels (PV) which transport blood containing releasing hormones; and the secondary portal plexus (SPP) which delivers blood (and releasing hormones) to the cells of the anterior pituitary. The photograph at the right is a scanning electron micrograph of the hypothalamo-hypophyseal portal system after vascular injection with latex (Mercox). It was provided with permission by Dr. H. Duvernoy, Faculté de médecine et de Pharmacie de Besançon, Laboratoire d'Anatomie, Place St. Jacques, 25030 Besançon, France. (Graphic by Sonja Oei.)

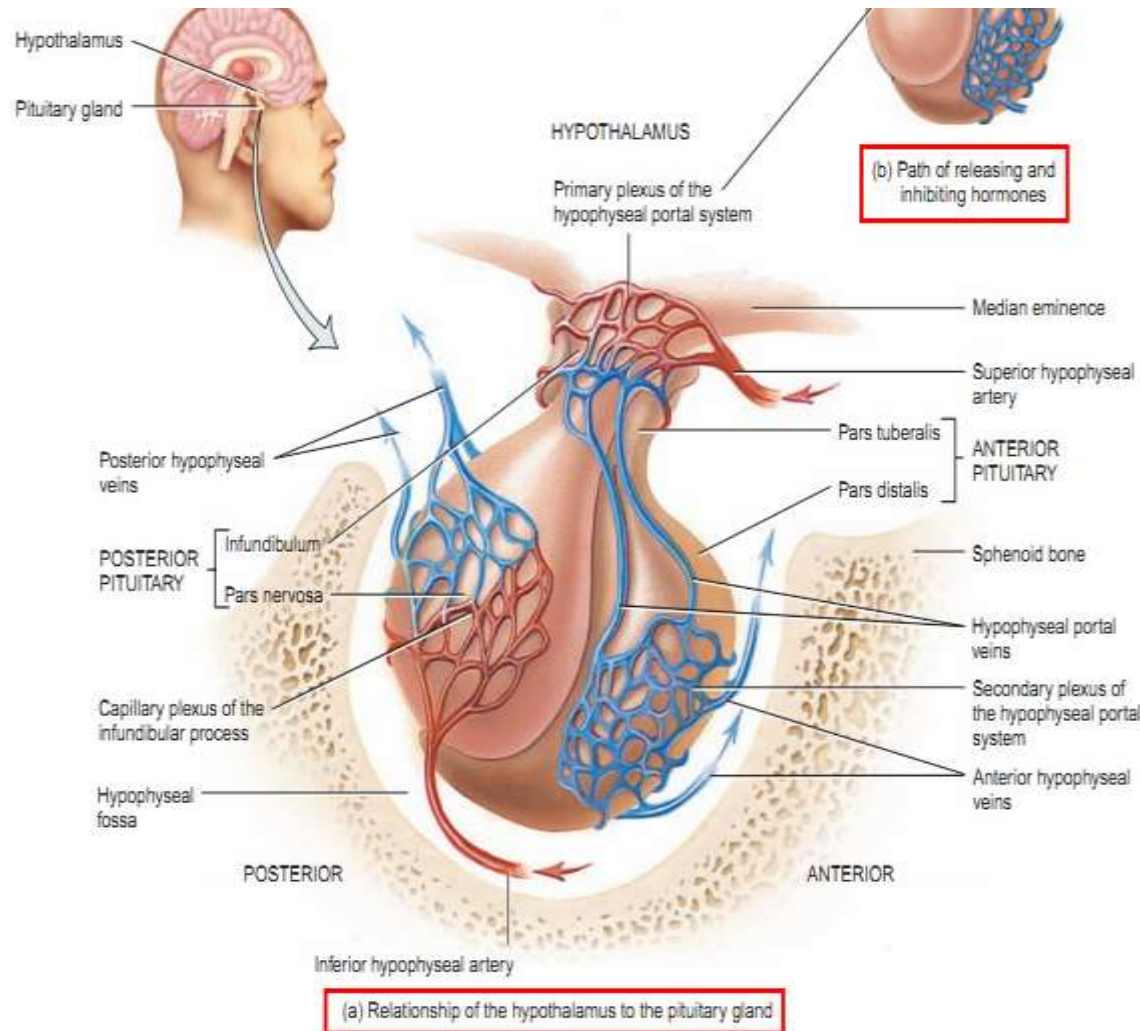
# Hypothalamohypophyseal Portal Vasculature



- Hypophysiotropic peptidergic or aminergic neurons terminate adjacent to the primary capillaries of the infundibulum (3, 5) or adjacent to the capillaries of the short portal vessels (2)
- Neurohypophyseal neurons project to the neurohypophysis and secrete neurohormones into the sinusoids of the neurohypophysis



# Hypothalamohypophyseal Portal Vasculature



- Blood supply – Internal carotid artery
- Superior hypophyseal artery (rostral)
- Inferior hypophyseal artery (caudal) – infundibulum and neurohypophysis
- Anterior hypophyseal artery (trabecular artery; mediorostral)

# Hypothalamic Regulation of Anterior Pituitary Hormones

- Gonadotropin Releasing Hormone – GnRH
- Corticotrophin Releasing Hormone – CRH
- Thyrotrophin Releasing Hormone – TRH
- Growth Hormone Releasing Hormone – GHRH
- Growth Hormone Inhibiting Factor- Sommatostatin
- Prolactin Inhibiting Factor – Dopamine
- Prolactin Stimulating Factors - oxytocin,

# Preoptic Area and Hypothalamus

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## INPUTS

Light:Dark Ratio

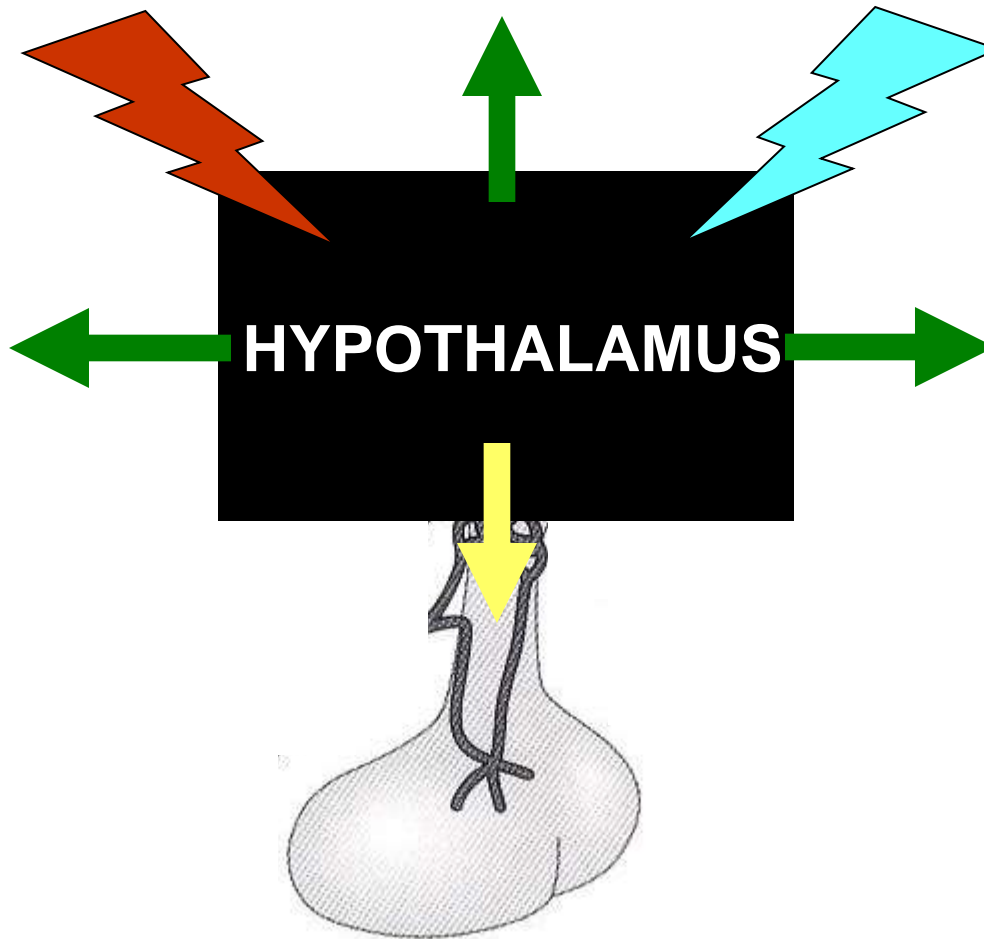
Smell

Nutritional Status

Sight

Stress

Neurotransmitters

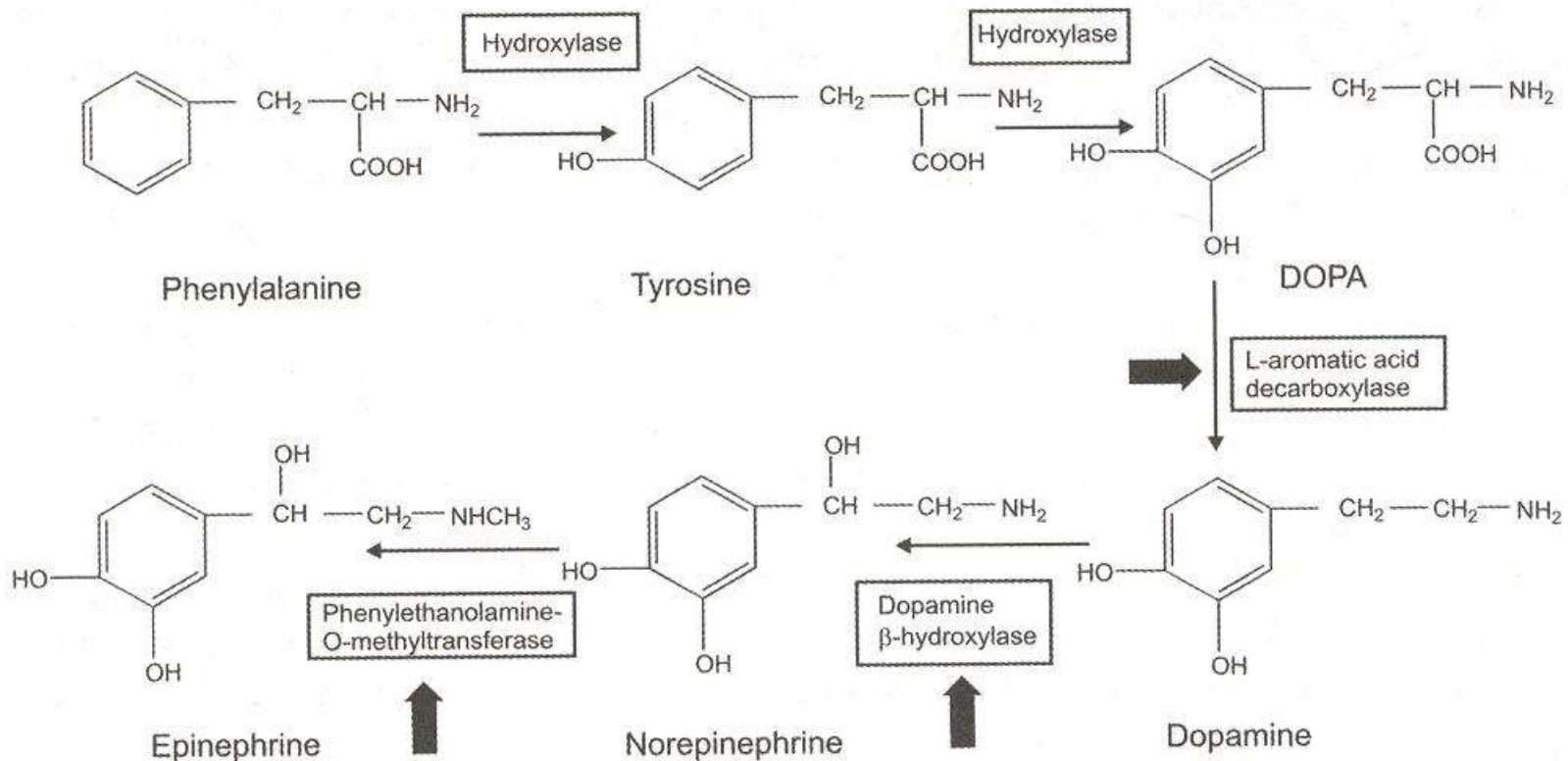


# Neurotransmitters/Neurohormones

- **Amino acid derivatives**

- **Catecholamines: dopamine, norepinephrine, epinephrine**

- **Derived from phenylalanine and tyrosine**



Hypothalamus  
GnRH, PIF, GHRH, CRH, TRH



Hypothalamo-Hypophyseal Portal  
System

**ANTERIOR PITUITARY GLAND**

**GONADOTROPHS**

Follicle Stimulating Hormone (FSH)

Luteinizing Hormone (LH)

**LACTOTROPHS**

Prolactin (PRL)

**SOMATOTROPHS**

Growth Hormone (GH)

**THYROTROPHS**

Thyroid Stimulating Hormone (TSH)

**CORTICOTROPHS**

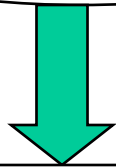
Adrenocorticotrophin Stimulating Hormone (ACTH)

# Pituitary

- Anterior Lobe
- Adenohypophysis
- Pars distalis
  - Endoectoderm origin
  - Produces
    - FSH
    - LH
    - PRL
    - GH
    - ACTH
    - TSH
- Posterior Lobe
- Neurohypophysis
- Pars nervosa
  - Neuroectoderm origin
  - Stores and releases
    - Vassopressin
    - Oxytocin
- Intermediate Lobe
- Pars intermedia
  - Neuroectoderm origin

**Hypothalamic Neurons**

Supraoptic  
Paraventricular



Axons

**POSTERIOR PITUITARY  
(PARS NERVOSA)**

Oxytocin - Neurophysin  
Vasopressin-Neurophysin

**Hypothalamic Neurons**

Melanocyte  
Stimulating Hormone Releasing  
Factor

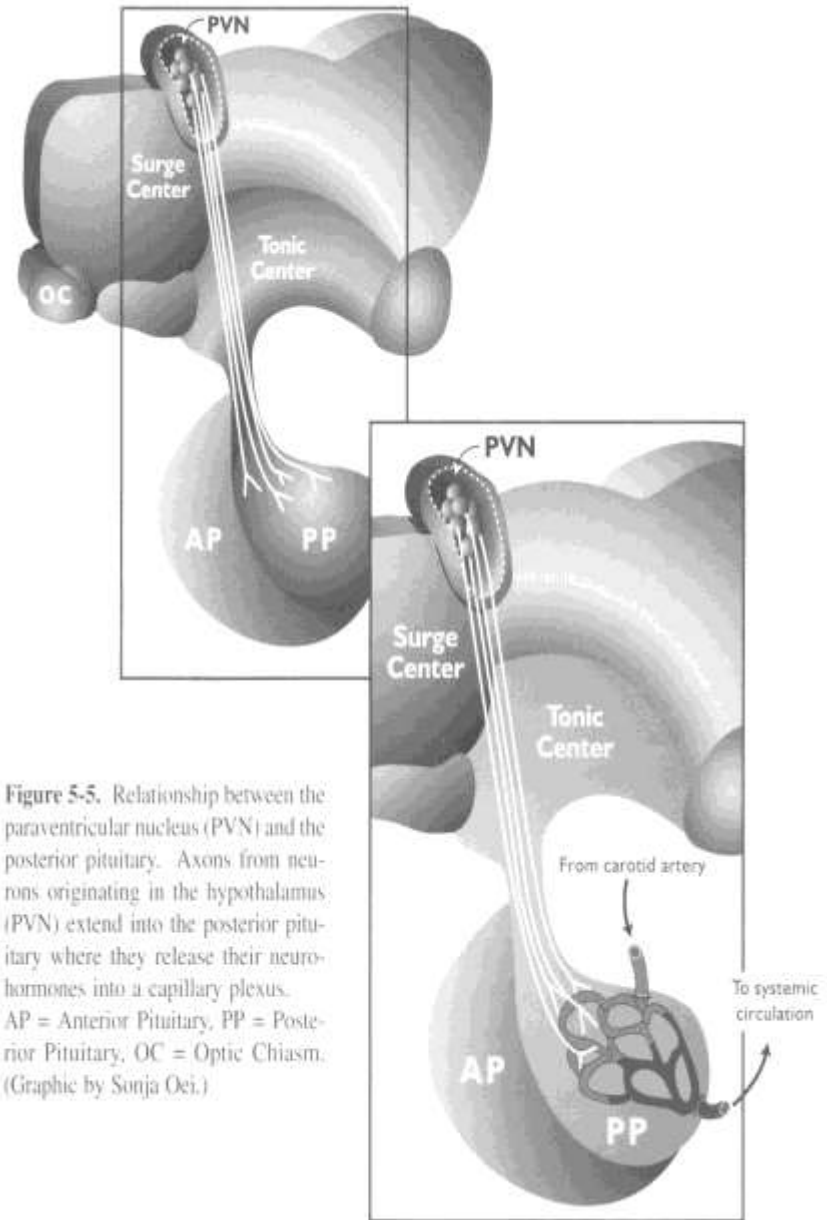


Nerve Tracts

**INTERMEDIATE LOBE OF  
PITUITARY**

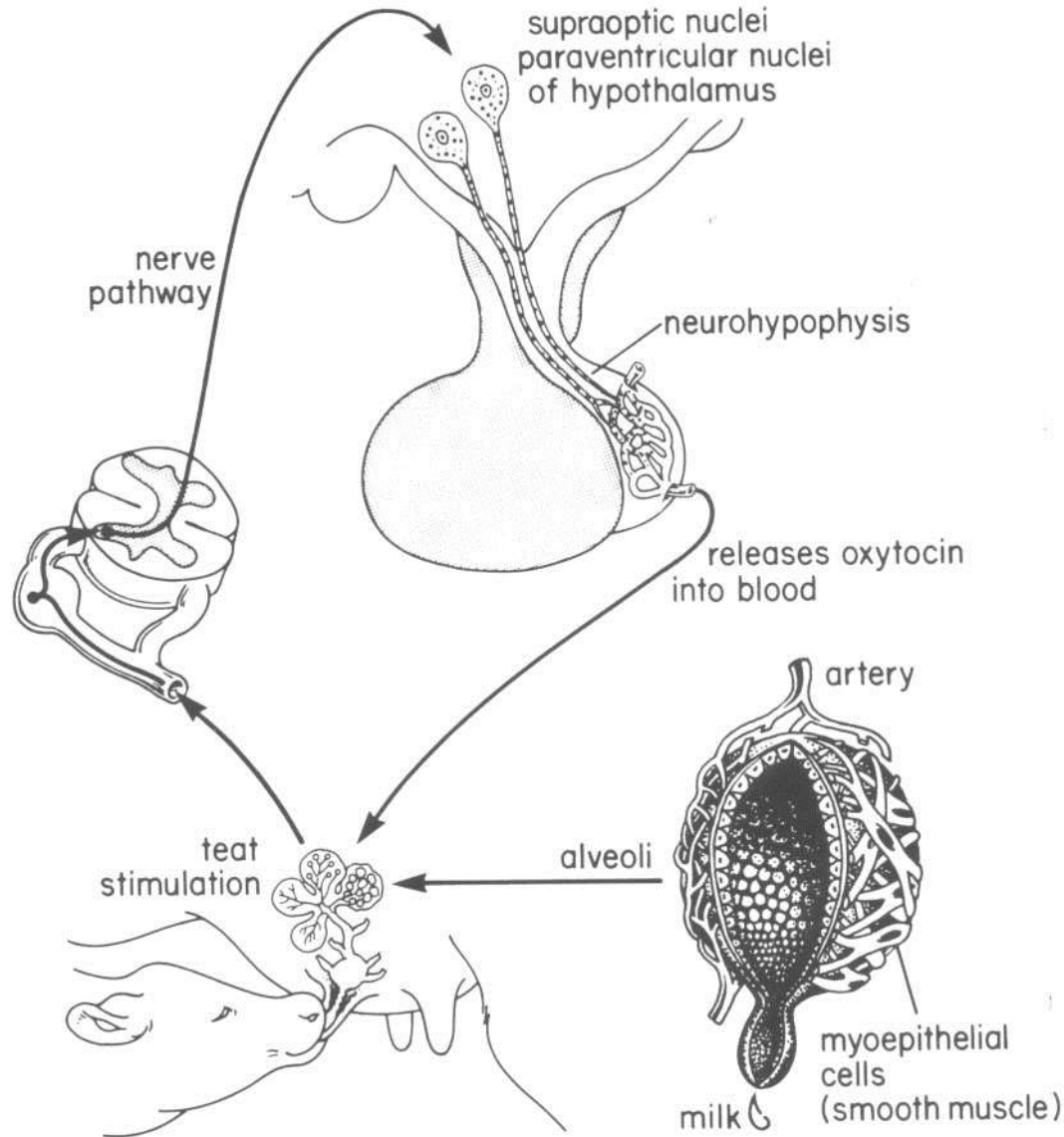
Melanocyte Stimulating  
Hormone (MSH)

- **Neural Supply to PP**
  - **Supraoptic nucleus**
    - Vassopressin-Neurophysin I
  - **Paraventricular nucleus**
    - Oxytocin-Neurophysin I
  - **Neurophysins**
    - Chaperone peptide forms complex with oxytocin and neurophysin
    - Hormone-Neurophysin Complex Transported via axons to Nerve Terminals in the Posterior Pituitary Gland
  - **Neural stalk**
    - Axons release Oxytocin + Neurophysin I or Vasopressin + Neurophysin I into capillaries draining Posterior Pituitary





# Neuro-Endocrine Reflex



# Pineal Gland (epiphysis)

- Photoreceptor in amphibians
- Endocrine gland in mammals
  - Influenced by light and season
  - Secretes melatonin
    - Melatonin Influences GnRH secretion
      - Long-day breeders - Horse
      - Short -day breeders - Sheep

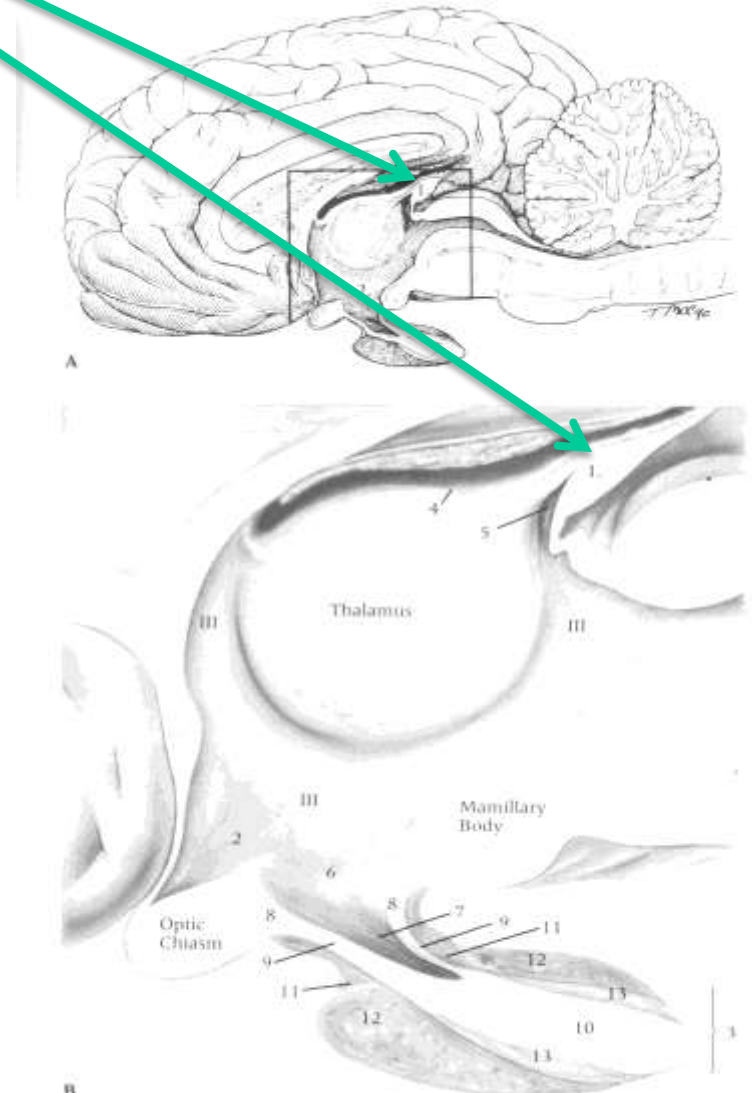


FIG. 1-1. A, Neuroendocrine contributors of the diencephalon to the reproductive system. B, Enlargement of a median section through the diencephalon: 1, Pineal gland; 2, hypothalamus; 3, hypophysis cerebri; III, third ventricle; 4, suprapineal recess of III; 5, pineal recess of III; 6, tuber cinereum; 7, infundibular recess of III; 8, median eminence; 9, infundibular stalk; 10, neural lobe; (8, 9, 10 - neurohypophysis); 11, pars tuberalis; 12, pars distalis; 13, pars intermedia; (11, 12, 13 - adenohypophysis).

# Female Reproductive Anatomy

- Ovaries
- Oviducts
- Uterus
- Cervix
- Vagina
- Vestibule
- Vulva
- Clitoris

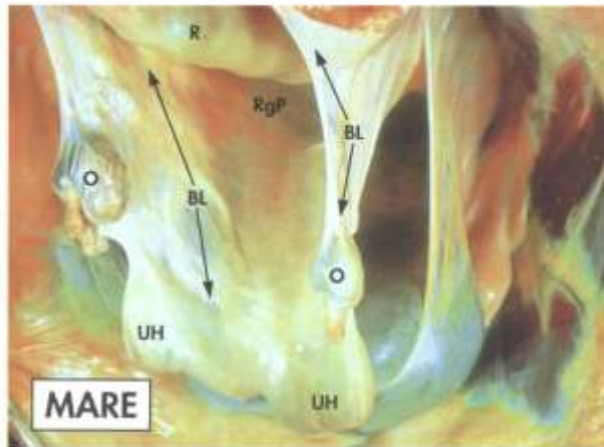
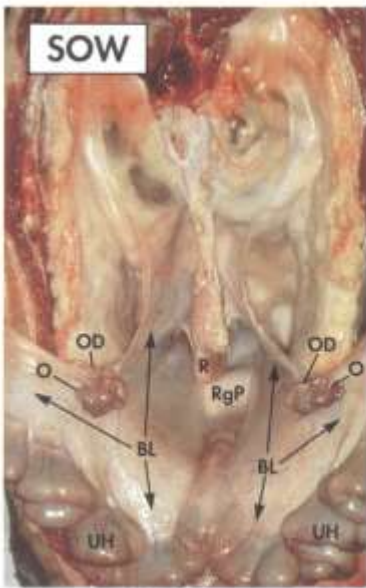
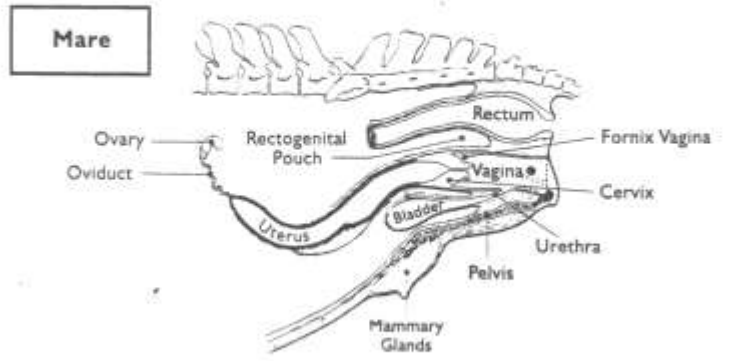
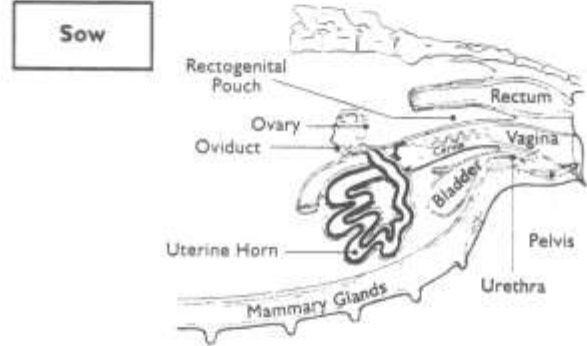
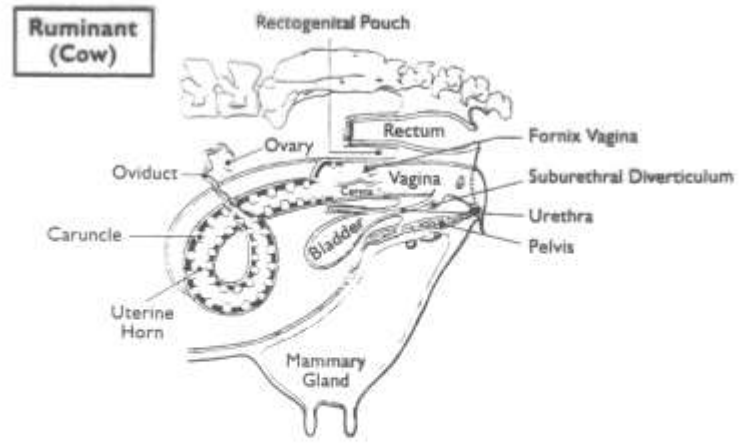
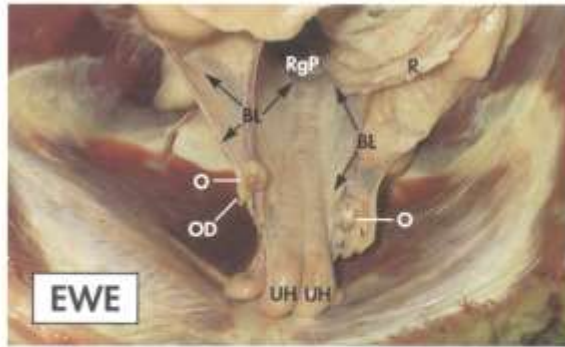
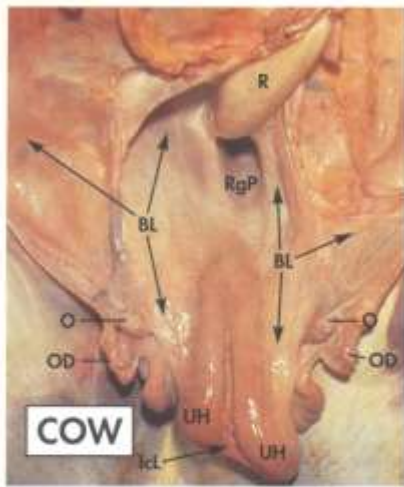


Figure 2-7. Caudal view of the cow, ewe, sow and mare (mare with permission from Günther, O. J.; see additional reading) reproductive tracts *in situ*. Intestines have been removed so that the reproductive tract is in full view. The tract is suspended by the broad ligament (BL) which is attached dorsally and is continuous with the peritoneum. BL = Broad Ligament; Icl = Intercornal Ligament; O = Ovary; OD = Oviduct; R = Rectum; RgP = Rectogenital Pouch; UH = Uterine Horn.

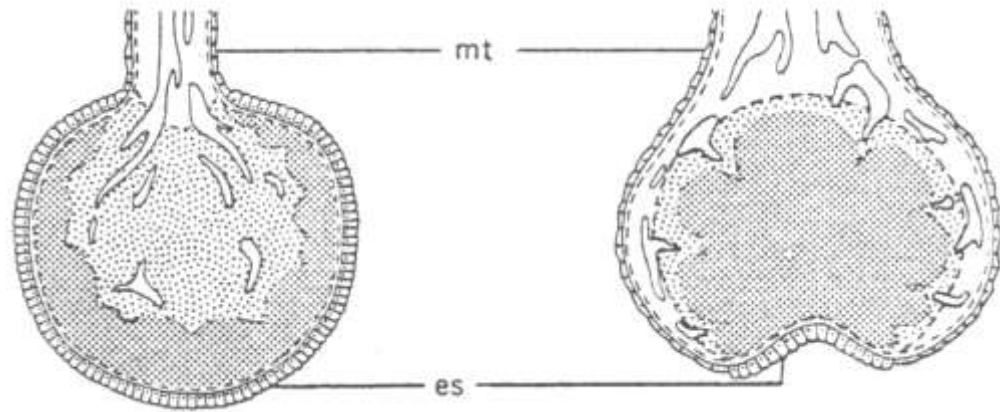
2-1. The reproductive organs in the ruminant (cow as an example), sow and mare as seen from midsagittal. Note the relationship of the tract to the rectum. Modified from Ellenberger and Baum (1943), *Handbuch der vergleichenden Anatomie der Haustiere*, 18th Edition, Zietzschmann, Ackerknecht and Grau, eds. Permission from er-Verlag, New York.

# Female Reproductive Anatomy

- Ovaries
- Oviducts
- Uterus
- Cervix
- Vagina
- Vestibule
- Vulva
- Clitoris

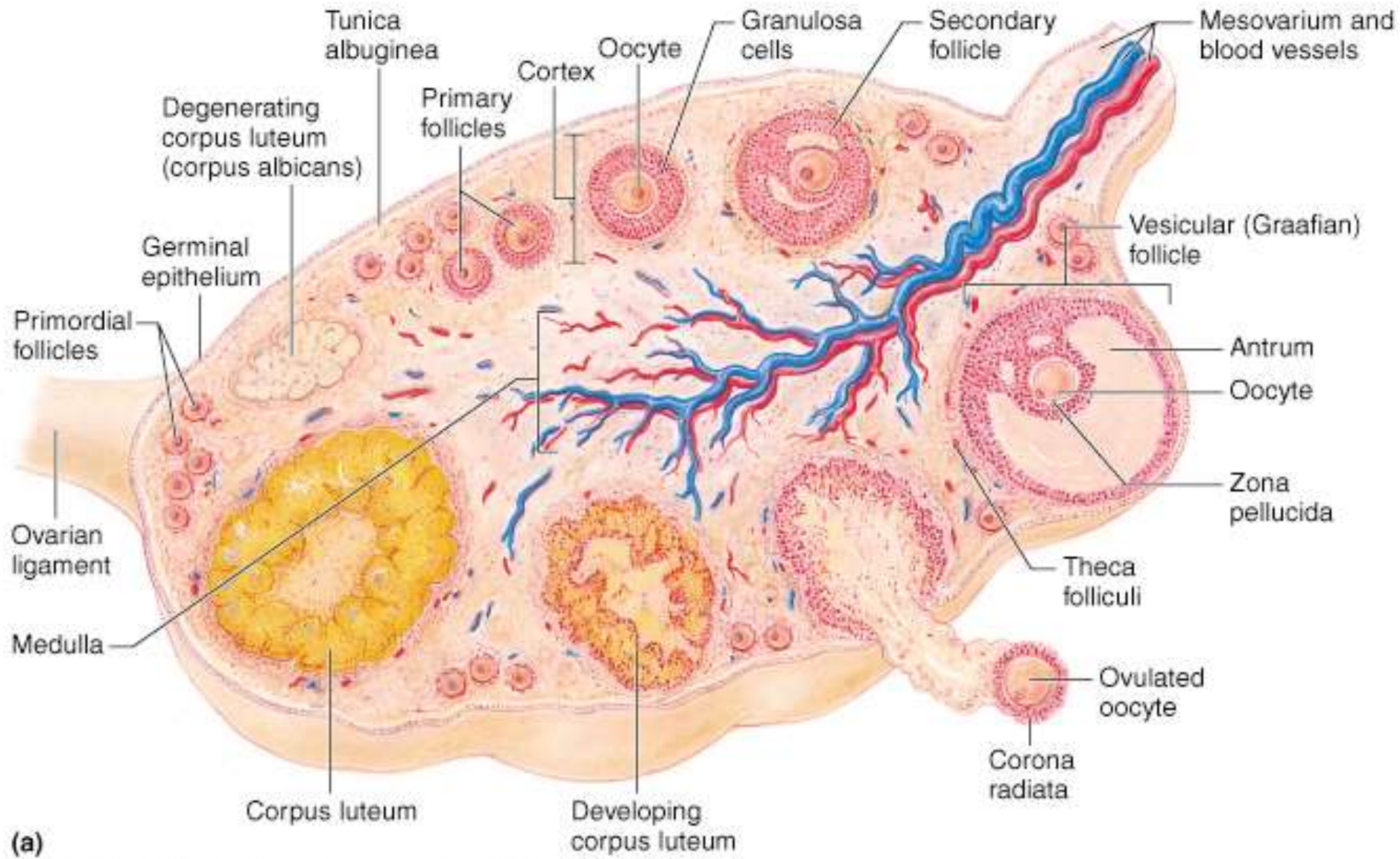
# Ovarian Architecture

- Cortex –outer zone
  - Covered by germinal epithelium
- Medulla – inner zone
  - Loose connective tissue
  - Stroma continuous with stroma of mesovarium at hilus



most species

equine



(a)

# OVARIAN CYCLE

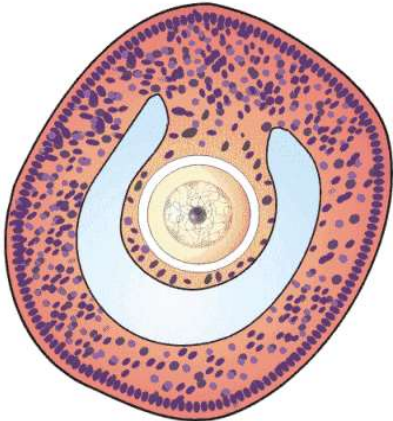
- 1** Primordial Follicle:  
has unilamellar structure  
contains a primary oocyte  
--approximate size 20-30  $\mu\text{m}$



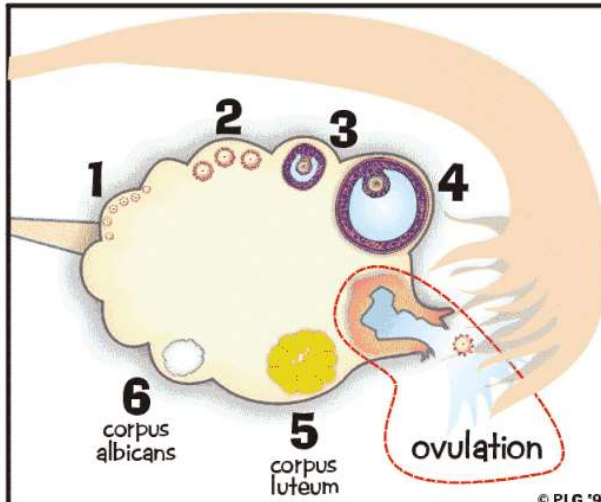
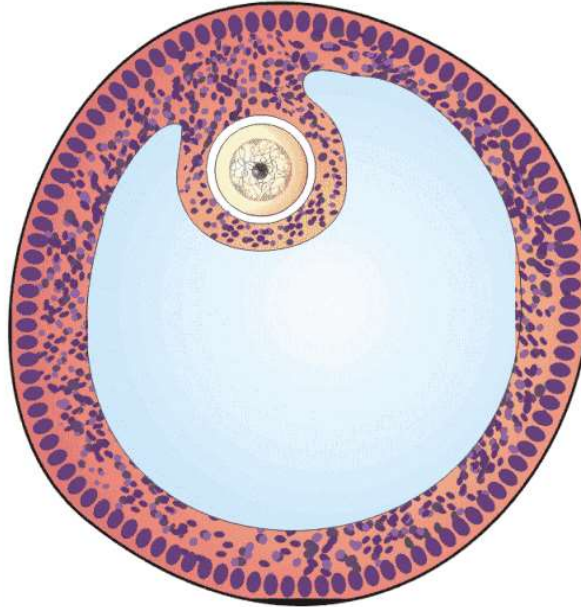
- 2** Early Primary Follicle:  
has multilamellar structure  
has a zona pellucida  
contains a primary oocyte  
--approximate size 45  $\mu\text{m}$



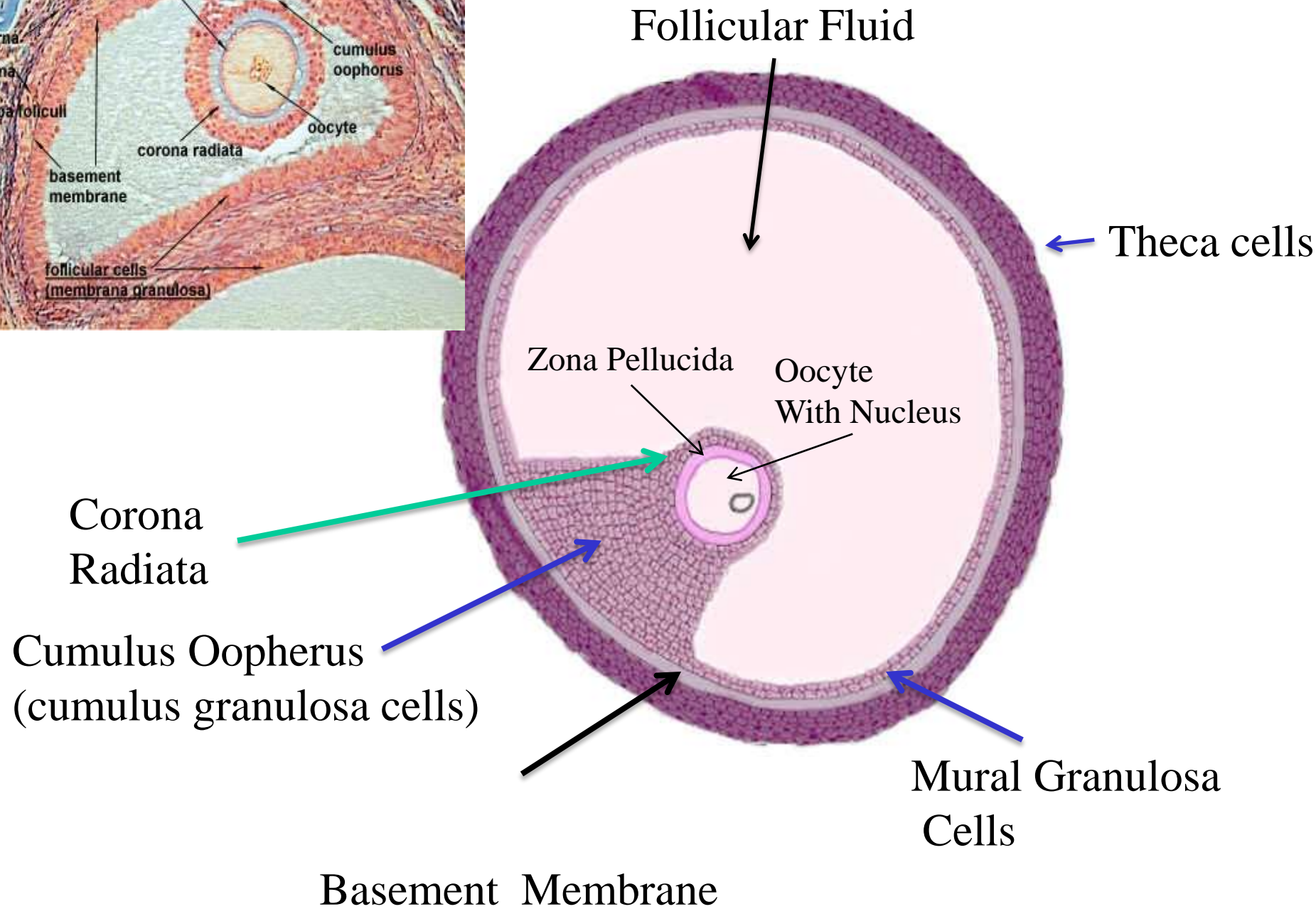
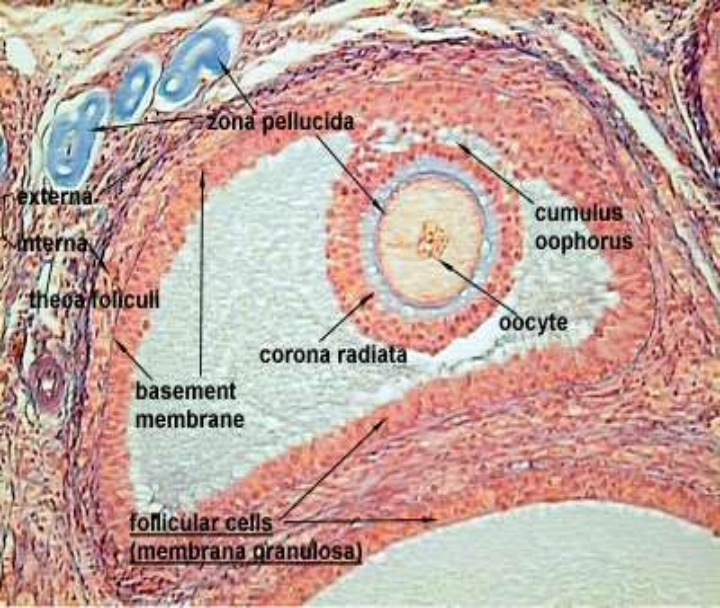
- 3** Secondary Follicle:  
has an antrum  
contains a primary oocyte  
--approximate size 125-150  $\mu\text{m}$


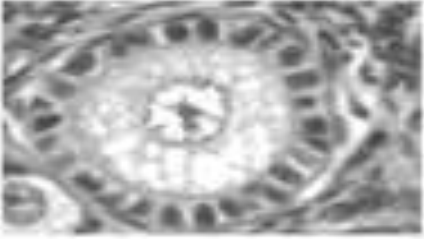





- 4** Mature (Graafian) Follicle  
contains a primary oocyte  
(approximate size 125-150  $\mu\text{m}$ )  
until hours before ovulation  
when meiosis I is completed  
presence of first polar body  
indicates secondary oocyte







		Sheep	Human	Rodent	
Primordial	Not receptive to gonadotrophins		BMP6 <sup>0</sup> GDF9 <sup>0</sup> ALK3 <sup>0/0</sup> ALK5 <sup>0</sup> ALK6 <sup>0</sup> BMPRII <sup>0/0</sup> Betaglycan <sup>0</sup>	ALK5 <sup>0</sup> TGFβRII <sup>0</sup> Smad 2 <sup>0/0</sup>	ALK5 <sup>0/0</sup> ALK6 <sup>0/0</sup> ActRII <sup>0</sup> ActRIIB <sup>0</sup> TGFβRII <sup>0/0</sup> Smad 2 <sup>0</sup> Smad 3 <sup>0</sup> Smad 5 <sup>0</sup> Smad 8 <sup>0</sup> Betaglycan <sup>0/0</sup>
			BMP15 <sup>0</sup> ALK6 <sup>0</sup> ActRIIB <sup>0/0</sup>	TGF-β1 <sup>0/1</sup> BMP15 <sup>0</sup> GDF9 <sup>0</sup> ALK5 <sup>0</sup>	BMP15 <sup>0</sup> GDF9 <sup>0</sup> ALK2 <sup>0/0</sup> ALK3 <sup>0/0</sup> ActRII <sup>0</sup> ActRIIB <sup>0</sup> BMPRII <sup>0</sup> Smad 2 <sup>0</sup>
Secondary (Preantral)	Responsive to gonadotrophins		TGF-β1, 2 <sup>0</sup> ALK3 <sup>0</sup> ALK5 <sup>0/1</sup> ALK6 <sup>0/1</sup> ActRIIB <sup>0</sup> BMPRII <sup>0</sup> TGFβRII <sup>0</sup> Betaglycan <sup>0/1</sup> Follistatin <sup>0</sup> FSRP <sup>0/1</sup>	TGF-β2 <sup>0</sup> ActRII <sup>0</sup>	TGF-β1 <sup>0/0</sup> TGF-β2 <sup>0</sup> TGF-β3 <sup>0/1, 0/1</sup> BMP6 <sup>0/0</sup> ALK3 <sup>0</sup> ALK6 <sup>0</sup> ActRIIB <sup>0</sup> TGFRII <sup>0</sup> Smad 2 <sup>0</sup> Smad 3 <sup>0/1</sup> Betaglycan <sup>0</sup> Follistatin <sup>0</sup>
			BMP6 <sup>0/0, 0/0</sup> ActRIIB <sup>0/0</sup>	TGF-β1 <sup>0/1, 0/1</sup> ALK5 <sup>0/1</sup> ActRII <sup>0</sup> ActRIIB <sup>0</sup> TGFβRII <sup>0/1</sup> Betaglycan <sup>0</sup> Follistatin <sup>0/0</sup>	TGF-β1 <sup>0</sup> TGF-β2 <sup>0</sup> PCRD <sup>0</sup>
Large antral	Gonadotrophin dependent			TGF-β2 <sup>0</sup> GDF9 <sup>0</sup> ALK2 <sup>0/1, 0/1</sup> ALK3 <sup>0/1</sup> ActRII <sup>0</sup> ActRIIB <sup>0/0, 0/1</sup> Smad 1 <sup>0/1</sup> Smad 2 <sup>0</sup> Smad 3 <sup>0/1</sup> Smad 5 <sup>0/1</sup> Betaglycan <sup>0</sup> FSRP <sup>0/1, 0/1</sup>	

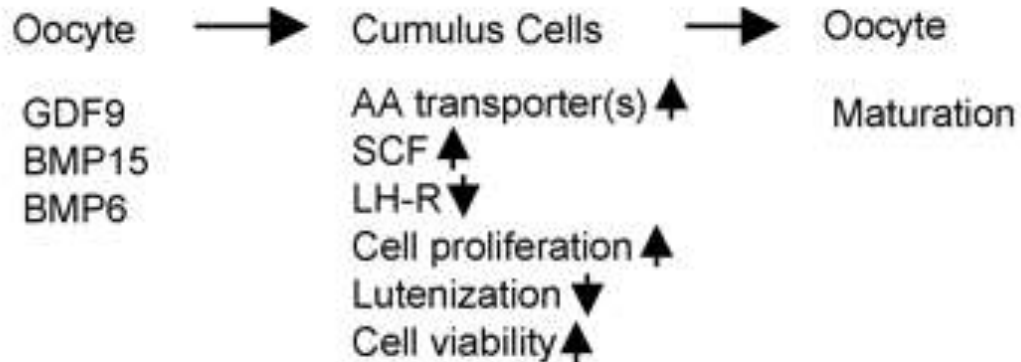
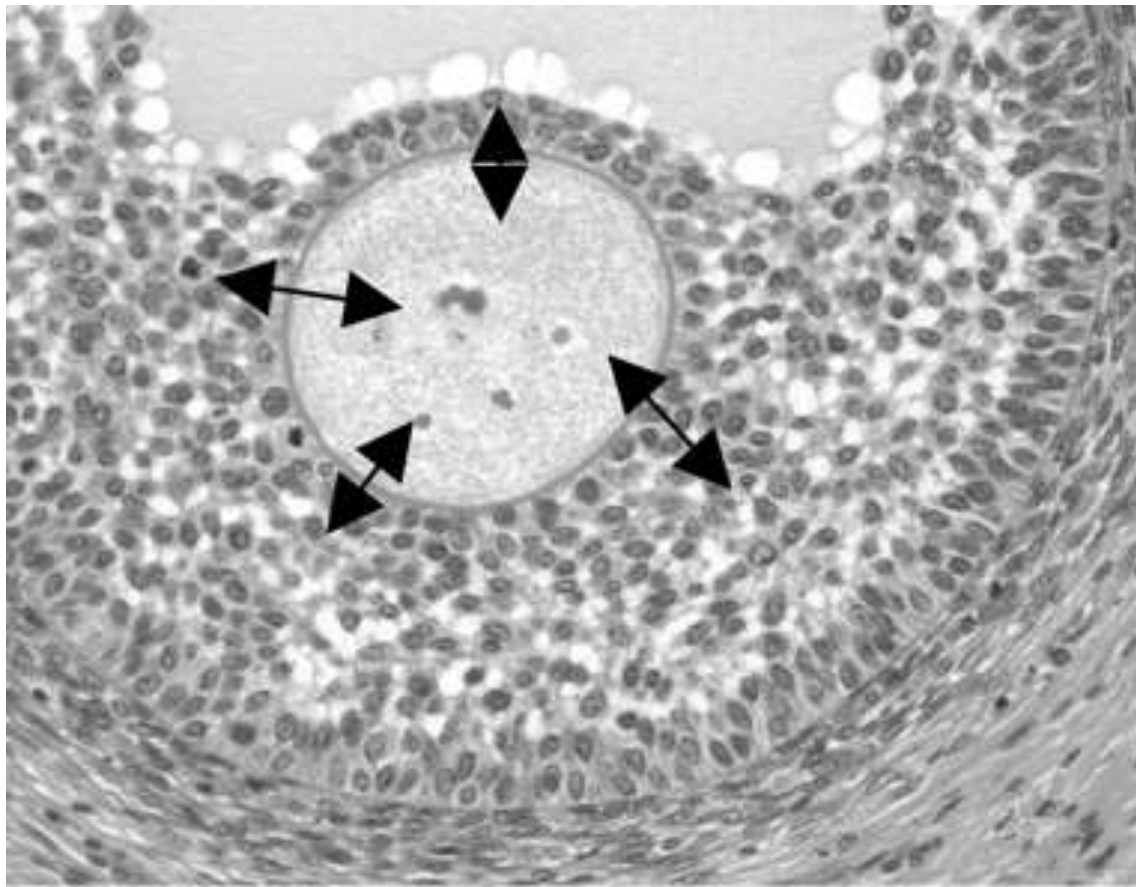
GDF, growth differentiation factor 9

BMP, bone morphogenic protein

AA – amino acid

SCF, stem cell factor

LH-R, LHCGR, luteinizing hormone receptor



# OVARY

- Functions
  - Gametogenesis – ovum, ova
  - Steroidogenesis – estrogen, progesterone
- Round, almond- or bean-shaped
  - Depends on species
- Paired
  - Most species, completely surrounded by a thin membrane, the *infundibulum*, which is a part of the *oviduct*.
- Suspended
  - caudal to kidneys in sublumbar region by the *mesovarium* (part of the *broad ligament* supporting the entire reproductive system)

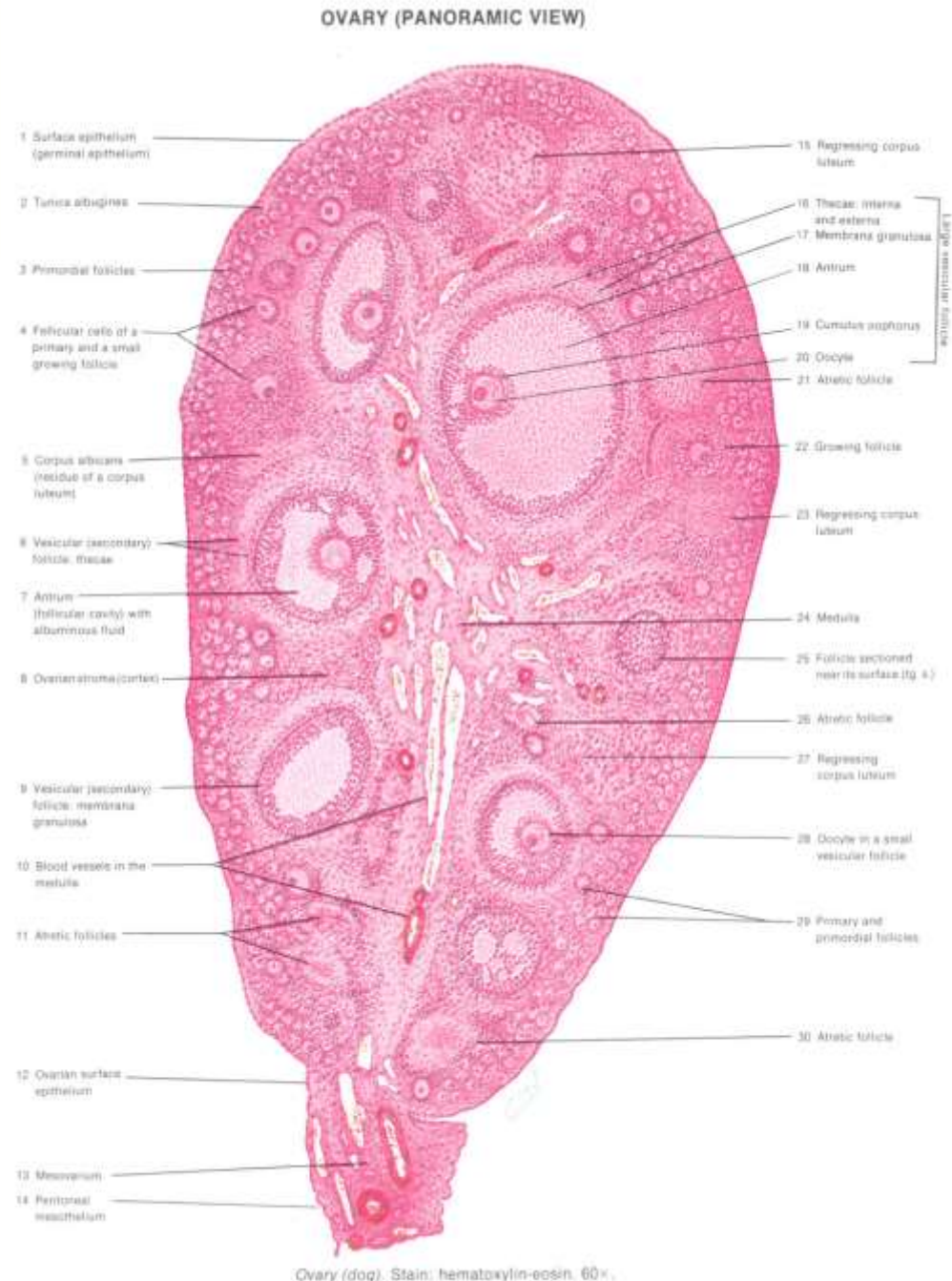
# Ovarian Histology

- **Germinal epithelium**

- simple squamous or low cuboidal
  - covers free surface of ovary
  - basement membrane absent

- **Tunica albuginea**

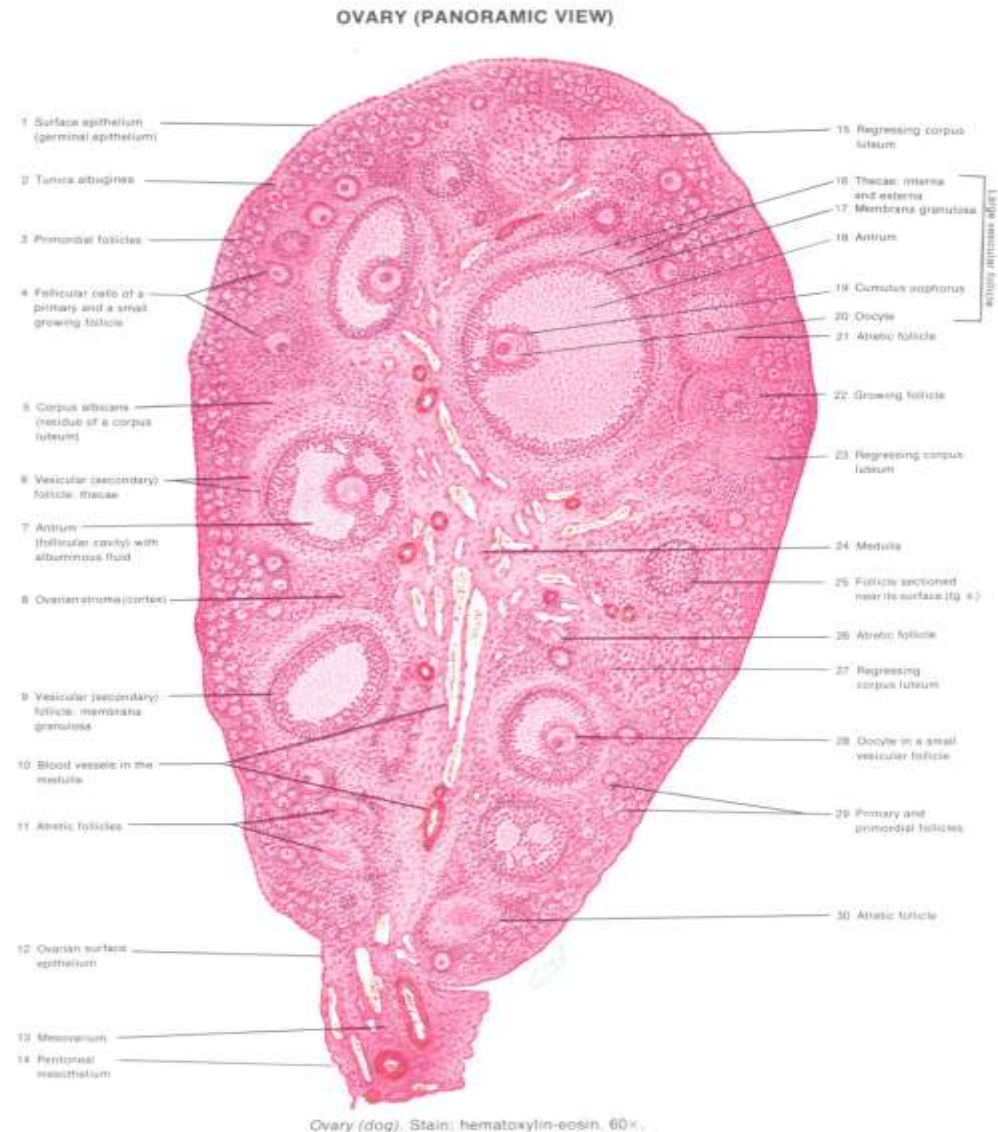
- dense layer of connective tissue beneath the germinal epithelium



Ovary (dog). Stain: hematoxylin-eosin. 60x.

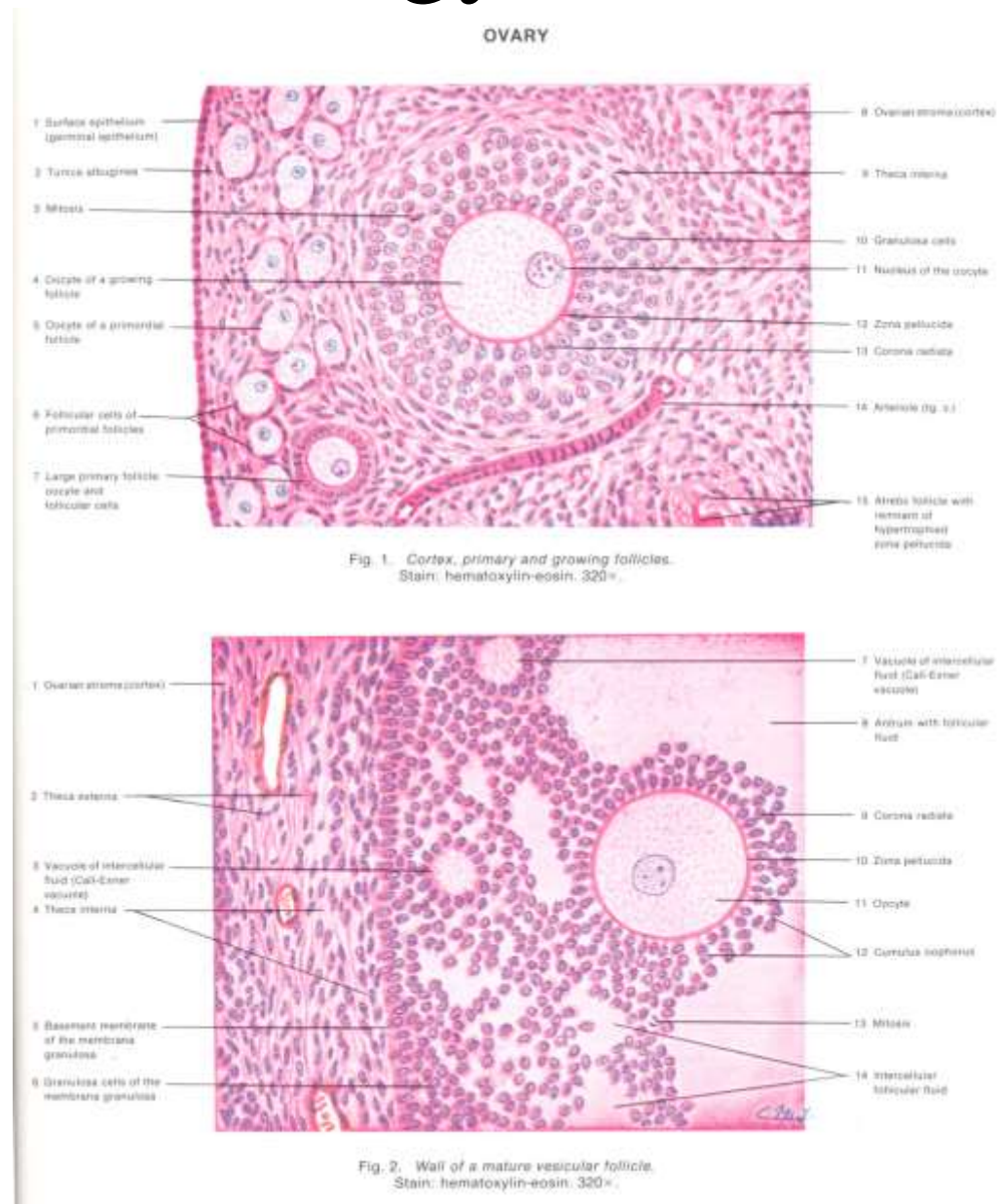
# Ovarian Histology

- **Primordial follicles**
  - immediately beneath the tunica albuginea
  - lacks a membrane
  - separated from adjacent interstitial tissue by a single layer of follicular (granulosa) cells
- **Primary follicles**
  - lifetime supply at birth
  - remain at this stage until puberty
  - most never ovulate, but undergo atresia

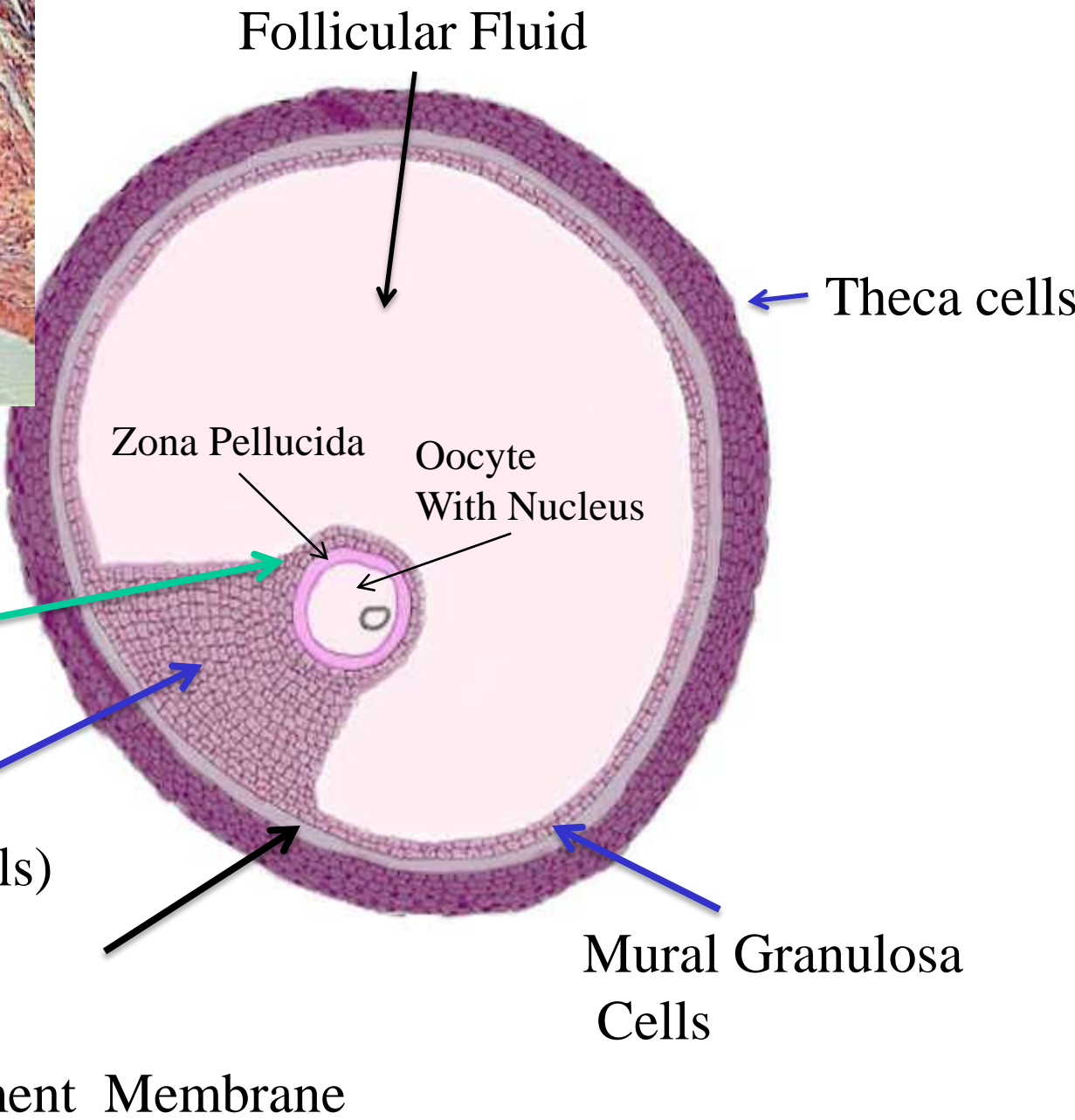
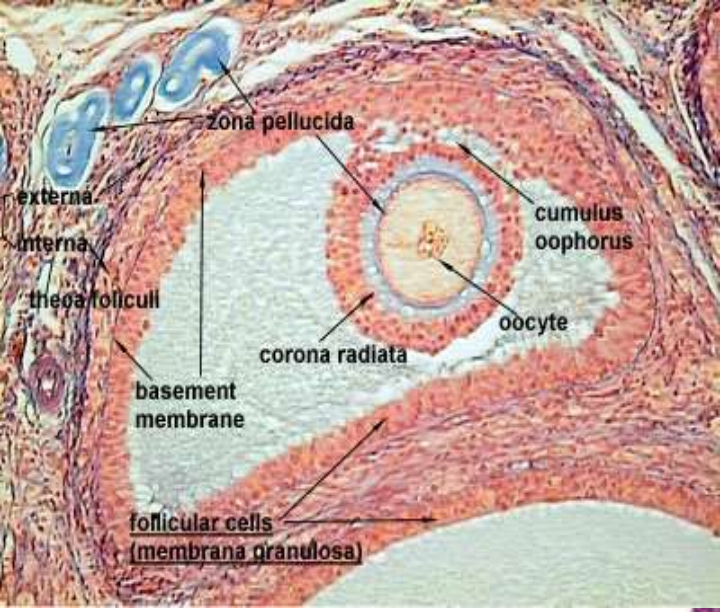


# Ovarian Histology

- **Secondary follicles**
  - growing follicles
  - increase in number of layers of granulosa cells
  - Zona pellucida
- **Tertiary follicles**
  - maturing follicles
  - antrum formation
    - fluid filled space
  - oocyte on mound of granulosa
    - Cumulus oophorus
  - granulosa layer immediately around oocyte
    - Corona radiata
  - Granulosa surrounded by
    - Theca interna
    - Theca externa



# MATURE GRAAFIAN FOLLICLE





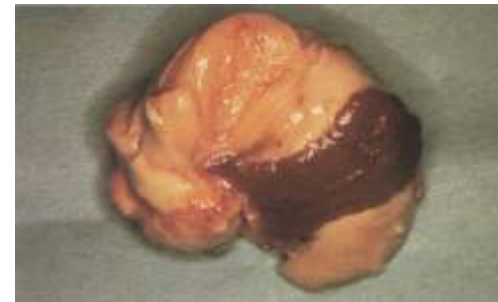
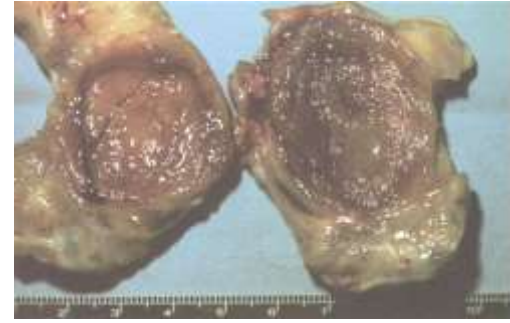
# Ovarian Histology

- **Mature Graafian Follicle**
  - Same structures as tertiary follicle, but larger
    - Layers of cells & volume of follicular fluid is greater
    - Stigma-like structure forms on surface of follicle to ovulate
    - Size of Ovulatory Follicle
  - Cow
    - 15-20 mm
  - Mare
    - 25-70 mm
  - Bitch, ewe, doe, sow
    - 5-10 mm



# Ovarian Histology

- **Corpus hemorrhagicum (CH)/Corpora hemorrhagica**
  - newly ruptured follicle
  - essentially a blood clot
- **Corpus luteum (CL)/Corpora lutea**
  - LH stimulates formation from theca interna and granulosa
  - temporary endocrine gland
    - progesterone
- **Corpus albicans (CA)/Corpora albicantia**
  - remains after CL regresses



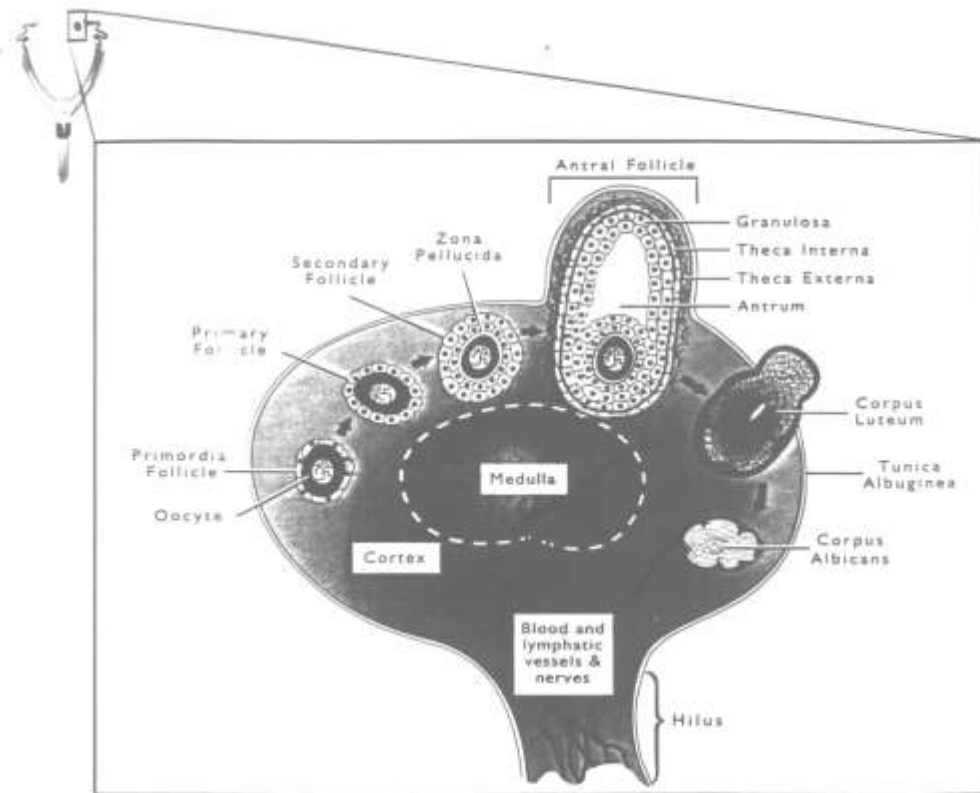
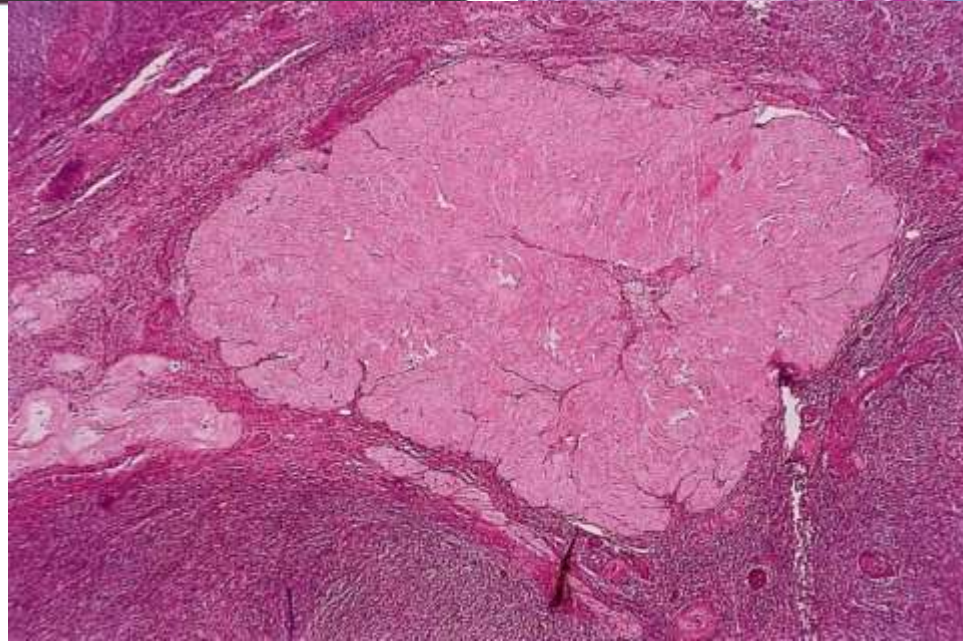
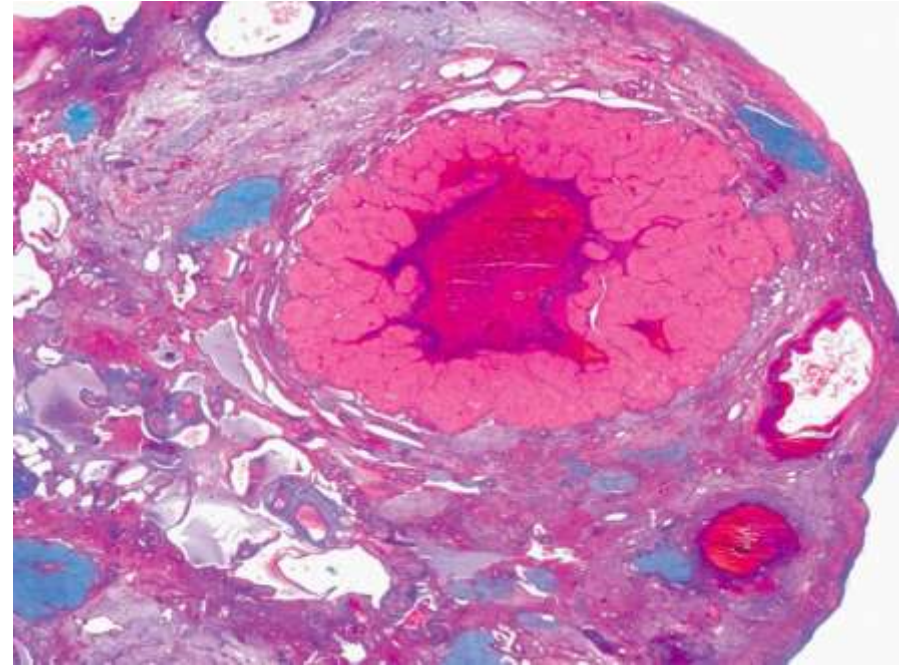
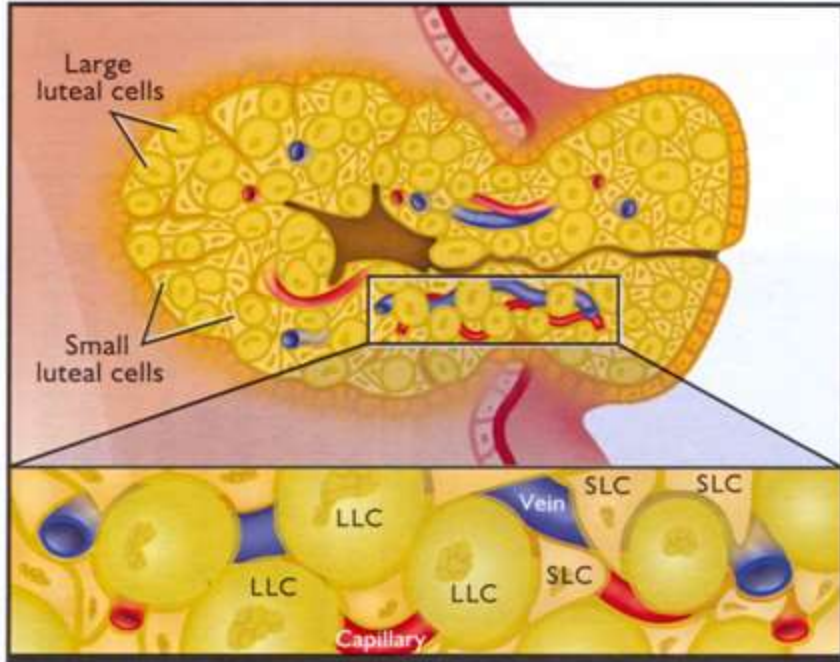


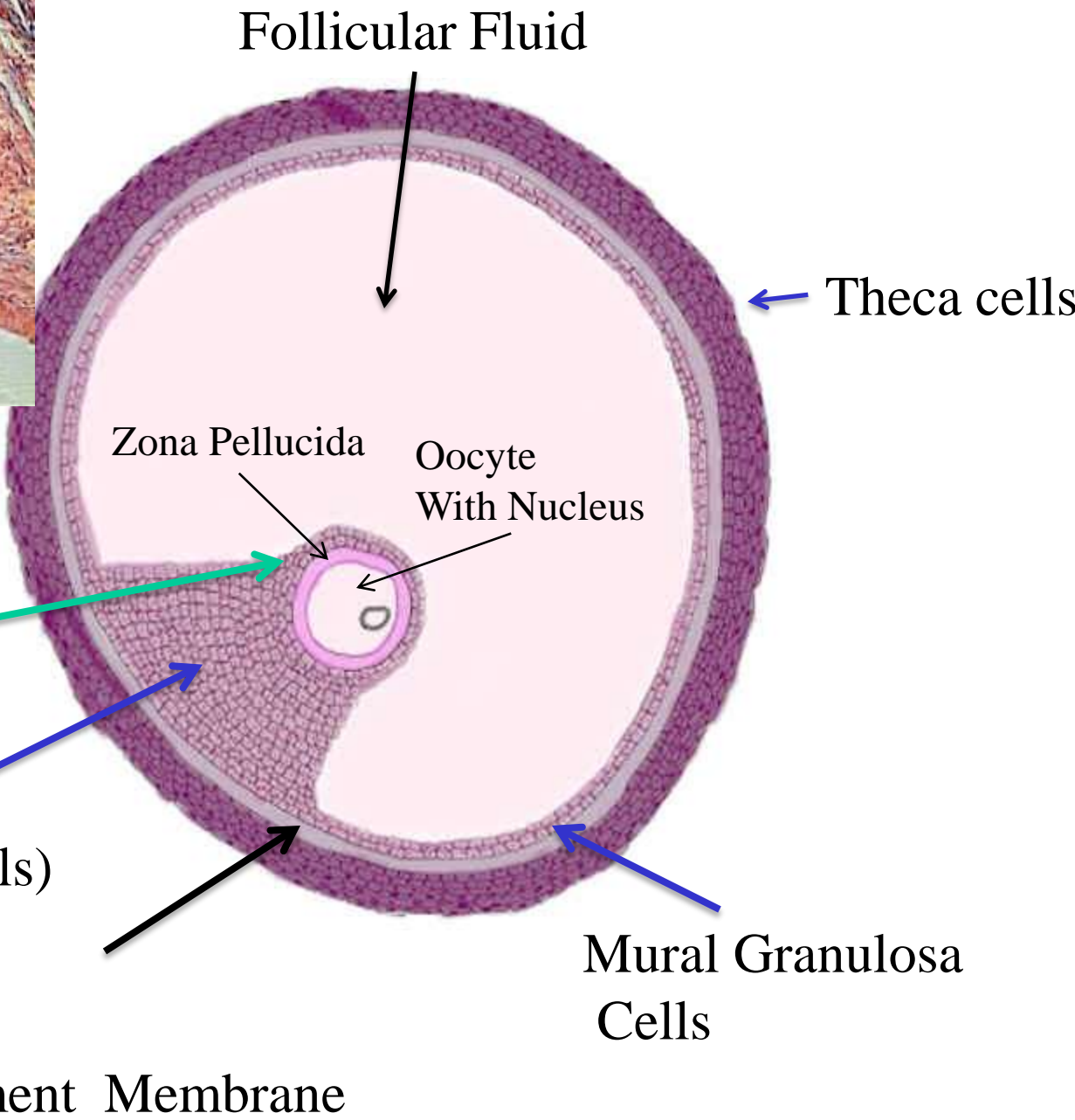
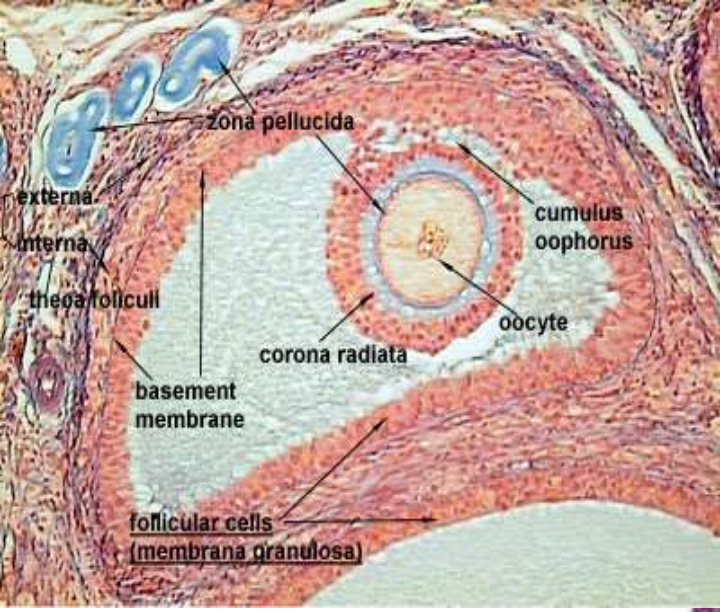
Figure 2-8, Schematic illustration of the ovary showing the primary structures and their sequence of development. It should be noted that, in general, all types of follicles are present within the ovary at any point in time. However, developing and functional corpora lutea may or may not be present depending on the stage of the estrous cycle. With the exception of the mare, development (and regression) of all ovarian structures occurs at random locations within the ovary. (Graphic by Sonja Oel.)

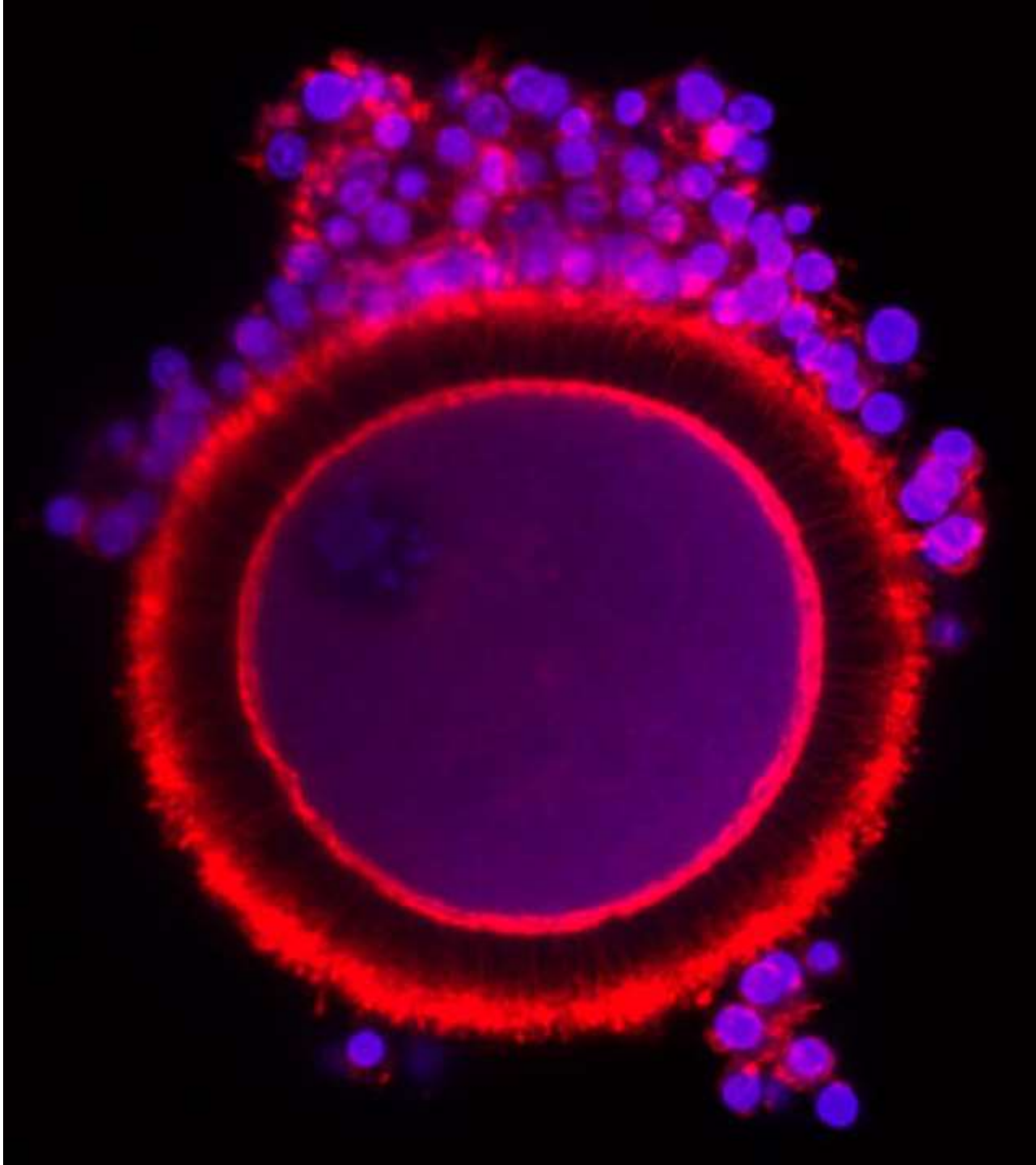


# CORPUS LUTEUM

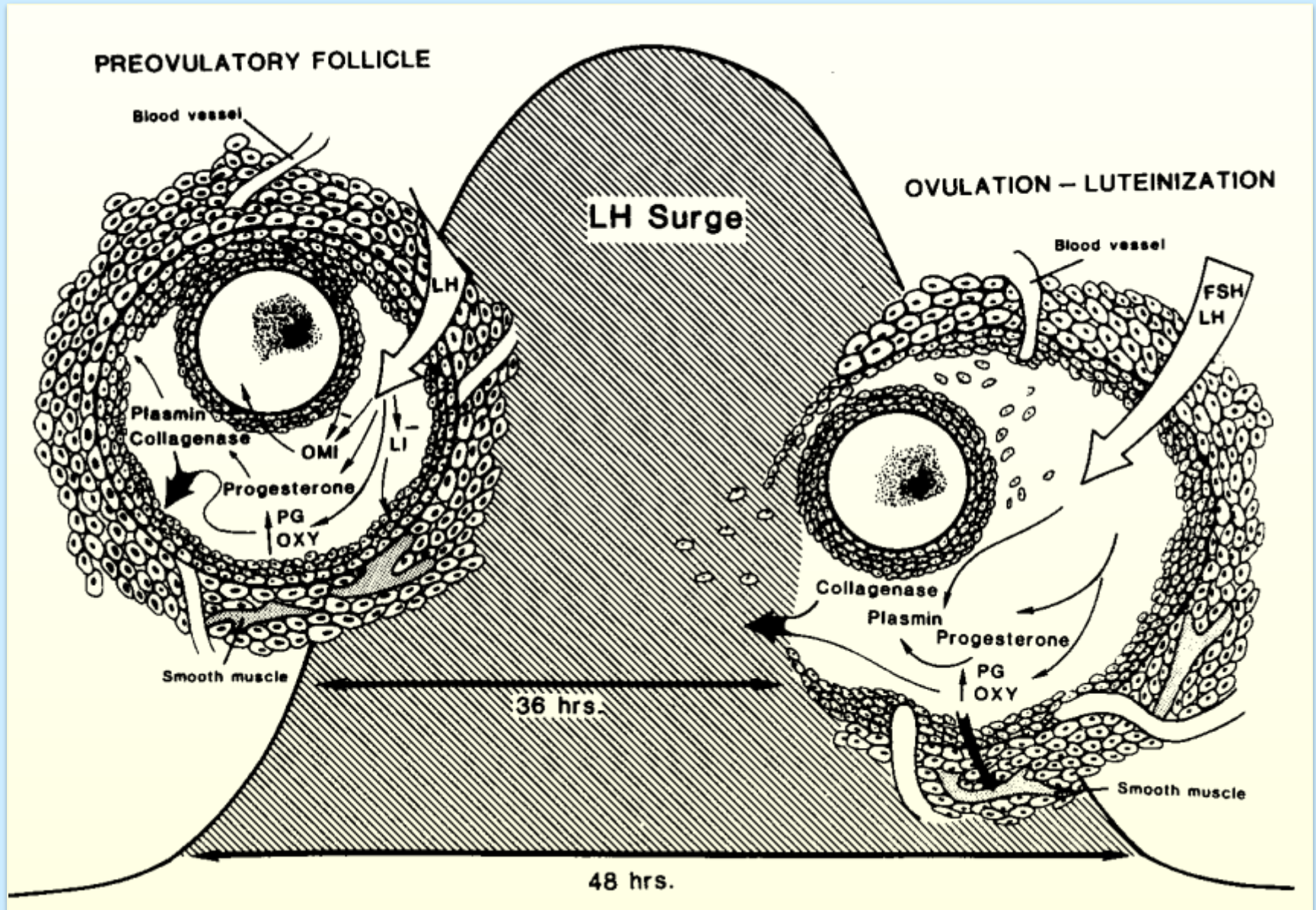


# MATURE GRAAFIAN FOLLICLE

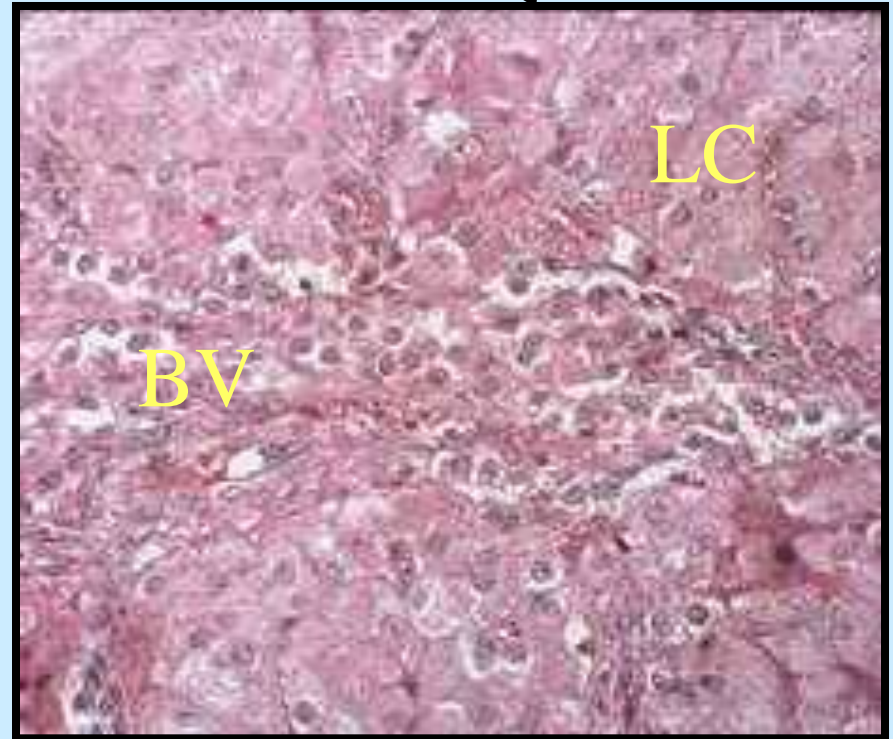
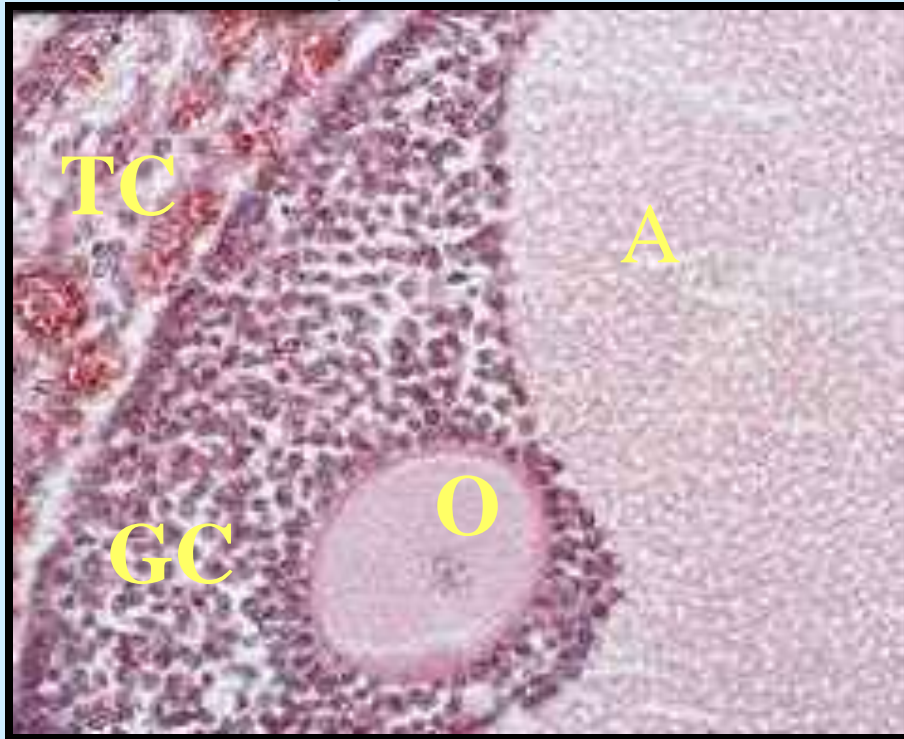
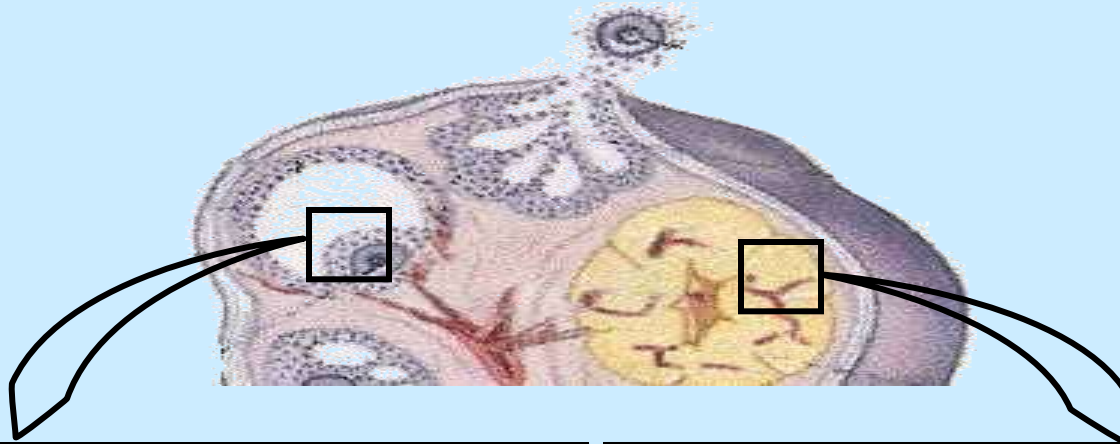




# Ovulatory Surge of Luteinizing Hormone



# Structural Changes During Luteinization

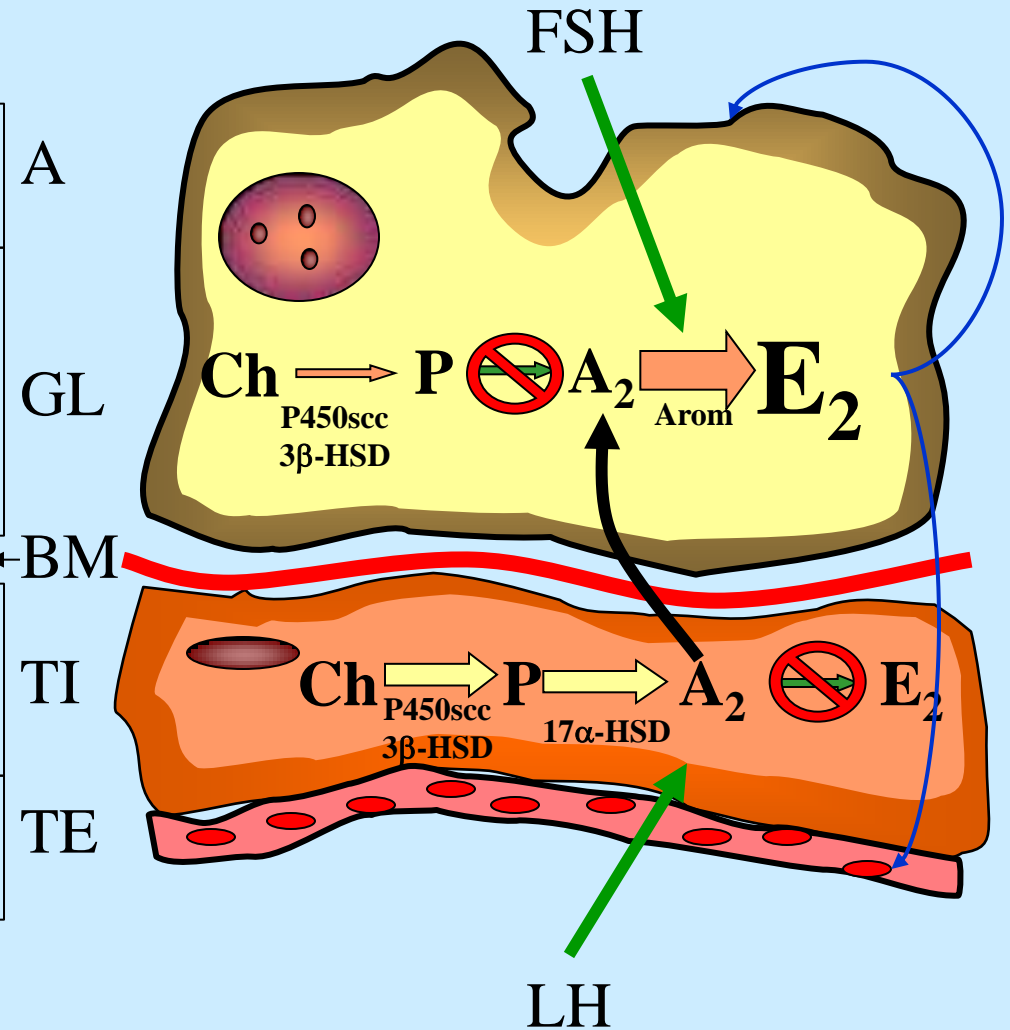
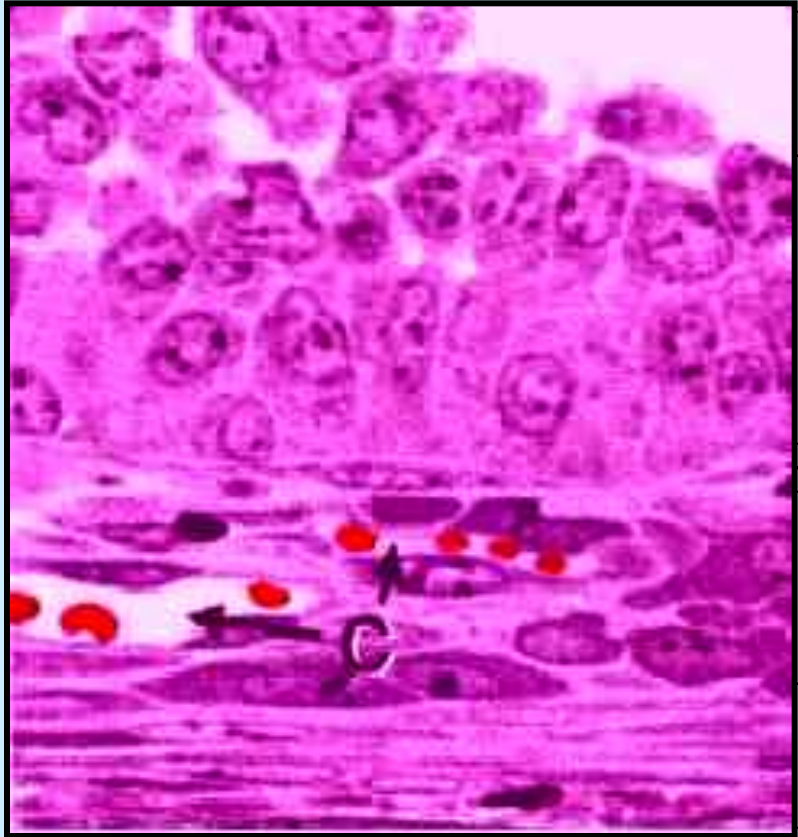




# Two Cell Theory for Ovarian Sex Steroid Production

- **THECA CELLS:** Cholesterol to Progestins (Pregnenolone and Progesterone and 17-alpha hydroxy progestins) to androgens (testosterone and dehydroepiandrosterone)
- **GRANULOSA CELLS:** Androgens to Estrogens VIA AROMATASE ENZYME
- **LUTEAL CELLS** – Cholesterol to Progesterone

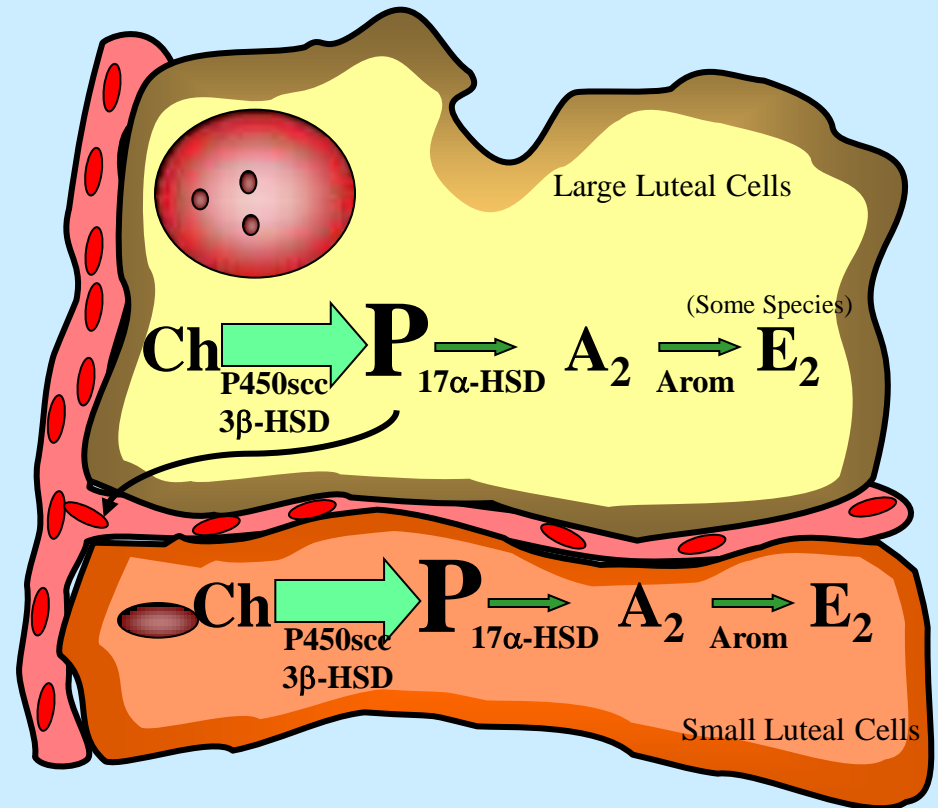
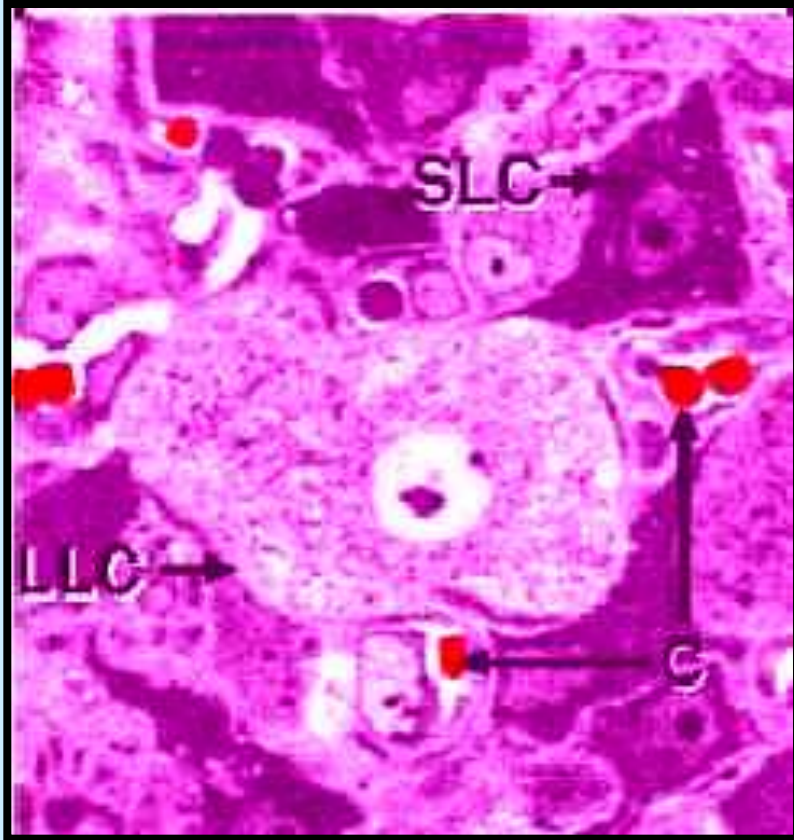
# Steroidogenesis Before LH Surge



A: Antrum; GL: Granulosas; BM; Basement Memb  
 TI: Theca Int. TE: T Ext.; C: Capillaries

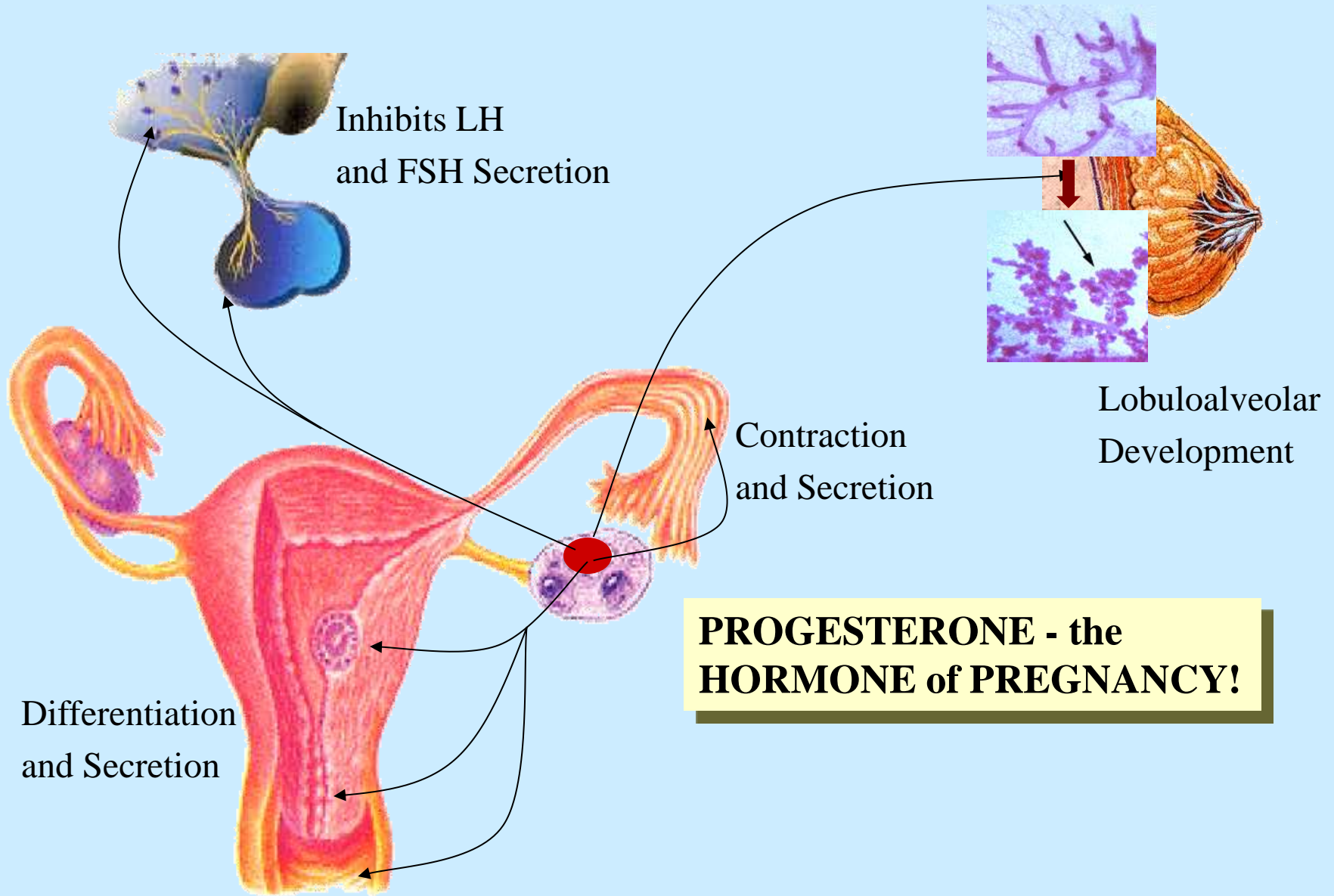
Ch: Cholesterol; P: Progesterone; A<sub>2</sub>: Androgen; E<sub>2</sub>: Estradiol

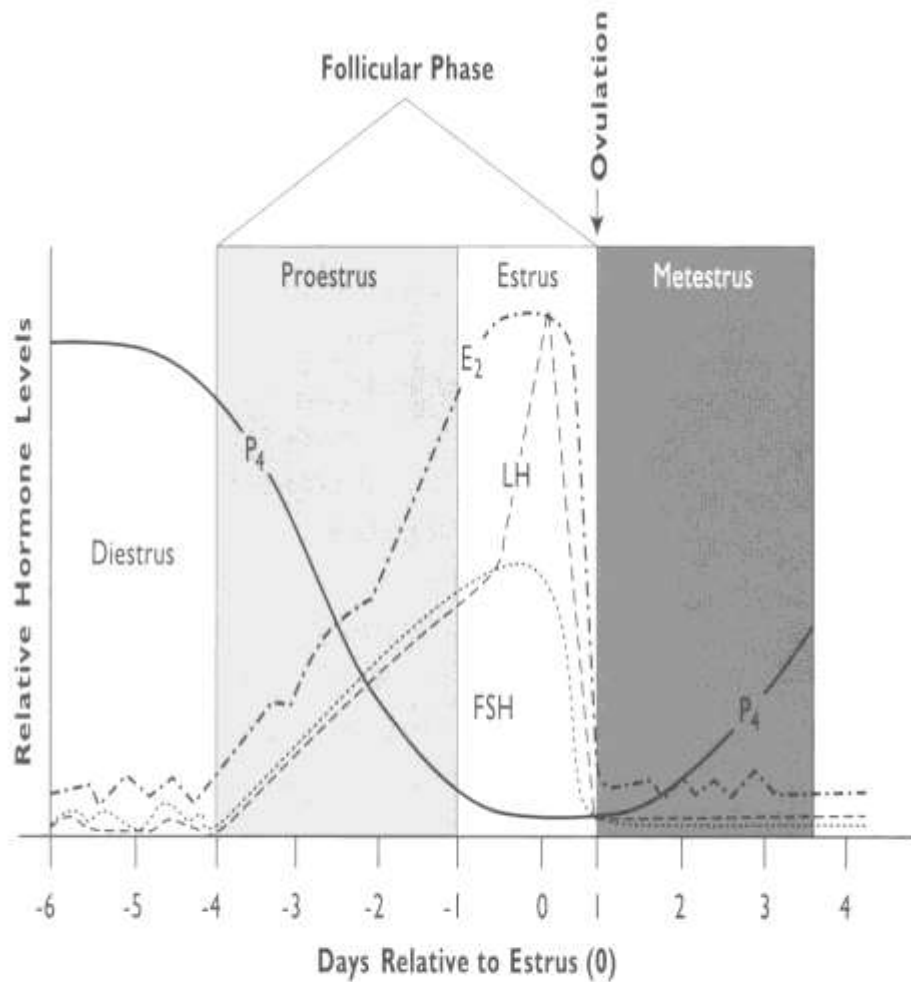
# Luteal Steroidogenesis



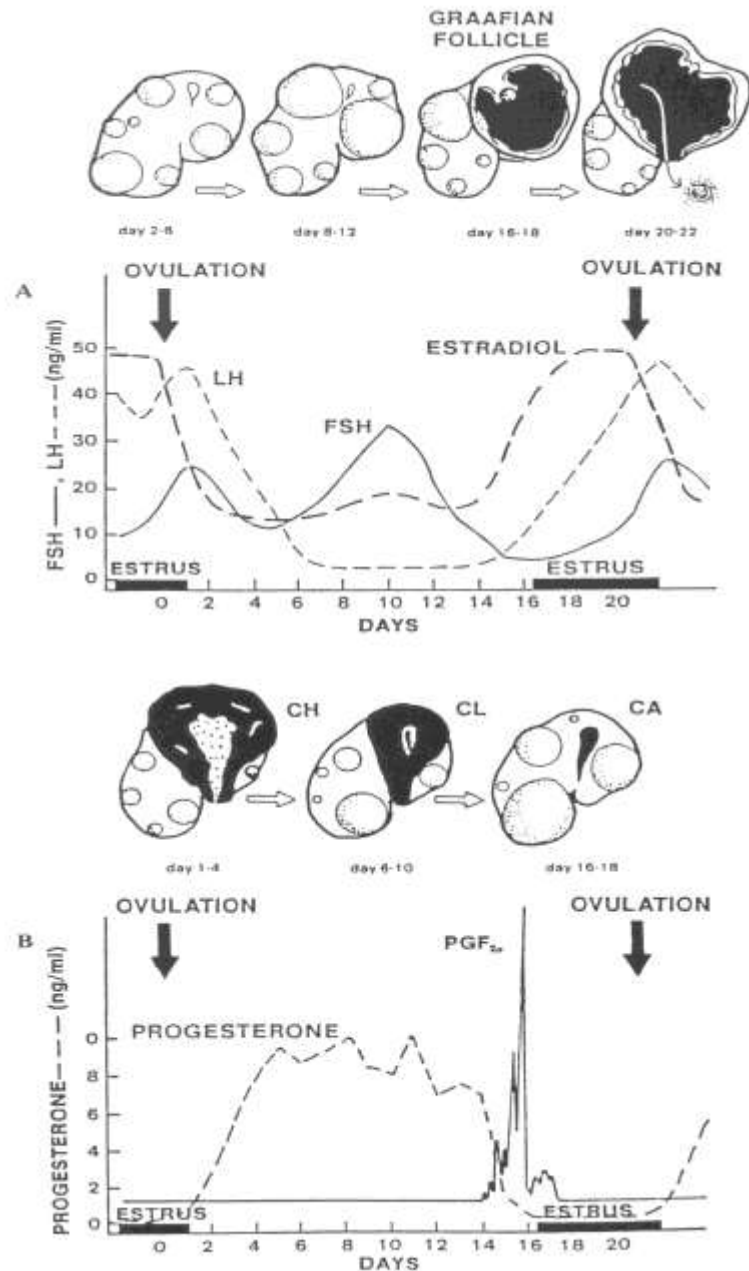
Ch: Cholesterol; P: Progesterone; A<sub>2</sub>: Androgen; E<sub>2</sub>: Estradiol

# Endocrine Effects of Progesterone



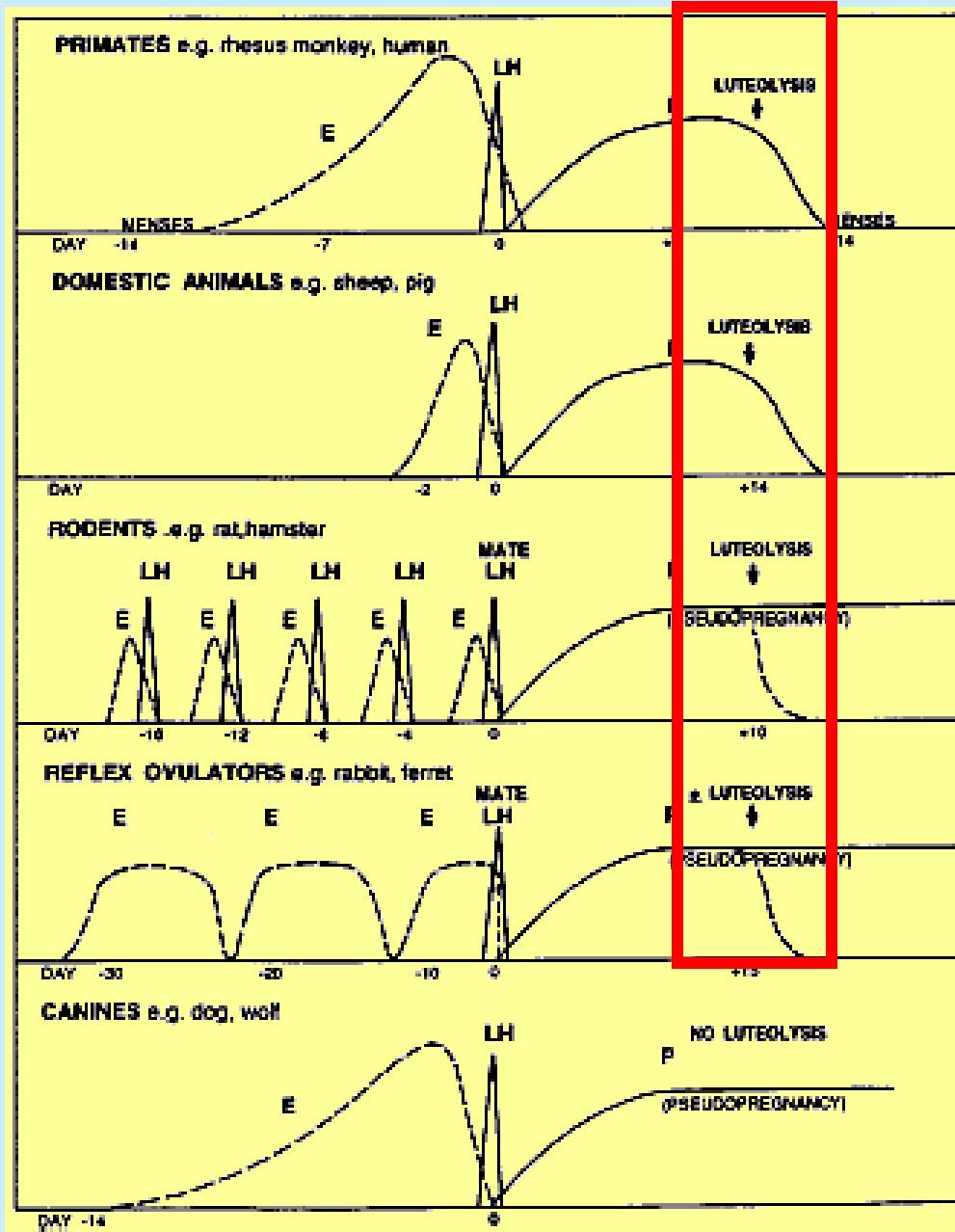


**Figure 8-4.** Changes in hormones during the follicular phase. As progesterone (P<sub>4</sub>) drops, FSH and LH increase together in response to GnRH. FSH and LH cause the production of estradiol (E<sub>2</sub>) by ovarian follicles (Figure 8-2). When the follicle reaches a certain maturational stage, it produces inhibin, which suppresses FSH secretion from the anterior pituitary. Thus, FSH does not surge with the same magnitude as LH. When estrogen reaches a threshold level (peak), the preovulatory surge of LH occurs, inducing ovulation.



(Legend appears on facing page)

# Duration of Luteal Function Across Species



Weeks

Weeks

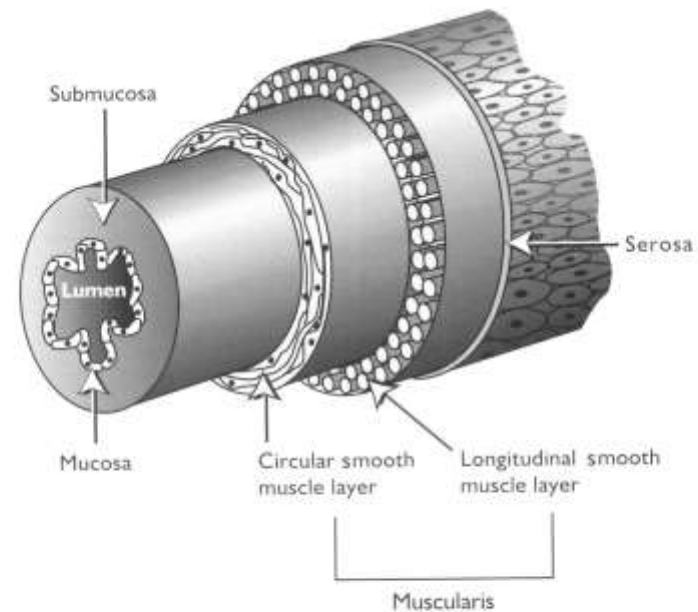
Days/Weeks

Weeks

Months

# Tubular Female Reproductive Tract

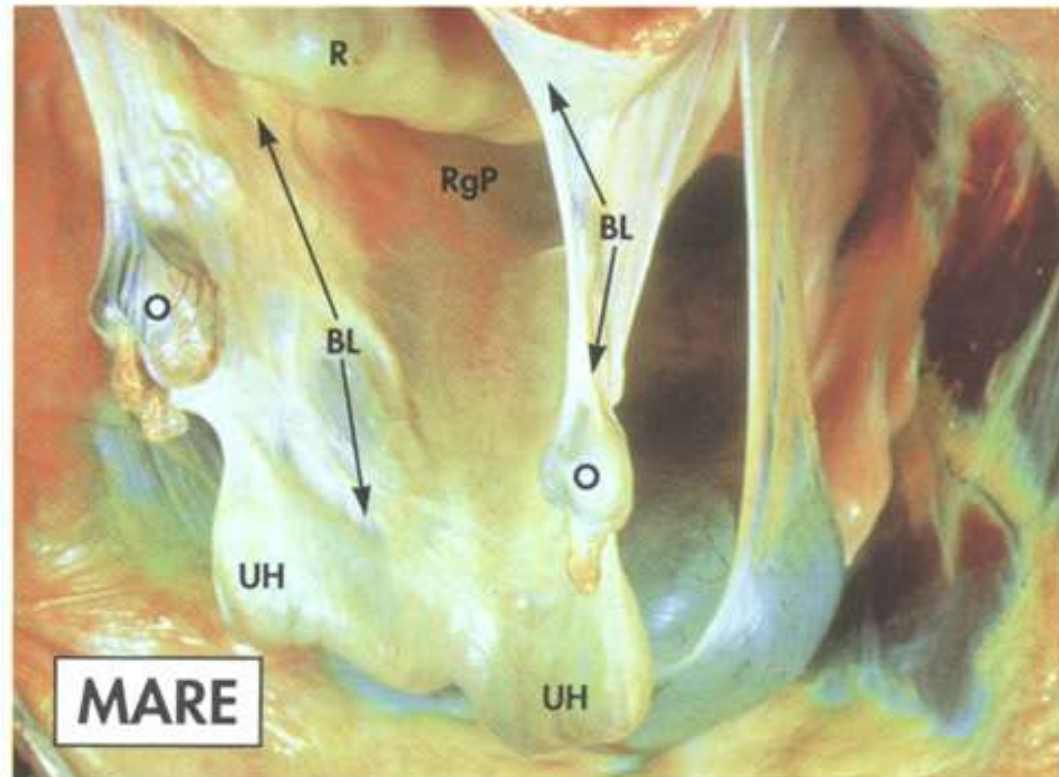
- Oviducts, uterus, cervix, vagina & vestibule
- Common basic structure
  - Four concentric layers
    - Serosa
    - Muscularis
    - Submucosa
    - Mucosa



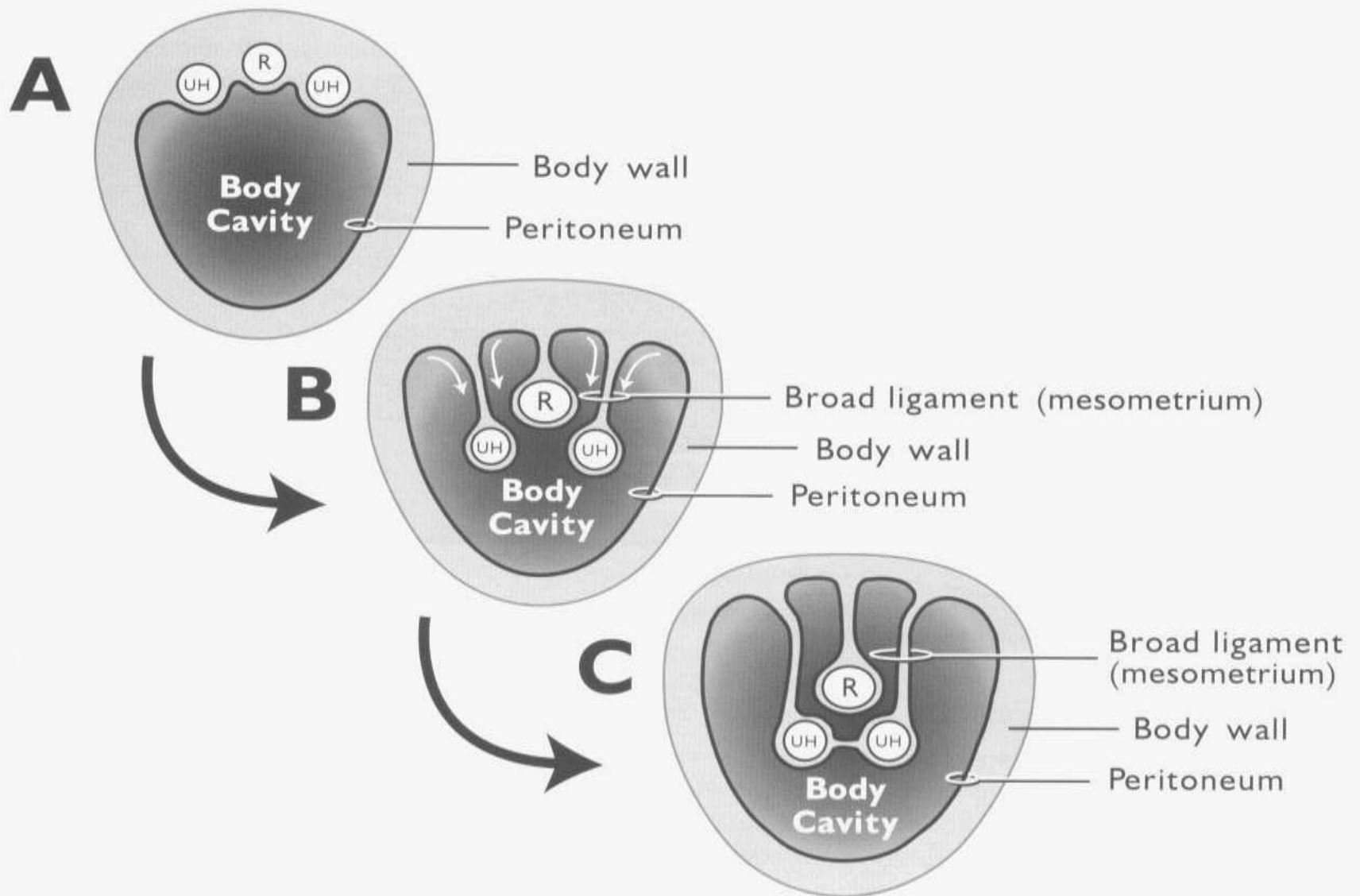
**Figure 2-5.** Schematic of the typical tubular composition in a cross section of the tubular portions of the female reproductive tract. The lumen is lined with epithelium called the mucosa, which is supported by the submucosa. Typically, the muscularis is composed of an inner layer of circular smooth muscle and an outer longitudinal layer of smooth muscle. The serosa is the connective tissue covering the tract. (Graphic by Sonja Oei.)

# Female Reproductive Tract

- Suspended in abdominal cavity by a fold of peritoneal lining
  - Broad Ligament: supports vessels, lymphatics & nerves to each part of tract
    - Mesovarium
      - Attaches to ovary at hi
    - Mesosalpinx
      - Supports oviduct
    - Mesometrium
      - Supports uterus







**Figure 2-6.** Embryonic development of the broad ligament. Initially, the uterine horns develop dorsal to the peritoneum (A). As the development continues, (UH = Uterine Horn; R = Rectum), it pushes into the body cavity (arrows in B) and eventually becomes completely surrounded by a layer of peritoneum (C). The broad ligament consists of two layers of peritoneum which "sandwiches" the tract between them (B and C). Each layer of peritoneum is continuous with the peritoneal lining of the body cavity. (Graphic by Sonja Oei.)

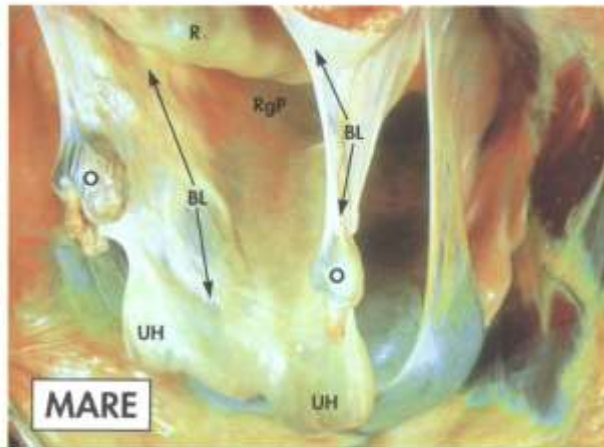
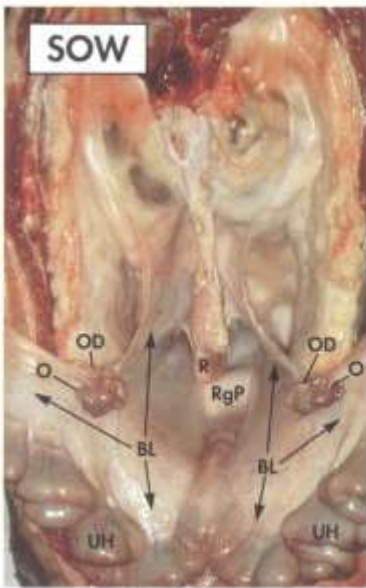
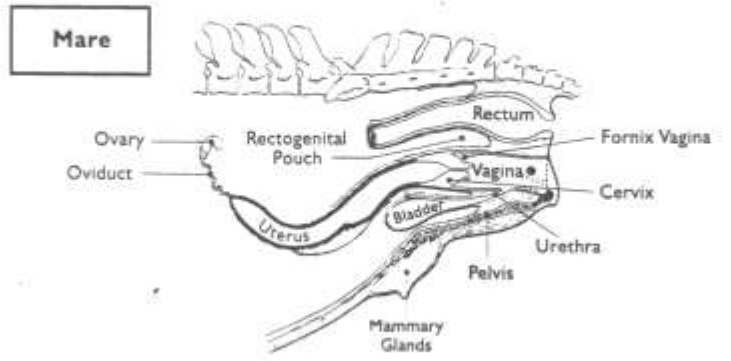
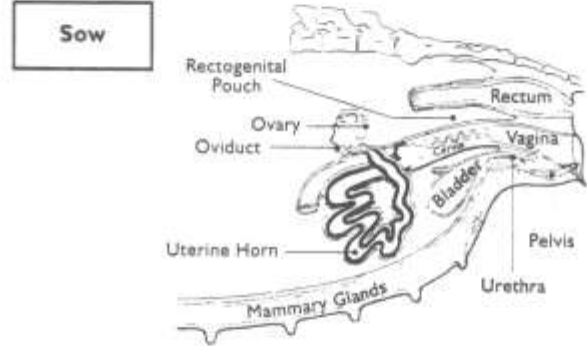
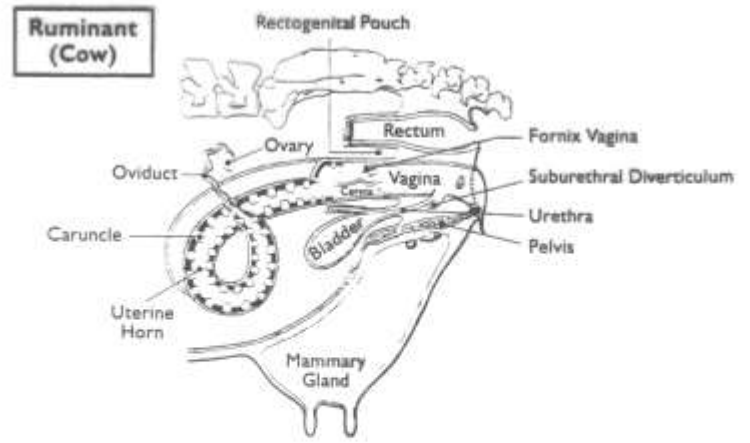
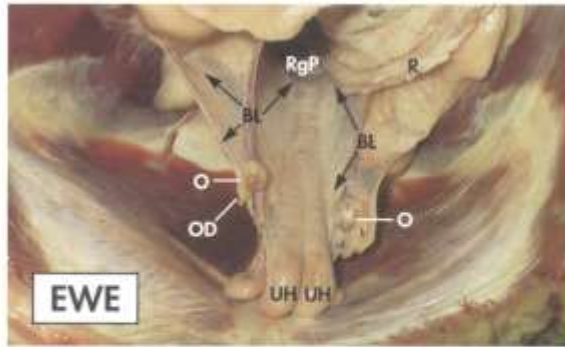
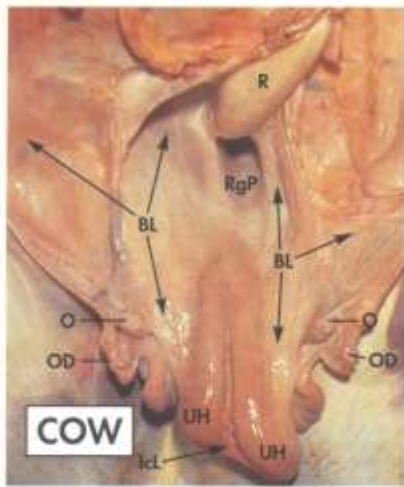
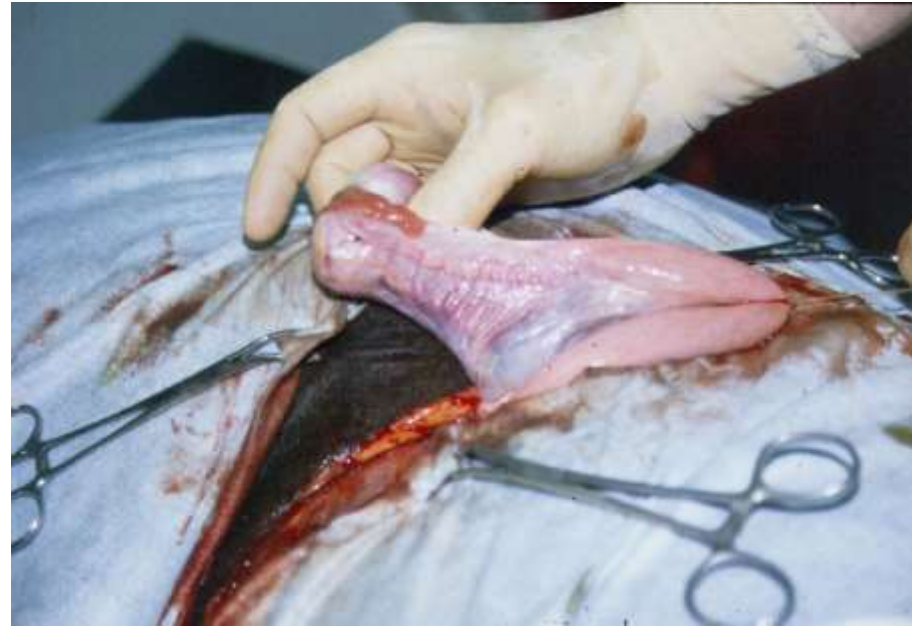


Figure 2-7. Caudal view of the cow, ewe, sow and mare (mare with permission from Günther, O. J.; see additional reading) reproductive tracts *in situ*. Intestines have been removed so that the reproductive tract is in full view. The tract is suspended by the broad ligament (BL) which is attached dorsally and is continuous with the peritoneum. BL = Broad Ligament; Icl = Intercornal Ligament; O = Ovary; OD = Oviduct; R = Rectum; RgP = Rectogenital Pouch; UH = Uterine Horn.

2-1. The reproductive organs in the ruminant (cow as an example), sow and mare as seen from midsagittal. Note the relationship of the tract to the rectum. Modified from Ellenberger and Baum (1943), *Handbuch der vergleichenden Anatomie der Haustiere*, 18th Edition, Zietzschmann, Ackerknecht and Grau, eds. Permission from er-Verlag, New York.

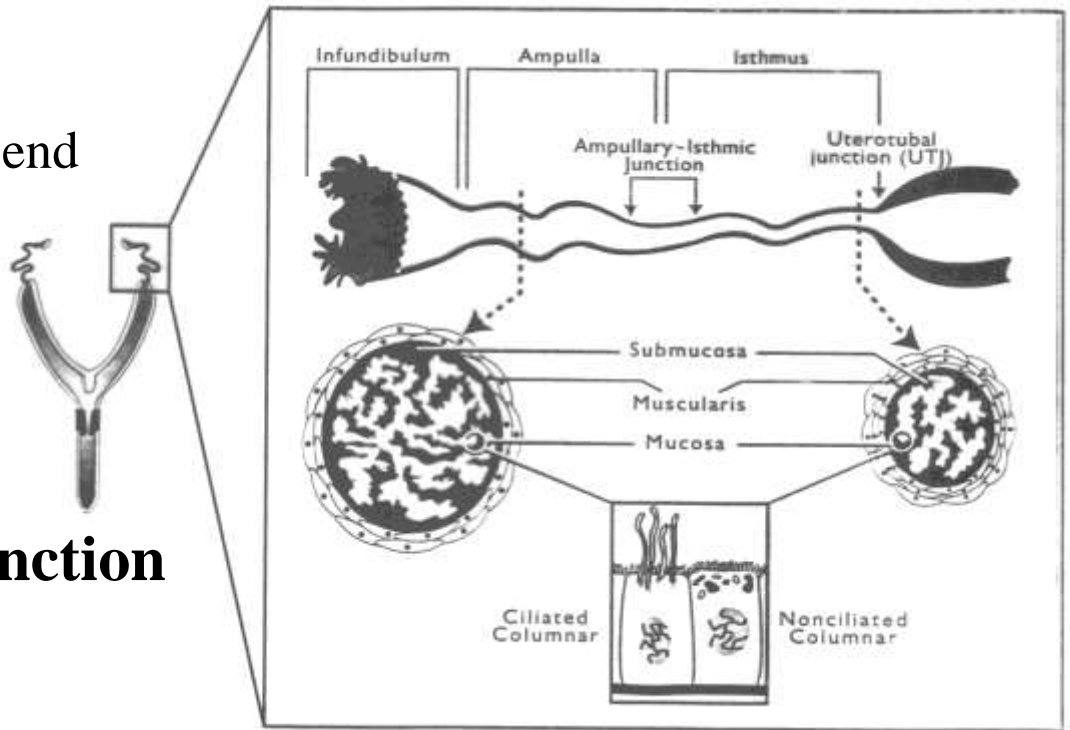
# Oviduct or Fallopian Tube

- **Supported by mesosalpinx**
  - **Open pouch or bursa for ovary; differs among species**
- **Functions**
  - **Ovum transport**
  - **Sperm storage & capacitation**
  - **Fertilization**
  - **Embryonic development**
- **Ciliated epithelial cells**
  - **Transport**
- **Nonciliated epithelial cells**
  - **Secretory**



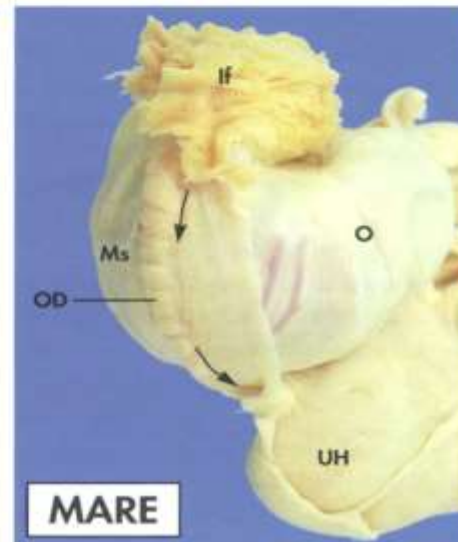
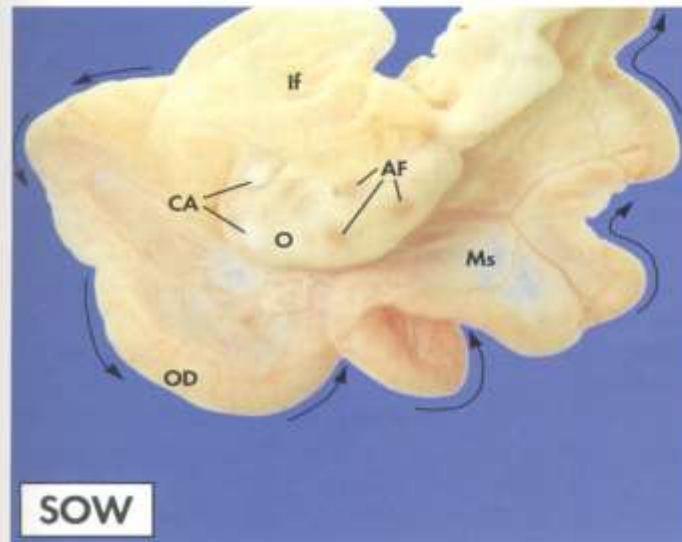
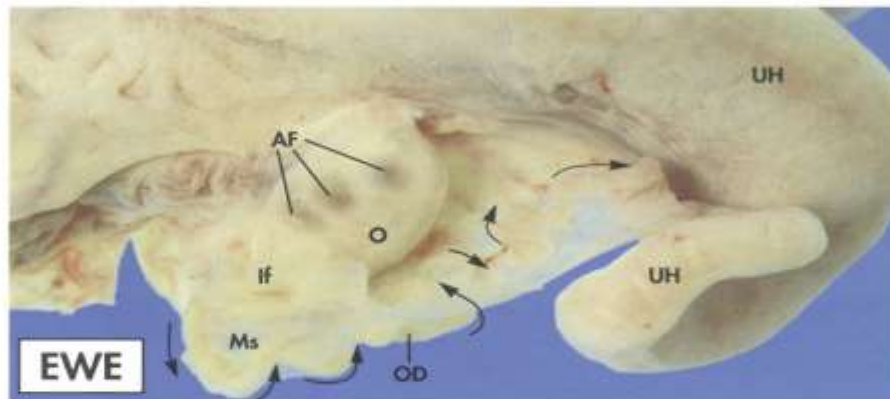
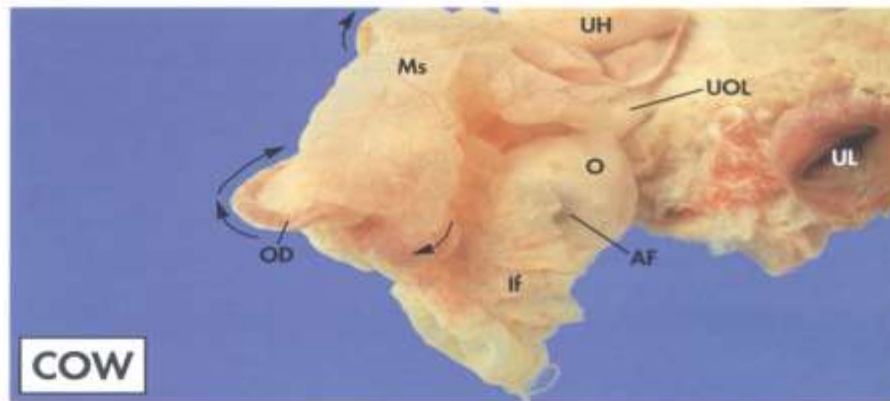
# Oviductal Anatomy

- **Infundibulum**
  - Funnel-shaped proximal end
  - Fimbriae
  - Captures ova
- **Ampulla**
  - Ovum transport
- **Ampullary-Isthmic Junction**
  - Site of fertilization
- **Isthmus**
  - Sperm reservoir
  - Early embryonic development



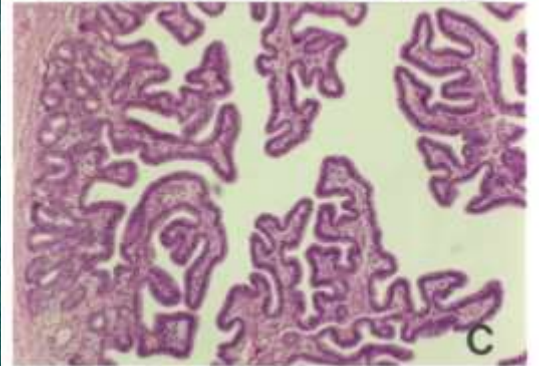
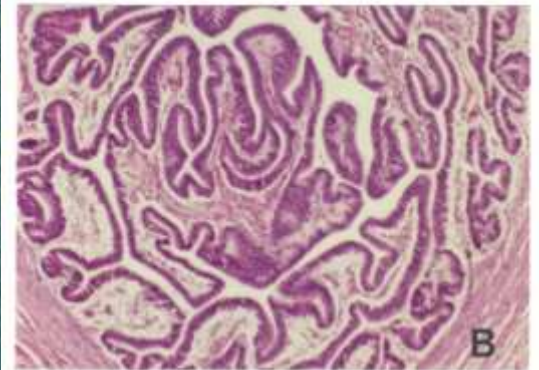
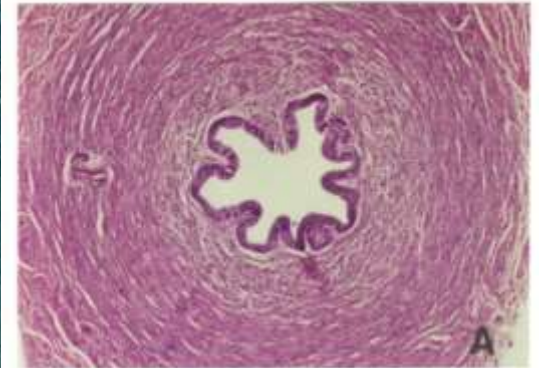
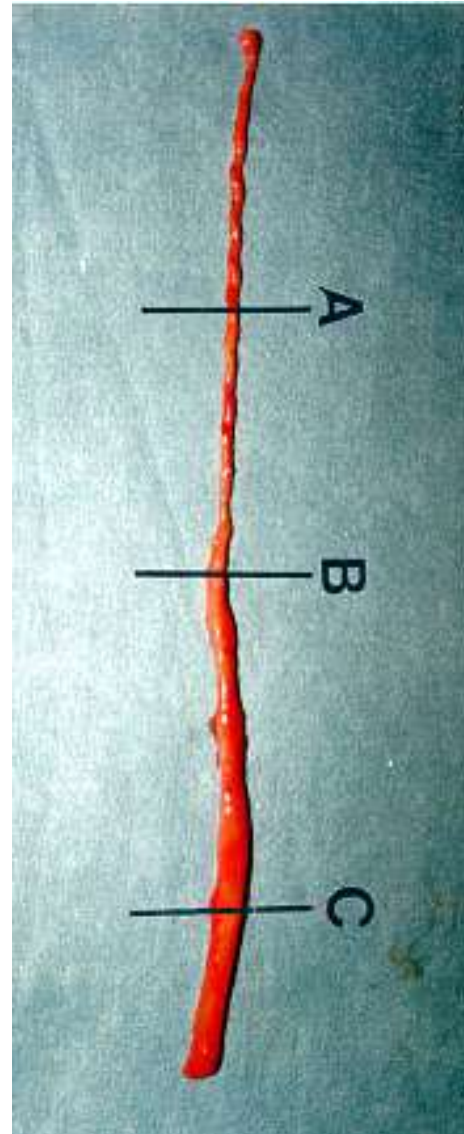
**Figure 2-10.** Relationship of the mesosalpinx to the oviduct in the cow, ewe, sow and mare. The infundibulum is a delicate membrane-like component of the oviduct, which is in close apposition to the ovary. Arrows indicate the direction of oocyte /embryo transport within the oviduct toward the uterus.

AF = Antral Follicle  
 CA = Corpus Albicans  
 If = Infundibulum  
 Ms = Mesosalpinx  
 O = Ovary  
 OD = Oviduct  
 UH = Uterine Horn  
 UOL = Utero-Ovarian Ligament  
 UL = Uterine Lumen



# Oviductal Secretory Proteins

- **Organ specific**
- **Region specific**
- **Cycle specific**
  - Quantitative & qualitative differences
- **Interaction with**
  - Ova
  - Embryos
  - Spermatozoa
- **Growth factors**

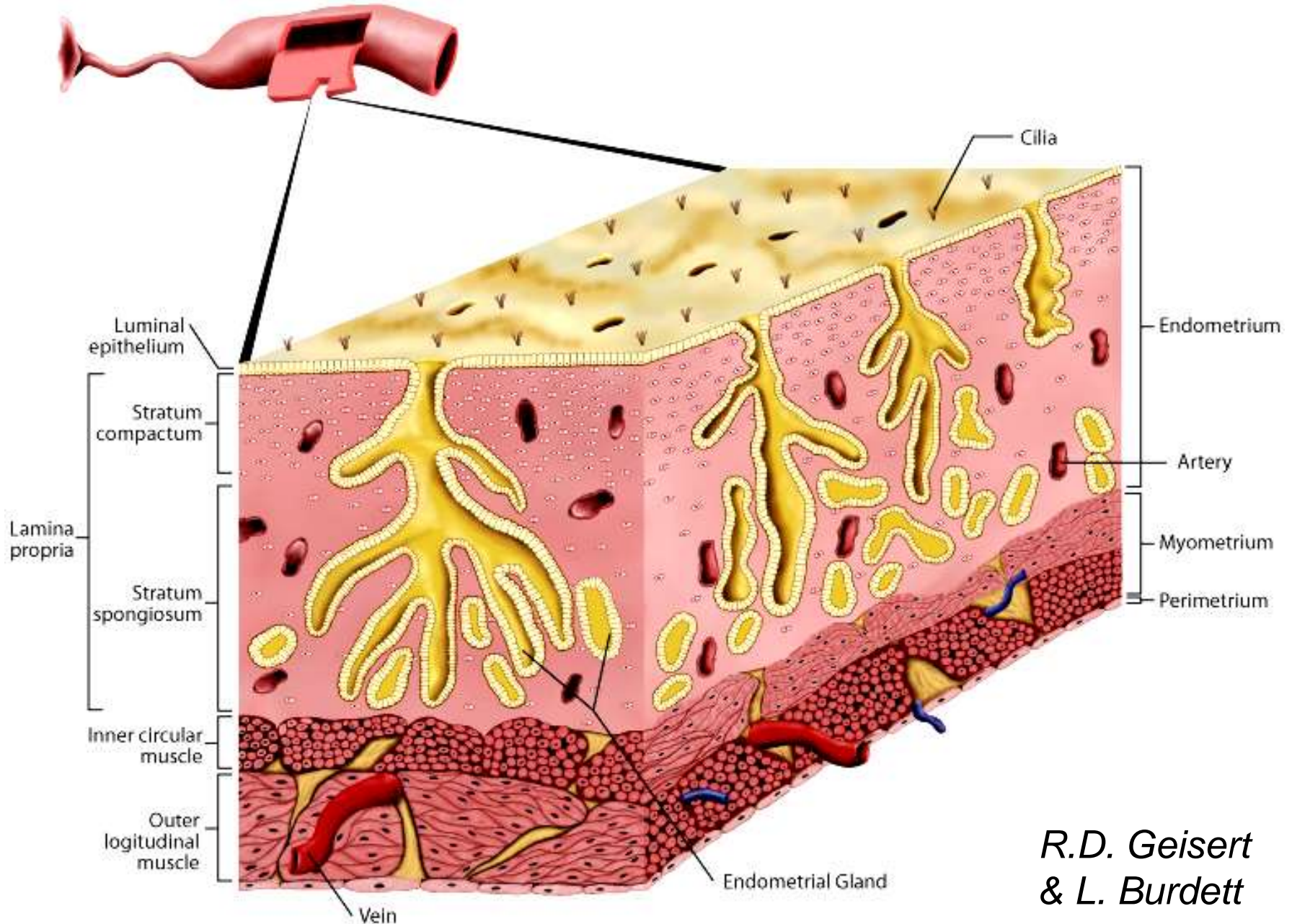


# Tubo-uterine Junction

- **Valve-like structure**
- **Regulates passage of**
  - **Embryos to uterus**
  - **Spermatozoa to oviduct**
  - **Other substances: block to entry into the oviduct**
- **Area of accumulation of sperm for movement into the oviduct**

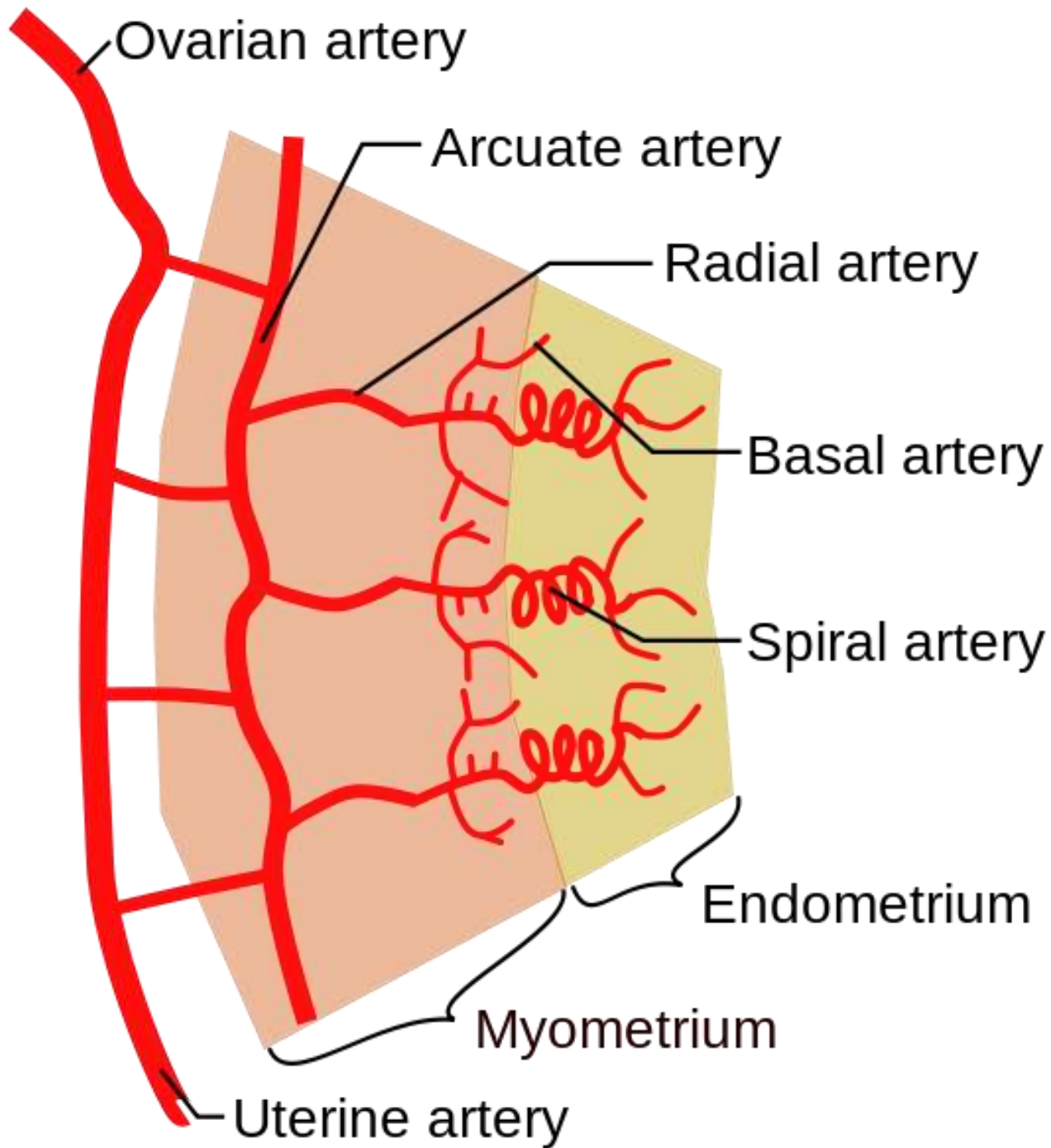


# Uterine Histoarchitecture



*R.D. Geisert  
& L. Burdett*





# Functions of the Uterus

- **Primary functions**
  - **Sperm transport to oviducts**
  - **Luteolysis & control of cyclicity**
  - **Development of the conceptus**
  - **Maternal contribution to placenta**
  - **Expulsion of fetus and fetal placenta**

# Uterus

- **Unique nomenclature**
  - **Serosa = perimetrium**
  - **Muscularis = myometrium**
  - **Mucosa + submucosa = endometrium**
    - **Luminal Epithelium**
    - **Superficial Glandular Epithelium**
    - **Glandular Epithelium**
- **Most species have two uterine horns (cornua)**
  - **Classification based on degree of development of uterine body**

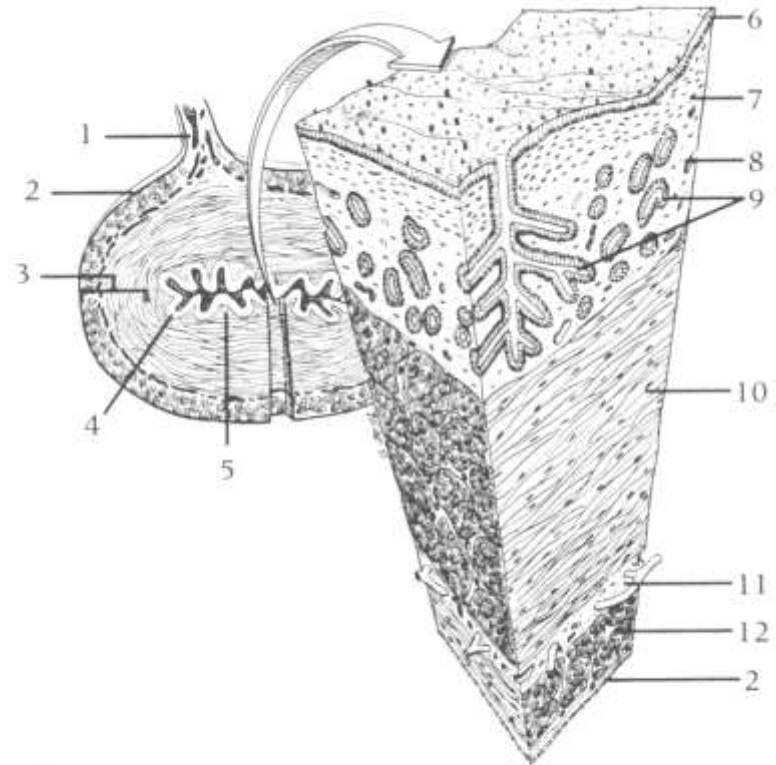
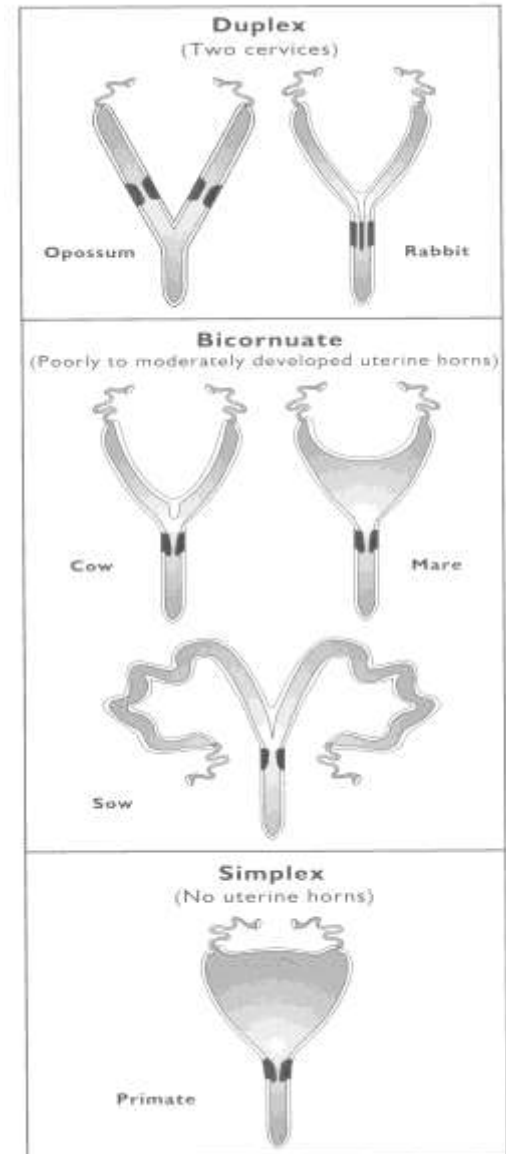


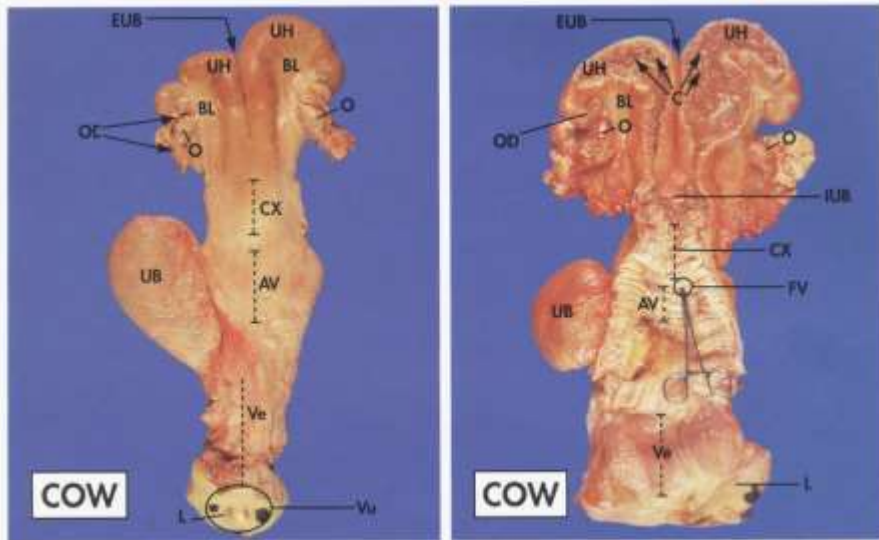
FIG. 1–7. Cross section of uterine horn. 1, Mesometrium; 2, perimetrium; 3, myometrium; 4, endometrium; 5, collagenous connective tissue core; 6, surface epithelium; 7, compact layer of lamina propria; 8, spongy layer of lamina propria; 9, endometrial glands; 10, internal (circular) layer of myometrium; 11, middle (vascular) layer of myometrium; 12, external (longitudinal) layer of myometrium.

# Uterine Classification

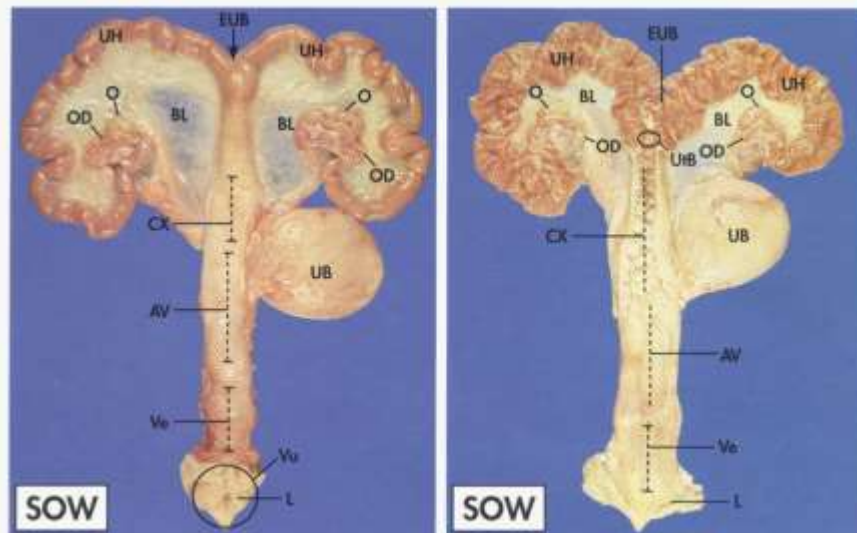
- **Duplex**
  - marsupials, lagomorphs, rodents
  - 2 cervices, 2 separate horns, no uterine body
  - Facilitates multi-sire and multi-treatment experiments
- **Bicornate (cow/ewe/mare)/Bipartite (sow)**
  - Moderate fusion (bipartite)
  - cow, ewe, doe, mare
    - 1 cervix, 2 uterine horns, 1 uterine body
  - Minimal fusion
  - sow, bitch, queen
    - 1 cervix, 2 uterine horns, 1 short uterine body
- **Simplex**
  - primates
  - 1 cervix, no uterine horns, prominent body



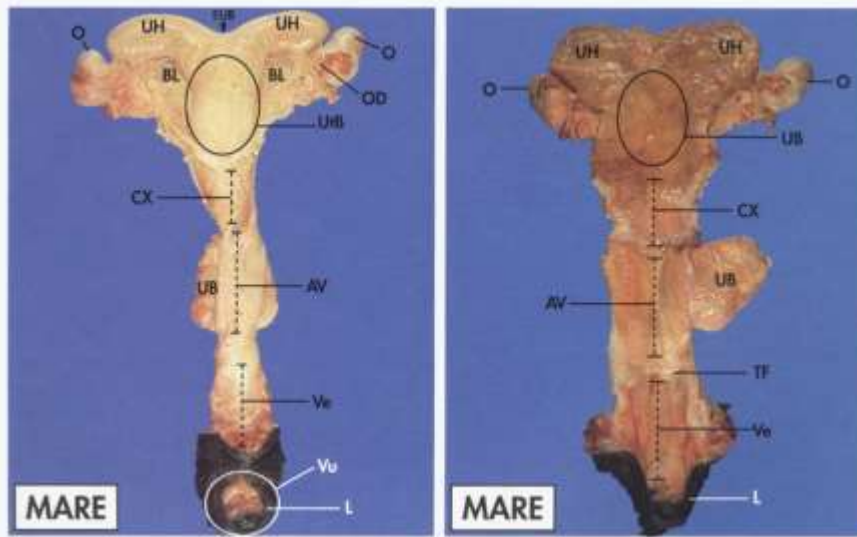
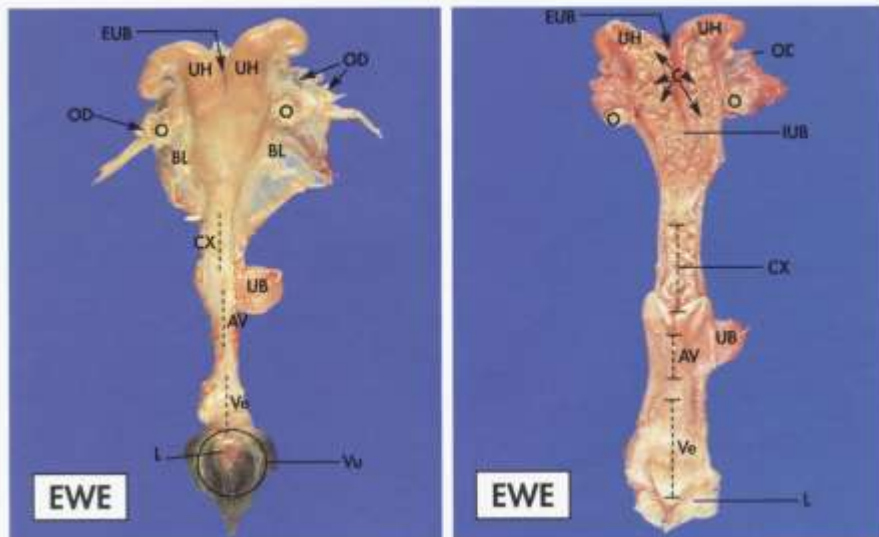
# Uterine Anatomy



**Figure 2-2.** Dorsal view of excised reproductive tracts from the cow and ewe. Left panels are intact. Specimens in the right panels have been opened to expose the interior of the tract. AV = Anterior Vagina; BL = Broad Ligament (mesometrial portion); C = Caruncle; CX = Cervix; EUB = External Uterine Bifurcation; IUB = Internal Uterine Bifurcation; L = Labia; O = Ovary; OD = Oviduct; UB = Urinary Bladder; UH = Uterine Horn; Ve = Vestibule; Vu = Vulva. Tip of forceps is in fornix vagina.



**Figure 2-3.** Dorsal view of excised reproductive tracts from the sow and mare. Left panels are intact specimens. Specimens in the right panels have been opened to expose the interior of the tract. AV = Anterior Vagina; BL = Broad Ligament (mesometrial portion); CX = Cervix; EUB = External Uterine Bifurcation; L = Labia; O = Ovary; OD = Oviduct; TF = Transverse Fold; UB = Urinary Bladder; UHB = Uterine Body; UH = Uterine Horn; Ve = Vestibule; Vu = Vulva.

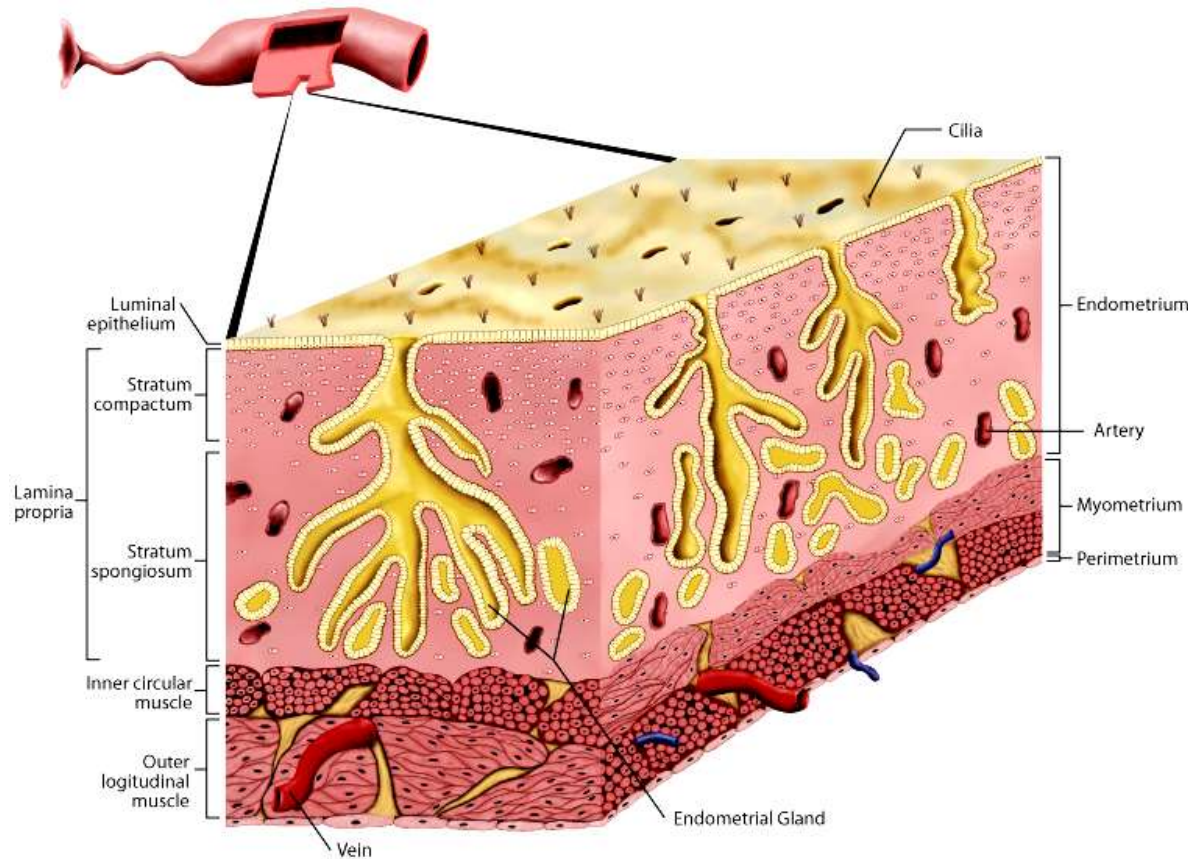


# Subprimate vs Primate Mammals: Distinctions Regarding Tubal Pregnancy and Regulation of Lifespan of the Corpus Luteum (CL)

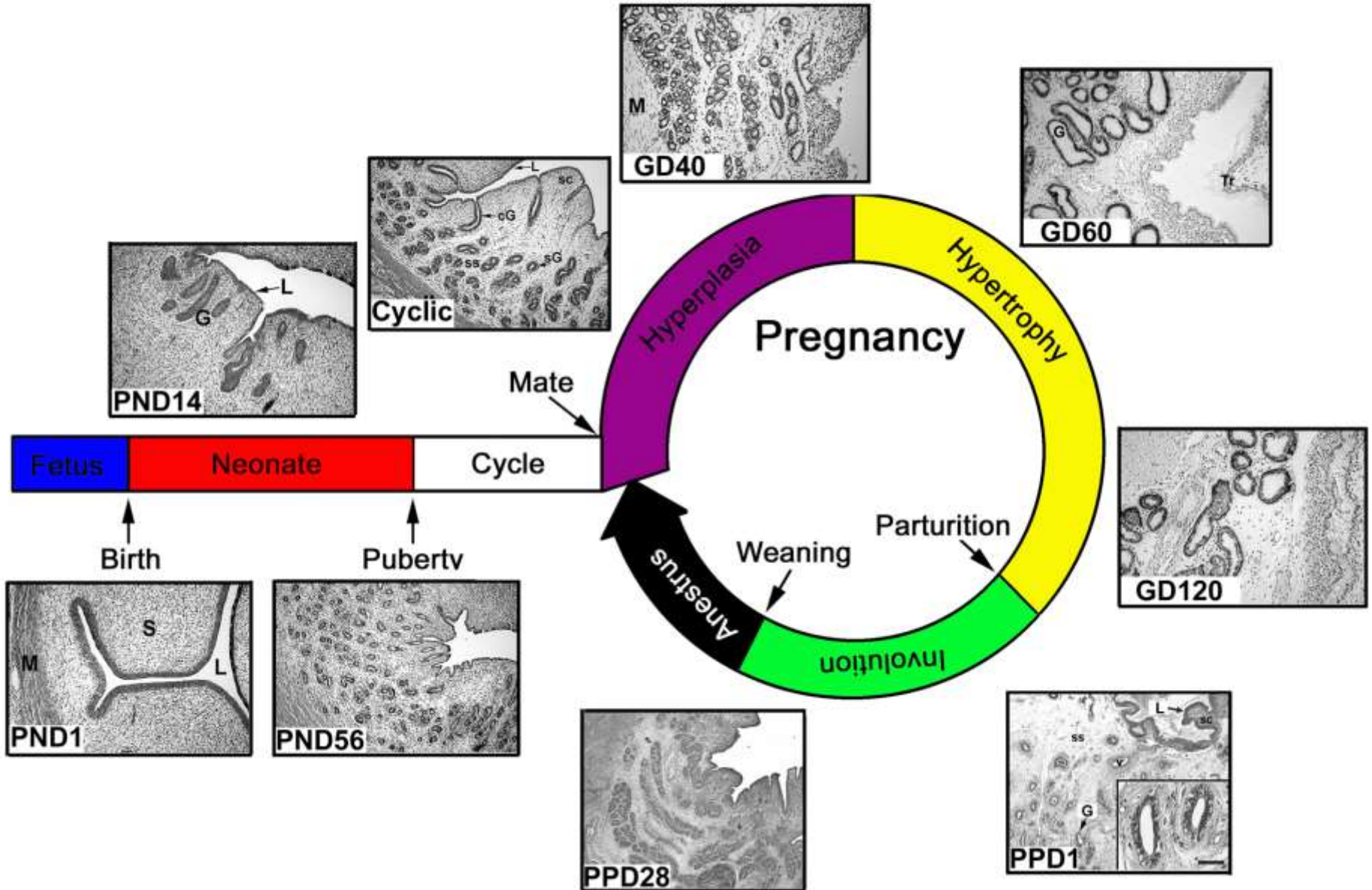
- Primates
  - Tubal Pregnancy
  - Uterine Independent Menstrual Cycles
- Subprimates
  - No Tubal Pregnancy
  - Uterine Dependent Estrous Cycles

# Endometrium

- Mucosa + submucosa
  - Epithelia
    - Luminal
  - Endometrial Glands
    - Glandular Epithelia
    - Superficial Glandular Epithelium
  - Blood vessels
  - Lymphatics
  - Stroma
    - Stratum Compactum
    - Stratum Spongiosum



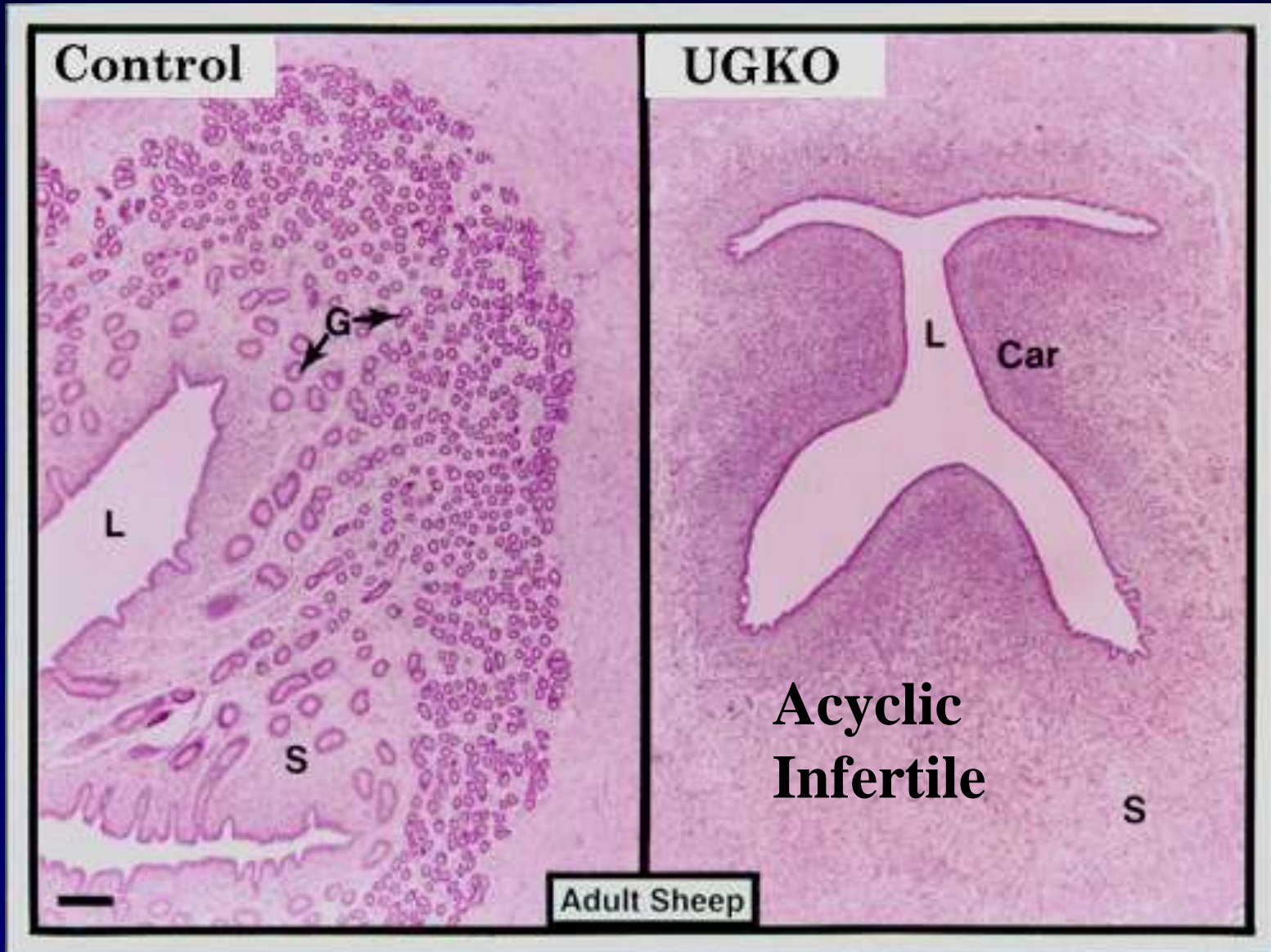
# Uterine Gland Life Cycle in Sheep





# Progestins Inhibit Endometrial Adenogenesis

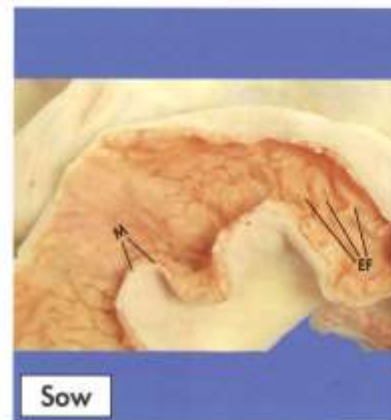
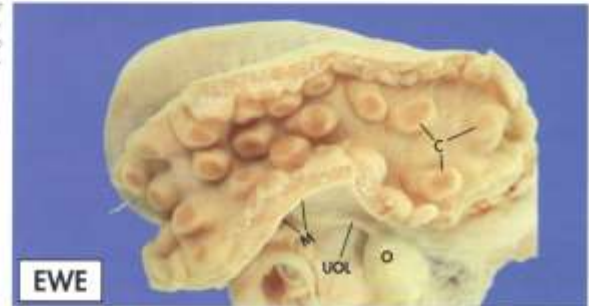
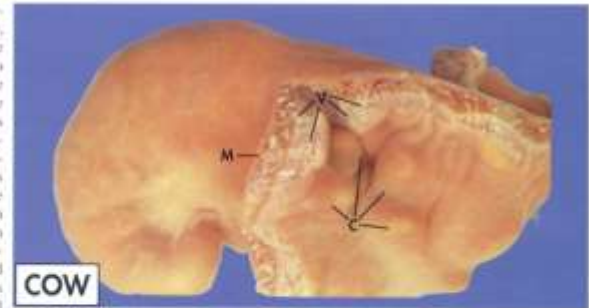
## No Glands, No Histotroph, No Pregnancy



# Comparative Anatomy

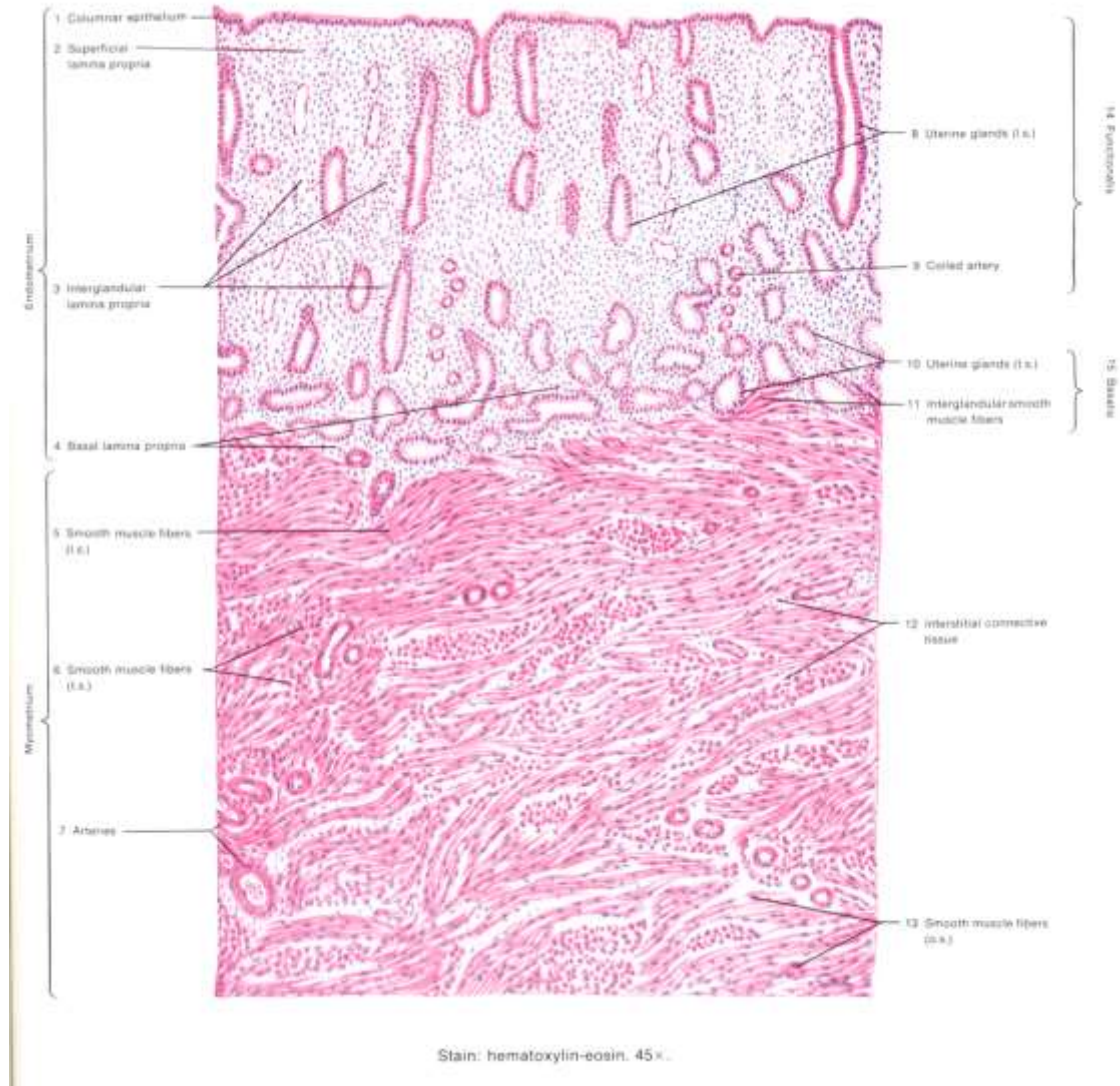
- Ruminants
  - Caruncles
    - Devoid of glands
    - Maternal portion of placentome
    - Vascular sites of attachment to Cotyledons – the vascular fetal portion of placentome
- Sow and Mare
  - Endometrial folds
- Primates
  - Very dynamic
  - Cyclic sloughing of endometrium (menstruation)

Figure 2-13, Excised uterine tissue from the cow, ewe, sow and mare. The uterus has been opened so that the endometrial surface can be visualized. In the cow and the ewe, caruncles (C) can be observed as protrusions from the endometrial surface. Blood vessels (V) are white, cord-like structures located beneath the surface of each caruncle. The endometrium of the sow and mare is characterized as having many endometrial folds (EF). Both the caruncles and the endometrial folds contribute to the maternal placenta if pregnancy occurs.  
C = Caruncles  
EF = Endometrial Folds  
M = Myometrium  
O = Ovary  
UOL = Utero-Ovarian Ligament  
V = Blood Vessels



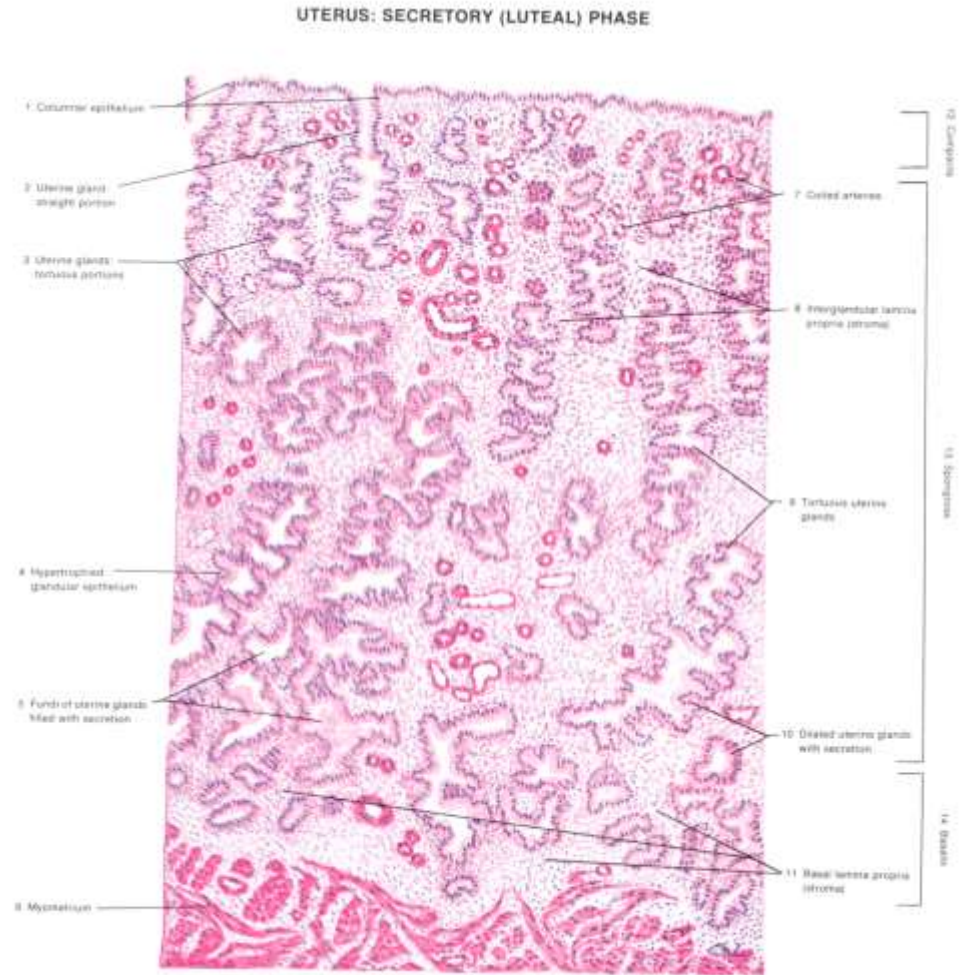
# Human Endometrium

## UTERUS: PROLIFERATIVE (FOLLICULAR) PHASE



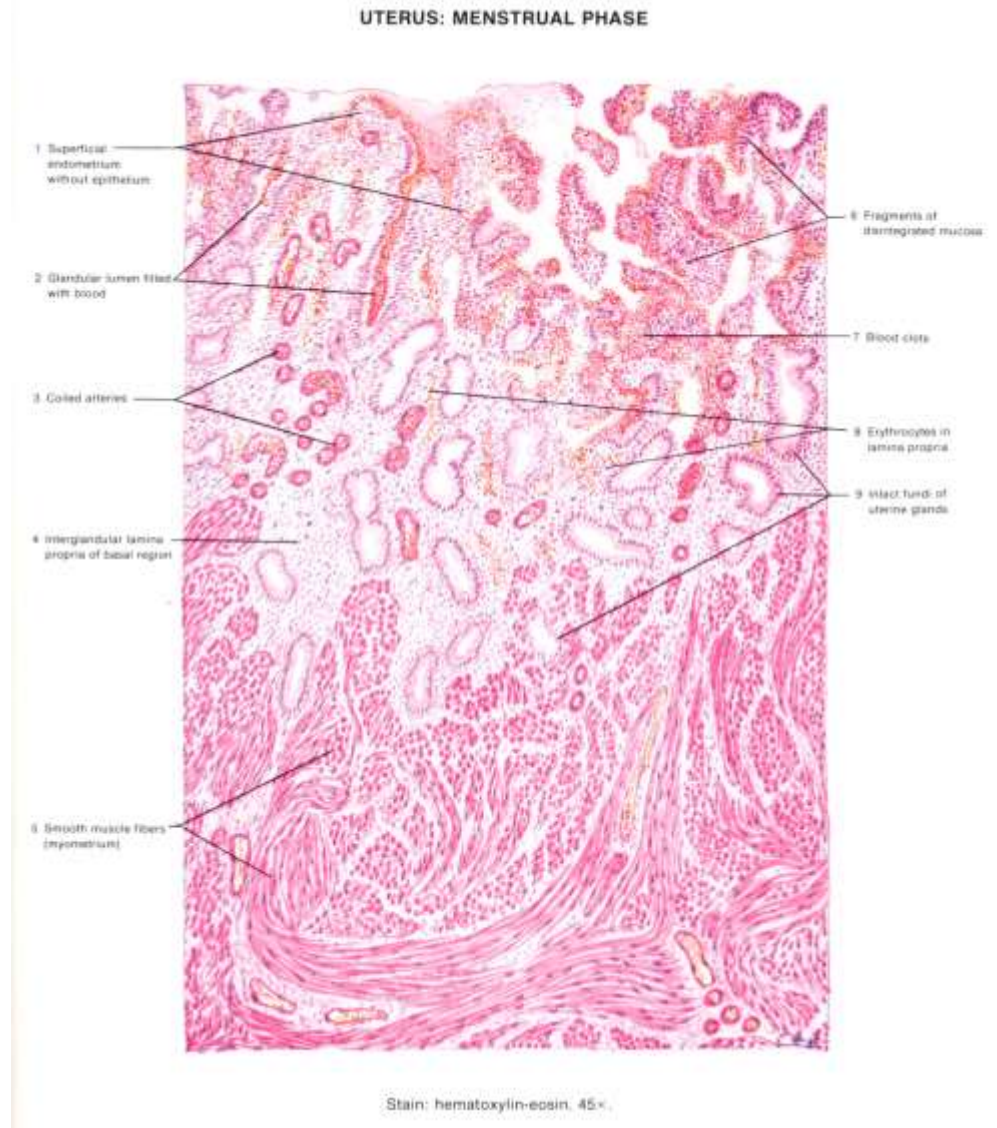
# Human Endometrium

- Secretory Phase
  - Endometrial thickening
    - Glands
      - ↑ secretory activity
      - ↑ distention
      - ↑ tortuosity
    - Stromal edema
    - Coiled arteries more superficial



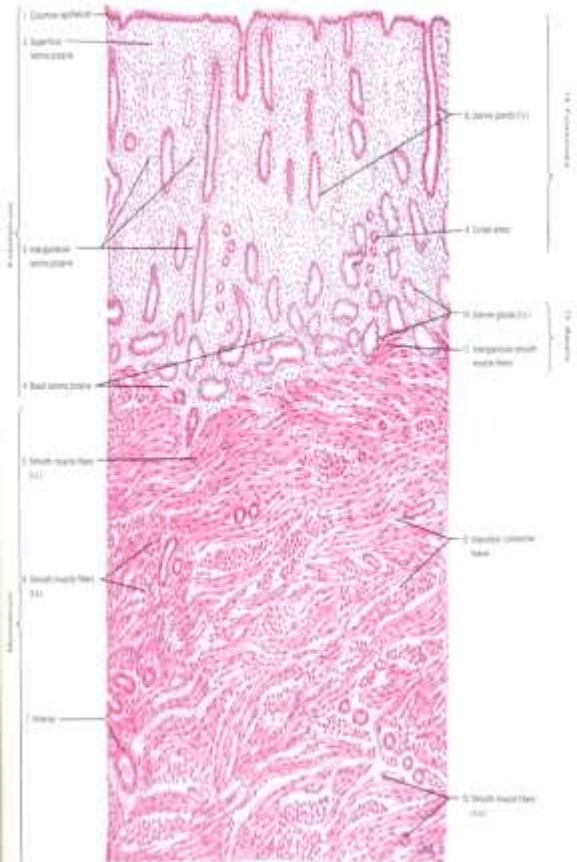
# Human Endometrium

- Menstrual Phase
  - Loss of superficial:
    - Epithelium
    - Glands
    - Stroma
    - Vessels
      - Necrosis
  - Deeper structures intact



# Human Endometrium

UTERUS: PROLIFERATIVE (FOLLICULAR) PHASE



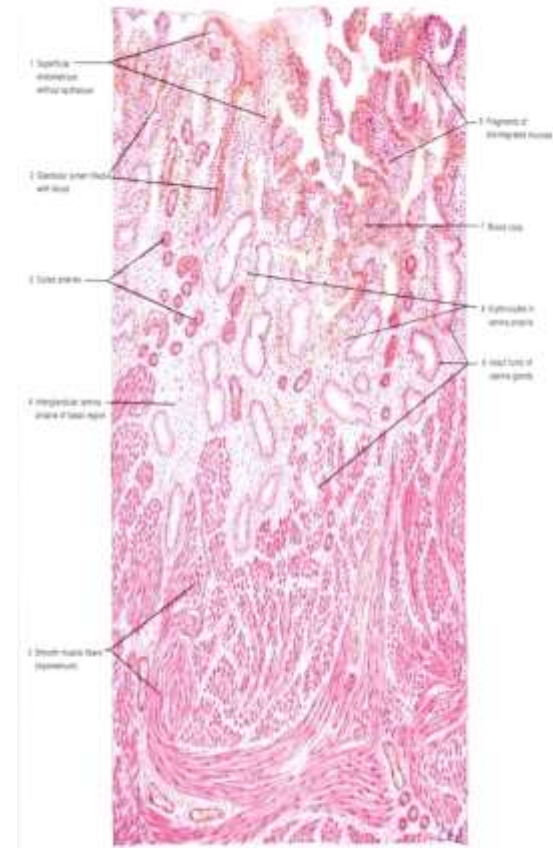
Stain: hematoxylin-eosin (H&E)

UTERUS: SECRETORY (LUTEAL) PHASE



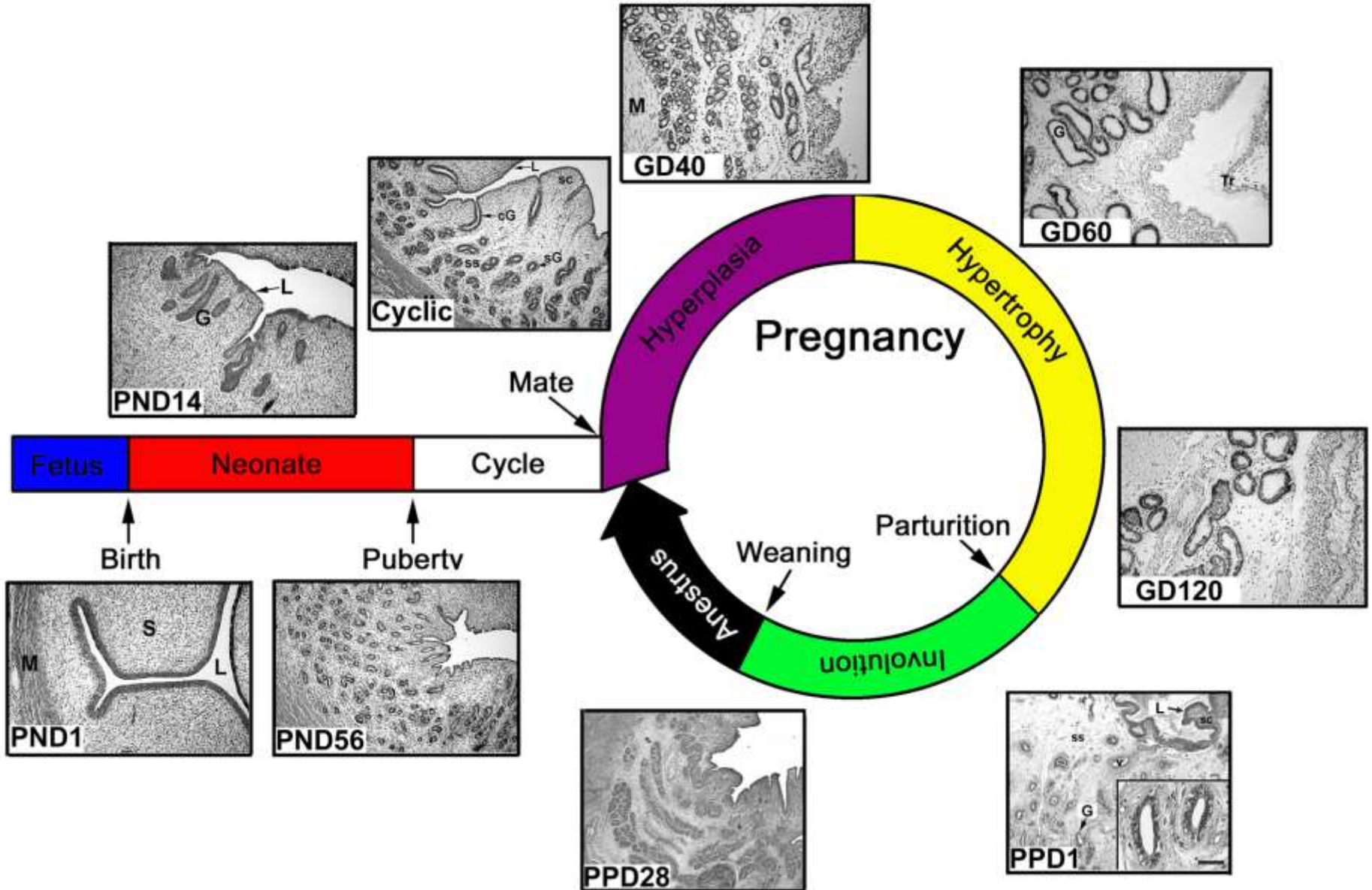
Stain: hematoxylin-eosin (H&E)

UTERUS: MENSTRUAL PHASE



Stain: hematoxylin-eosin (H&E)

# Uterine Gland Life Cycle in Sheep



# Uterine Prostaglandins

- Produced by endometrium
  - Arachidonic acid
  - Specific timing for pulsatile PGF release – estradiol and oxytocin
  - Uterine irritation/infection
- Luteolytic
  - Vascular spasm
  - Direct effect on luteal cells
- CL sensitivity
  - Timing
    - Mare, cow, ewe, doe vs sow
  - Dose
    - Sow & ruminants vs mare
      - Vascular anatomy

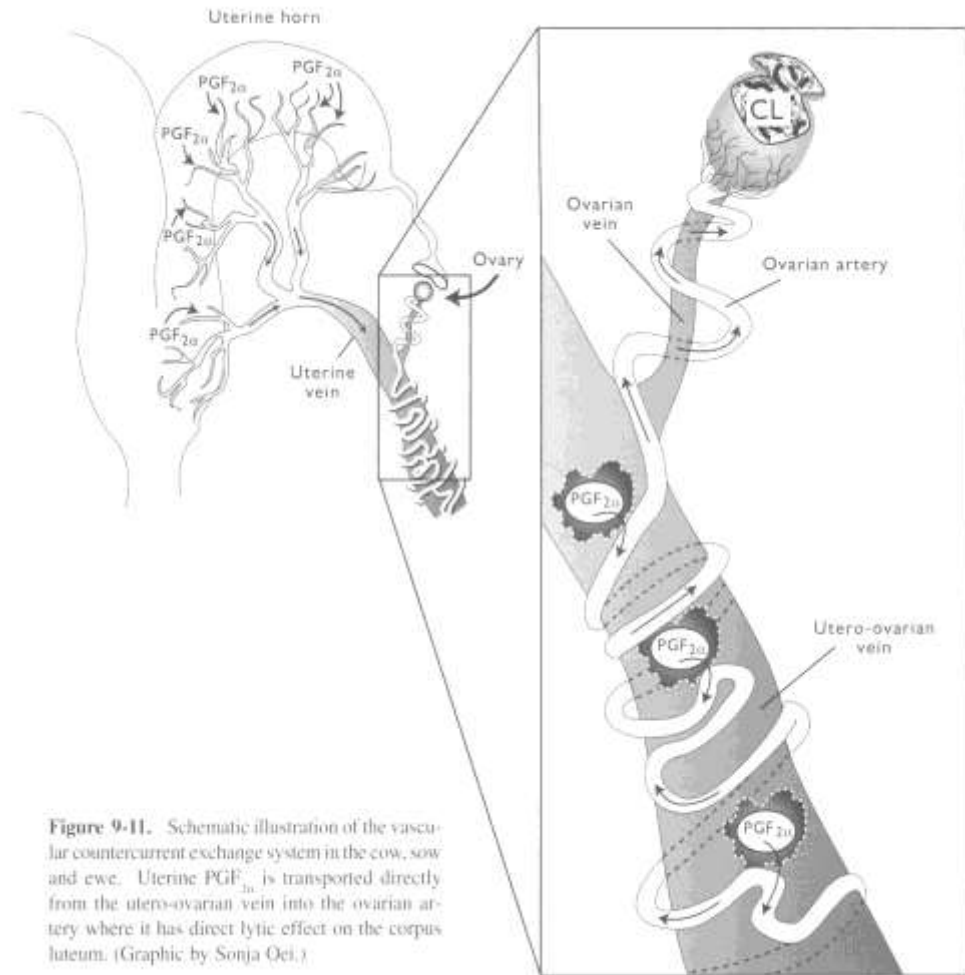
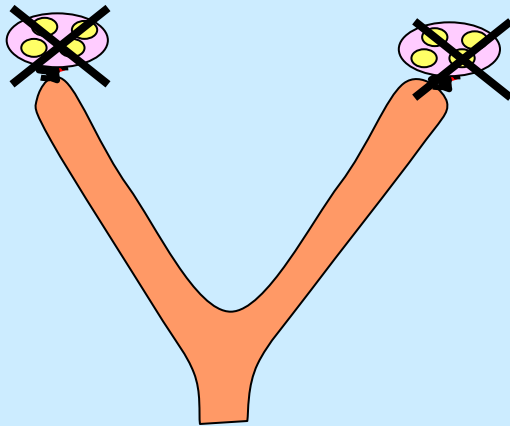
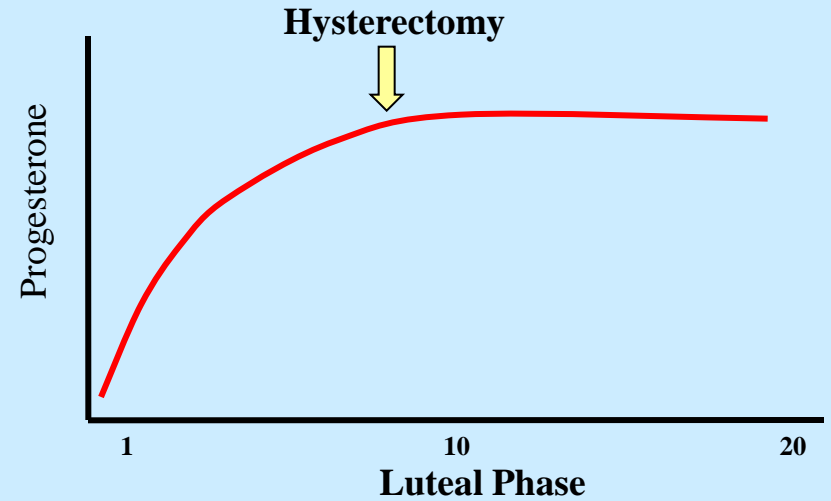
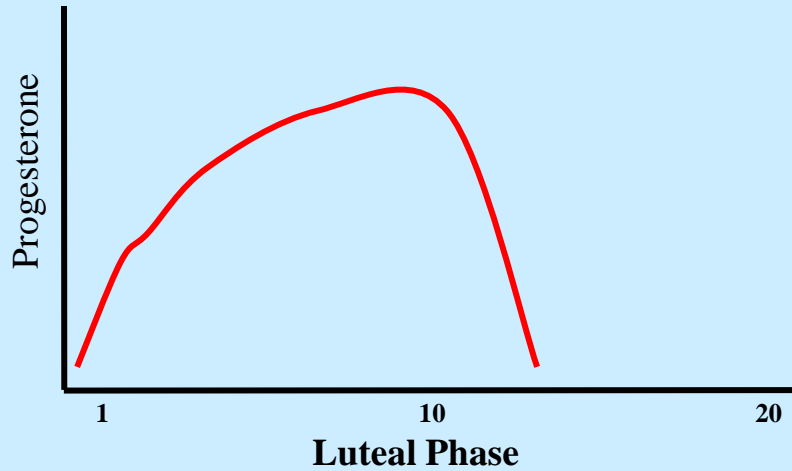


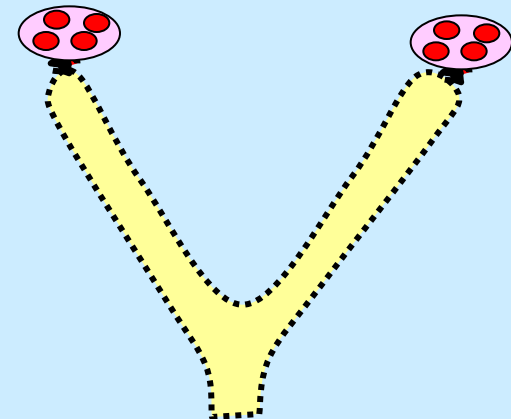
Figure 9-11. Schematic illustration of the vascular countercurrent exchange system in the cow, sow and ewe. Uterine PGF<sub>2α</sub> is transported directly from the utero-ovarian vein into the ovarian artery where it has direct luteolytic effect on the corpus luteum. (Graphic by Sonja Oei.)



# The Uterus Regulates the Life Span of the Corpus Luteum.

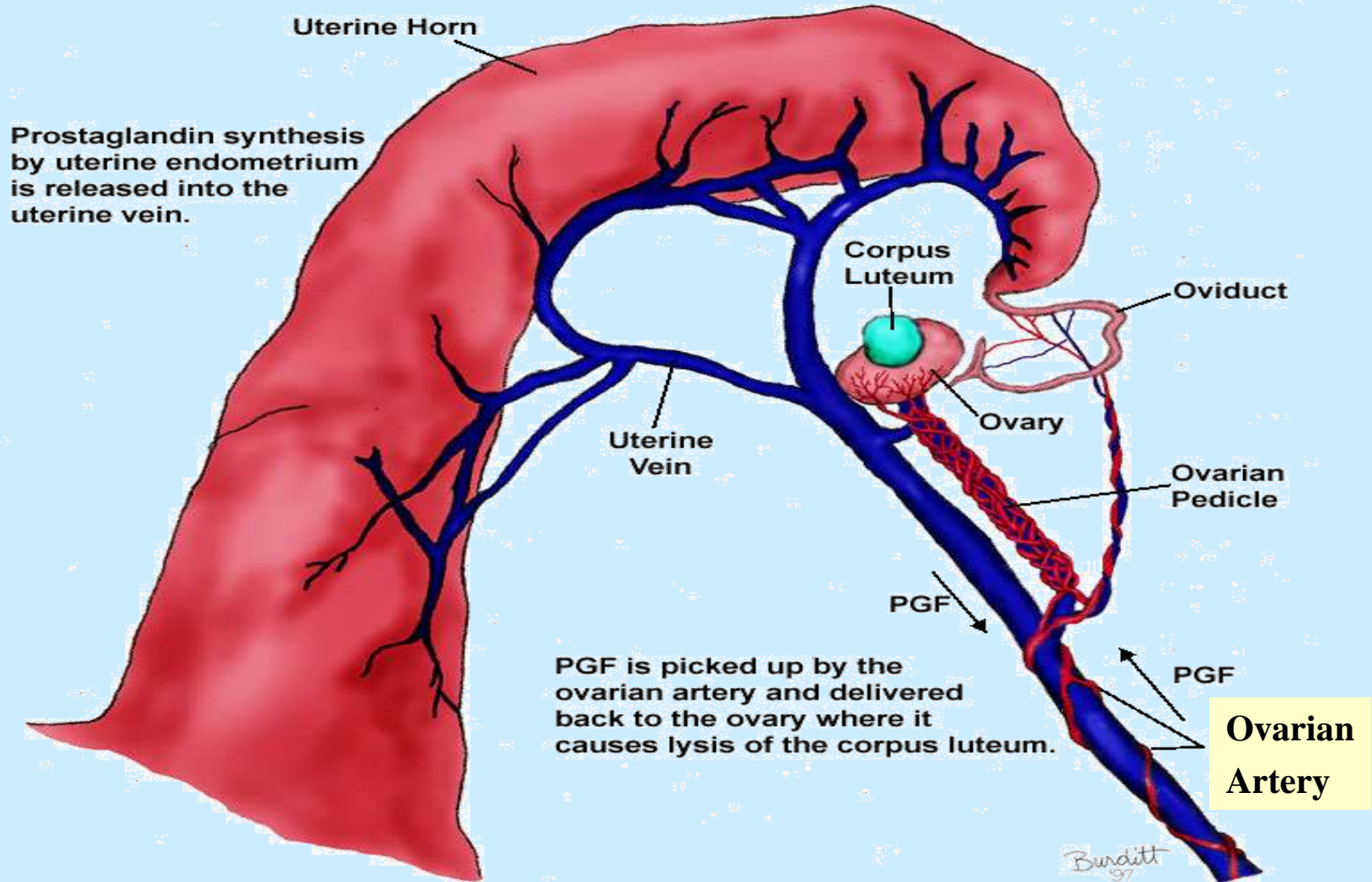


Intact Animal



Hysterectomized Animal

# Uterus-Ovary Connection



# Cervix

- Separates uterus & vagina
- Muscular organ w/constricted lumen
  - Well developed circular muscle
  - Many elastic fibers
  - Highly folded mucosa
  - Mucous cells in epithelium
    - Thick tenacious mucus
    - Cervical plug
  - Species variation
    - Anatomy
    - Physiology
- Seals to protect uterus
- Ferguson Reflex

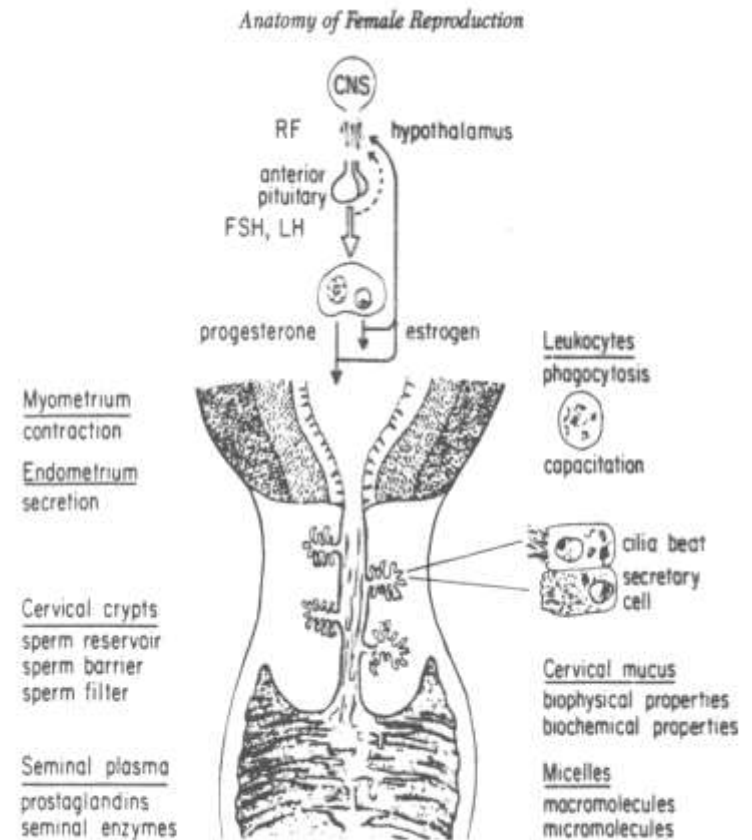
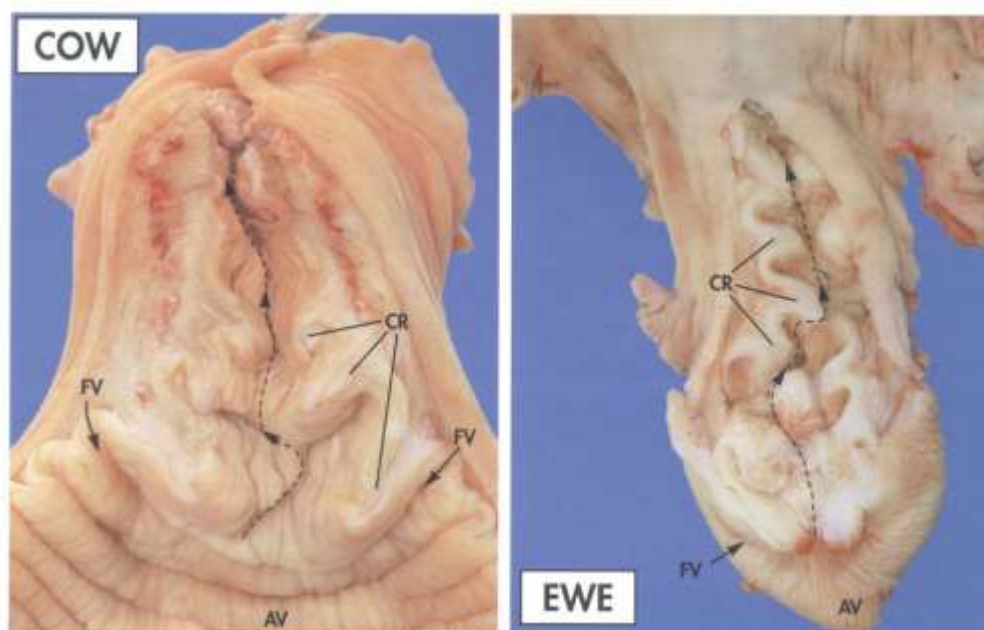
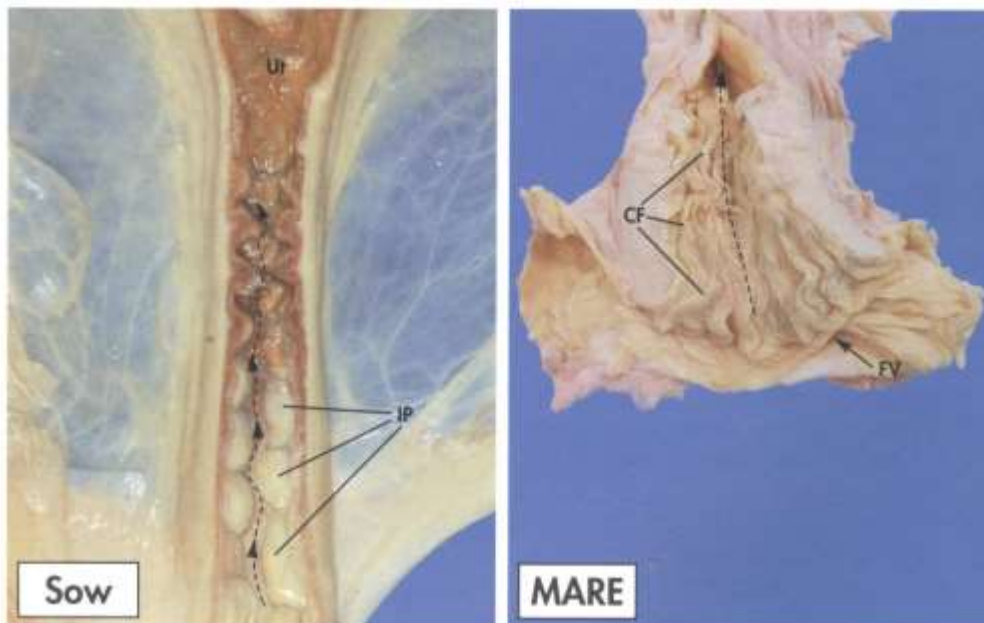


FIG. 2-24. Comparative aspects of the anatomy and physiology of the cervix.

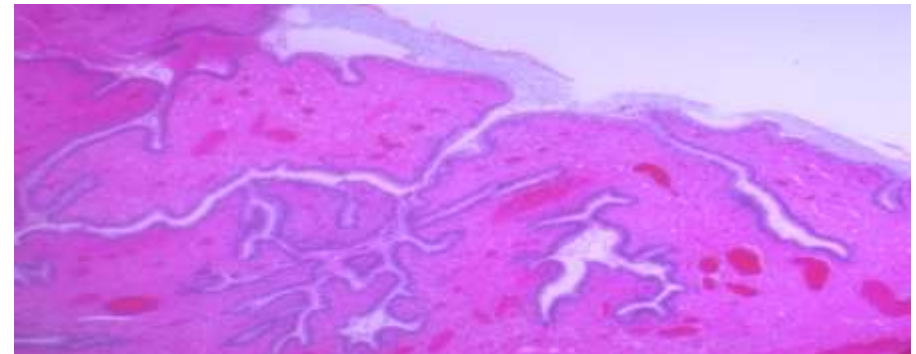
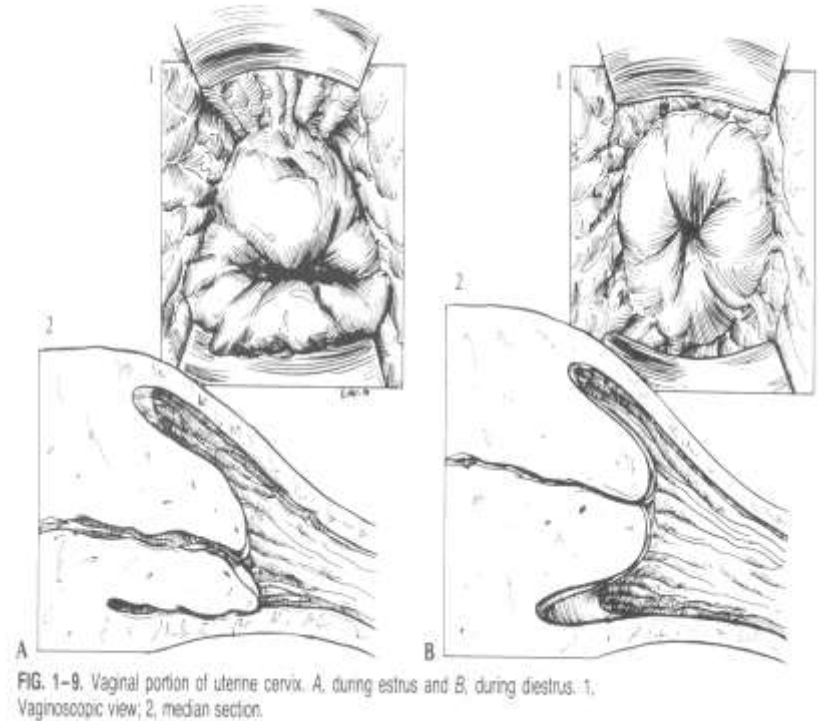


**Figure 2-15.** Excised cervical tissue from the cow, ewe, sow and mare. The cervix of the cow and ewe have distinct, well developed protrusions called cervical rings (CR). The sow has interdigitating prominences (IP). The mare has no cervical rings but has many longitudinal cervical folds (CF) which are continuous with the endometrial folds of the uterus. Arrows indicate the pathway of the cervical canal from the anterior vagina (AV) toward the uterus. AV = Anterior Vagina; CF = Cervical Folds; CR = Cervical Rings; FV = Fomix Vagina; IP = Interdigitating Prominences; Ut = Uterus.



# Cervix of the Mare

- Dramatic cyclic changes
  - Length
  - Diameter
  - Tone
- No mucous glands
- Simple muscular ring
  - Easily dilated



# Vagina & Vestibule

- Female copulatory organ
- Vagina
  - From cervix to hymen
  - Fornix
    - Recess around cervix
    - Absent in sow and bitch
  - Mucosa undergoes cyclic changes
    - Used to stage cycle in bitch
- Vestibule
  - Hymen to vulva
  - Urethral orifice
  - Suburethral diverticulum
    - Cow & sow

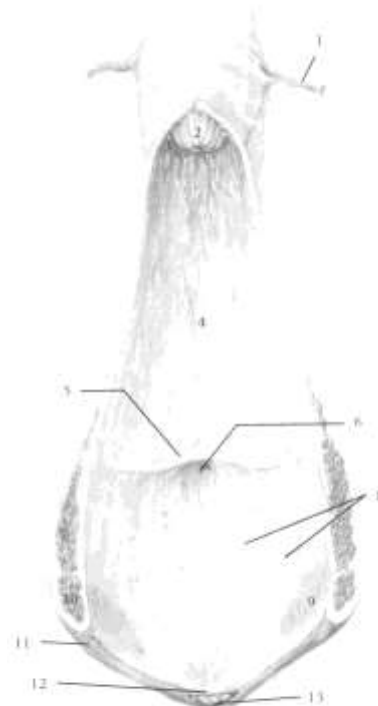


FIG. 1-8. Dorsal view of opened vagina and vulva: 1, Vaginal artery; 2, vaginal portion of cervix; 3, vagina fornix; 4, ventral vaginal wall; 5, transverse fold; 6, urethral orifice; 7, vestibular constrictor muscle; 8, orifices of vestibular glands; 9, locus of submucosal vestibular bulb; 10, vulvar constrictor muscle; 11, vulvar labium; 12, transverse perineal fold (clitoral prepuce); 13, clitoral glans.

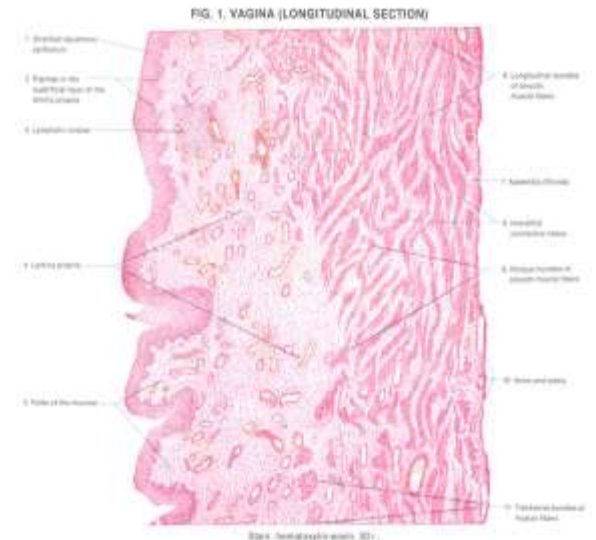
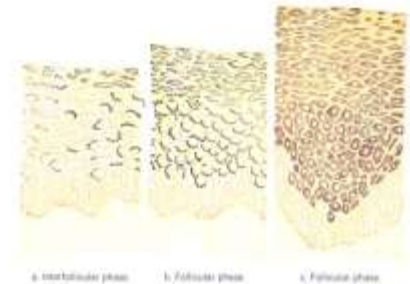


FIG. 2. GLYCOGEN IN HUMAN VAGINAL EPITHELIUM



Stain: Mennel's toluidine technique.

# Vulva & Clitoris

- Vulva

- Labia

- Humans

- Labia minora
      - Labia majora

- Commissures

- Two constrictor muscles

- Constrictor vulvae

- Striated
      - posterior

- Constrictor vestibuli

- Smooth
      - anterior

- Clitoris

- Homologue of penis

- Erectile tissue

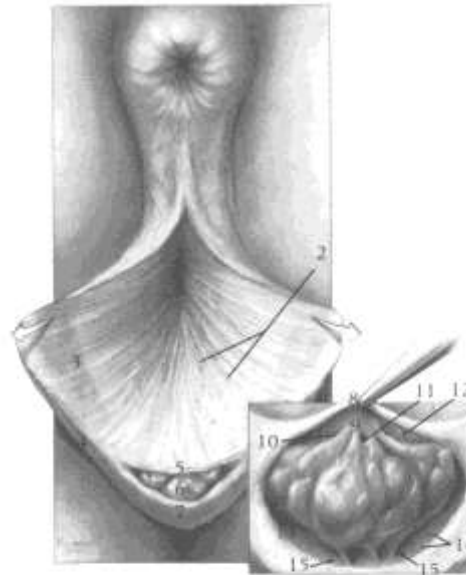


FIG. 1–10. View of vulva and vestibule through parted vulvar labia. 1, Dorsal commissure; 2, orifices of vestibular glands; 3, location of vestibular bulb (beneath darker mucous membrane); 4, vulvar labium; 5, transverse frenular fold (clitoral prepuce); 6, clitoral glans; 7, ventral commissure. Inset: clitoral glans. 8, Transverse frenular fold retracted; 9, frenulum; 10, openings of lateral sinuses; 11, opening of median sinus; 12, locations of frenular sinuses; 13, clitoral fossa; 14, labial recesses; 15, locations of ventral sinuses. (Locations of sinuses adapted in part from McAllister, R.A., and Sack, W.D.: Identification of anatomic features of the equine clitoris as potential growth sites for *Taylorella equigenitalis*. J. Am. Vet. Med. Assoc., 196:1965–1966, 1990.)

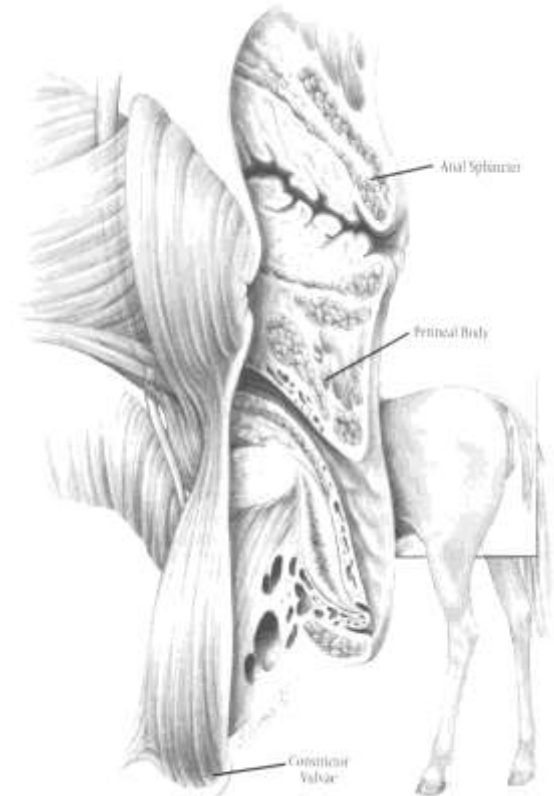


FIG. 2–1. Caudolateral and median cross section of the mare's perineum. (Courtesy of G.W. Thoder and B.R. Evans, Colorado State University.)