



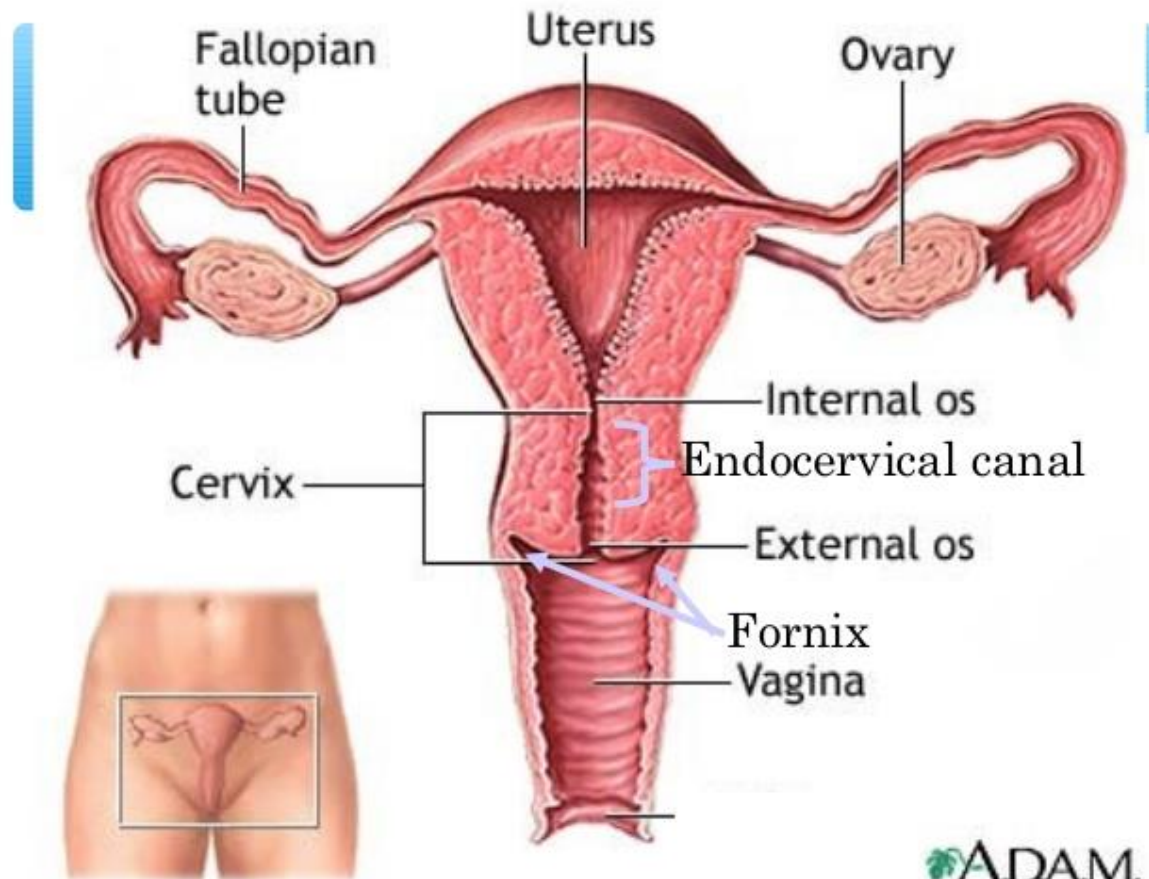
КАЗАНСКИЙ (ПРИВОЛЖСКИЙ) ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ

The Female Reproductive System



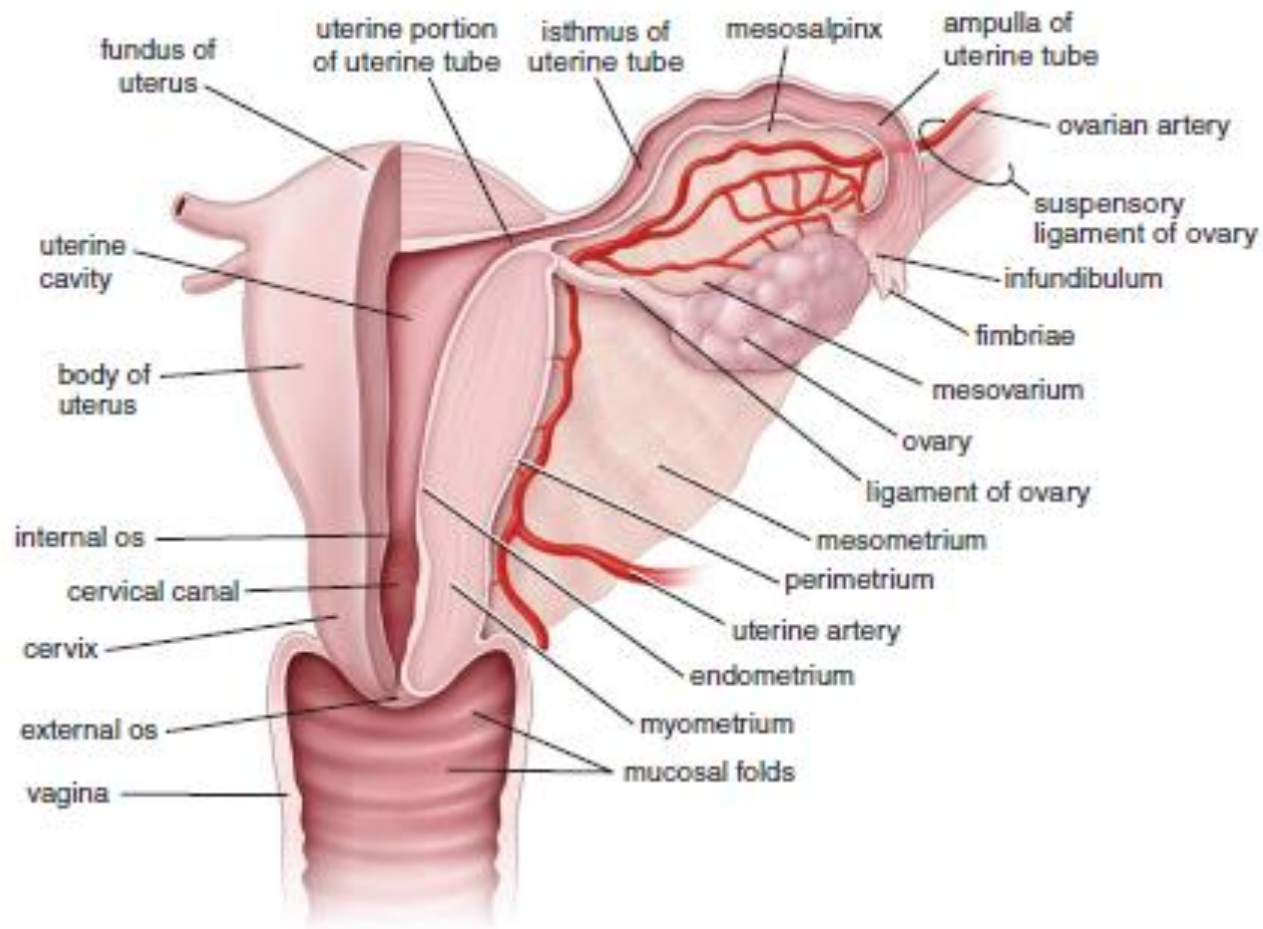
The Female Reproductive System

The female reproductive system consists of internal genital organs and external genitalia



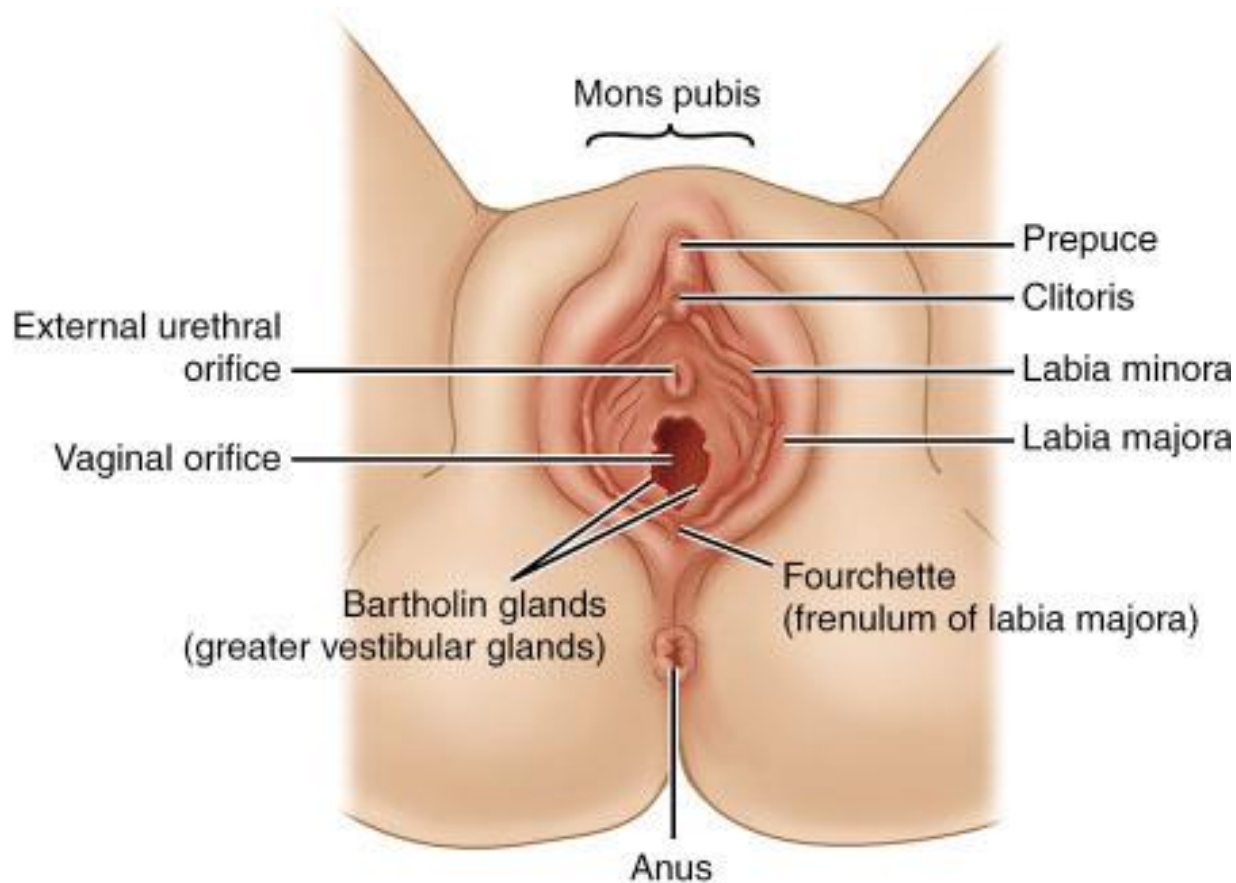
The internal female reproductive organs

- ovaries, uterine tubes, uterus, and vagina



The external genitalia

- mons pubis, labia majora and minora, clitoris, vestibule and opening of the vagina, and external urethral orifice



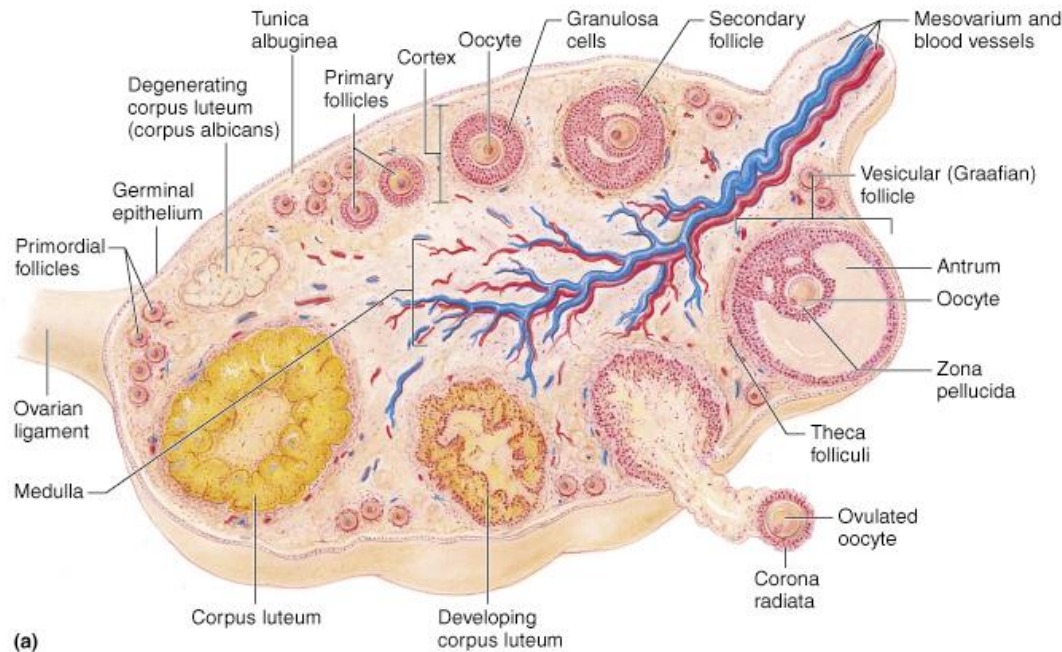
Functions

Organ	Function
Ovary	Produce ova Produce hormones: estrogen and progesterone
Fallopian tubes	Catches ova and transports it to the uterus
Uterus	Site of implantation and developing of the embryo Formation of placenta
Vagina	Entry of sperm and exit of baby at birth

Ovarian Structure

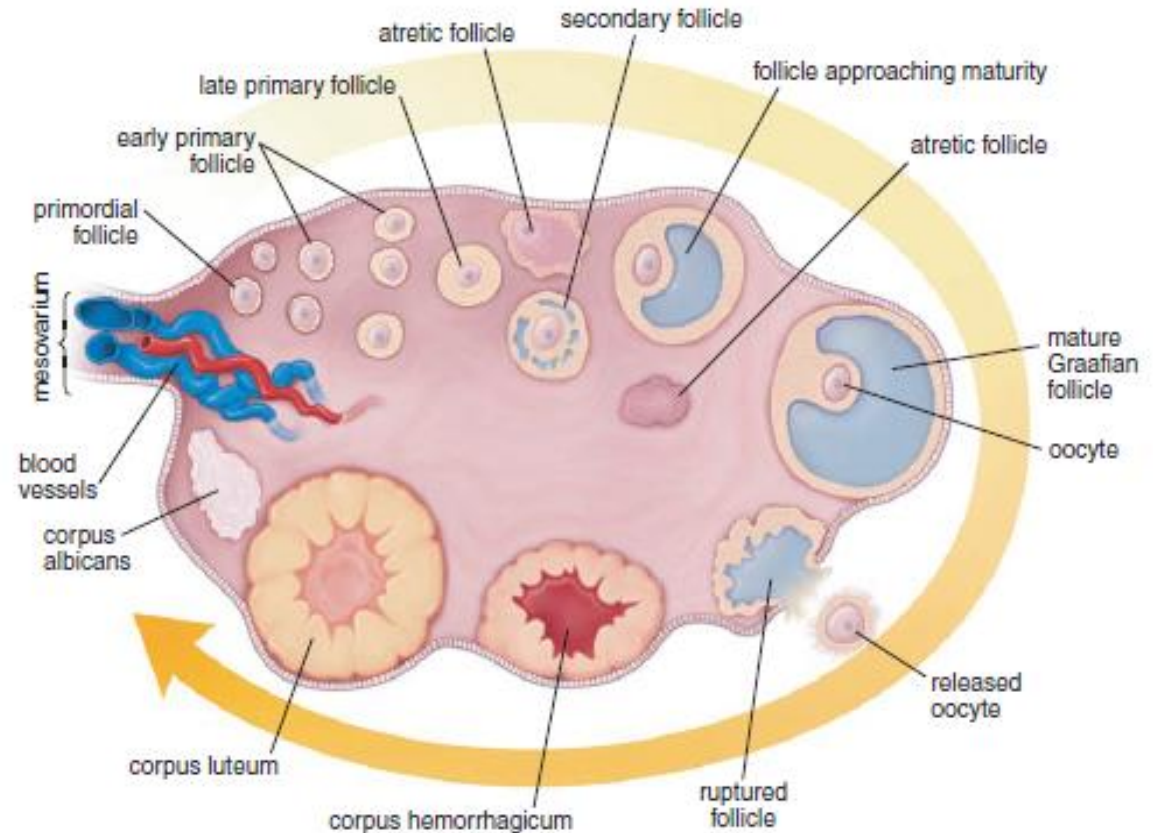
- The **medulla** or **medullary region** - the central portion of the ovary, contains loose connective tissue, blood vessels, lymphatic vessels, and nerves
- The **cortex** or **cortical region** - the peripheral portion of the ovary surrounding the medulla. The cortex contains the **ovarian follicles** embedded in a richly cellular connective tissue
- **“Germinal epithelium”** (simple cuboidal epithelium) instead of mesothelium covers the ovary

Tumors that arise from the epithelial surface of the ovary account for more than 70% of ovarian cancers. The origin of surface epithelial tumors may be related to repeated disruption and repair of the germinal epithelium that occurs during ovulations.



Production of gametes and steroid hormones are the two major functions of the ovary.

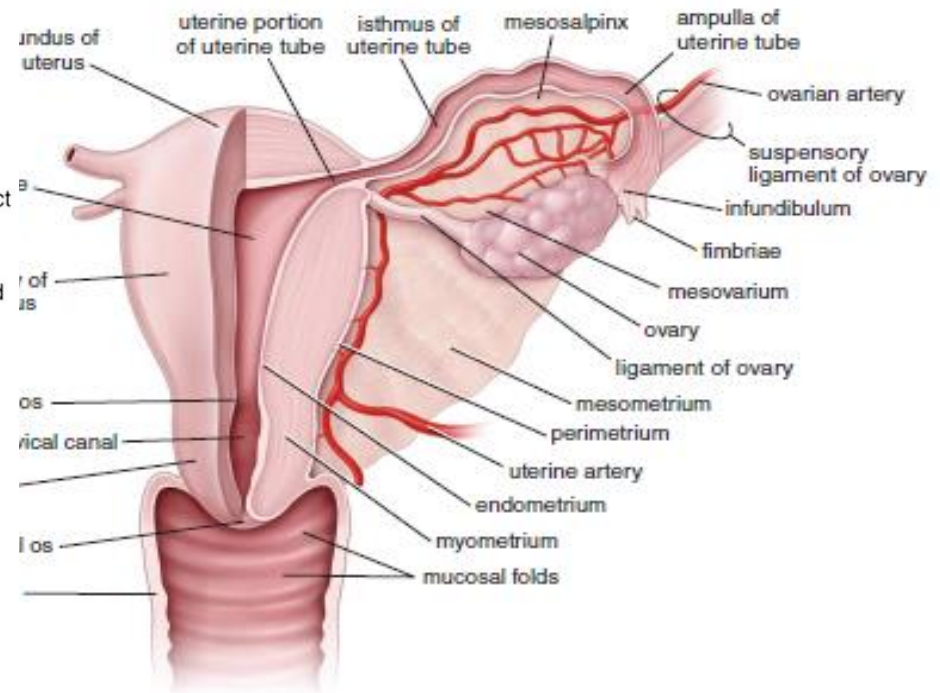
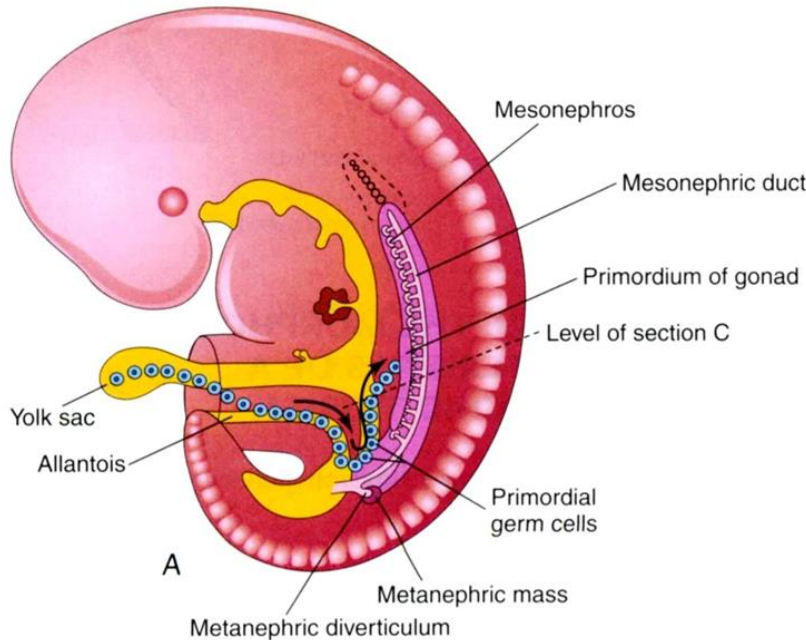
- **Oogenesis** - production of gametes
- **Oocytes** - developing gametes
- **Ova** - mature gametes are called



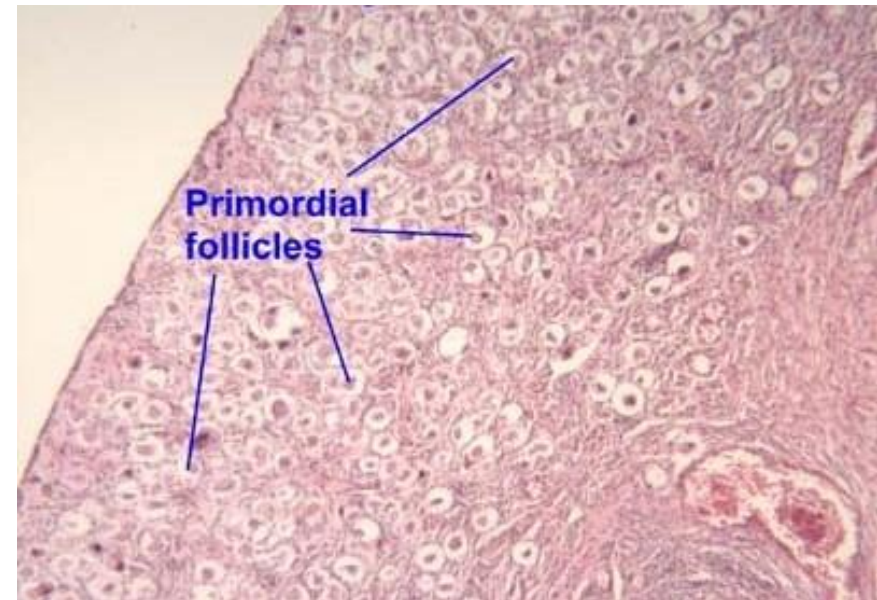
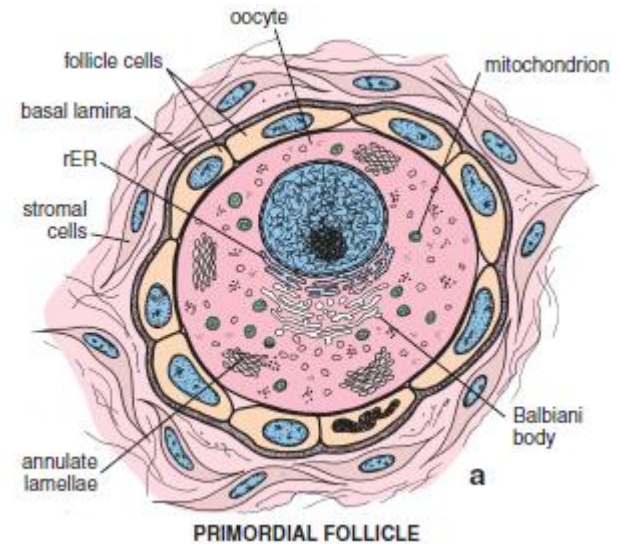


Female Reproduction

- Unlike males, who are able to produce sperm cells throughout their life, females produce a limited number of egg cells.
- During early fetal development germ cells migrate into the ovaries and differentiate into oogonia



- The oogonia divide by mitosis for the next few months and some differentiate into primary oocytes.
- By fifth month of development there are about 7 million primary oocytes, but most will degenerate by the birth time
- Those that remain will be surrounded by a single layer of squamous epithelial cells (follicle cells) called a primordial follicle.
- Degeneration of primary oocytes continues.
- At birth = 1million primordial follicles
- At puberty 400,000 remain

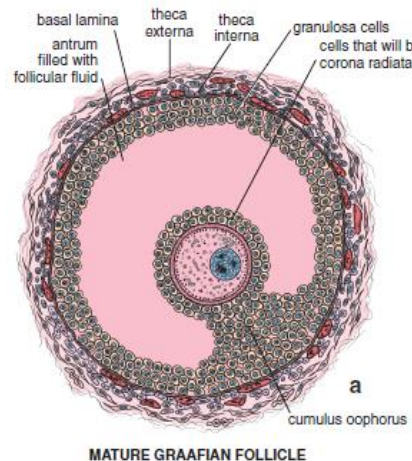
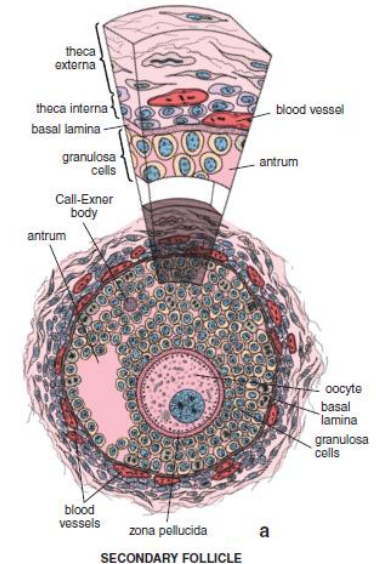
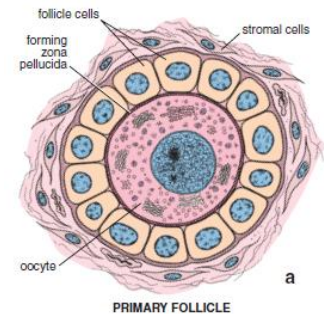
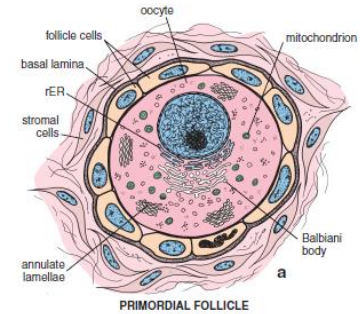


Ovarian follicles

Ovarian follicles provide the microenvironment for the developing oocyte.

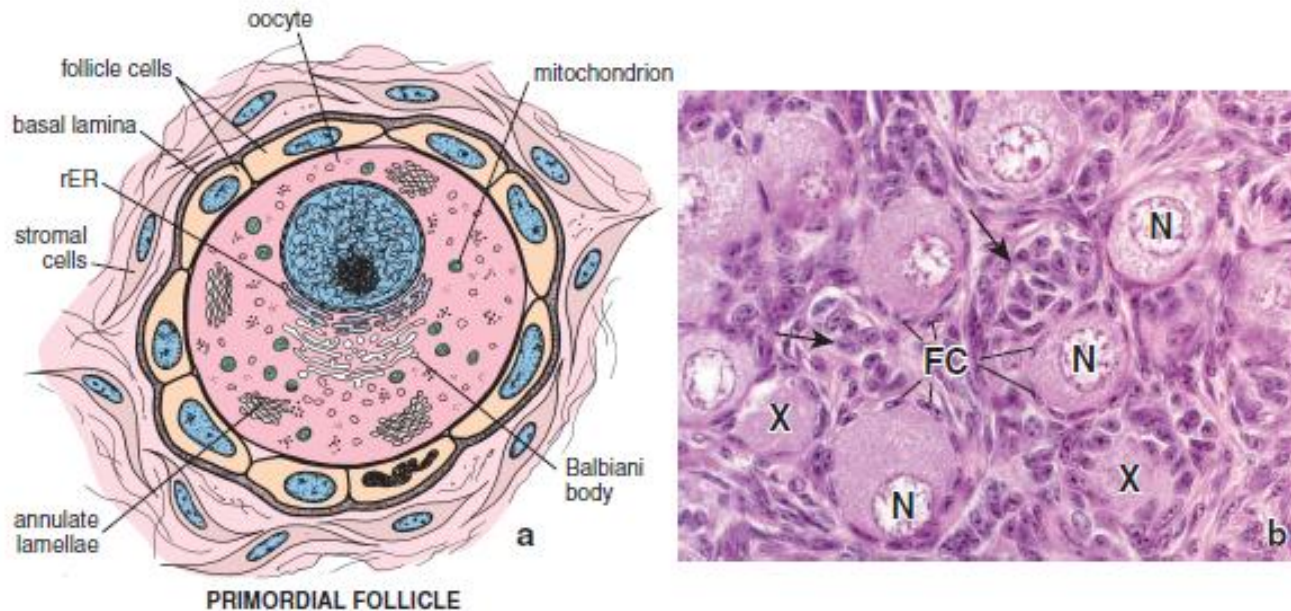
□ Three basic types of **ovarian follicles** can be identified on the basis of developmental state:

1. **primordial follicles;**
2. **growing follicles** which are further subclassified as primary, secondary tertiary (or antral) follicles;
1. **mature follicle or Graafian follicles.**

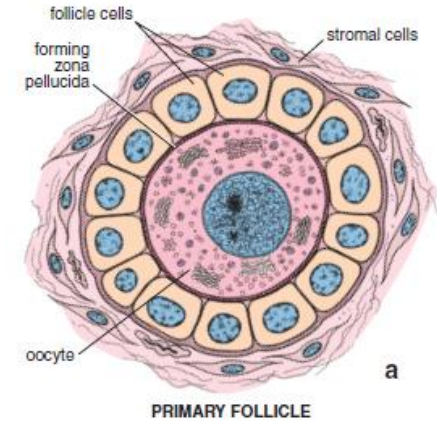


The primordial follicle is the earliest stage of follicular development

- In the mature ovary, primordial follicles are found in the stroma of the cortex
- The **primary oocytes** within the primordial follicles begin the first meiotic division in the embryo, but the process is **arrested at the prophase of I meiotic division**
- **One layer of squamous follicular cells**
- *This long period of meiotic arrest exposes the primary oocyte to adverse environmental influences and may contribute to errors in meiosis. Such errors result in anomalies such as trisomy of chromosome 21 (Down syndrome)*



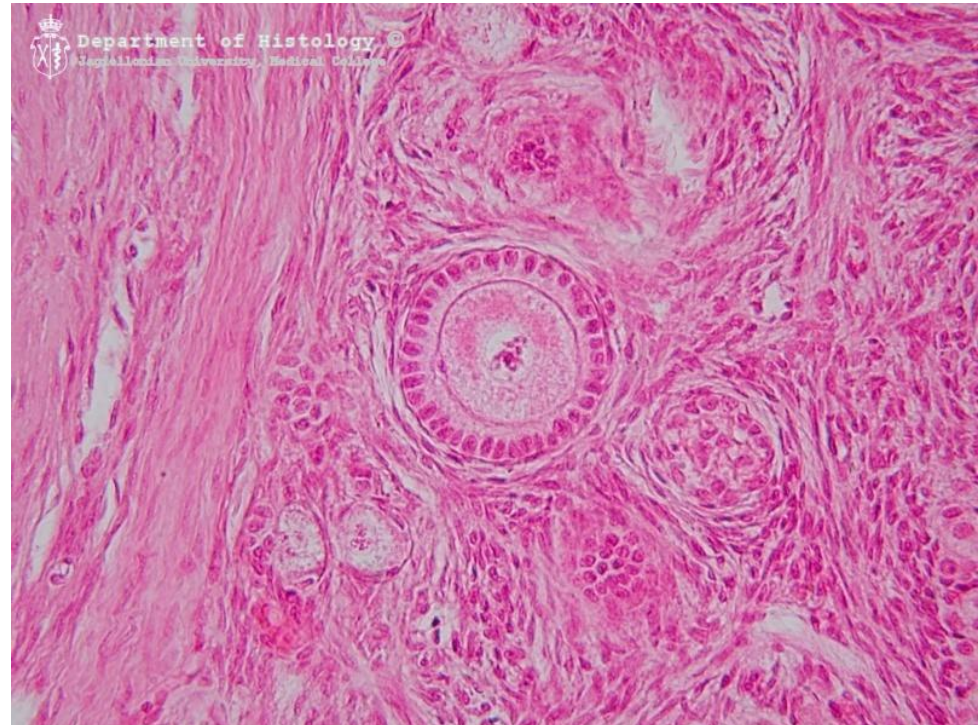
Primary follicles

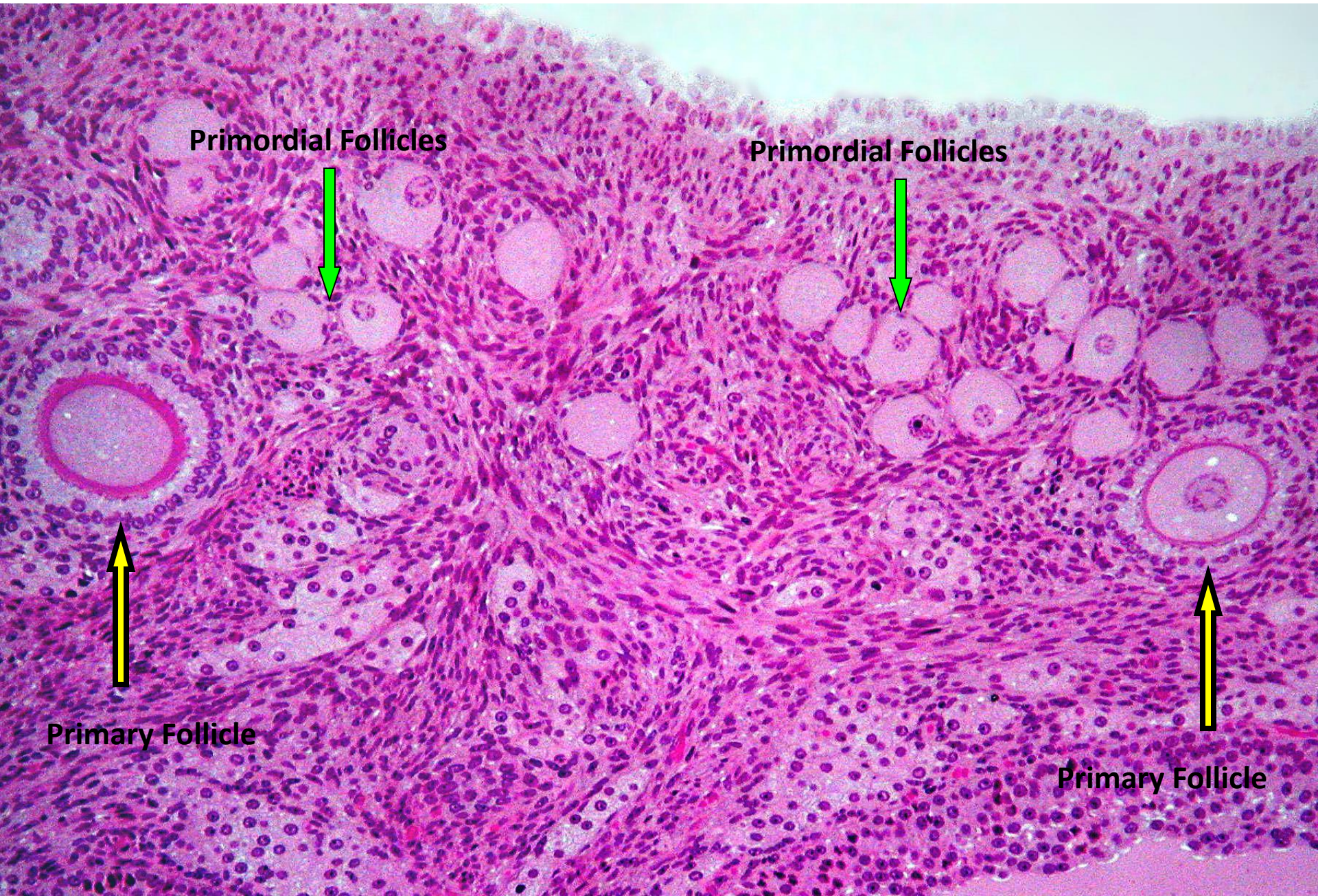


Primary oocyte

One layer of cuboidal follicle cells

Zona pellucida is formed between follicle cells and oocyte





Primordial Follicles



Primordial Follicles



Primary Follicle



Primary Follicle



Secondary follicles

❑ Follicle cells undergo stratification

❑ Connective tissue cells form the theca layers of the secondary follicle:

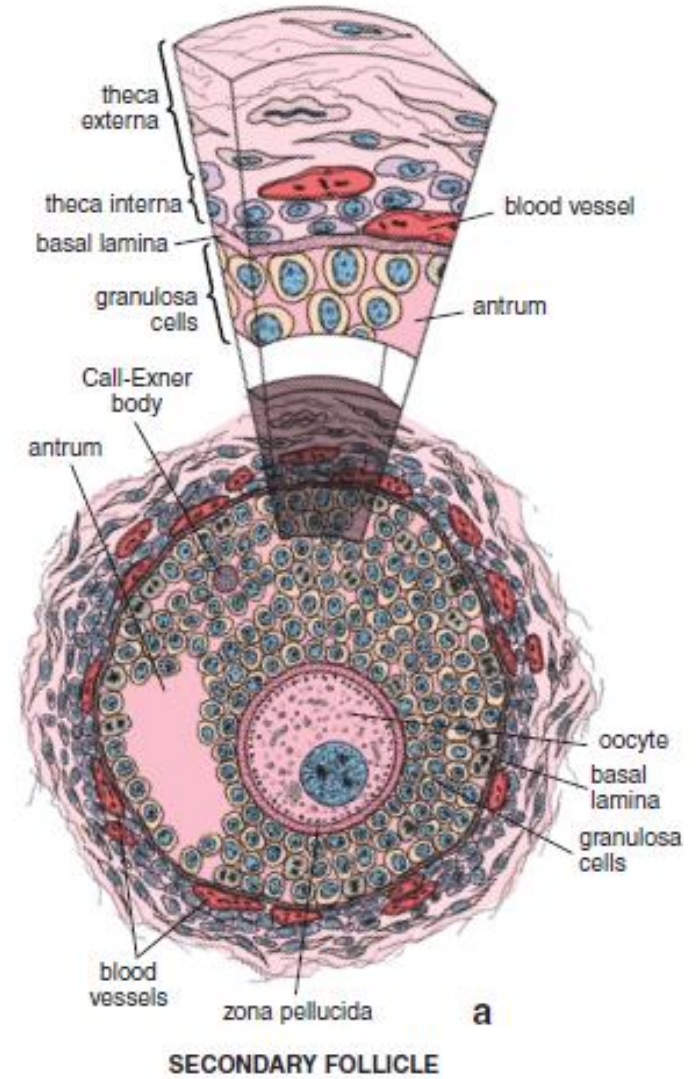
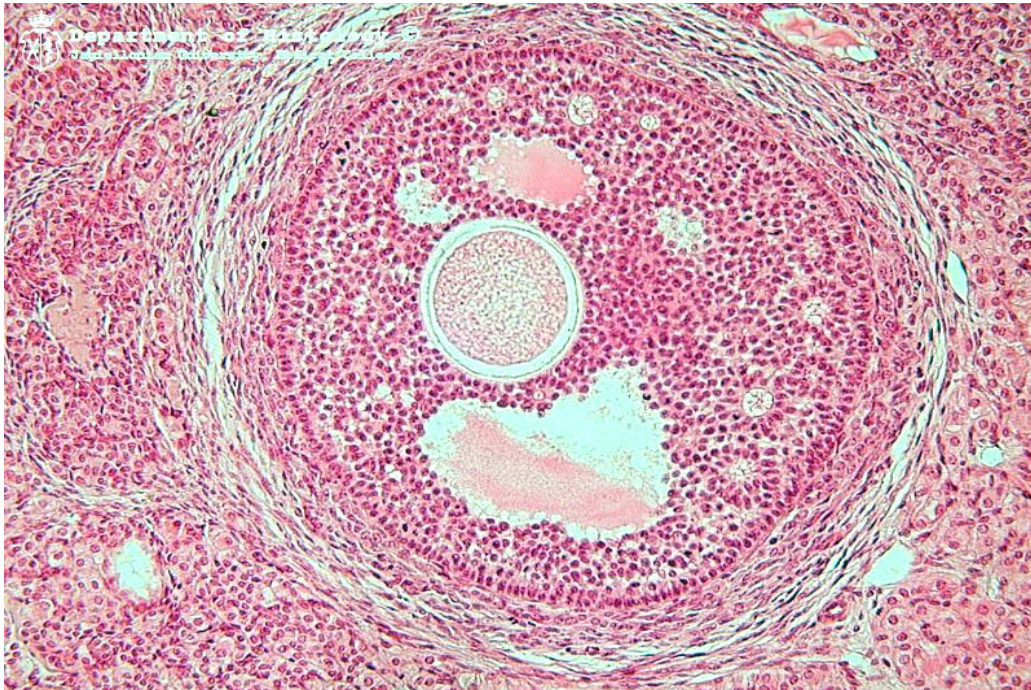
➤ The **theca interna** is the inner, highly vascularized layer of cuboidal secretory cells. They synthesize and secrete the androgens that are the precursors of estrogen.

➤ The **theca externa** is the outer layer of connective tissue cells. It contains mainly smooth muscle cells and bundles of collagen fibers.

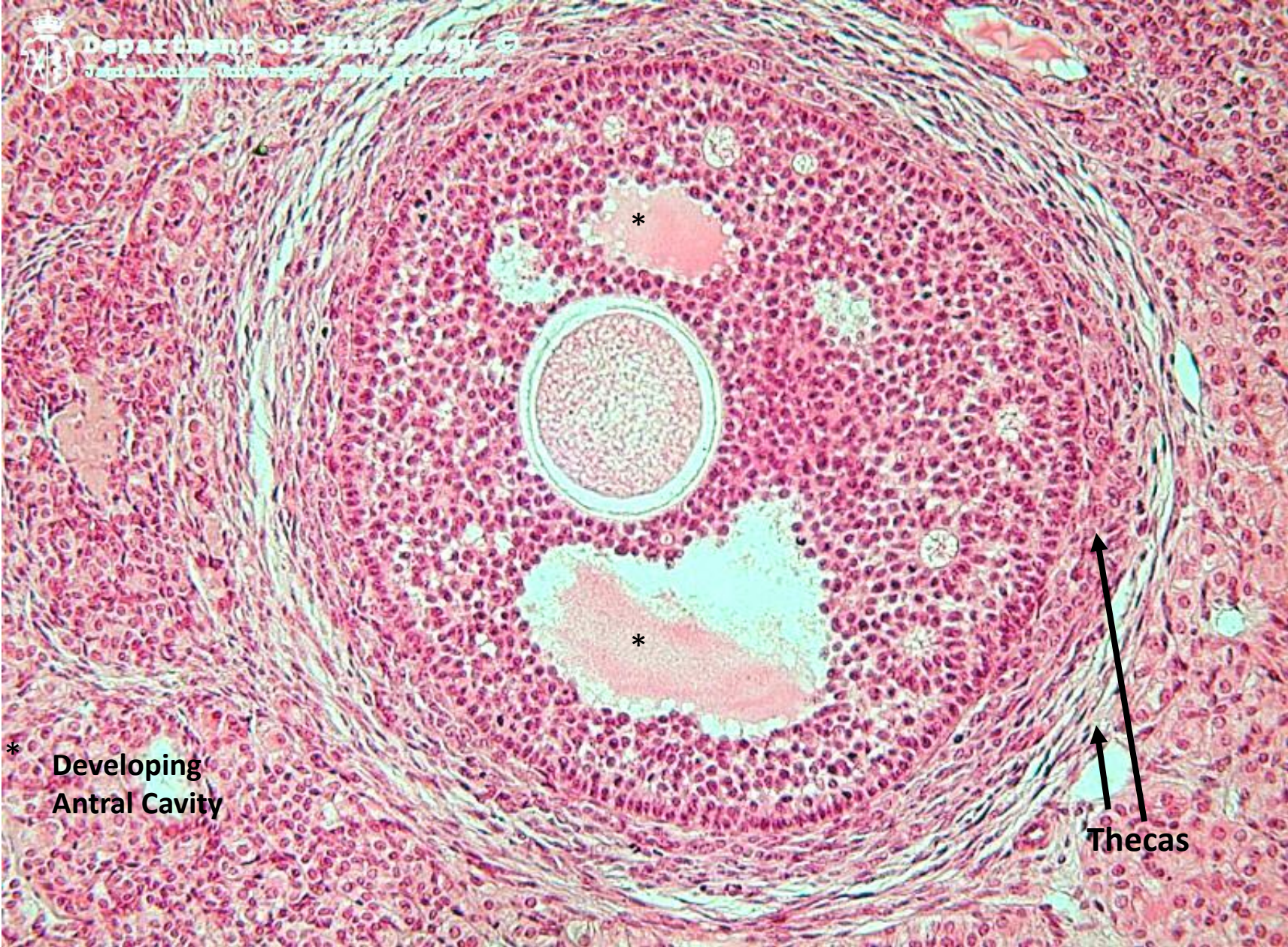


Tertiary follicles

- Follicular cells form the granulosa layer of the follicle
- Formation of fluid-containing cavities

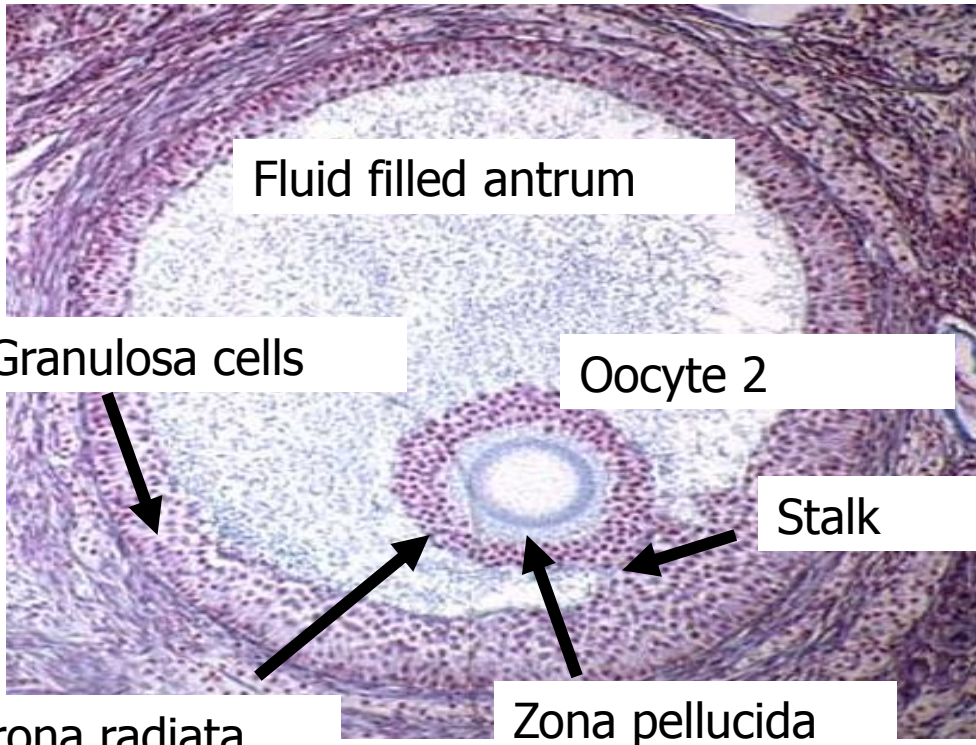
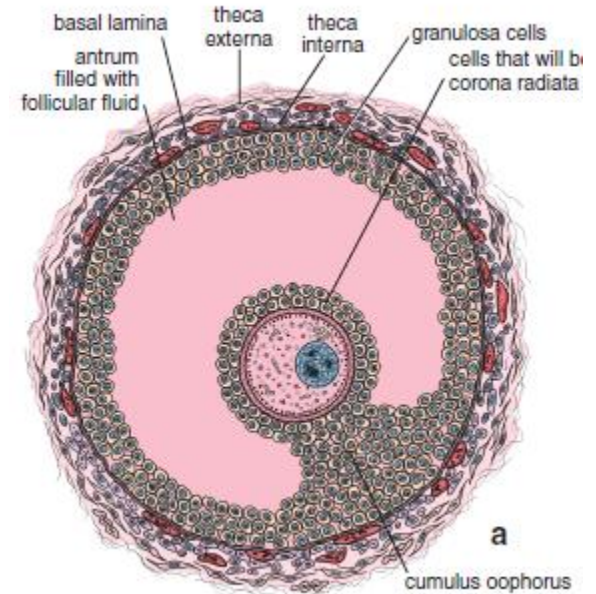


Tertiary Follicle



Mature Graafian follicle

- The mature or Graafian follicle contains a large cavity (antrum)
- Before ovulation first meiotic division is over, forming secondary oocyte
- The secondary oocyte is arrested at metaphase in the second meiotic division.



Tertiary Follicle

Graafian Follicle



Thecas

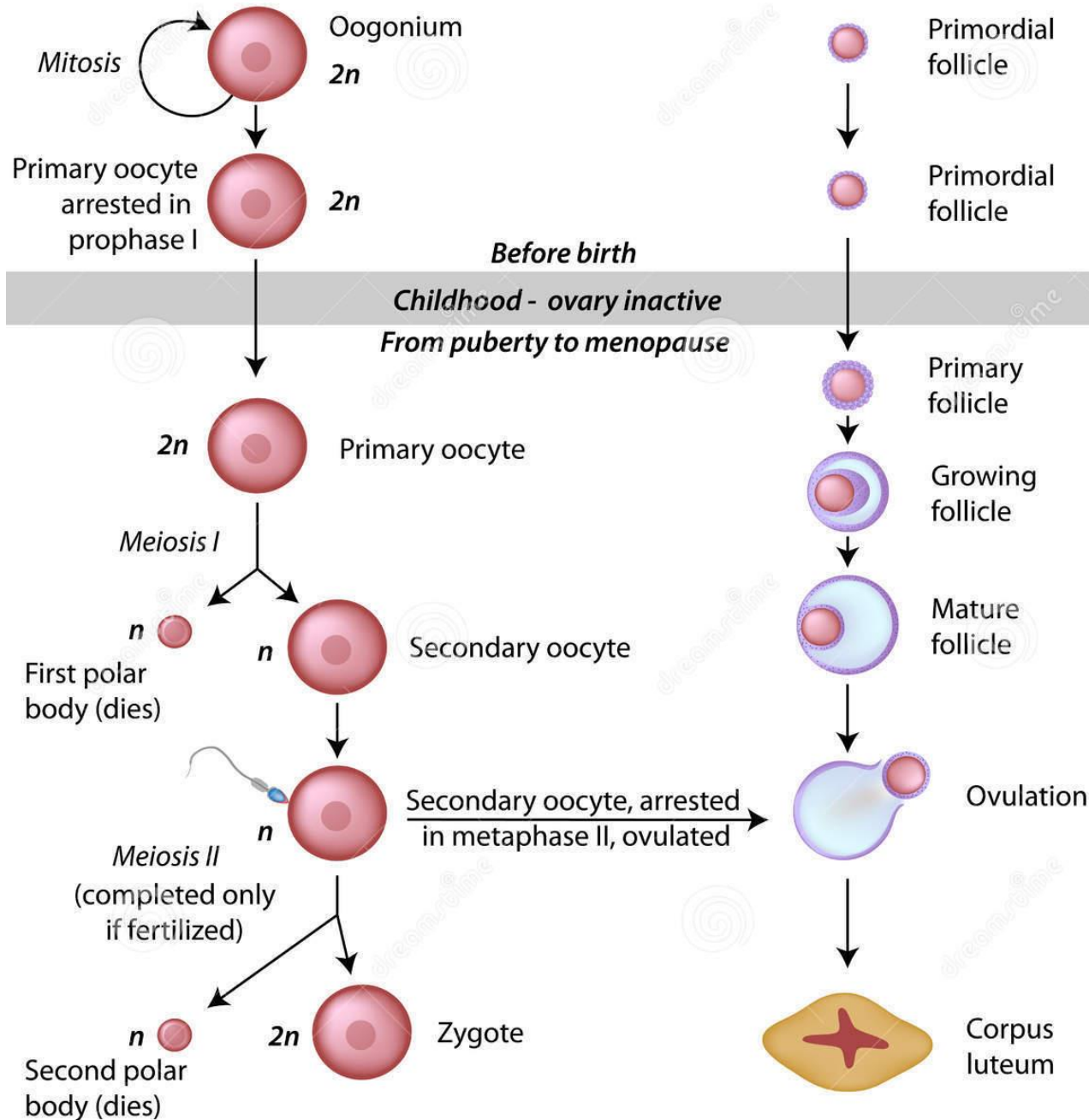
Antral
Cavity

Corona
Radiata

Cumulus
Oophorus

Oogenesis

Follicle development



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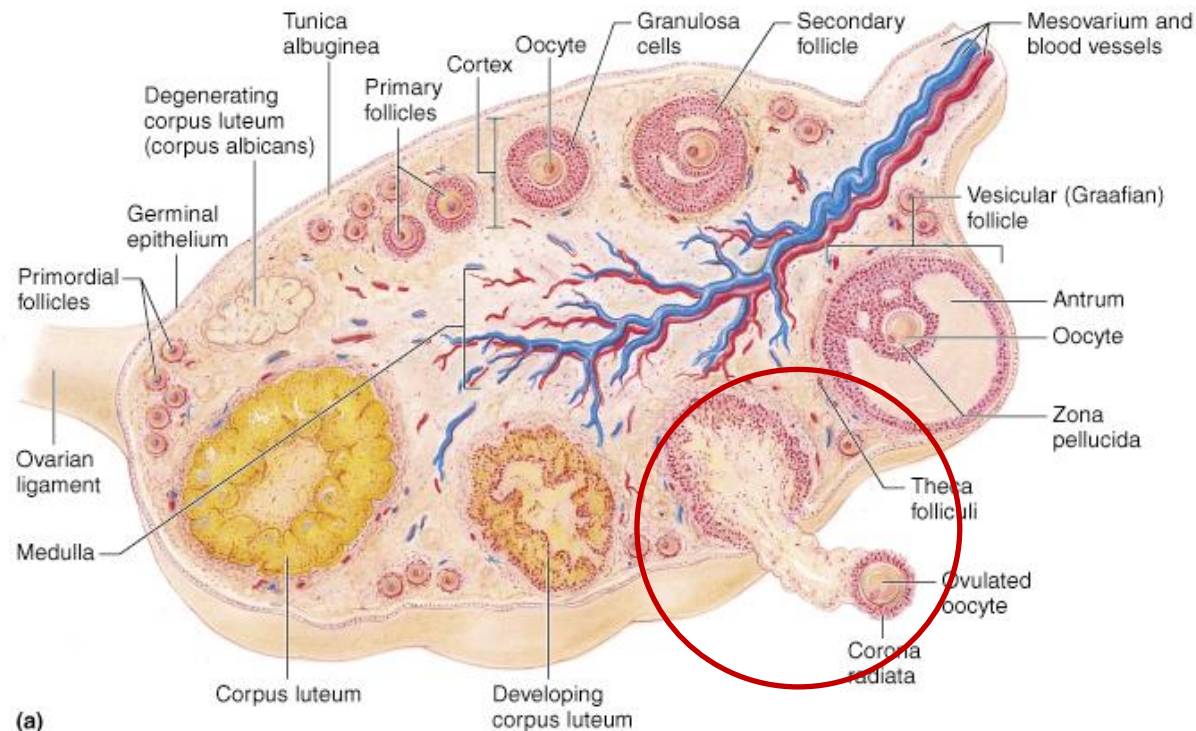


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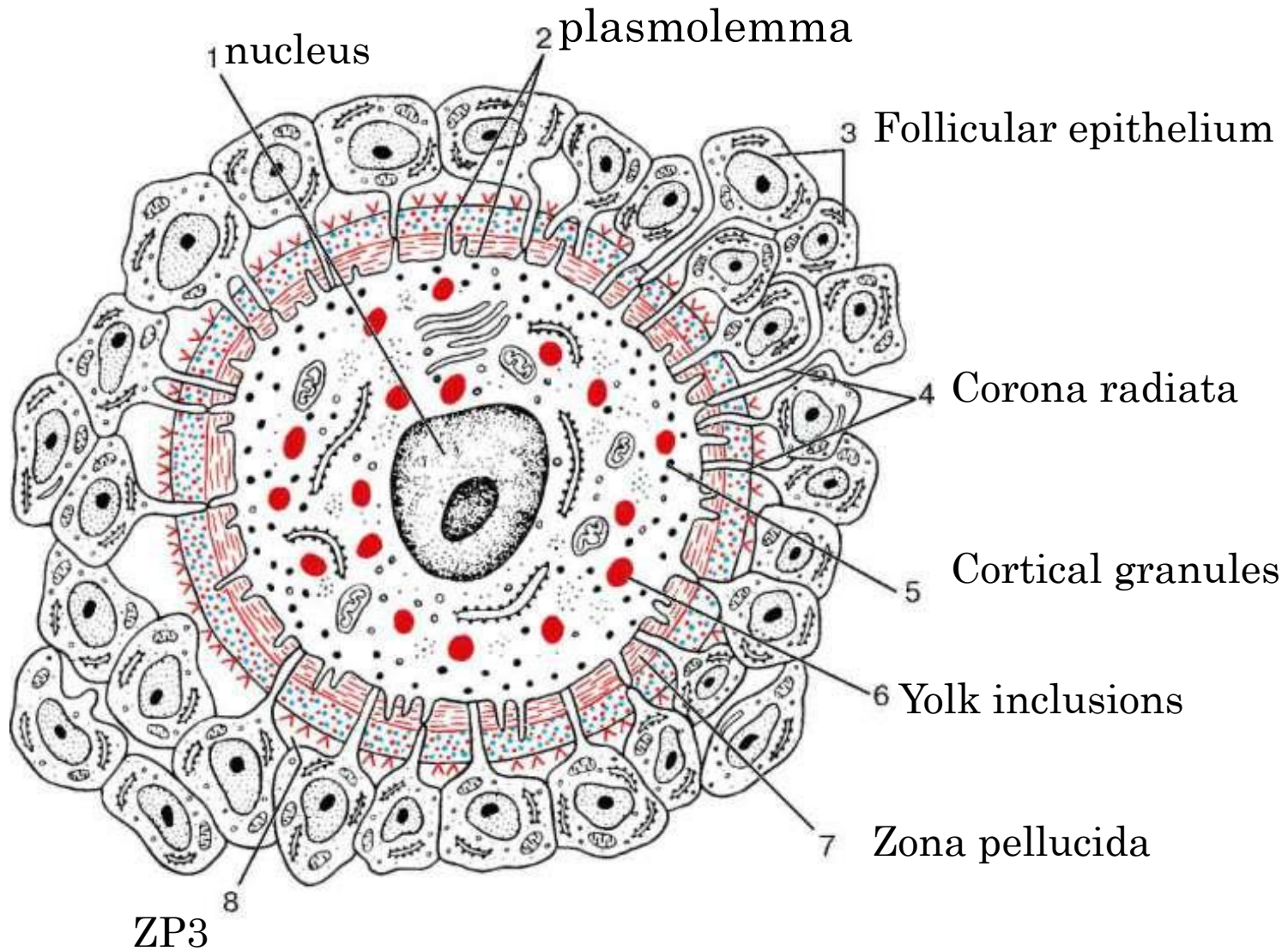


- **Ovulation** is the process by which a **secondary oocyte** is released from the Graafian follicle
- **Ovulation is a hormone-mediated process**
- Normally, only one follicle completes maturation in each cycle and ruptures to release its secondary oocyte
- After ovulation, the secondary oocyte remains viable for approximately 24 hours. If fertilization does not occur during this period, the secondary oocyte degenerates as it passes through the uterine tube.



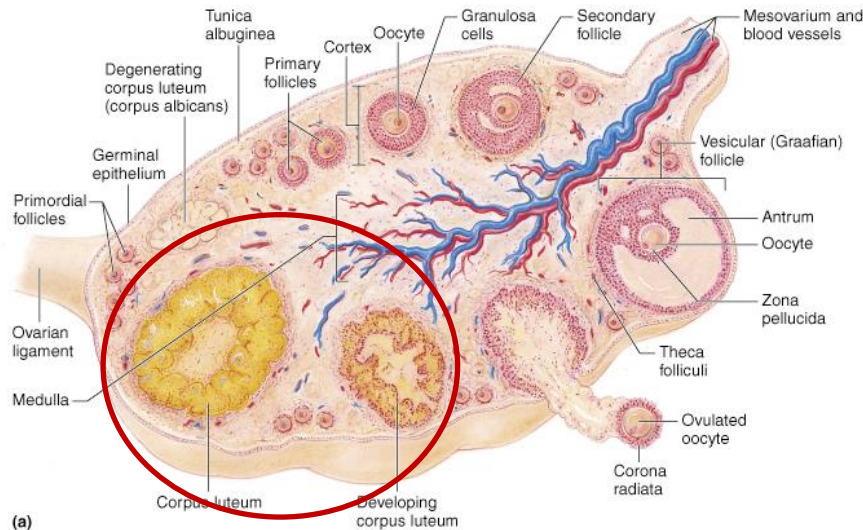


Ovum



Corpus Luteum of menstruation

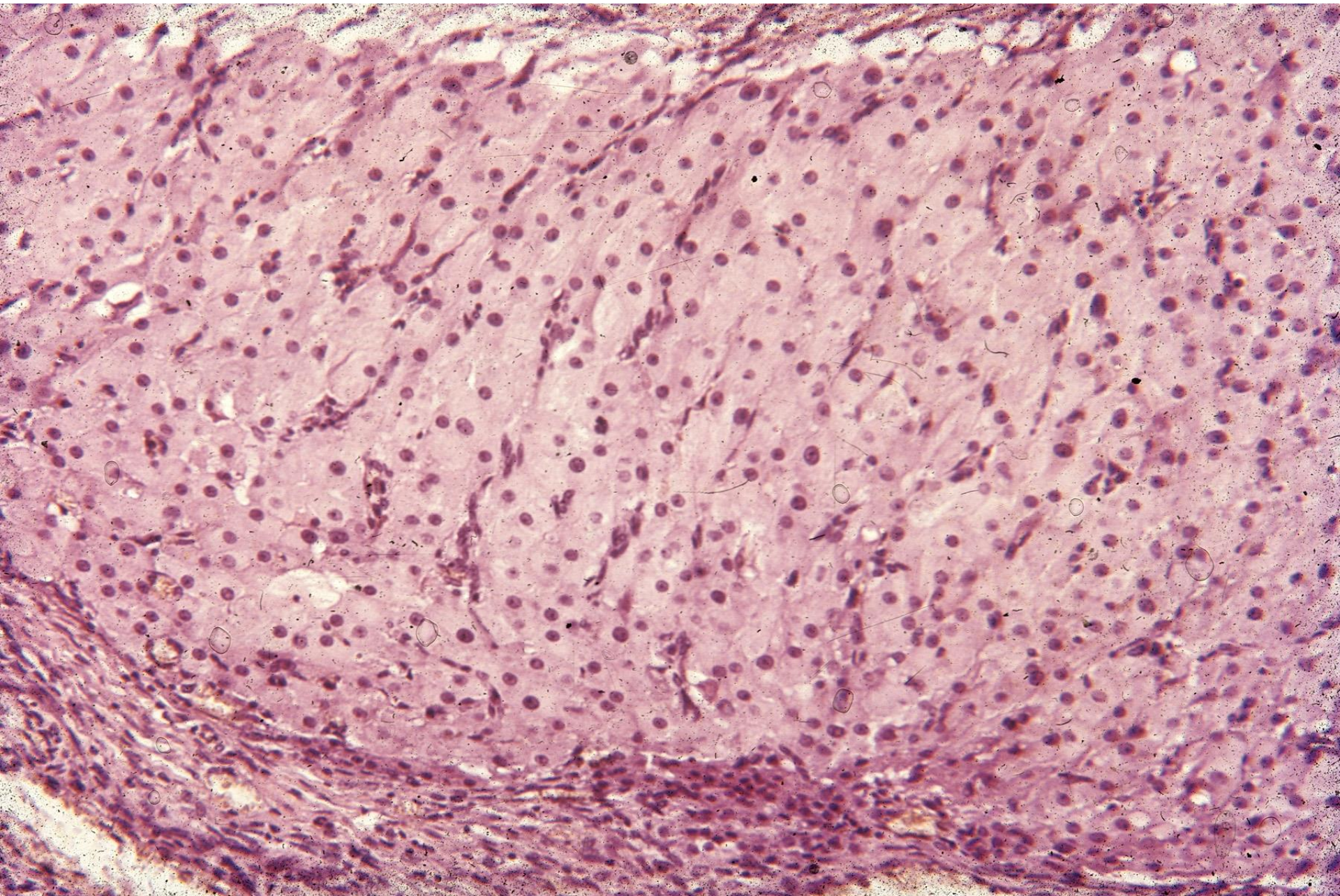
- The collapsed follicle undergoes reorganization into the corpus luteum after ovulation
- The **Corpus Luteum cells** secrete progesterone and estrogens
- The corpus luteum begins to degenerate about 10 to 12 days after ovulation - the **corpus albicans** (a white scar)



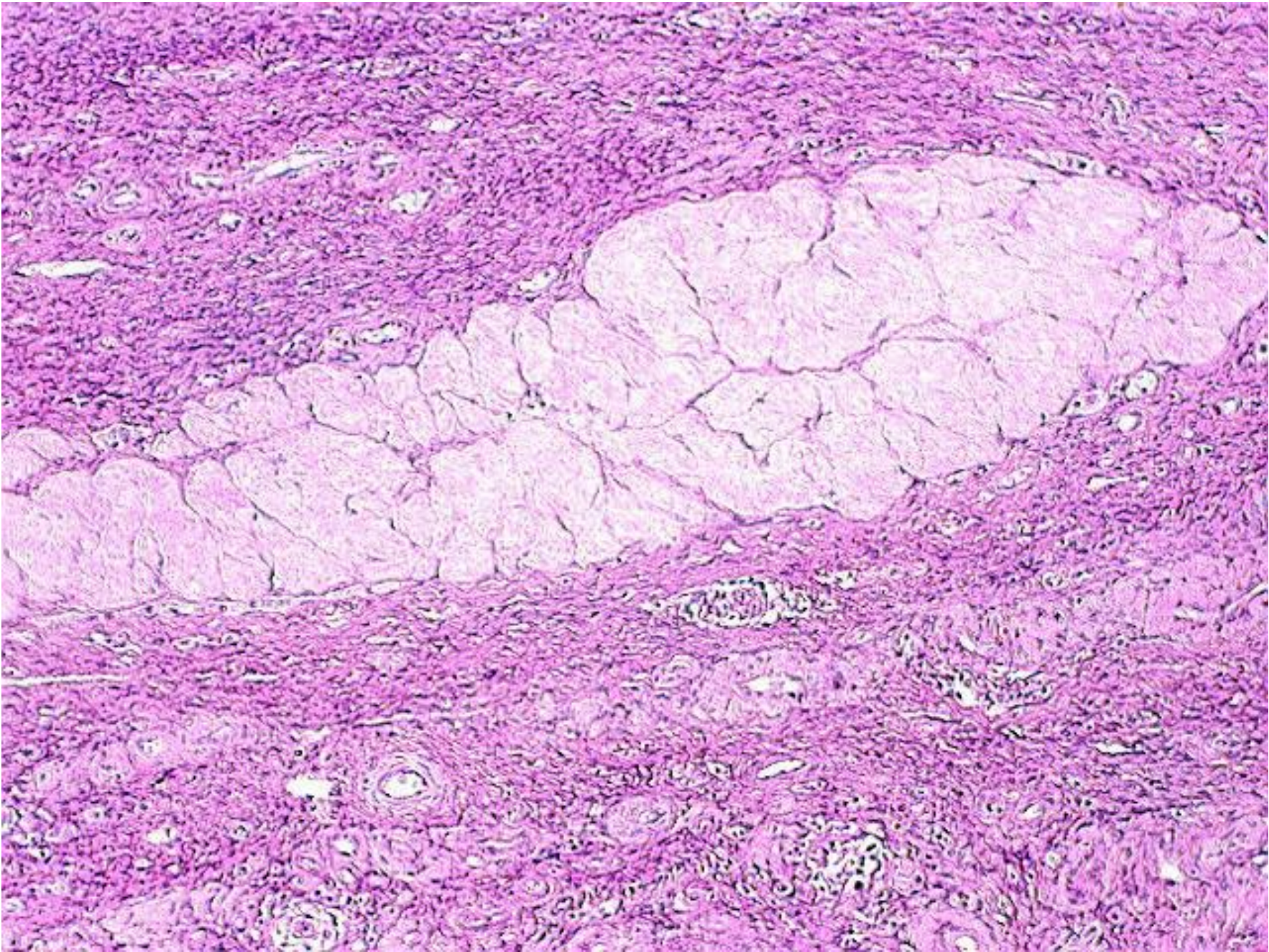
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Corpus Luteum



Low Magnification – Corpus Albicans – a degenerated Corpus Luteum



Corpus Luteum of Pregnancy

- Formed after fertilization and implantation
- *Secrete estrogen, progesterone and **relaxin***
- **Relaxin** – *hormone that loosens the fibrocartilage of pubic symphysis allowing the pelvic opening to enlarge during the labor*



Two major groups of steroid hormones—**estrogens and progestogens**—are secreted by the ovaries

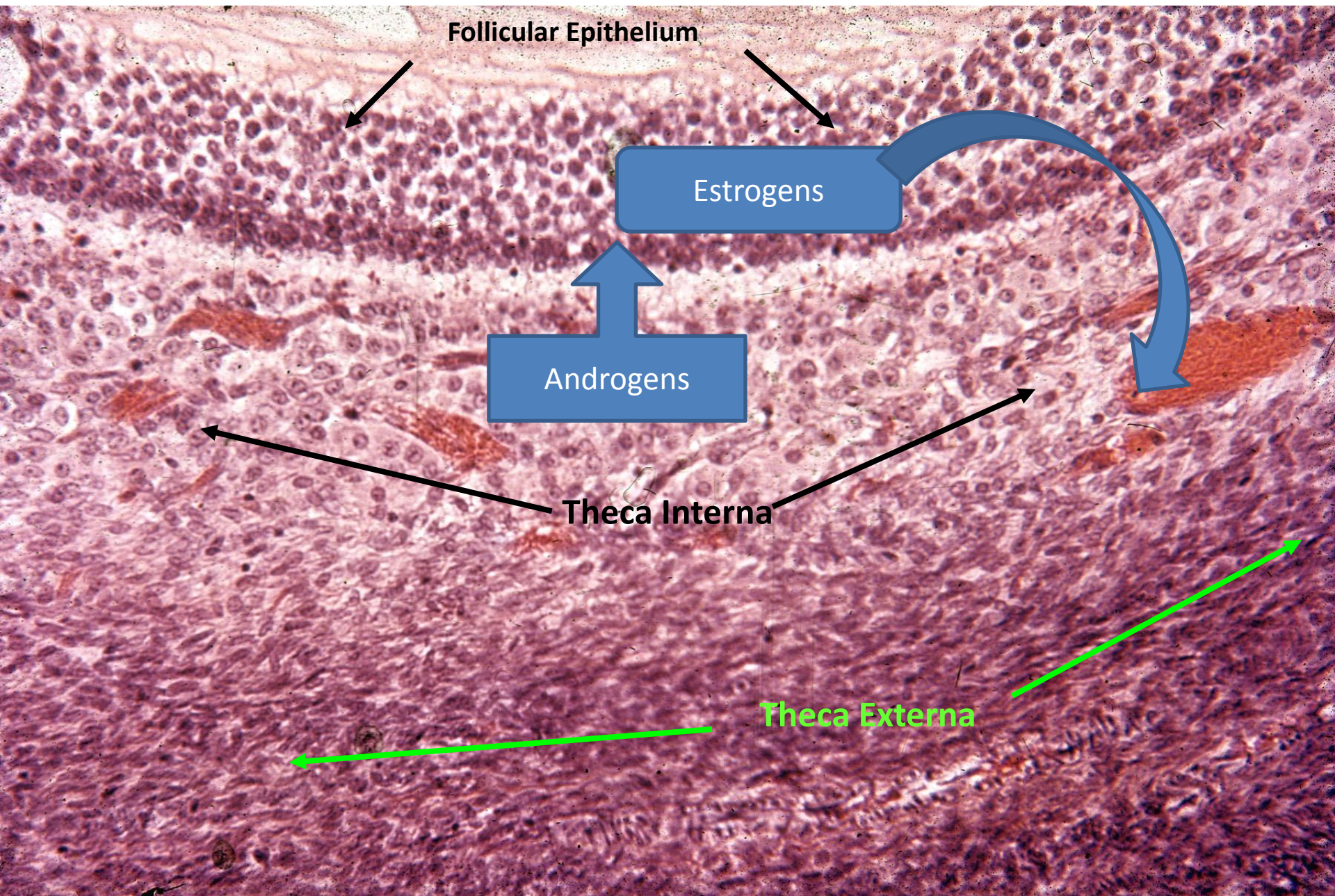
Estrogen

- ✓ promote the growth and maturation of internal and external sex organs
- ✓ responsible for the female sex characteristics that develop at puberty
- ✓ act on mammary glands to promote breast development by stimulating ductal and stromal growth and accumulation of adipose tissue

Progesterone

- ✓ prepare the internal sex organs, mainly the uterus, for pregnancy
- ✓ prepare the mammary gland for lactation by promoting lobular proliferation.

- In humans, **Luteinizing Hormone** (adenohypophysis) stimulates the cells of the theca interna to secrete androgens, which serve as estrogen precursors.
- Some androgens are transported to the granulosa cells.
- In response to **Follicular Stimulating Hormone** (adenohypophysis) , the granulosa cells catalyze the conversion of androgens to estrogens, which in turn stimulate the granulosa cells to proliferate and thereby increase the size of the follicle.



Follicular Epithelium

Estrogens

Androgens

Theca Interna

Theca Externa

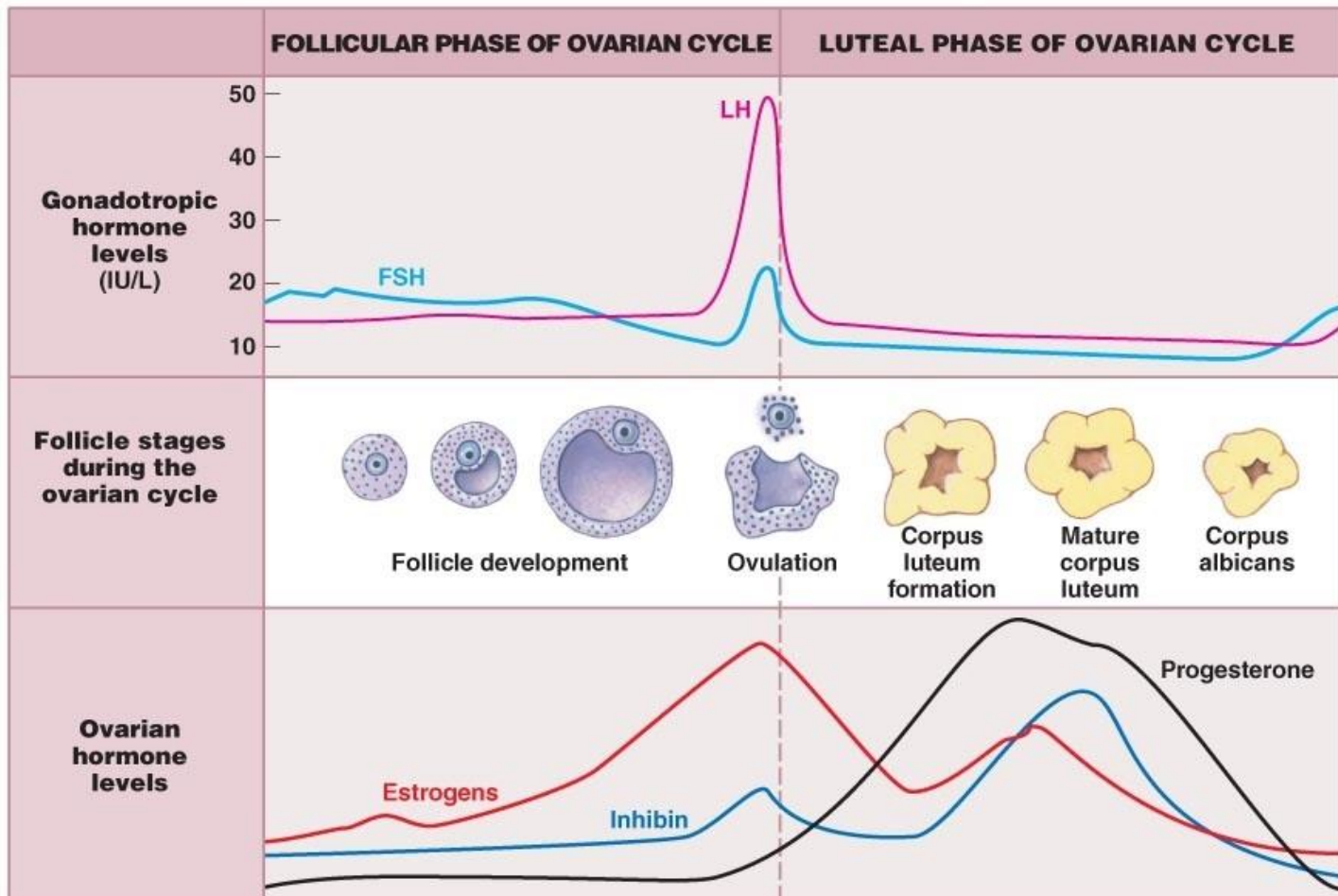
High Mag – Graafian Follicle

Ovarian Cycle

Ovary undergoes cyclic changes that involve two phases:

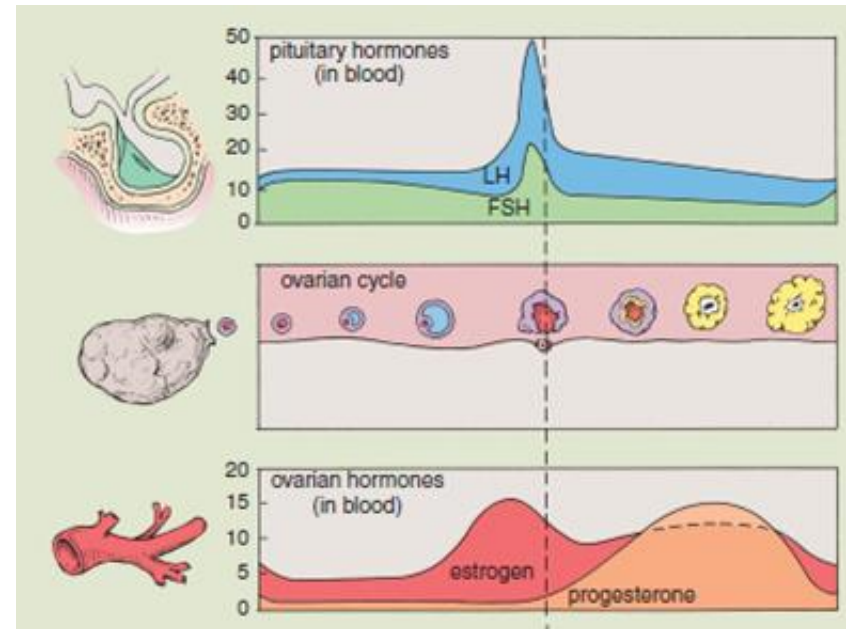
- Follicular phase
- Luteal phase

Ovulation occurs between the two phases.



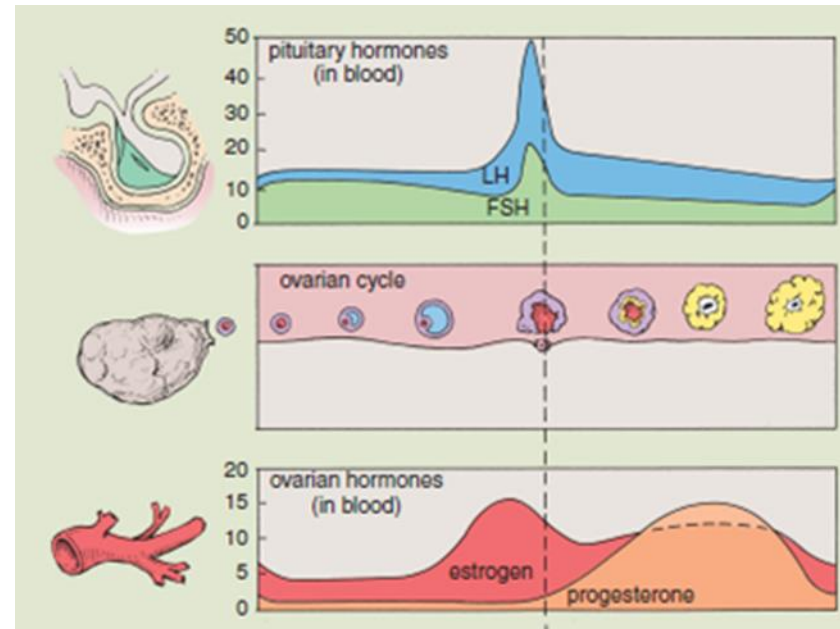
Follicular phase

- Under the influence of pituitary **FSH** a small number of primary follicles (10 to 20) start to grow and develop.
- Growing follicles produce **estrogen**
- Raising level of estrogen in blood – **negative feedback** on the pituitary gland to reduce the secretion of FSH
- The surge of **LH**
- **Ovulation** is induced by a surge of the LH level and occurs approximately 10 to 12 hours after the peak of the LH
- **LH** starts the formation of **corpus luteum** at the place of collapsed follicle

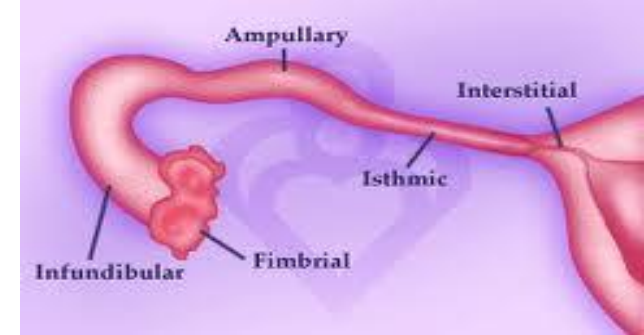


Luteal phase

- The **luteal phase** begins immediately after ovulation
- The granulosa and thecal cells of the ruptured follicle undergo morphologic transformation to form the corpus luteum
- Estrogens and large amounts of progesterone are secreted by the corpus luteum
- Under the influence of progesterone, the endometrium undergoes changes, which are essential for the preparation of the uterus for implantation in the event that the egg is fertilized.



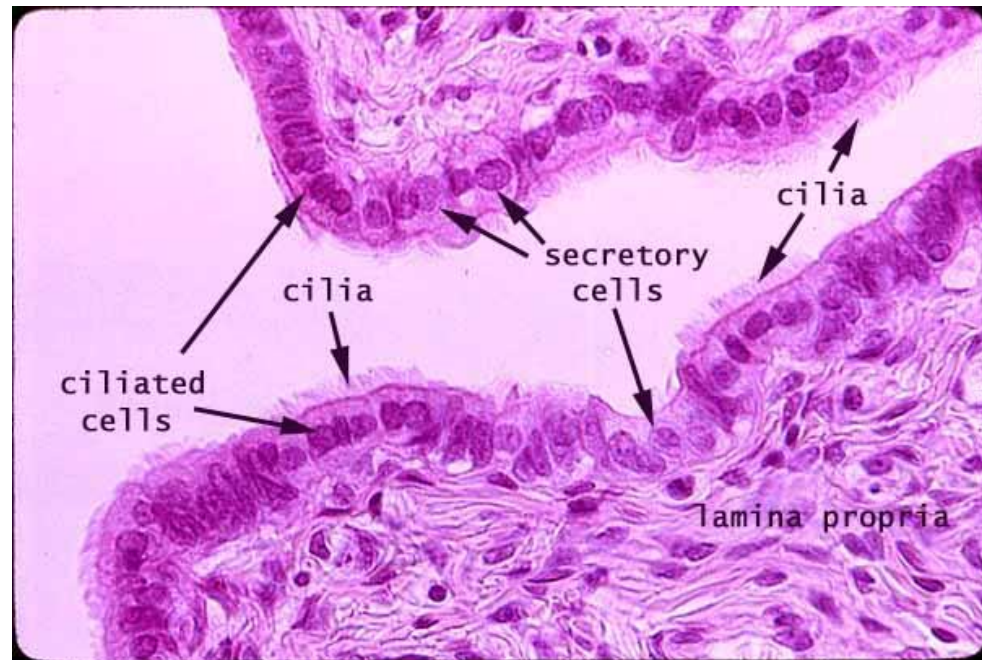
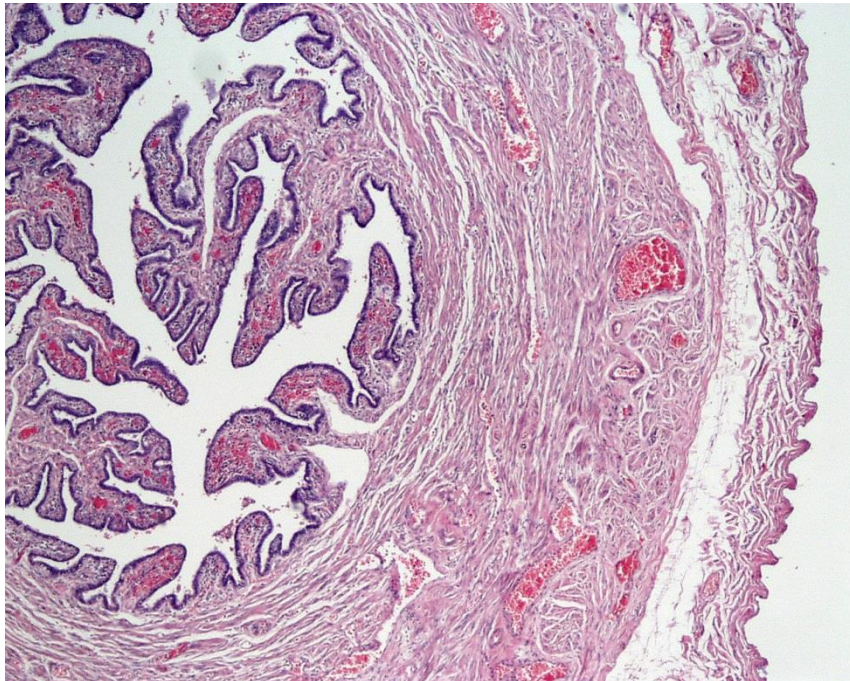
Uterine Tubes (Fallopian Tubes)



- Receive the ovulated oocyte and provide a site for fertilization
- Empty into the uterus via the **isthmus**
- Expand distally around the ovary forming the **ampulla**
- The ampulla ends in the funnel-shaped, ciliated infundibulum containing fingerlike projections called **fimbriae**

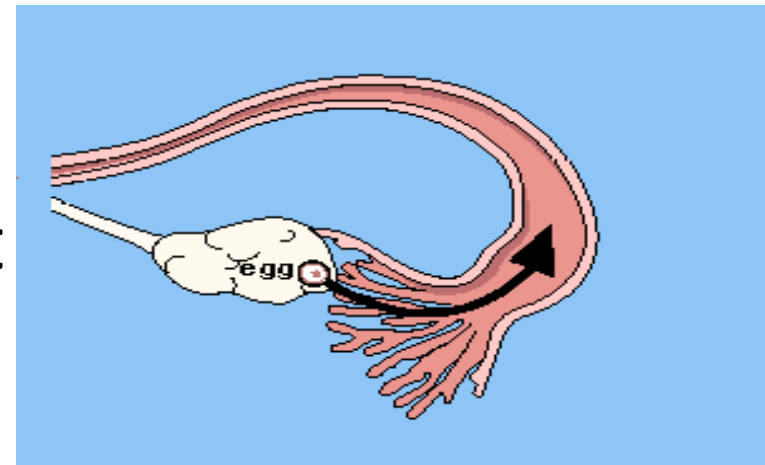
The wall of the uterine tube is composed of three layers

- The **serosa** or peritoneum is the outermost layer
- The **muscularis** is organized into an inner circular and an outer longitudinal layers.
- The **mucosa** exhibits relatively thin longitudinal folds that project into the lumen of the uterine tube.
- The **mucosal lining** is simple columnar epithelium composed of two kinds of cells—ciliated and nonciliated. The wave of the cilia is directed toward the uterus. **Nonciliated, peg cells** are secretory cells that produce the fluid that provides nutritive material for the ovum.



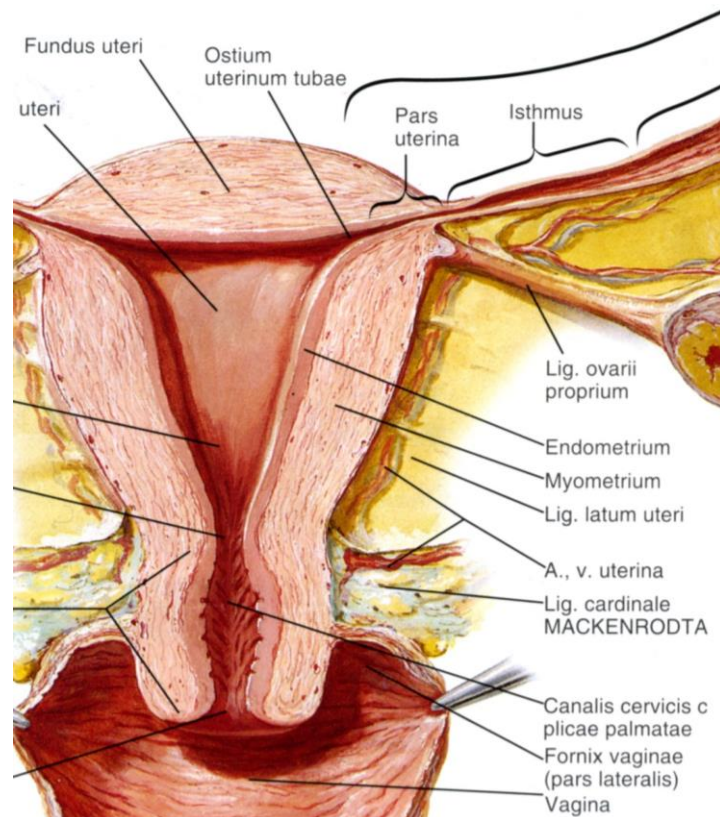
Function

- Events occurring in the uterine tube:
 - **Fimbriae** sweep oocyte into tube
 - cilia & peristalsis move it along
 - sperm reaches oocyte in ampulla, fertilization occurs within 24 hours after ovulation
 - Formation of zygote
 - Zygote reaches uterus about 7 days after ovulation



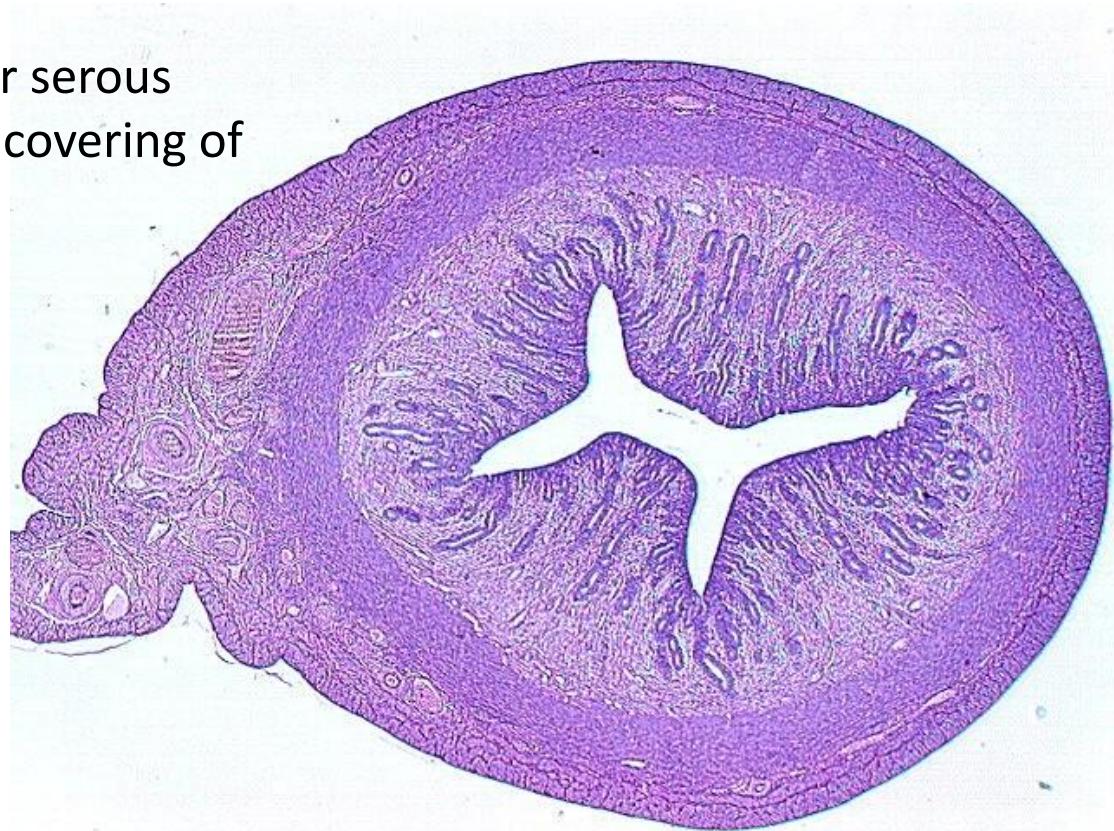
Uterus

- ❑ The **uterus** is divided into two regions:
 1. The **body** is the large upper portion of the uterus.
 2. The **cervix** is the lower, barrel-shaped part of the uterus separated from the body by the **isthmus**. The lumen of the cervix, the **cervical canal**, has a constricted opening at each end. The **internal os** communicates with the cavity of the uterus; the **external os** with the vagina



Uterus

- The uterine wall is composed of three layers
 1. The **endometrium** is the mucosa of the uterus.
 2. The **myometrium** is the thick muscular layer.
 3. The **perimetrium**, the outer serous layer or visceral peritoneal covering of the uterus



Uterus

- The endometrium varies from 1 mm to 6 mm in thickness depending of the **phases of the menstrual cycle**
- It is lined by a **simple columnar epithelium** with a mixture of secretory and ciliated cells.
- The surface epithelium invaginates into the underlying lamina propria, the **endometrial stroma**, forming the uterine glands.

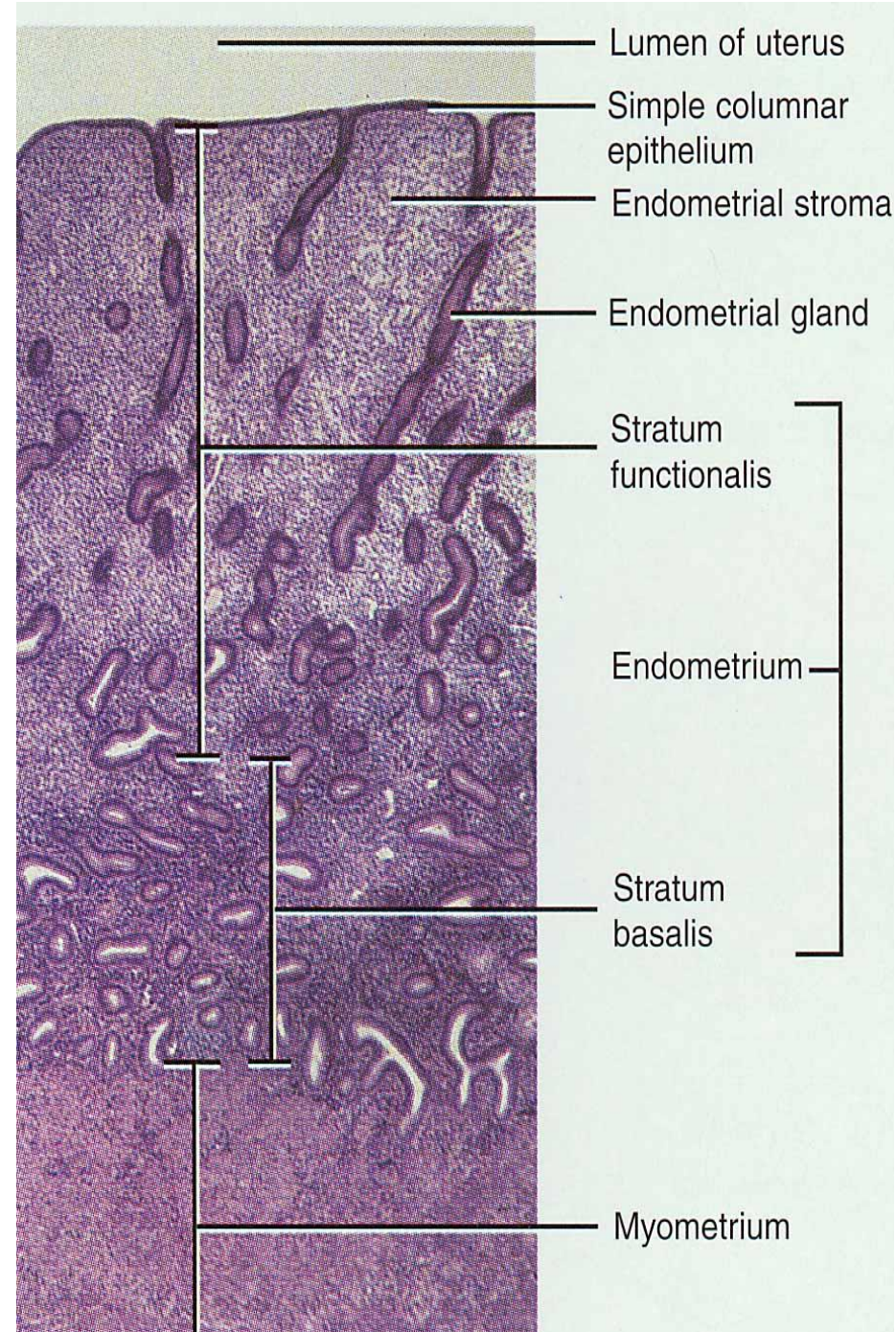
Simple columnar epithelium

Endometrial glands

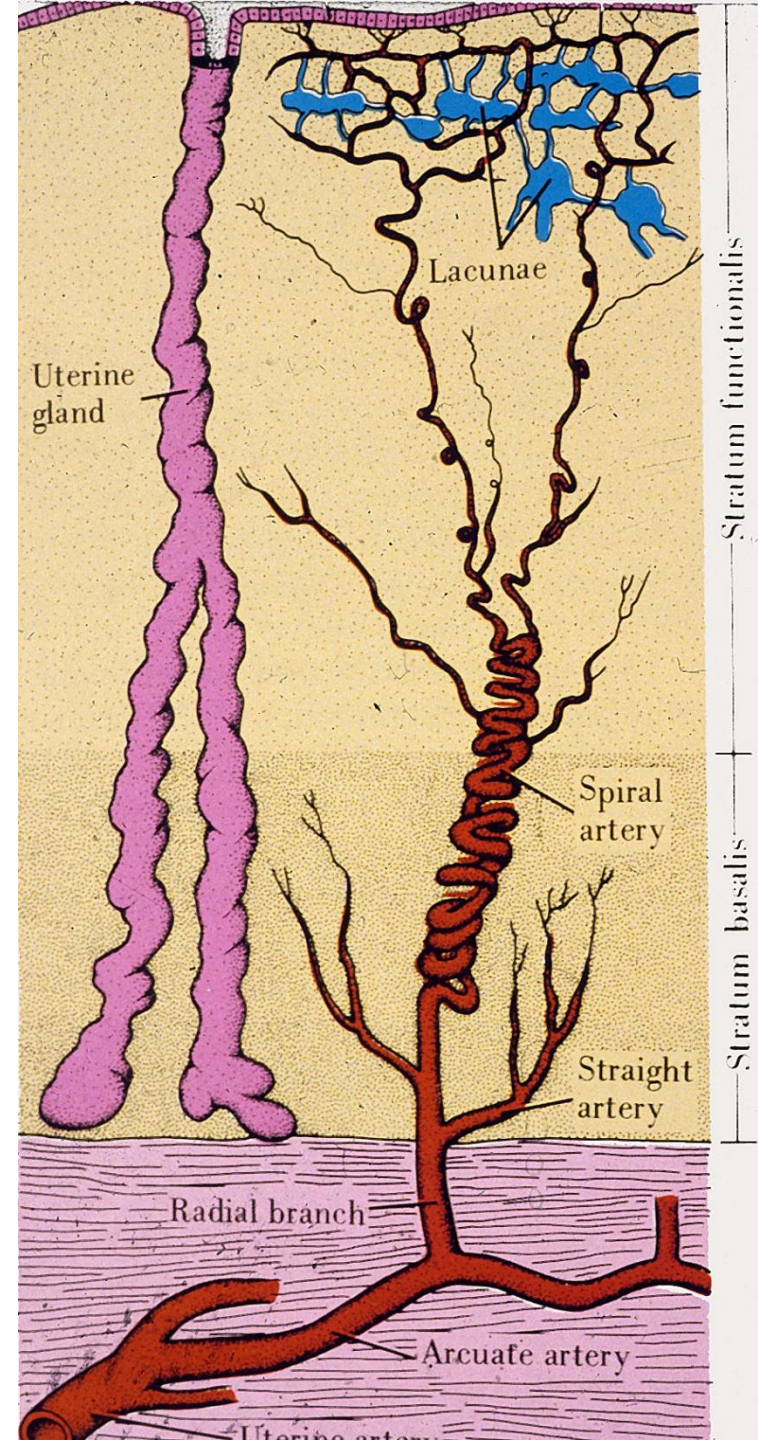


Uterus

- ❑ The endometrium consists of two layers or zones that differ in structure and function:
- The **stratum functionale** or **functional layer** is the thick part of the endometrium. The stratum functionale is the layer that proliferates for implantation and sheds in case implantation doesn't happen (menstruation)
- The **stratum basale** or **basal layer** is retained during menstruation and serves as the source for the regeneration of the stratum functionale.



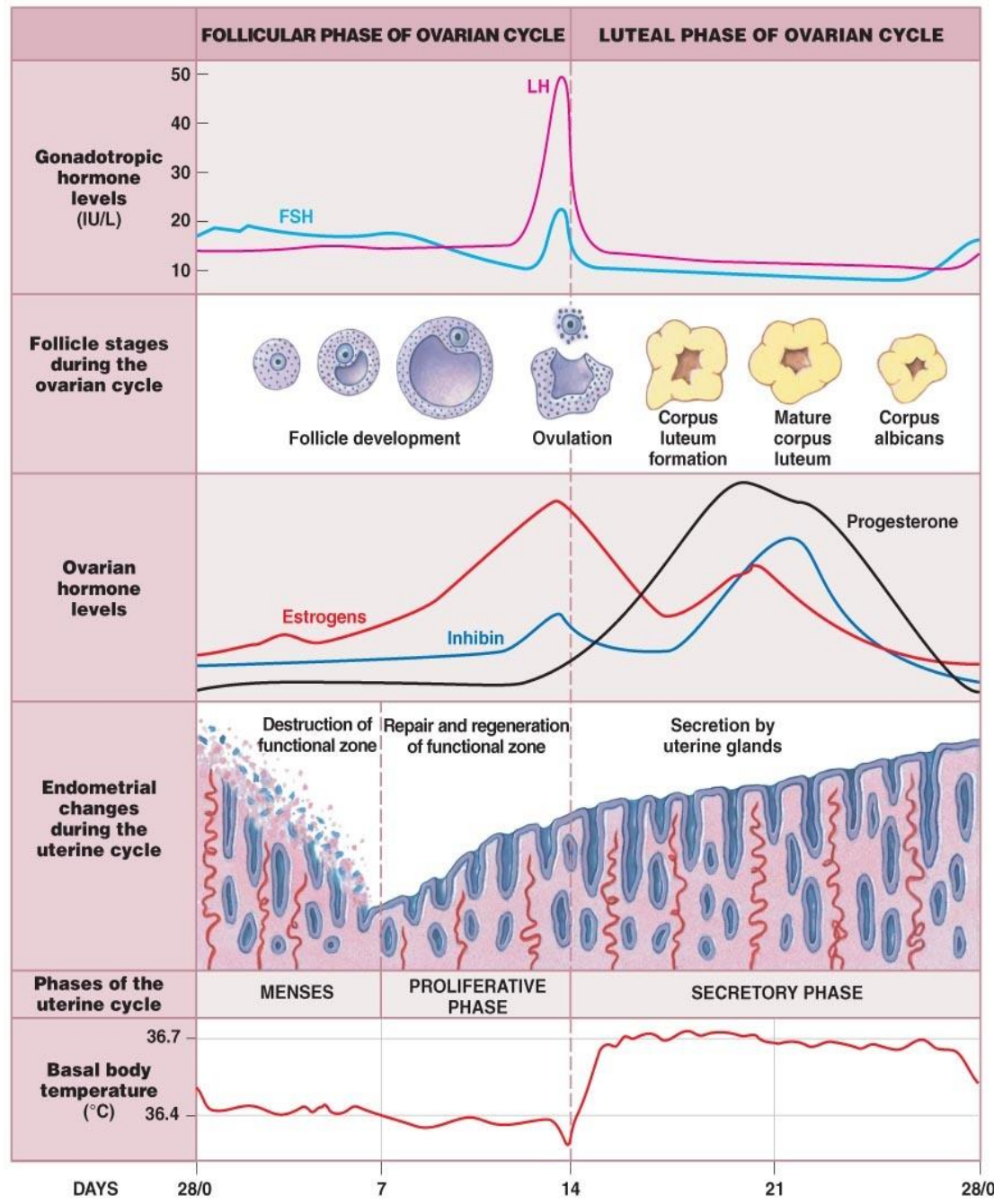
- ❑ The endometrium contains a unique system of blood vessels
- The uterine artery gives off 6 to 10 arcuate arteries that anastomose in the myometrium.
- Branches from these arteries, the **radial arteries**, enter the basal layer of the endometrium where they give off small straight arteries that supply this region of the endometrium.
- The main branch of the radial artery continues upward and becomes highly coiled; it is therefore called the **spiral artery**.
- The straight arteries and the proximal part of the spiral arteries do not change during the menstrual cycle. The distal portion of the spiral arteries, under the influence of estrogens and progesterone, undergoes degeneration and regeneration with each menstrual cycle.



Menstrual cycle

The endometrium undergoes cyclic changes controlled by ovarian estrogen and progesterone that prepare it for the implantation of the embryo

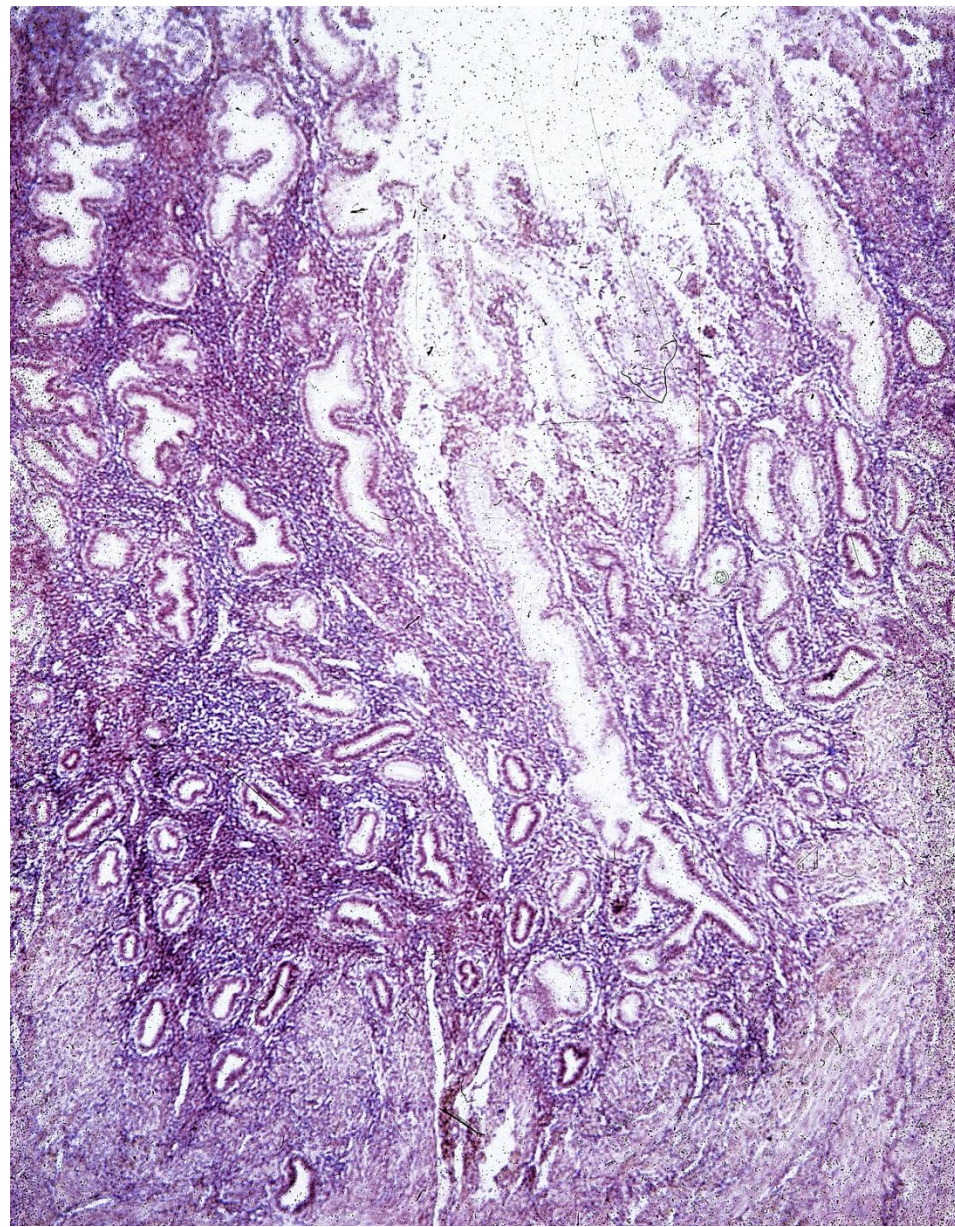
- ❑ The menstrual cycle is divided into three phases:
 - The menstrual phase
 - The proliferative phase
 - The secretory phase



The key events in the ovarian and uterine cycles

Menstrual Phase

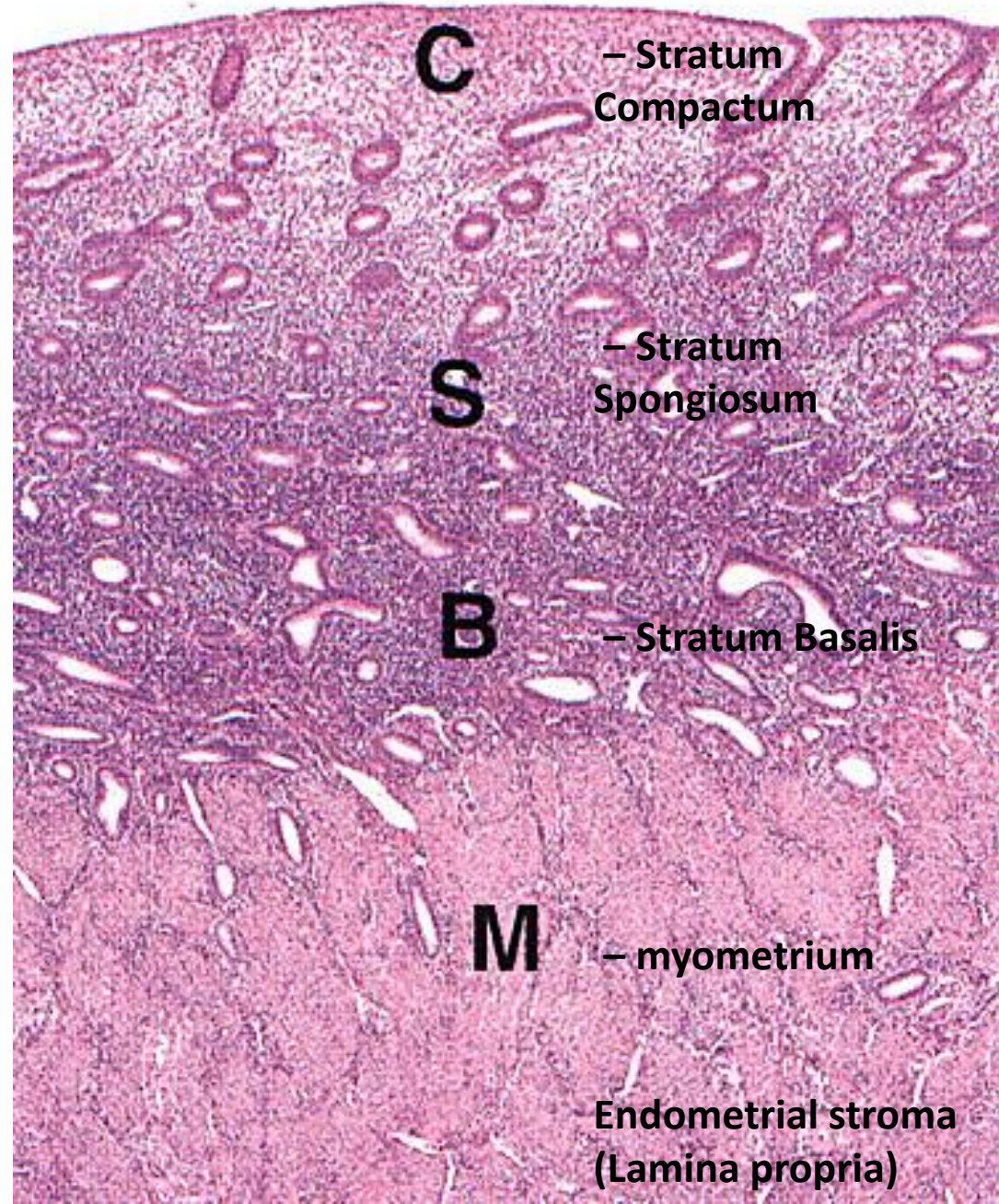
- First day of menstrual bleeding – day 5 of the cycle
- Decrease of ovarian progesterone level (degeneration of corpus luteum)
- Constriction of coiled arteries
- Ischemia, degeneration and shedding of functional layer of endometrium which are discharged through vagina together with blood (menstrual bleeding)
- Straight arteries are not sensitive to hormonal changes
- Basal layer remains intact



Menstrual (degenerating)
Endometrium

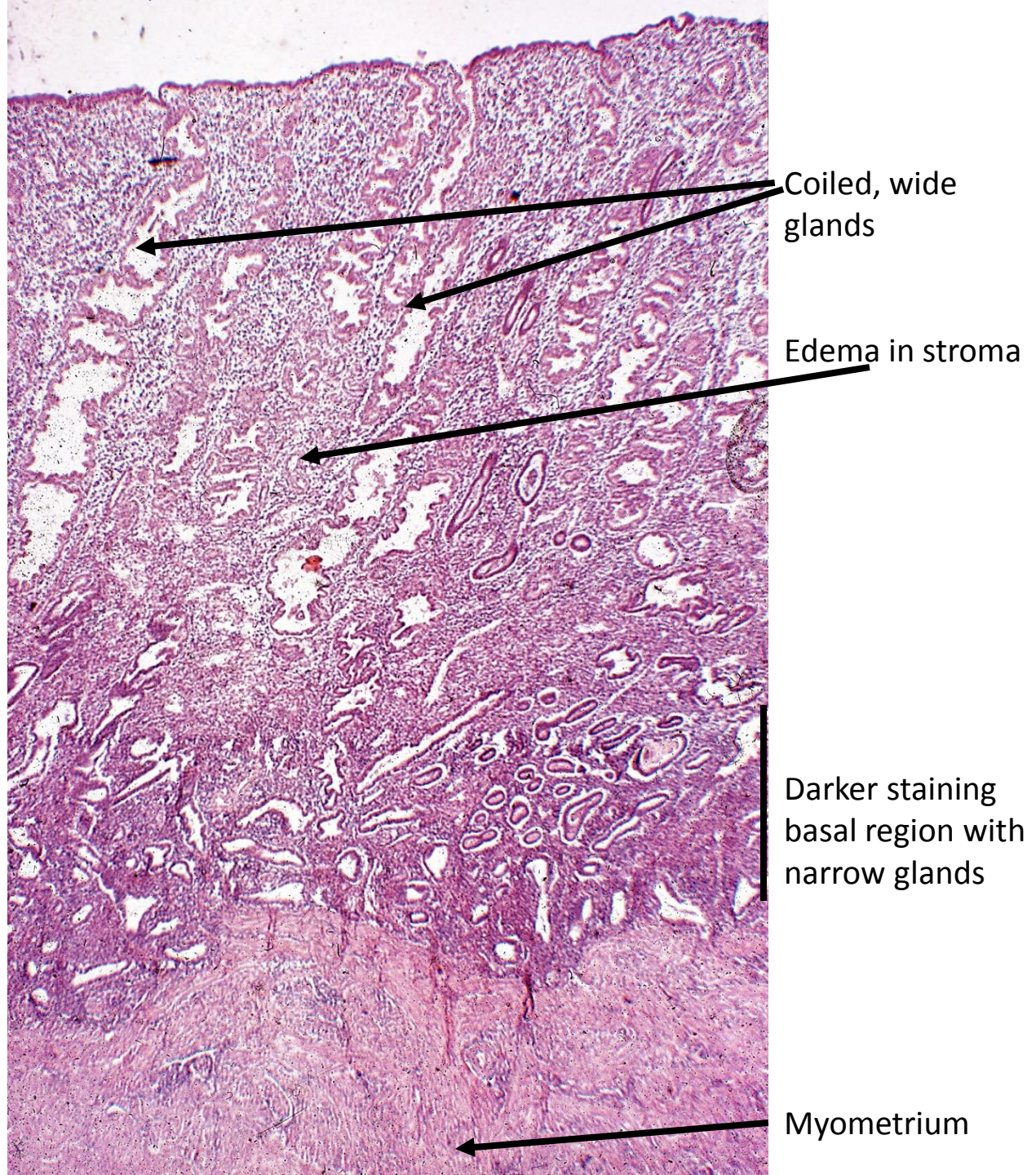
Proliferating phase

- Day 4-6 – day 14 of the cycle
- Increasing level of estrogen (growing follicles in the ovary)
- Functional layer of endometrium regenerates from basal layer in preparation for future implantation
- Functional layer thickens, glands lengthen, but remain straight

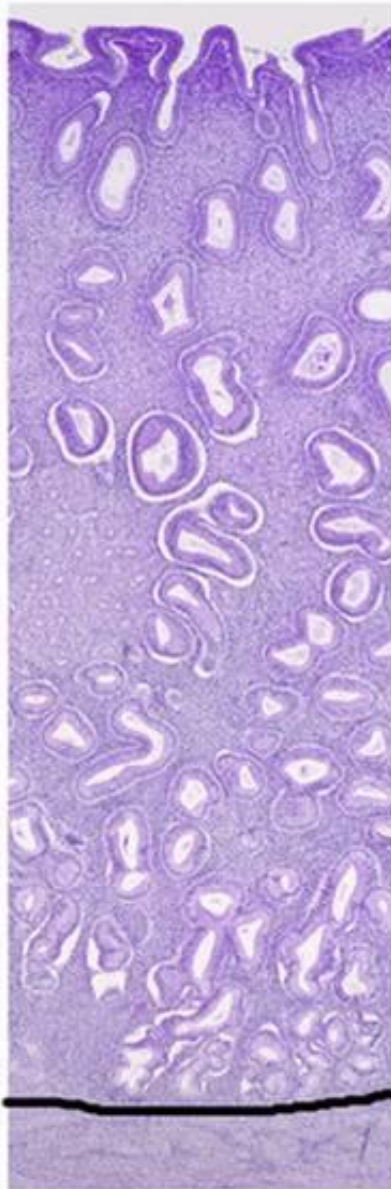


Secretory phase

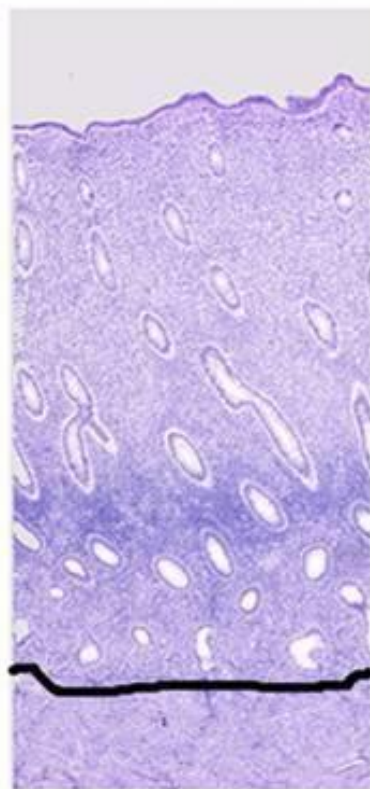
- Day 14 – Day 28
- Increasing level of progesterone (developing corpus luteum) causes edema of lamina propria and endometrial thickening.
- Glands grow, coil and increase secretion of glycoproteins (nutrition of embryo)
- Endometrium is prepared for implantation
- If implantation doesn't happen the menstrual cycle starts over again

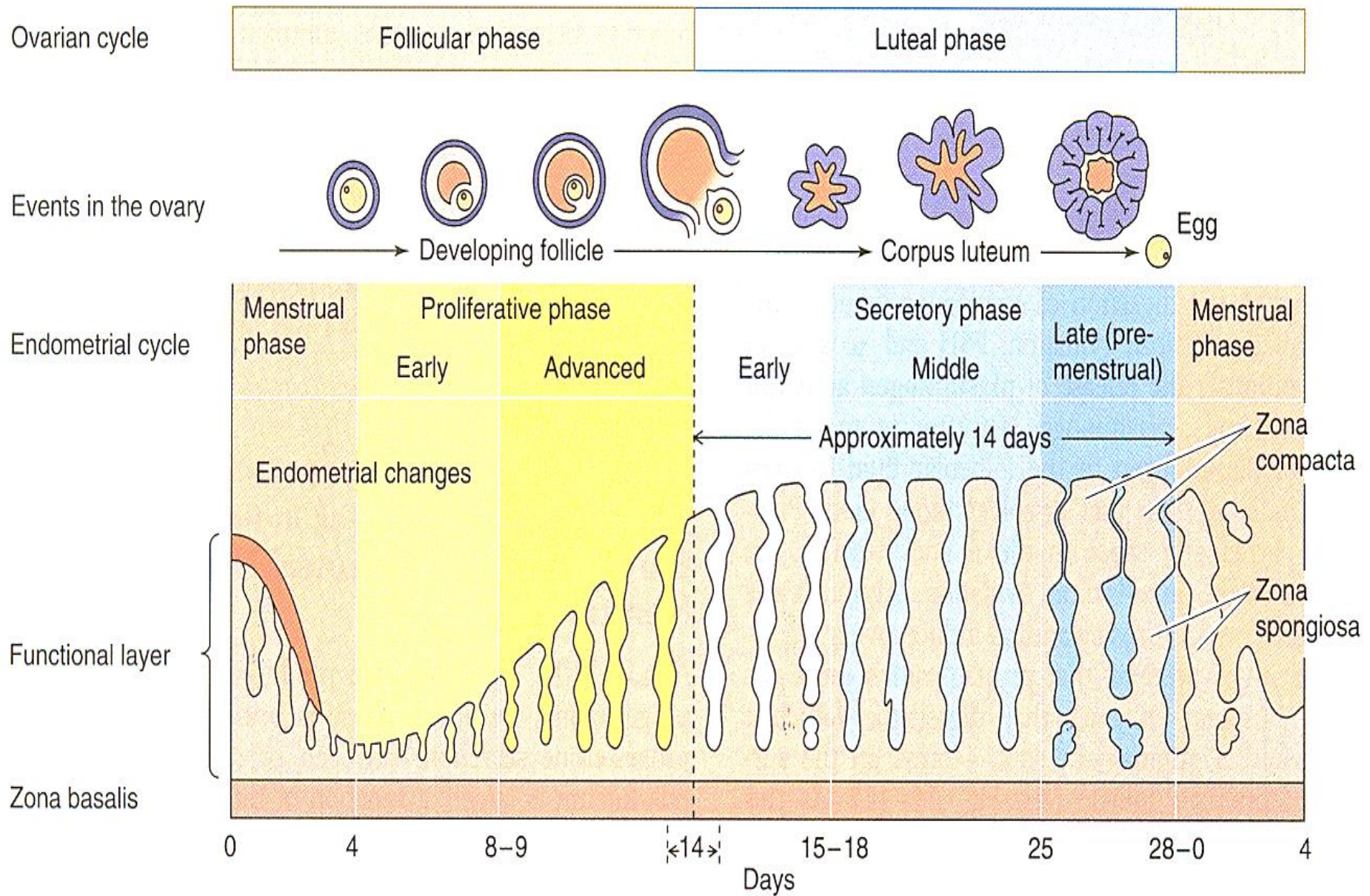


Secretory



Proliferative



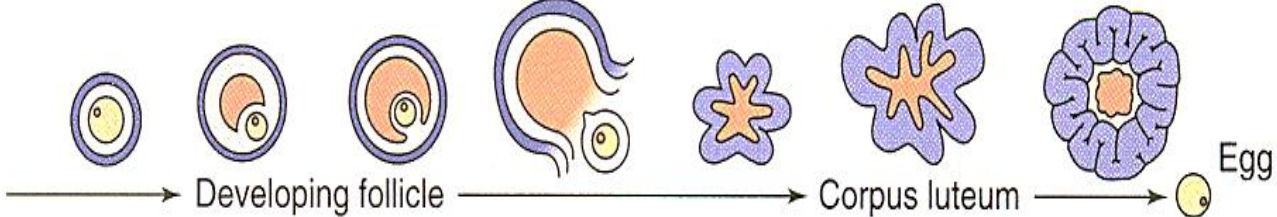


Ovarian cycle

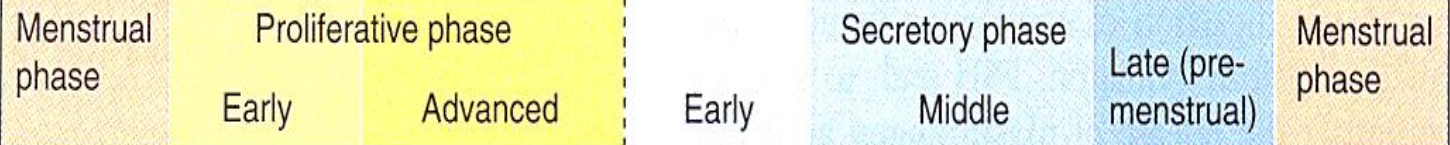
Follicular phase

Luteal phase

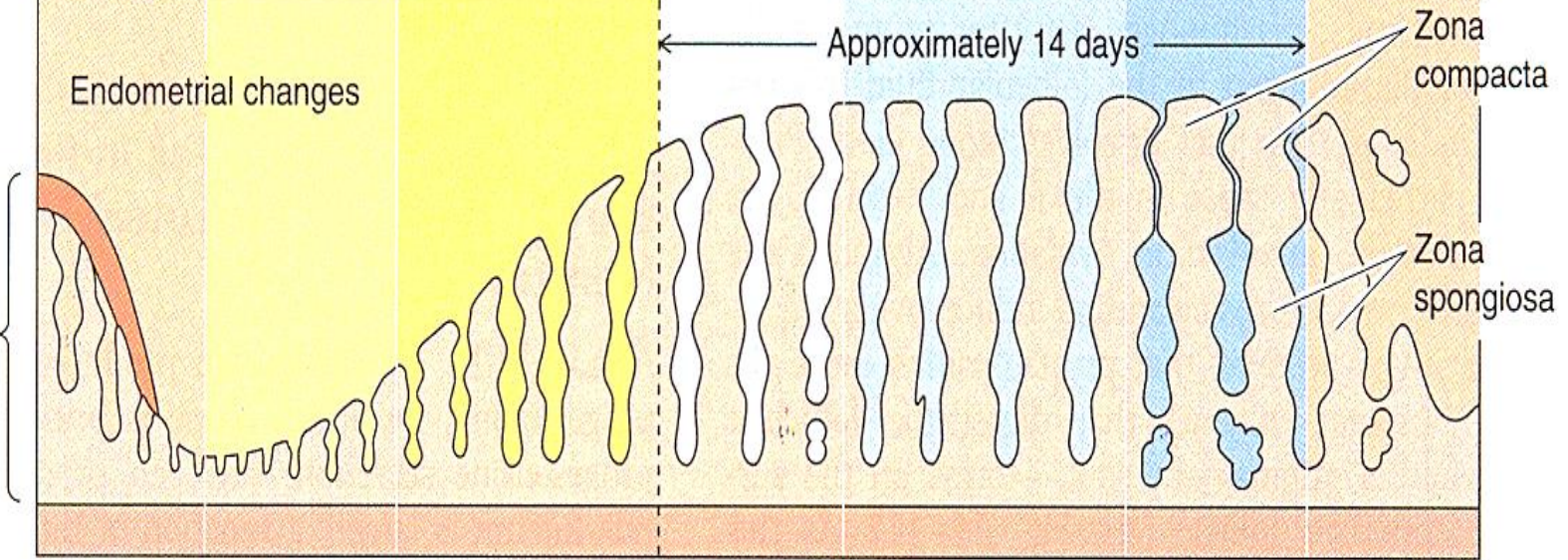
Events in the ovary



Endometrial cycle



Functional layer



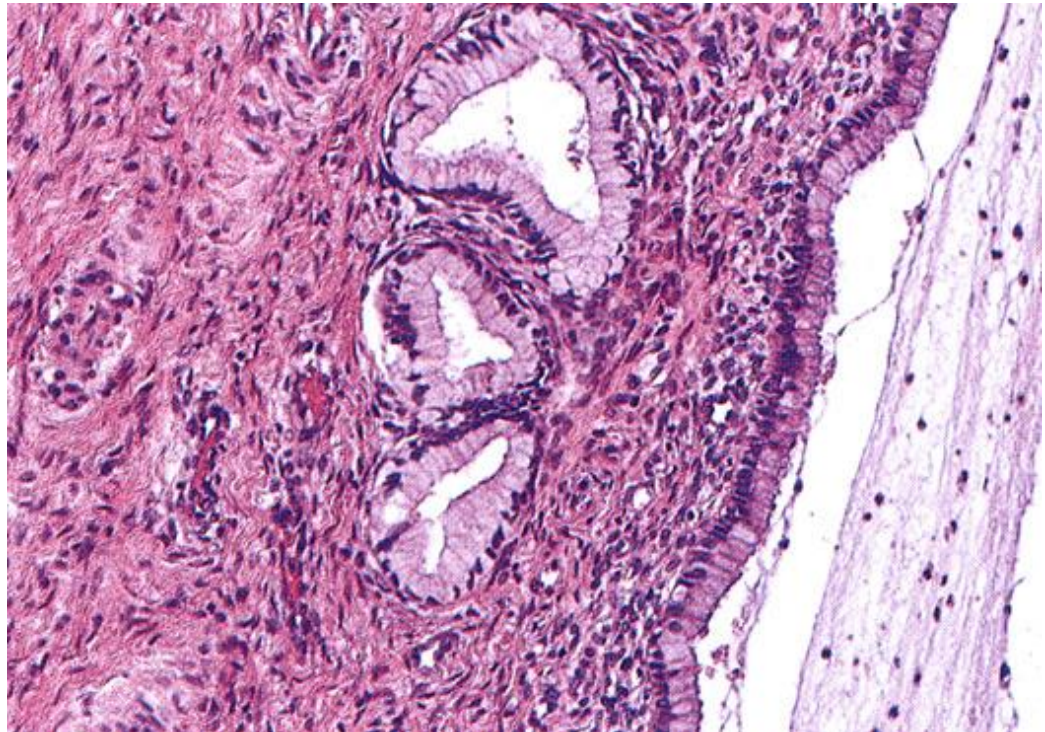
Zona basalis

0 4 8-9 <14> 15-18 25 28-0 4

Days

Cervix

- During each menstrual cycle the **cervical glands** undergo important functional changes that are related to the transport of spermatozoa within the cervical canal.
- The amount and properties of the mucus secreted by the gland cells vary during the menstrual cycle under the influence of the ovarian hormones.
- At midcycle, the amount of mucus produced increases 10-fold. This mucus is less viscous and appears to provide a more favorable environment for sperm migration.

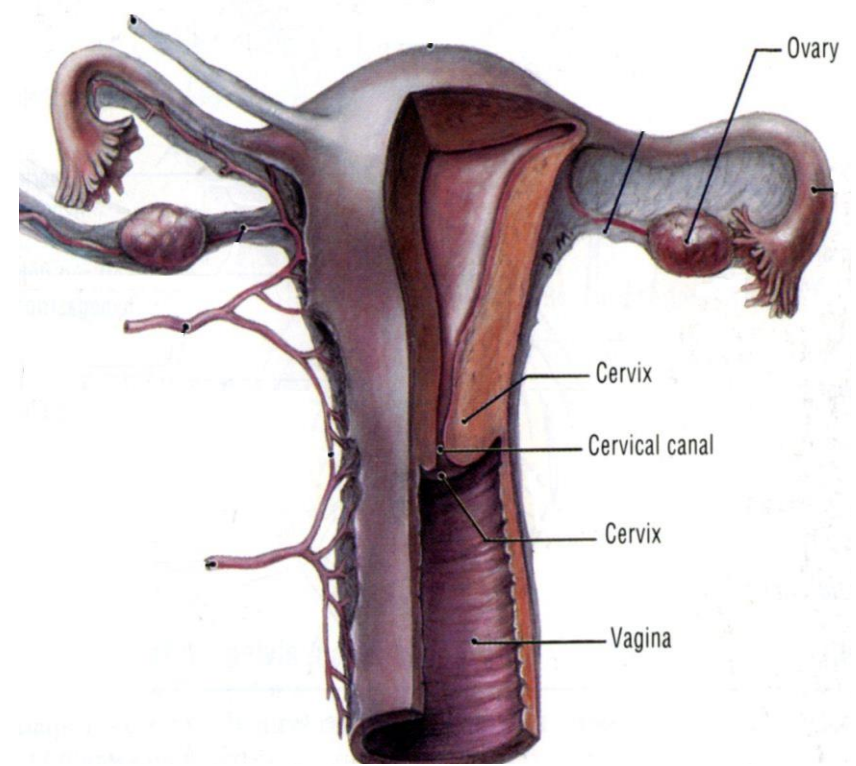


Cervical lining – Epithelium with a dense lamina propria (lp)



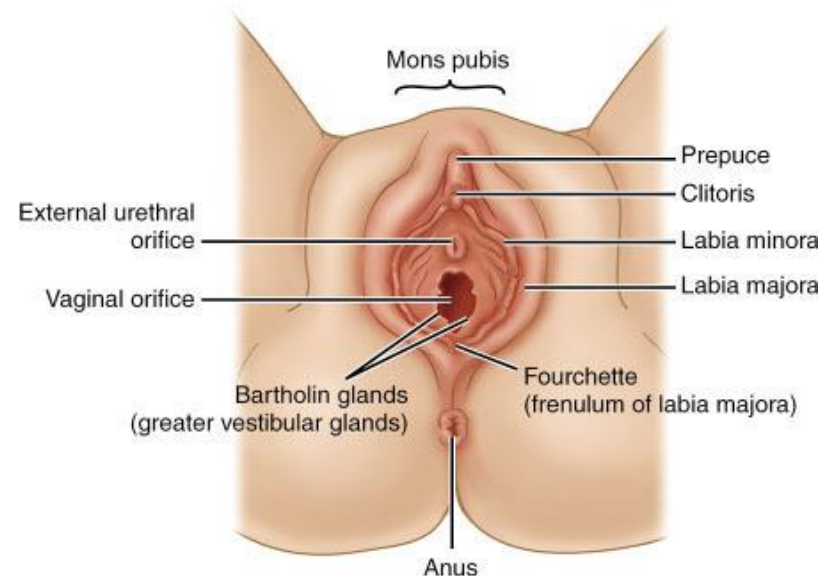
Vagina

- The **vagina** is a fibromuscular tube that joins internal reproductive organs to the external environment.
- The **vagina** is a fibromuscular sheath extending from the cervix to the vestibule, which is the area between the labia minora.
- In a virgin, the opening into the vagina may be surrounded by the **hymen**, folds of mucous membrane extending into the vaginal lumen.
- The **vagina** is lined by stratified, squamous nonkeratinized epithelium and lacks glands



□ The **female external genitalia** consist of the following parts, which are collectively referred to as the **vulva** and have a stratified squamous epithelium:

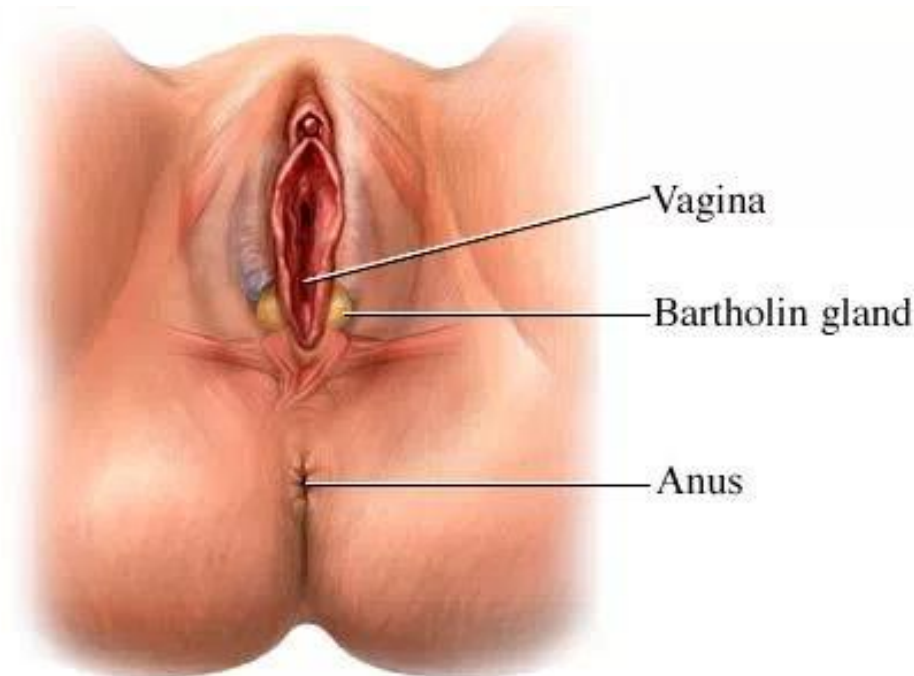
- **Mons pubis**: fatty pad over the pubic symphysis
- The **labia majora** are two large longitudinal folds of skin, homologous to the skin of the scrotum, that extend from the mons pubis and form the lateral boundaries of the urogenital cleft. The outer surface, like that of the mons pubis, is covered with pubic hair. The inner surface is smooth and devoid of hair. Sebaceous and sweat glands are present on both surfaces.
- The **labia minora** are paired, hairless folds of skin that border the vestibule. Abundant melanin pigment is present in the deep cells of the epithelium. Large sebaceous glands are present in the stroma.
- The **clitoris** is an erectile structure that is homologous to the penis. Its body is composed of two small erectile bodies, the **corpora cavernosa**; the glans clitoris is a small, rounded tubercle of erectile tissue. The skin over the glans is very thin, forms the prepuce of the clitoris, and contains numerous sensory nerve endings.



Bartholin's Glands

(aka: Vestibular Glands)

- The Bartholin's glands are located on each side of the vaginal opening.
- They secrete fluid that helps lubricate the vagina.



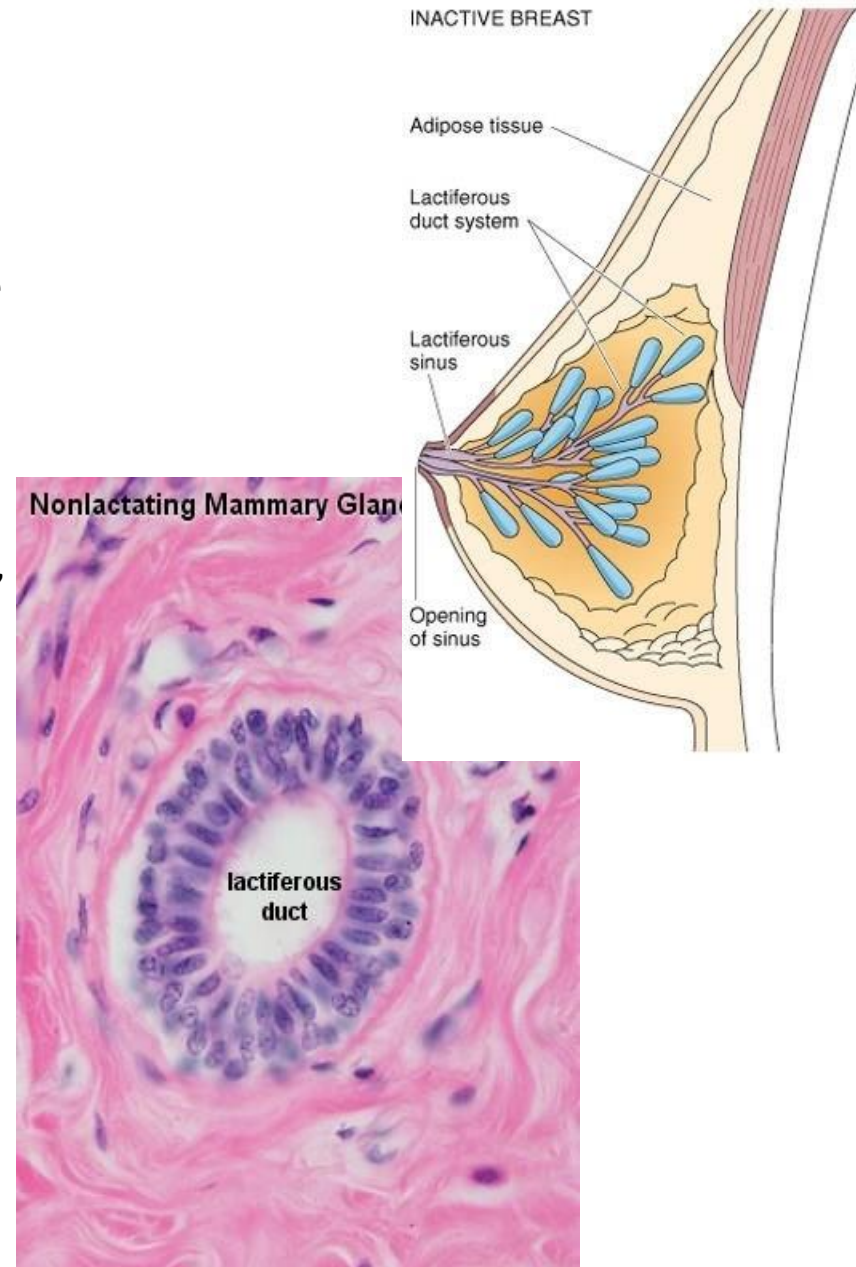
Urethra

- Short compared to a male urethra
- Carries only urine
- Lined by transitional epithelium in the upper part and stratified squamous epithelium in the lower part
- Muscles of urogenital diaphragm surrounding the urethra make the external voluntary sphincter



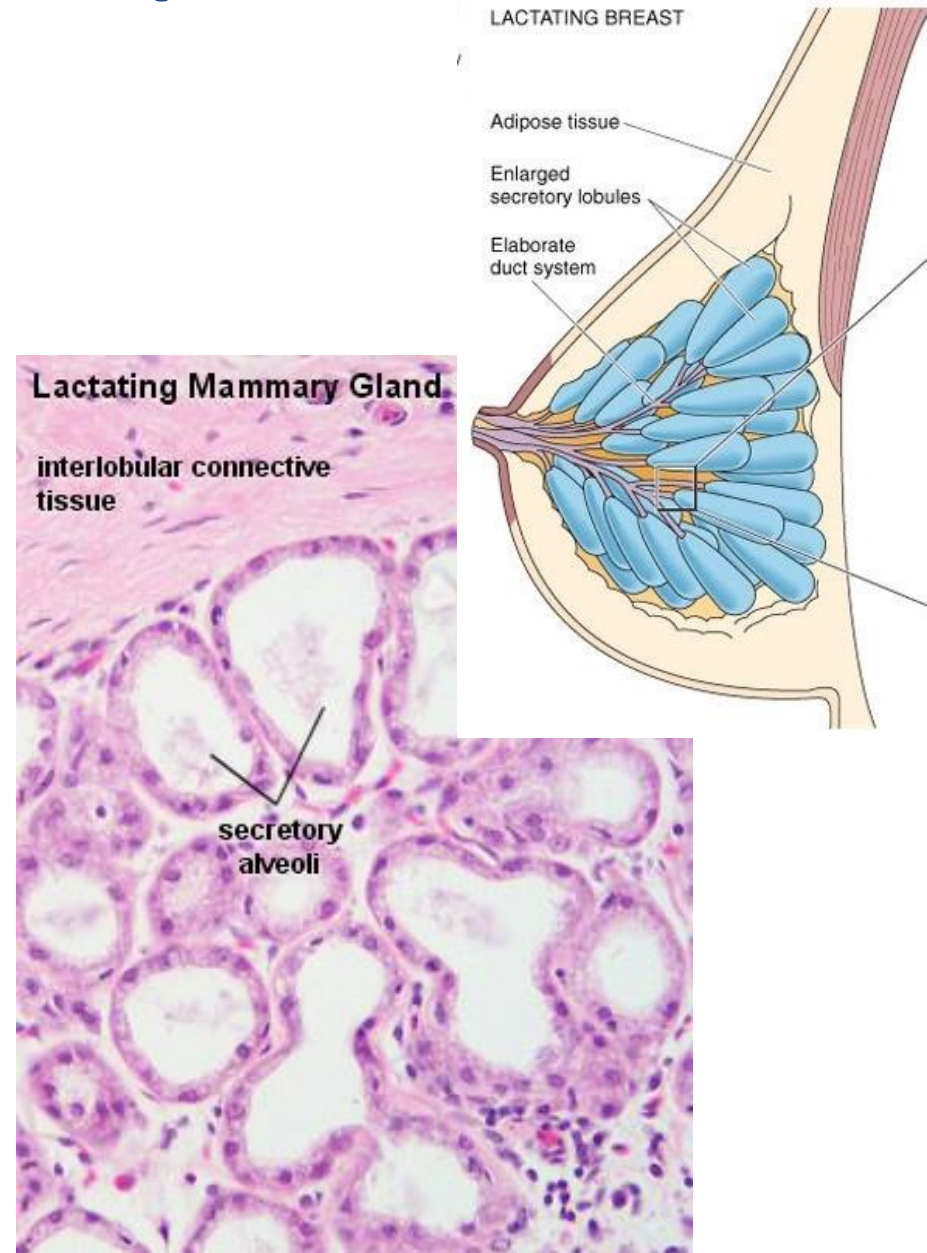
Mammary gland (non-lactating)

- Modified sweat glands of the skin
- Compound branched alveolar glands
- 15-25 lobes separated by dense connective tissue and fat
- Each lobe contains an individual gland
- The excretory duct of each lobe, ***lactiferous duct***, has its own opening on the nipple
- The lactiferous duct has a *two layered epithelium* - basal cells are cuboidal whereas the superficial cells are columnar. The secretory units are ***alveoli***, which are lined by a cuboidal or columnar epithelium.
- *A layer of myoepithelial cells is always present between the epithelium and the basement membrane of the branches of the lactiferous duct and the alveoli.*



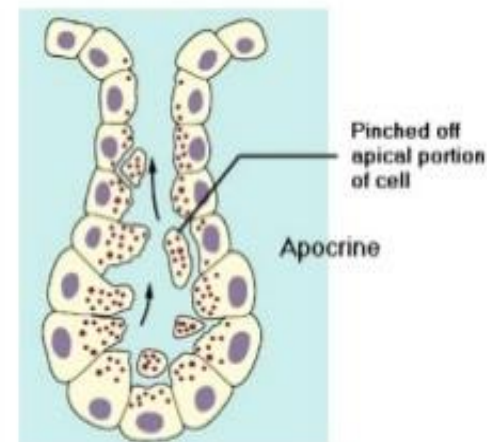
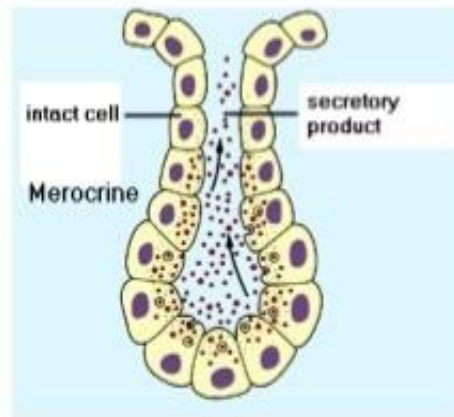
Mammary gland (lactating)

- Elevated levels of estrogen and progesterone during the first half of pregnancy induces growth and formation of new alveoli and terminal branches of ducts
- Reduction in the amount of intra- and interlobular connective tissue
- During the second half of pregnancy growth of the mammary glands continues due to increases in the height of epithelial cells and an expansion of the lumen of the alveoli.



Lactation

- Human milk – a unique complex nutritive fluid with immunologic and growth promoting properties
- Breast milk is the most appropriate source of nutrition for babies
- **Secretion** of milk - under the influence of hormone **prolactin**.
- The protein component of milk - by merocrine secretion, the lipid component – by apocrine secretion
- **Ejection** of milk – under the influence of **oxytocin**



Thank you for attention

