Female reproductive system

MUDr. Andrea Felšöová

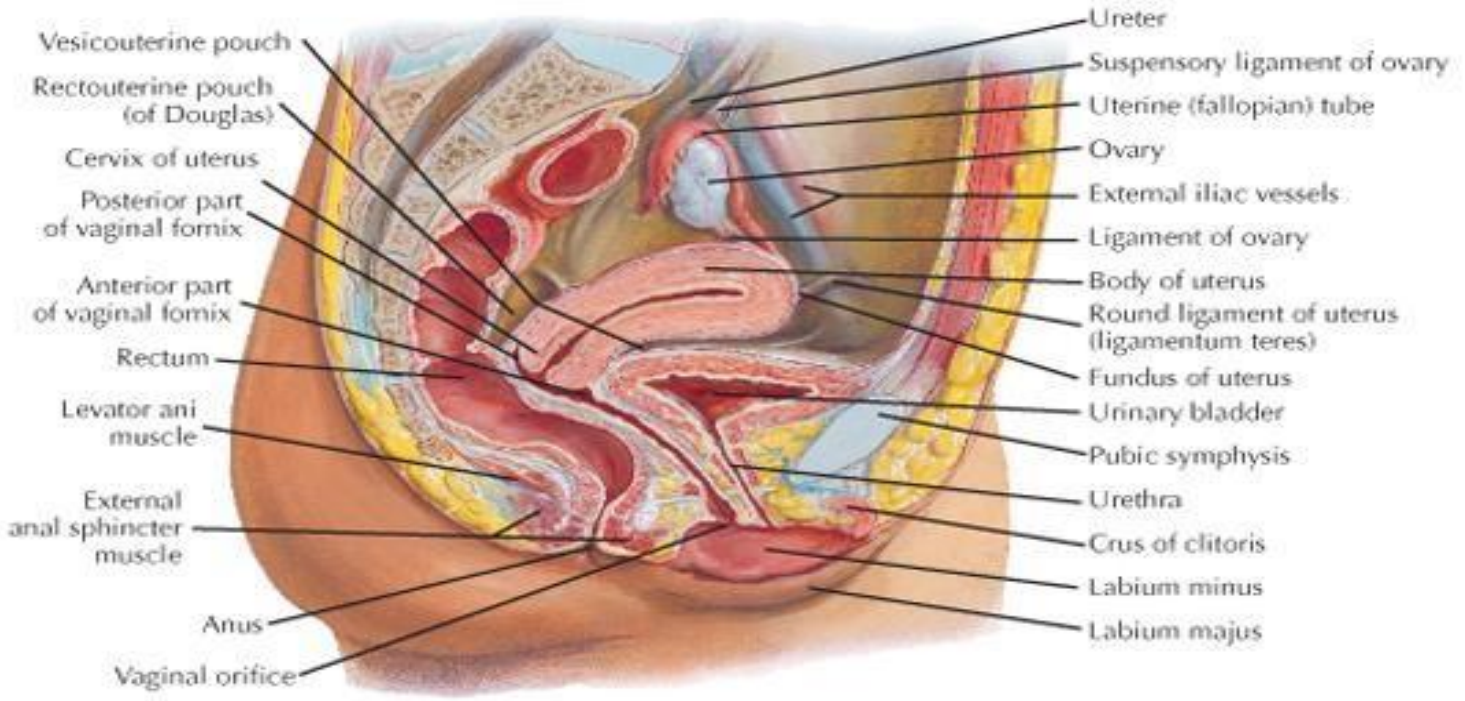
Female reproductive system

- Paired ovaries
- Uterine tubes (fallopian tubes)
- Uterus
- Vagina

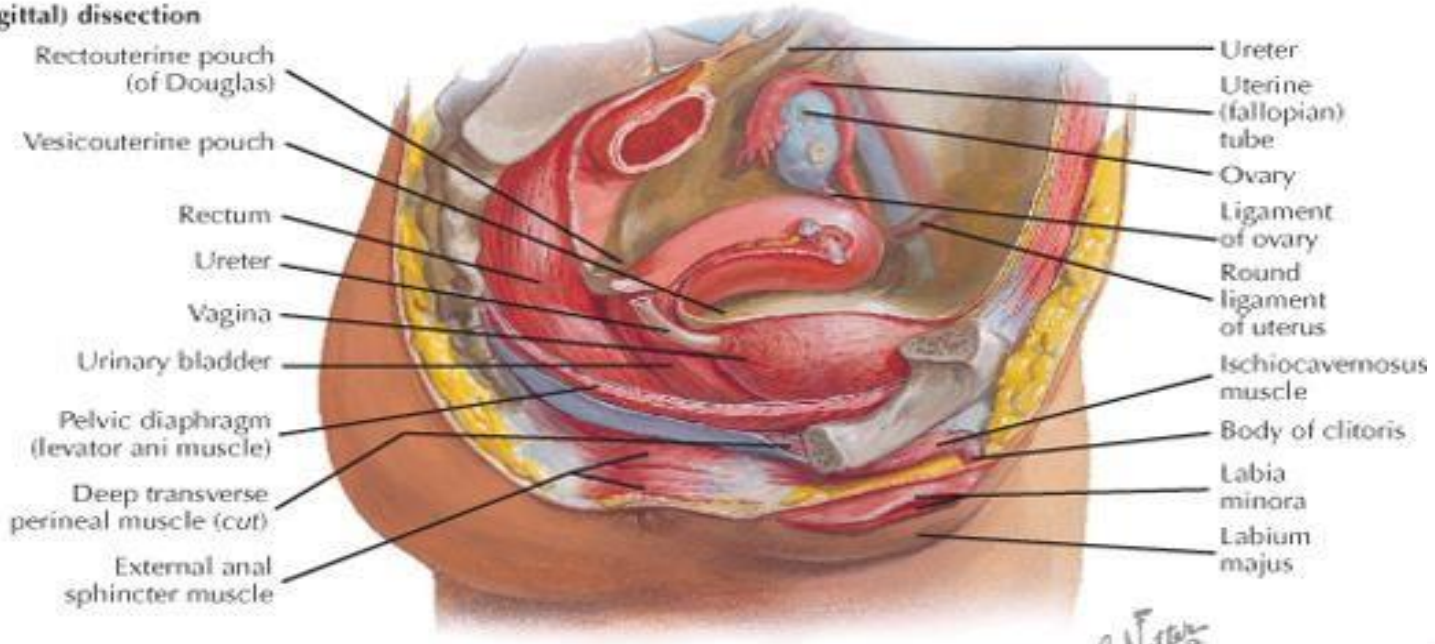
- Labia majora
- Labia minora
- Clitoris

Topography of the female pelvic viscera: medial and paramedial sagittal views.

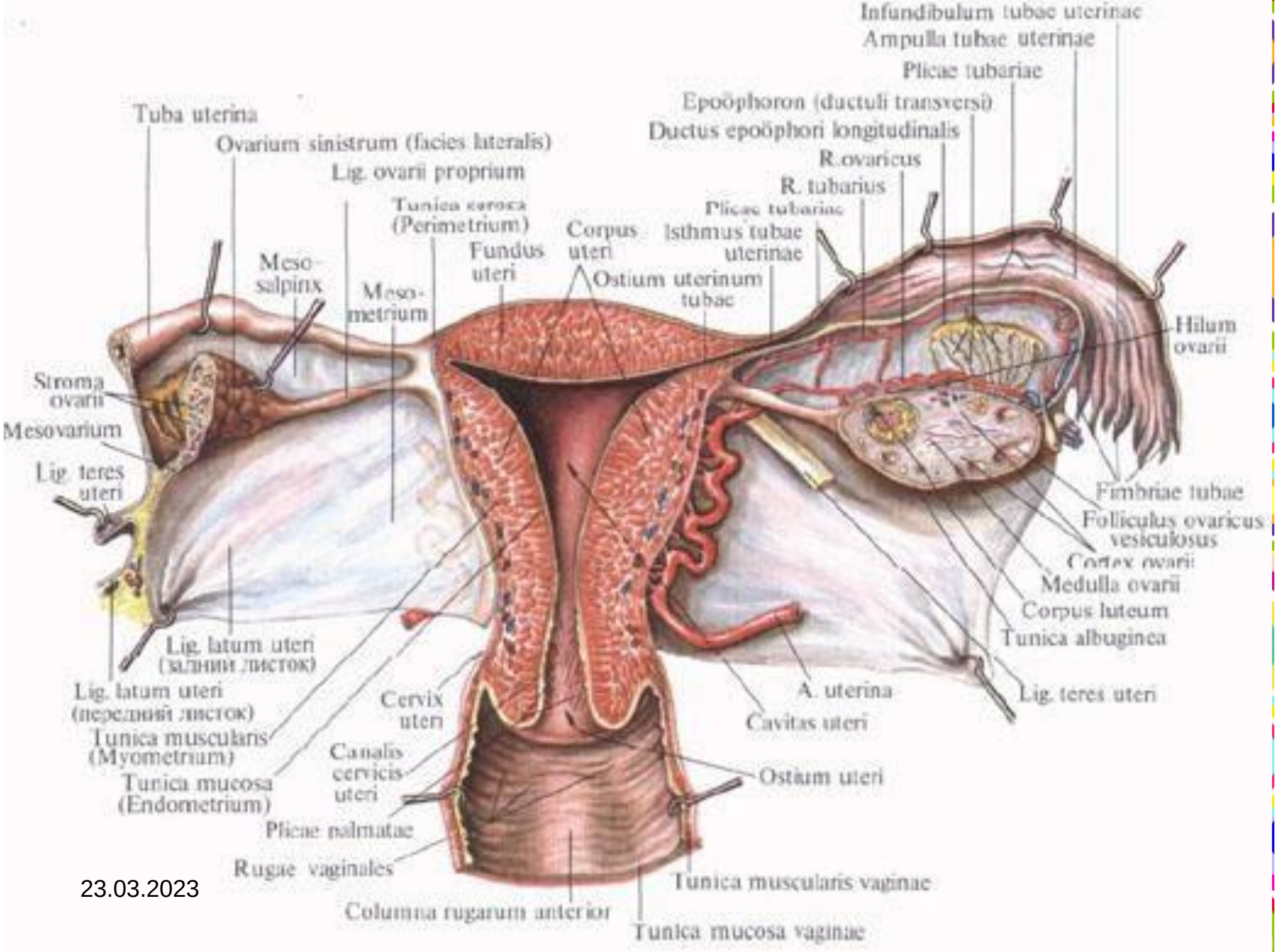
Median (sagittal) section



Paramedian (sagittal) dissection



F. Netter M.D.
C. Machado M.D.


Infundibulum tubae uterinae
Ampulla tubae uterinae
Plicae tubariae
Epoöphoron (ductuli transversi)
Ductus epoöphori longitudinalis
R. ovaricus
R. tubarius
Plicae tubariae
Tuba uterina
Ovarium sinistrum (facies lateralis)
Lig. ovarii proprium
Tunica serosa
(Perimetrium)
Corpus uteri
Isthmus tubae uterinae
Meso-
salpinx
Fundus uteri
Meso-
metrium
Ostium uterinum tubae
Hilum ovarii
Stroma ovarii
Mesovarium
Lig. teres uteri
Fimbriae tubae
Folliculus ovaricus vesiculosus
Cortex ovarii
Medulla ovarii
Corpus luteum
Tunica albuginea
Lig. latum uteri
(задний листок)
Lig. latum uteri
(передний листок)
A. uterina
Lig. teres uteri
Cervix uteri
Cavitas uteri
Tunica muscularis
(Myometrium)
Canalis cervicis uteri
Ostium uteri
Tunica mucosa
(Endometrium)
Plicae palmatae
Rugae vaginales
Tunica muscularis vaginae
Columna rugarum anterior
Tunica mucosa vaginae

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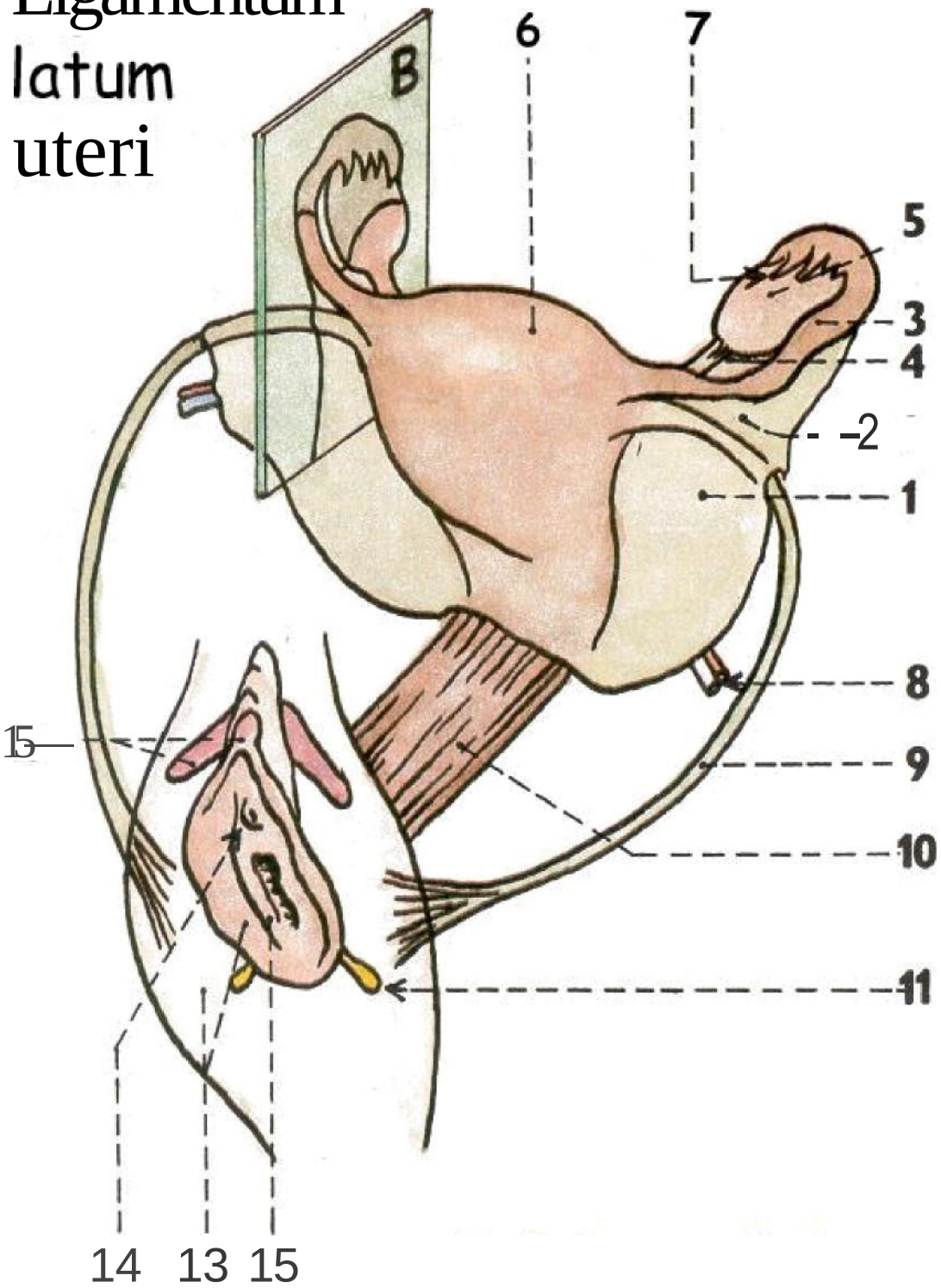
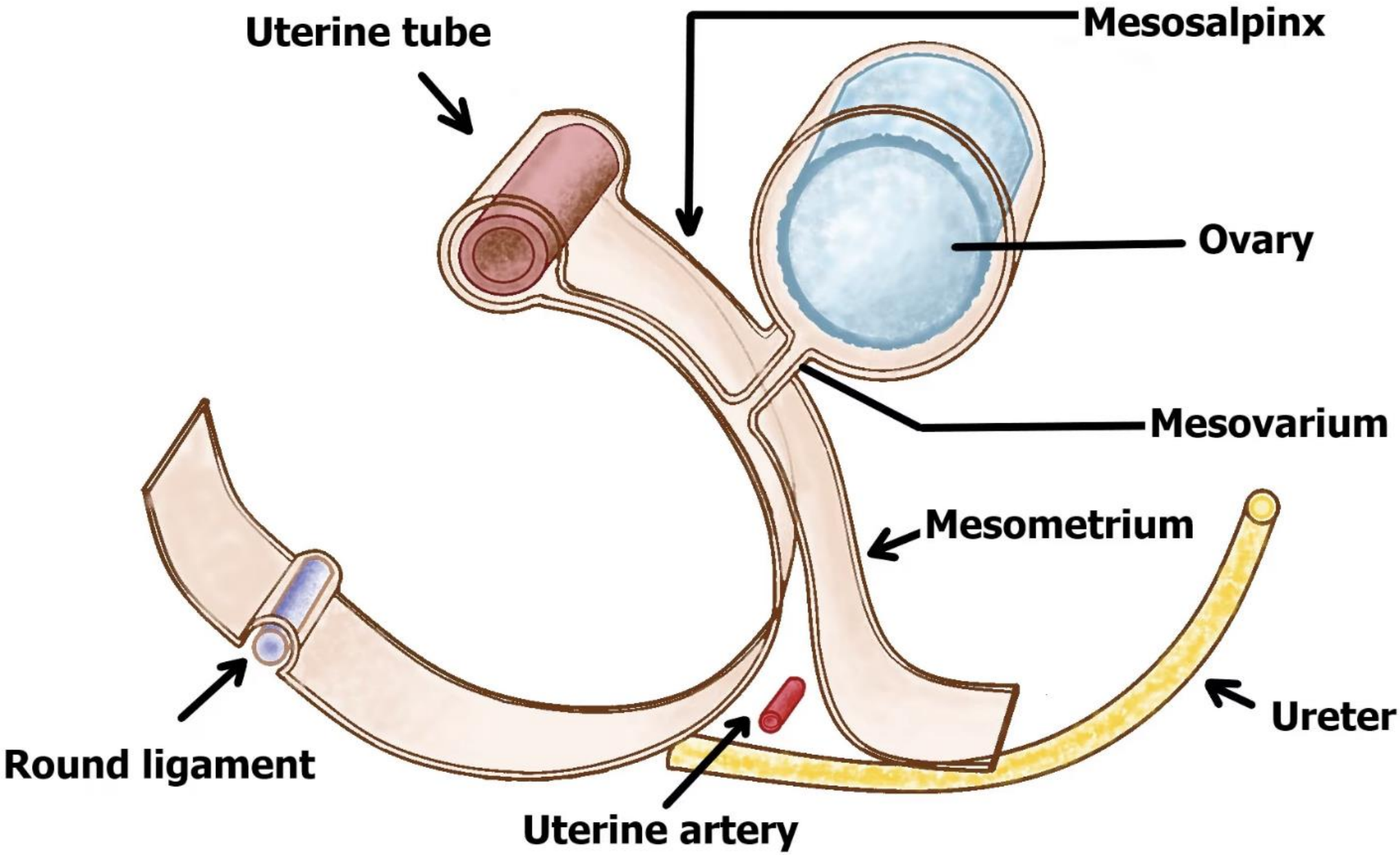
Ligamentum latum uteri

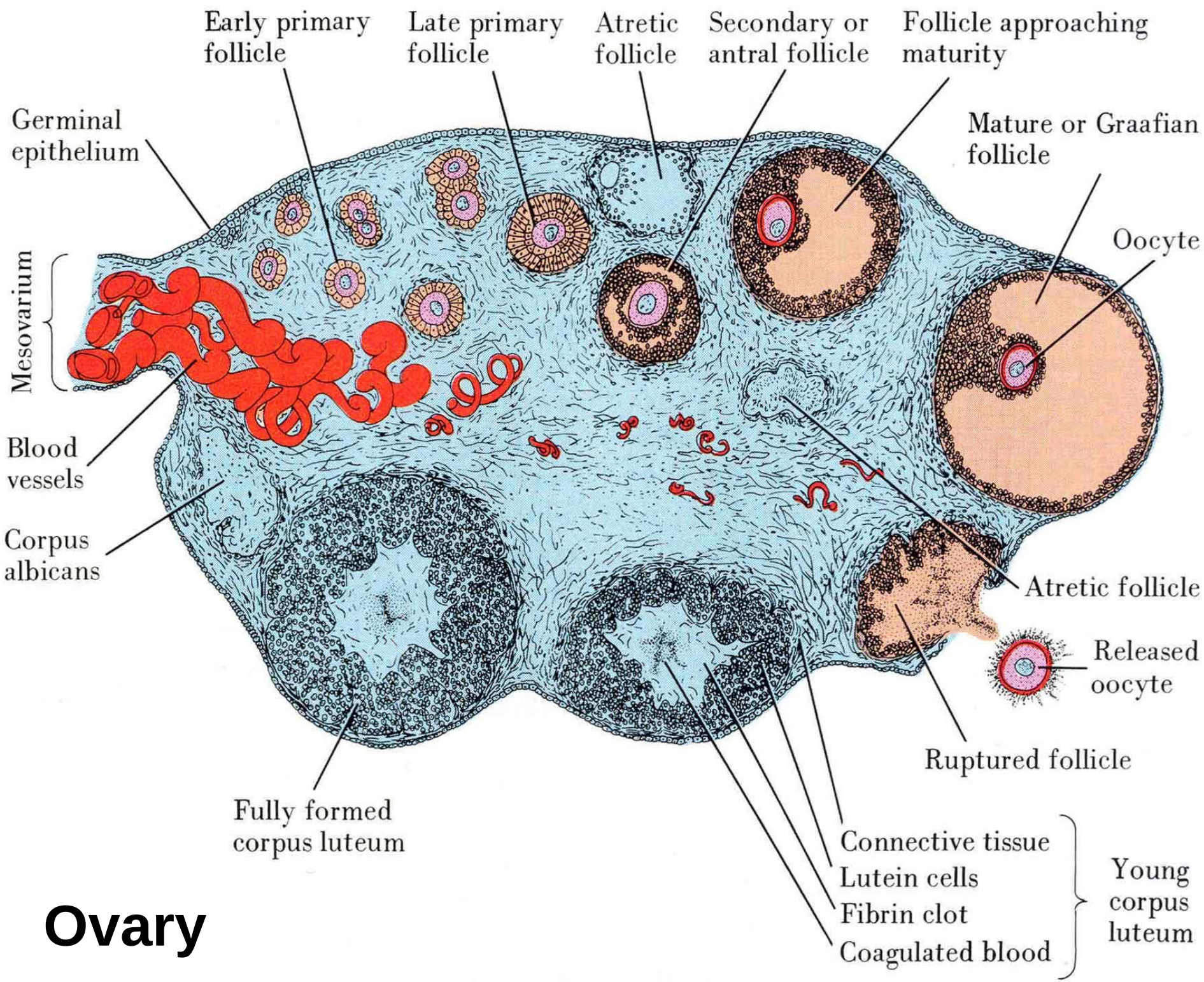



Uterine tube
Mesosalpinx
Ovary
Mesovarium
Mesometrium
Ureter
Round ligament
Uterine artery

Ovaries

- Almond-shaped glands (3x2x1cm)
- **Ovarian surface epithelium**
  - Germinal epithelium (misnomer)
    - **These cells are not source of ova!!!**
    - Modified mesothelial cells
    - Simple cuboidal-columnar epithelium
- **Tunica albuginea**
  - Fibrous connective tissue under the epithelium
    Not true tunica like in testes

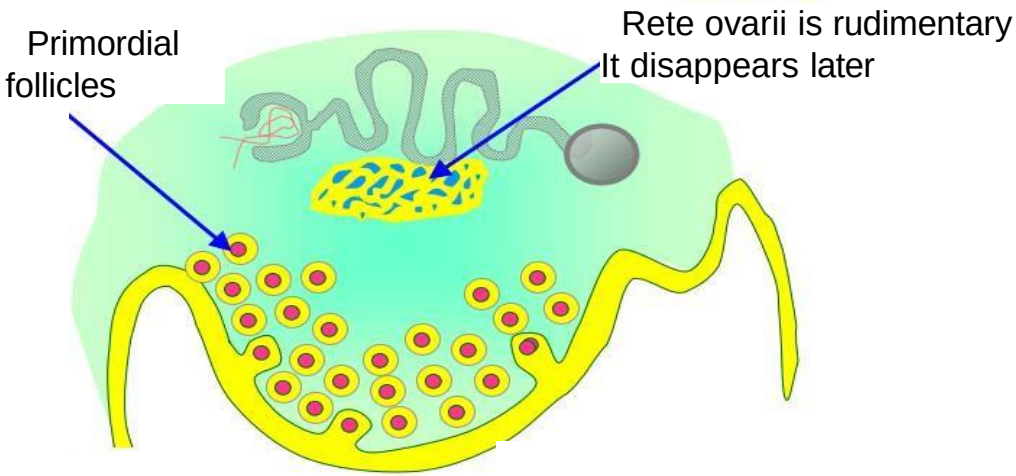
Gross appearance of ovary.
A. Newborn, external aspect. B. Pubertal (age 15 years), sectioned surface. Note elongate shape and multiple cystic follicles. C. Adult (age 30), external aspect. D. Postmenopausal, external aspect. Note shrunken, gyriform appearance.


Early primary follicle
Late primary follicle
Atretic follicle
Secondary or antral follicle
Follicle approaching maturity
Germinal epithelium
Mature or Graafian follicle
Oocyte
Mesovarium
Blood vessels
Corpus albicans
Atretic follicle
Released oocyte
Ruptured follicle
Fully formed corpus luteum
Connective tissue
Lutein cells
Fibrin clot
Coagulated blood
Young corpus luteum

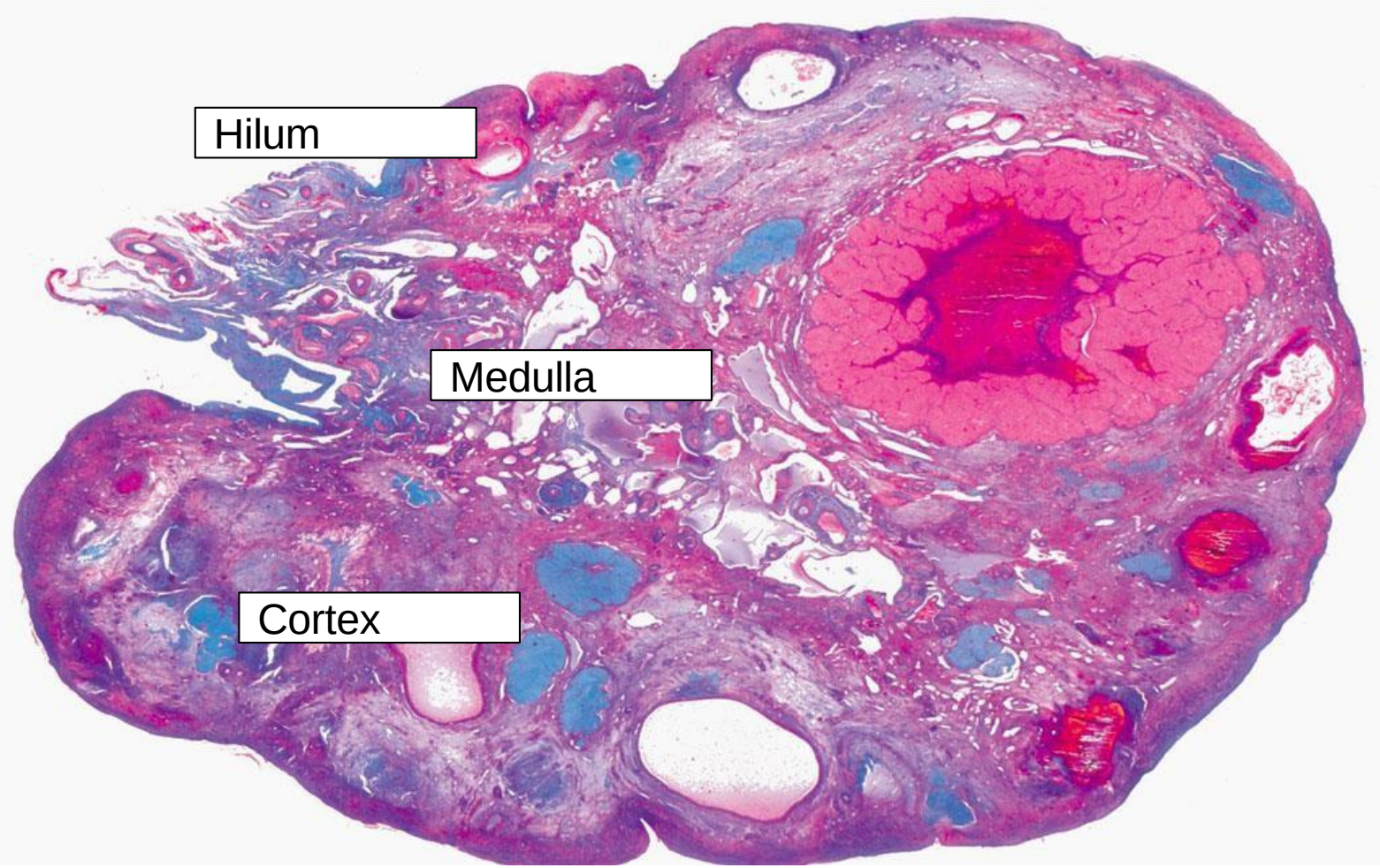
Ovary

Ovaries

- **Medulla** = inner part
- **Cortex** = outer part



Ovaries



Cortex – contains follicles
Medulla – loose connective tissue and vessels

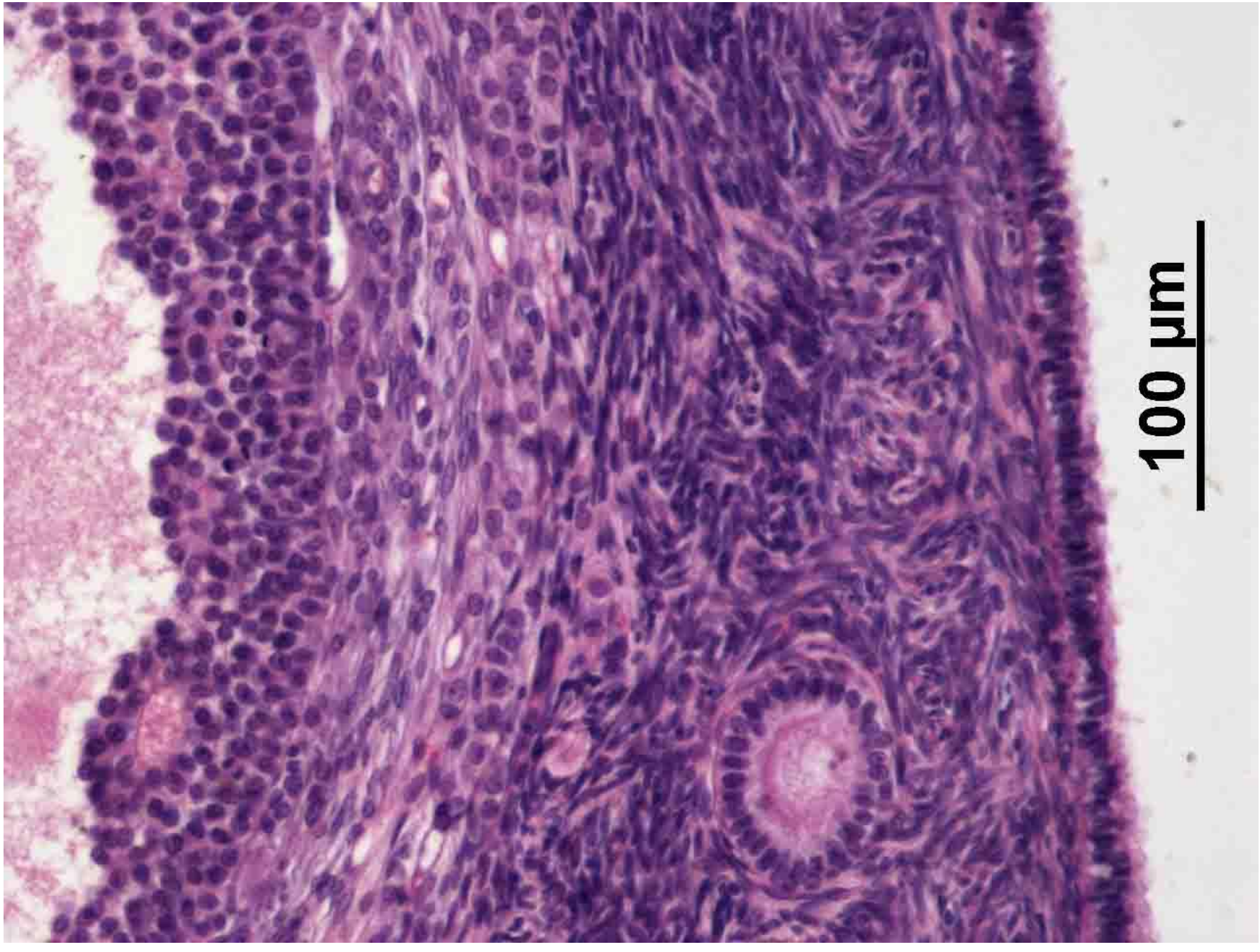
Ovarian cortex

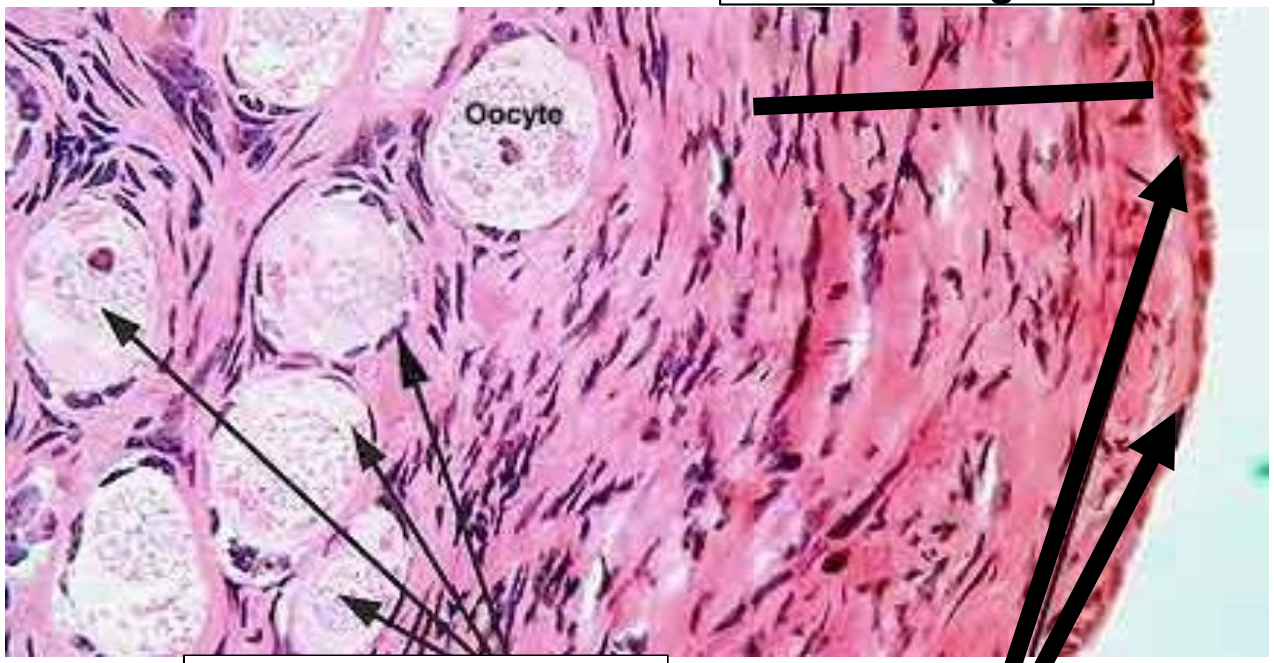
- **Ovarian surface epithelium**
- **“Tunica albuginea”**

- **Ovarian follicles**
  - Various size and different stages of maturation
- **Connective tissue stroma**
  - Special fibroblasts, collagen and reticular fibres, smooth muscle cells

Surface epithelium

single, focally pseudostratified layer of modified peritoneal cells.

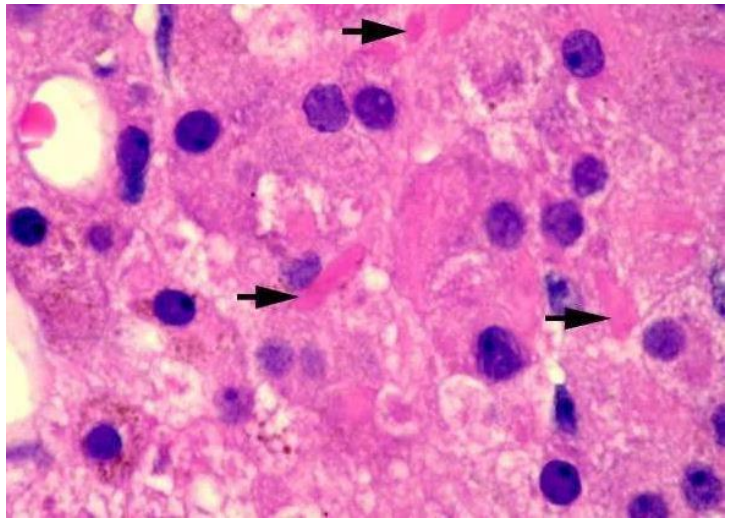


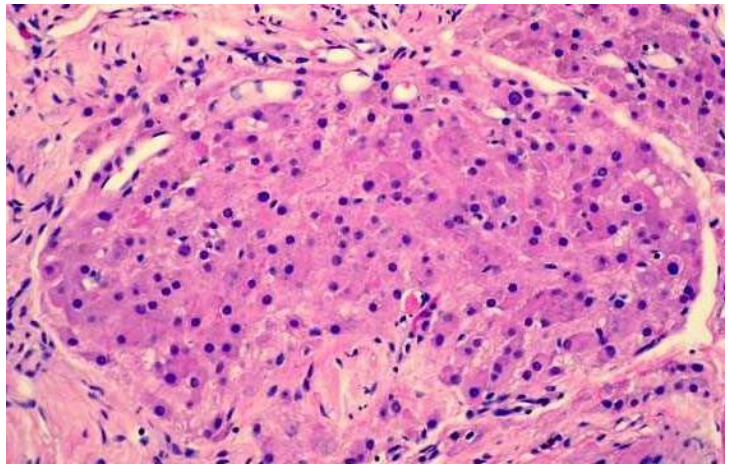


The epithelium used to be called **germinal.**
Since oocytes are not derived from the epithelium, this term is no longer used. The origin is **mesothelium.**

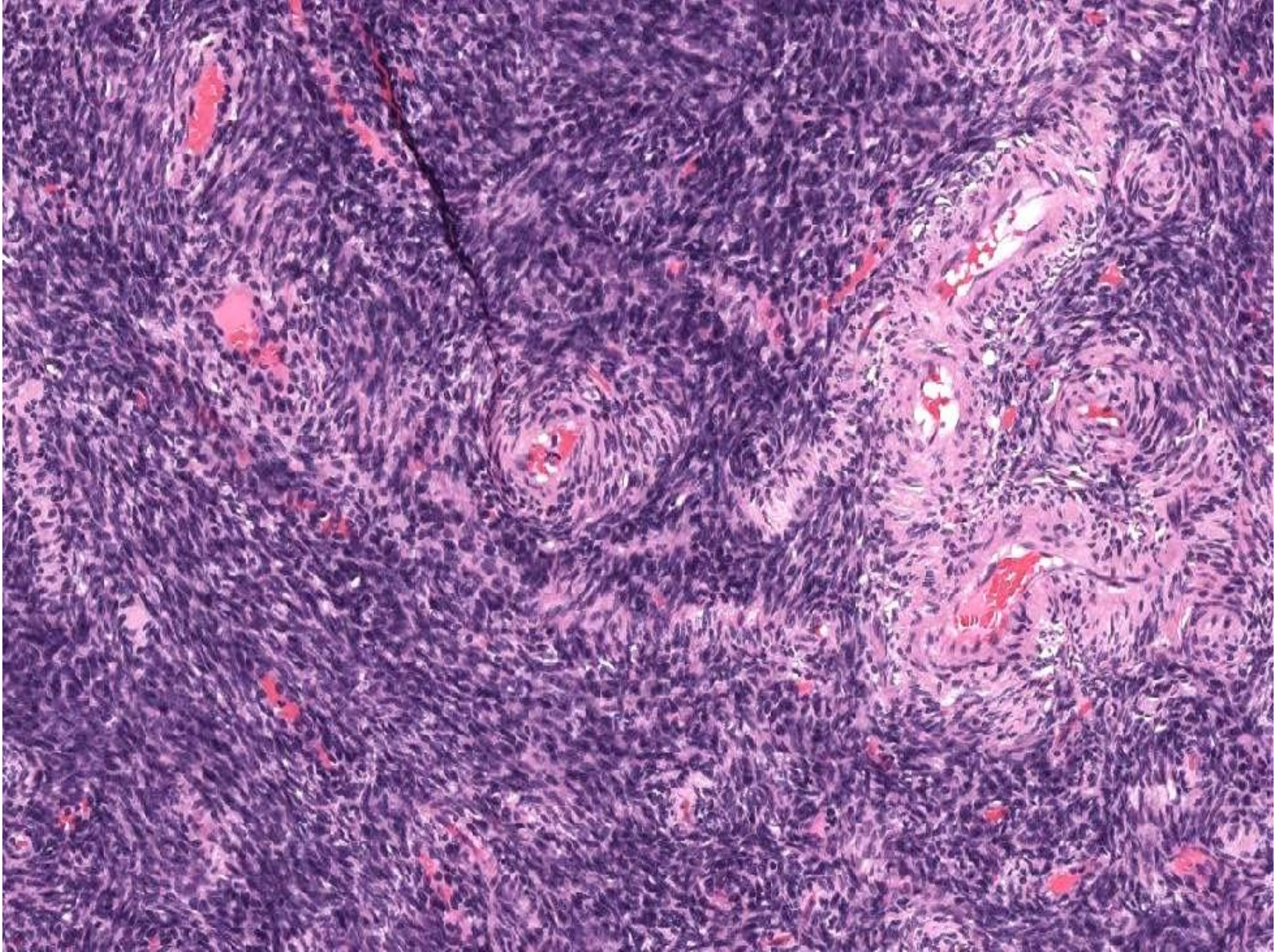
Ovarian medulla

- Loose connective tissue
- Nerves
- Blood vessels
- Lymphatics
- **Ovarian hilus cells**



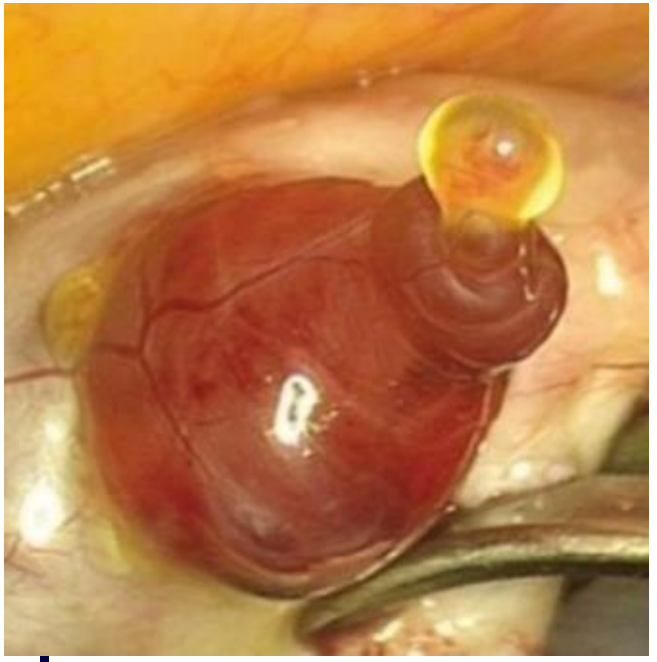


- **No ovarian follicles here**



Ovarian follicles

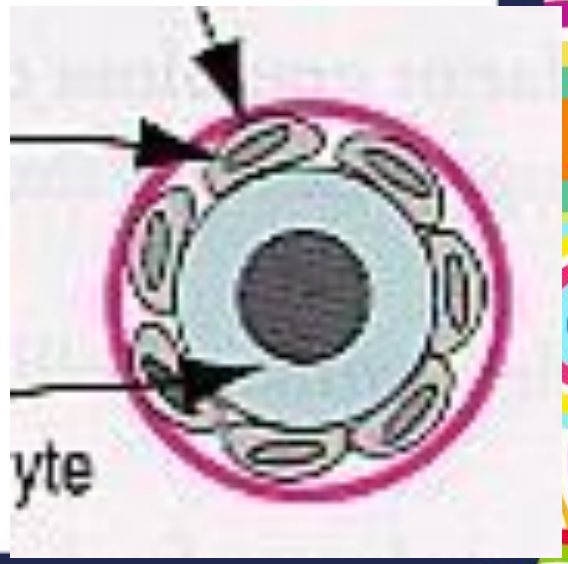
- One oocyte
- Layer/s of follicular cells

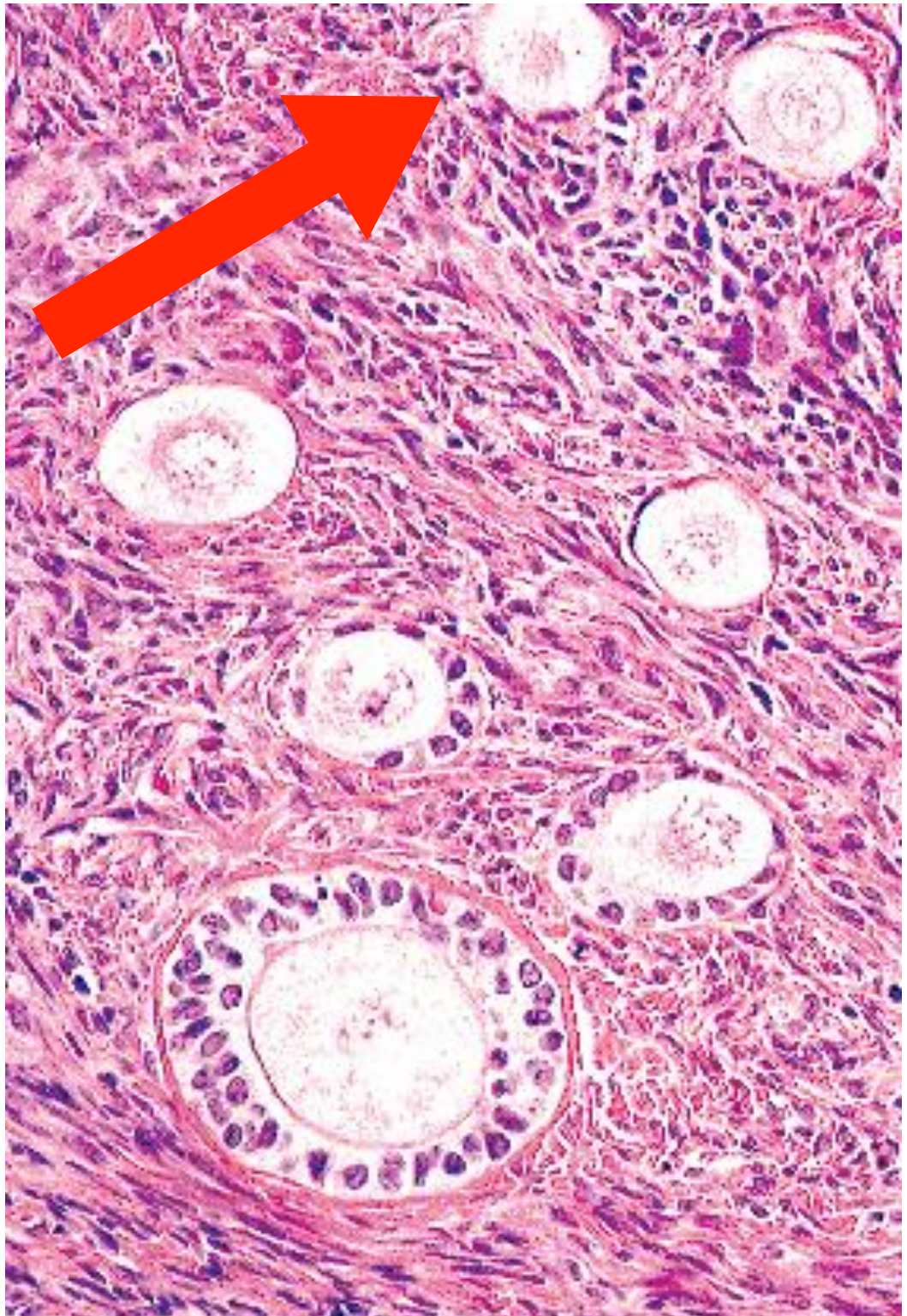


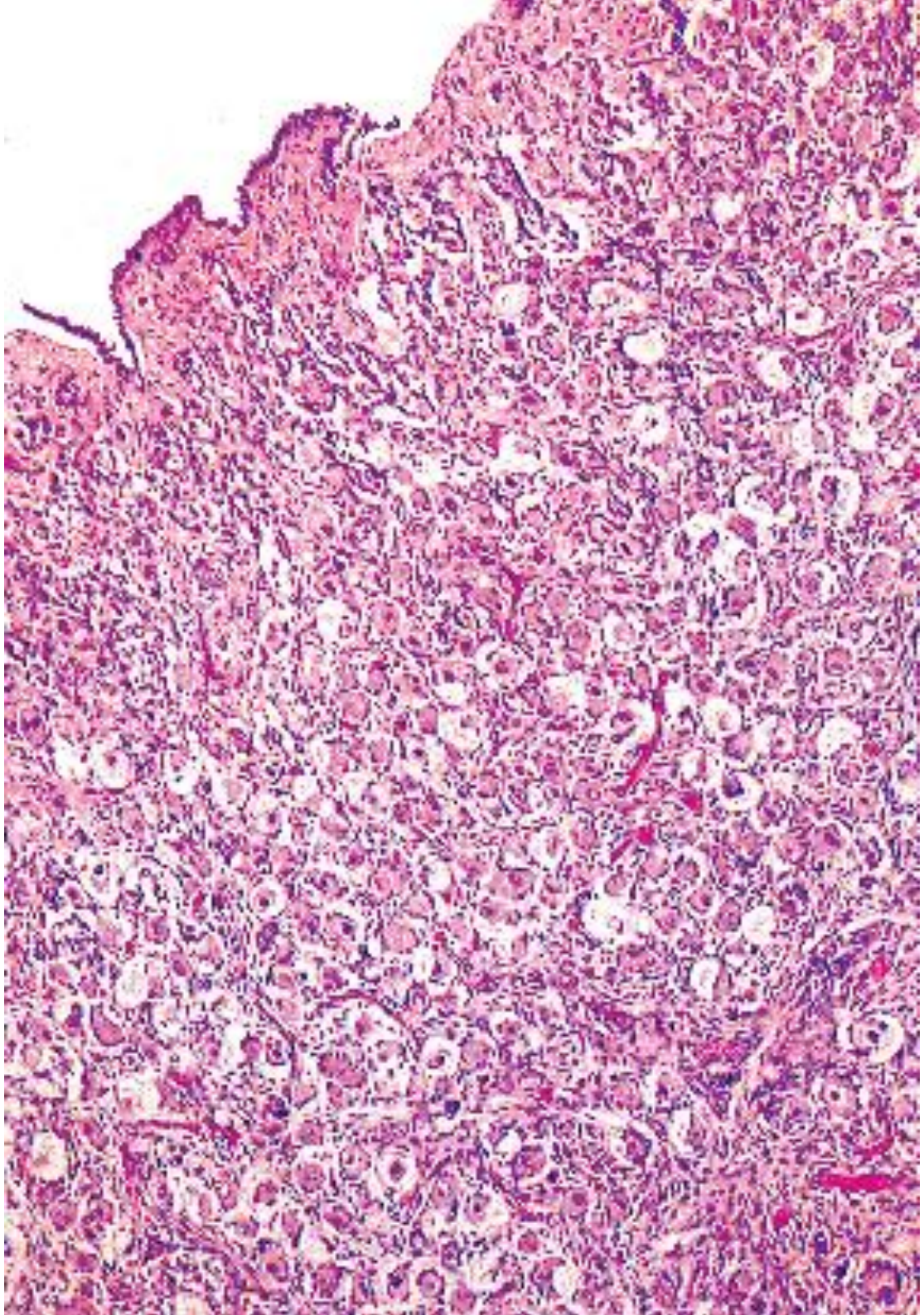
- Primordial follicle
- Primary follicle
  - Unilaminar
  - Multilaminar
- Secondary / preantral follicle
- Tertiary / antral follicle
- Graafian follicle

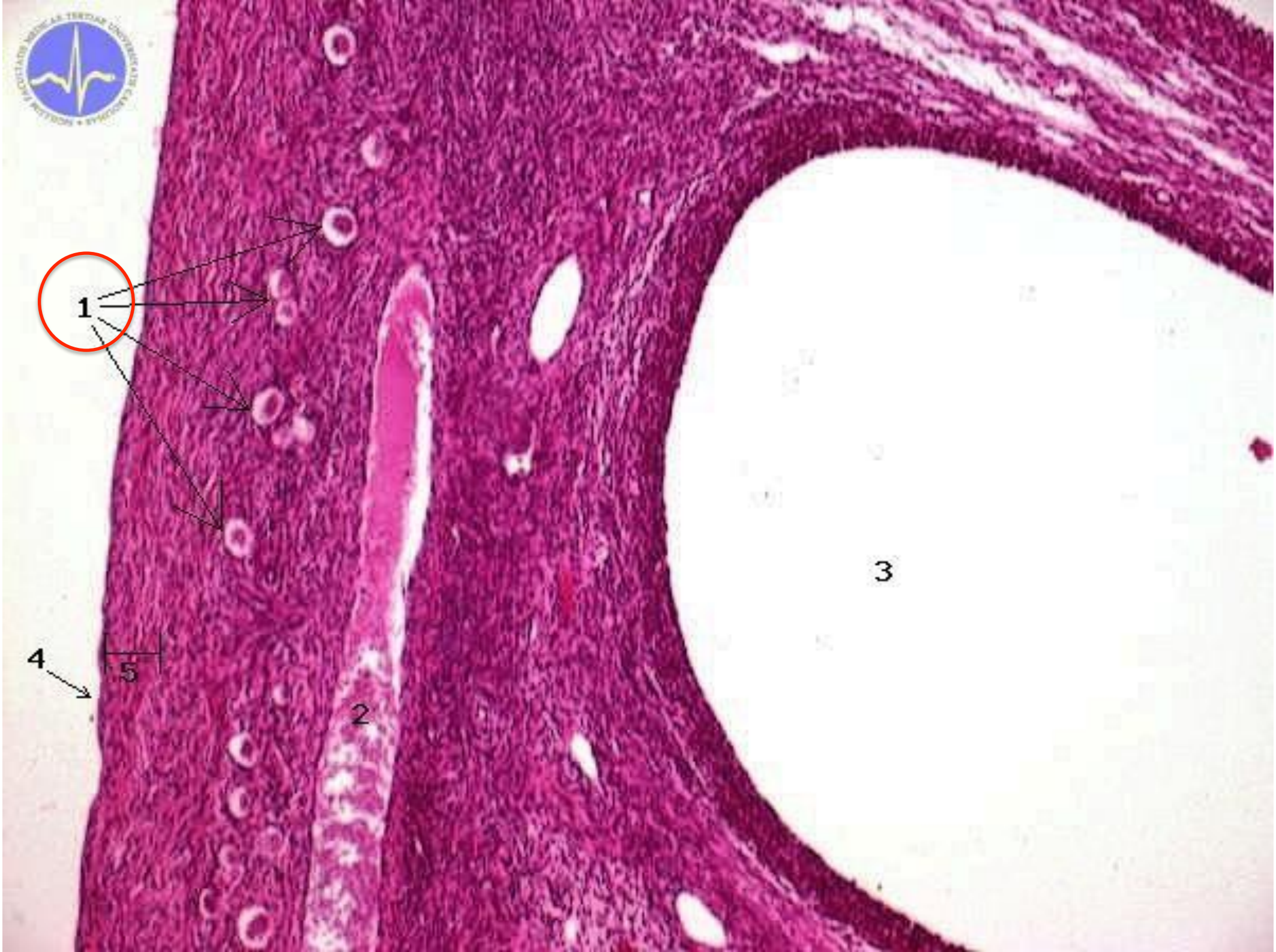
Primordial follicles

- **Oocyte**
  - Big eccentric nucleus
- One layer of squamous epithelial cells
  = **follicular cells**








1
2
3
4
5

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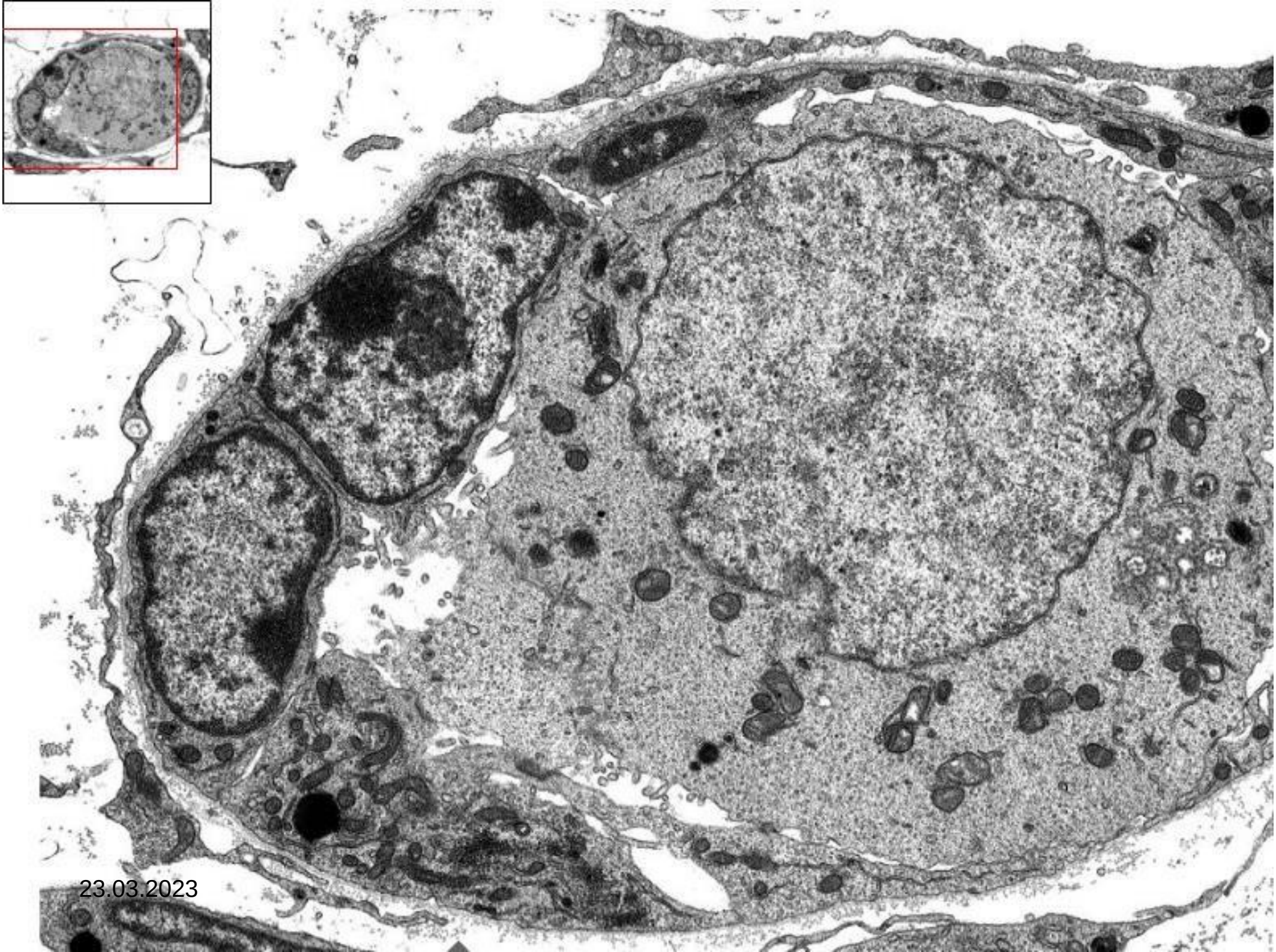
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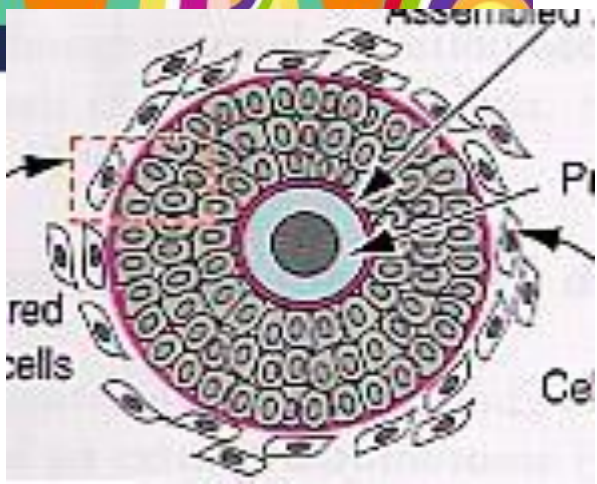
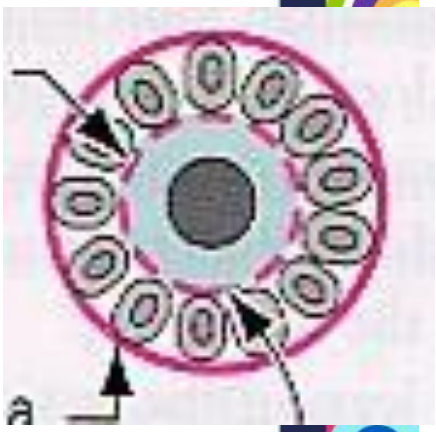
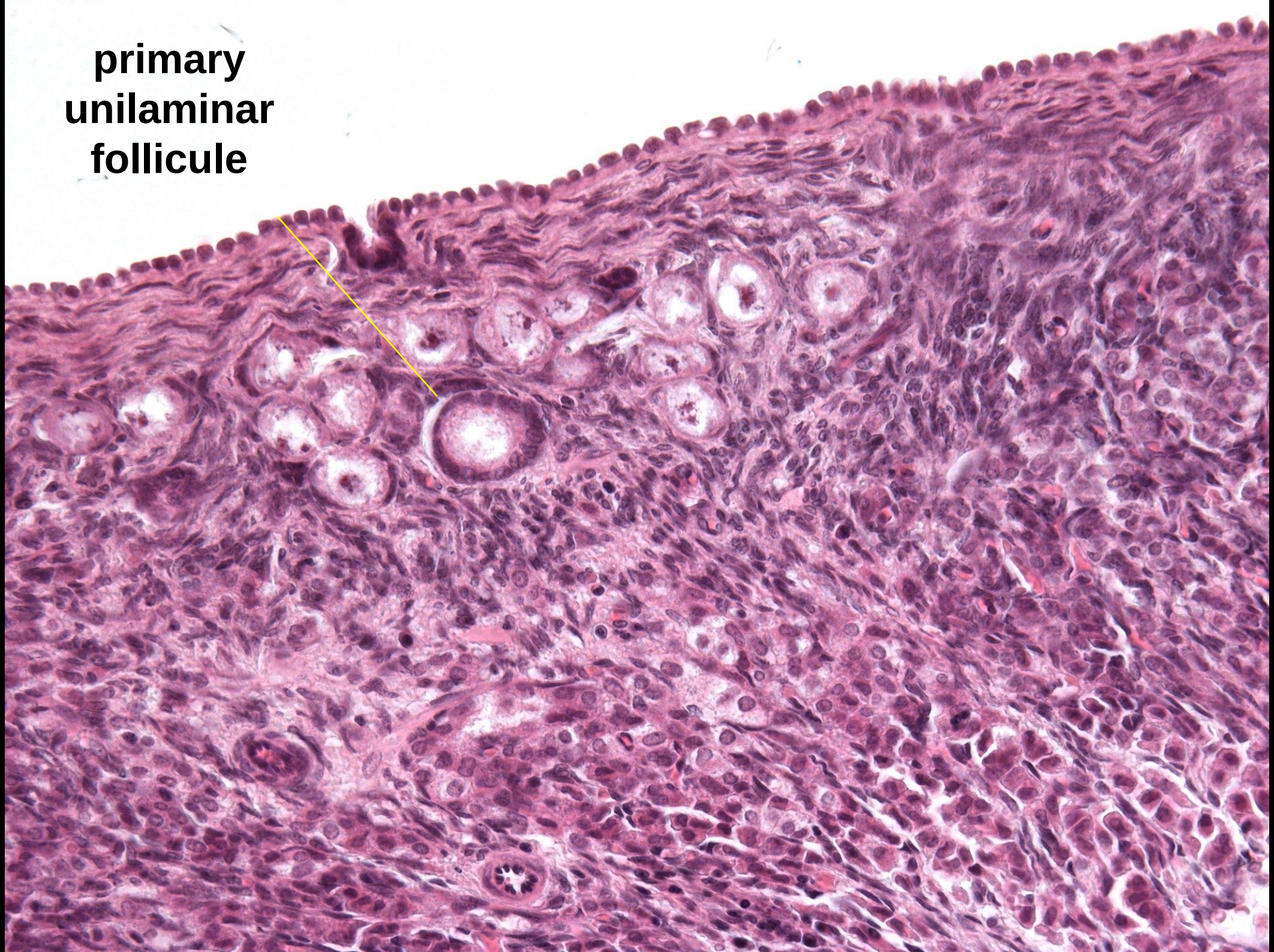
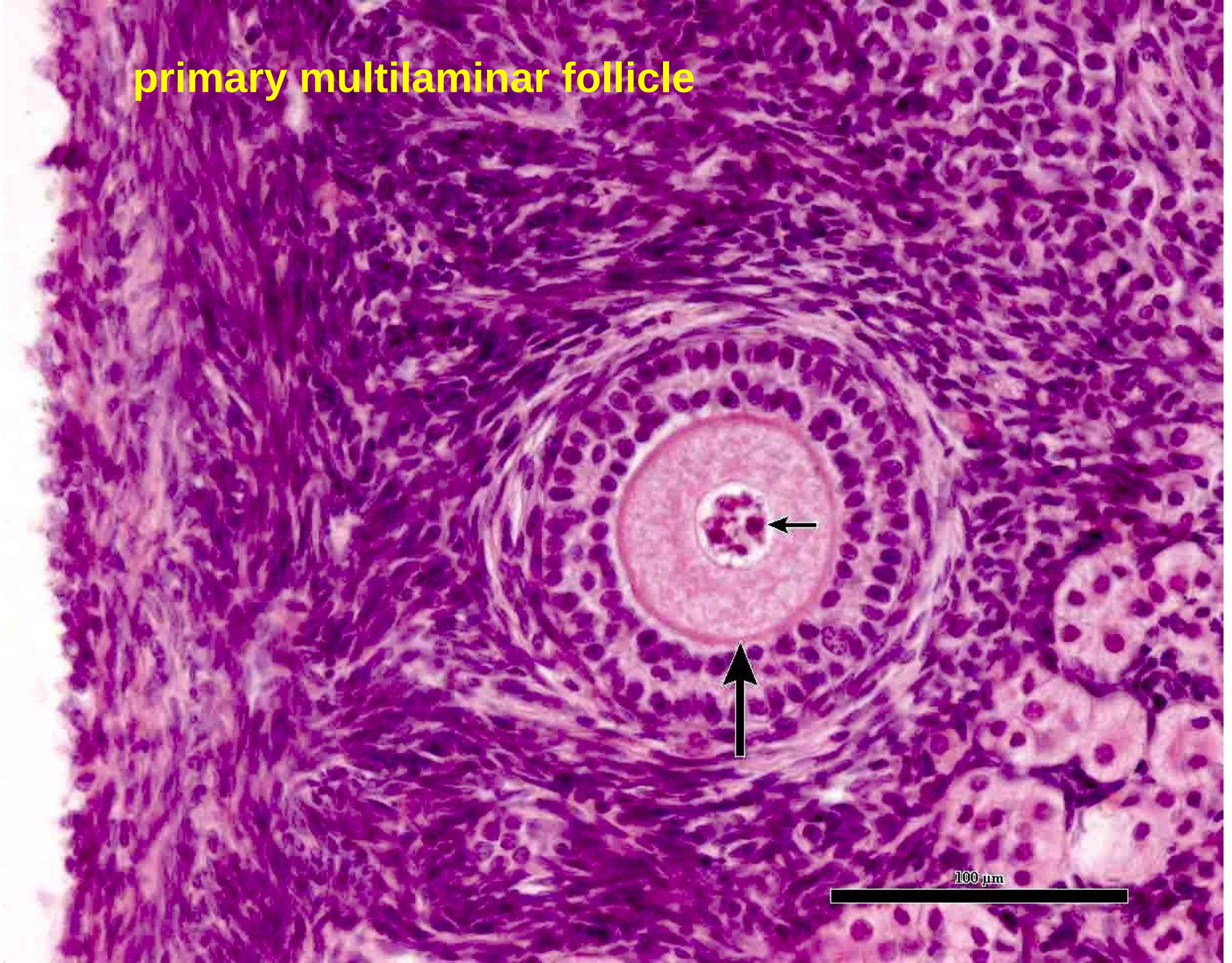
Primary follicle

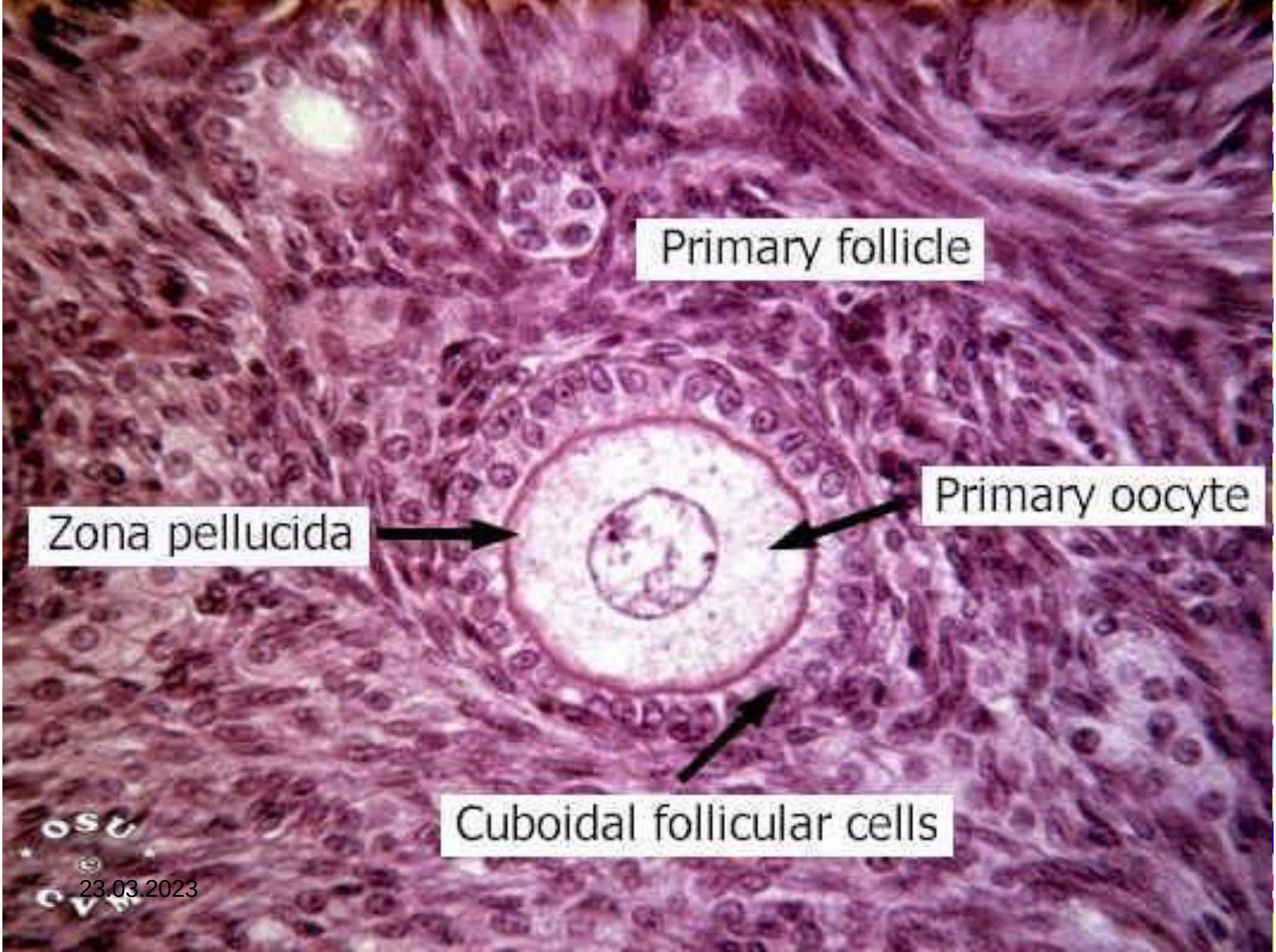


- Unilaminar / multilaminar
- **Follicular cells**
  - Cuboidal, proliferation
  - Granular appearance --- **Granulosa cells**
- **Zona pellucida**
  - Extracellular proteoglycan layer
- **Theca folliculi**
  - Concentric sheath of interstitial stromal cells




primary
unilaminar
follicule


primary multilaminar follicle
100 µm


Primary follicle
Zona pellucida
Primary oocyte
Cuboidal follicular cells

1.-primary follicle

2.-follicular (granulosa) cells

3.- oocyte

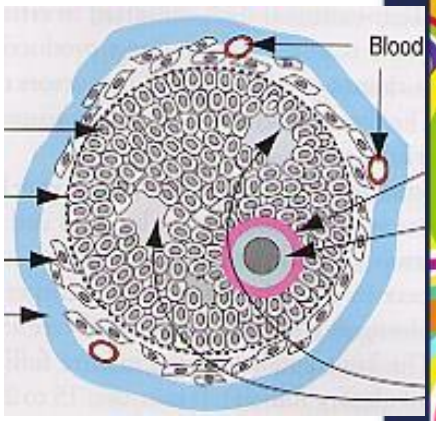
4.- zona pellucida

5.- primordial follicle

8.- interstitial connective tissue

9.- theca

Secondary follicle



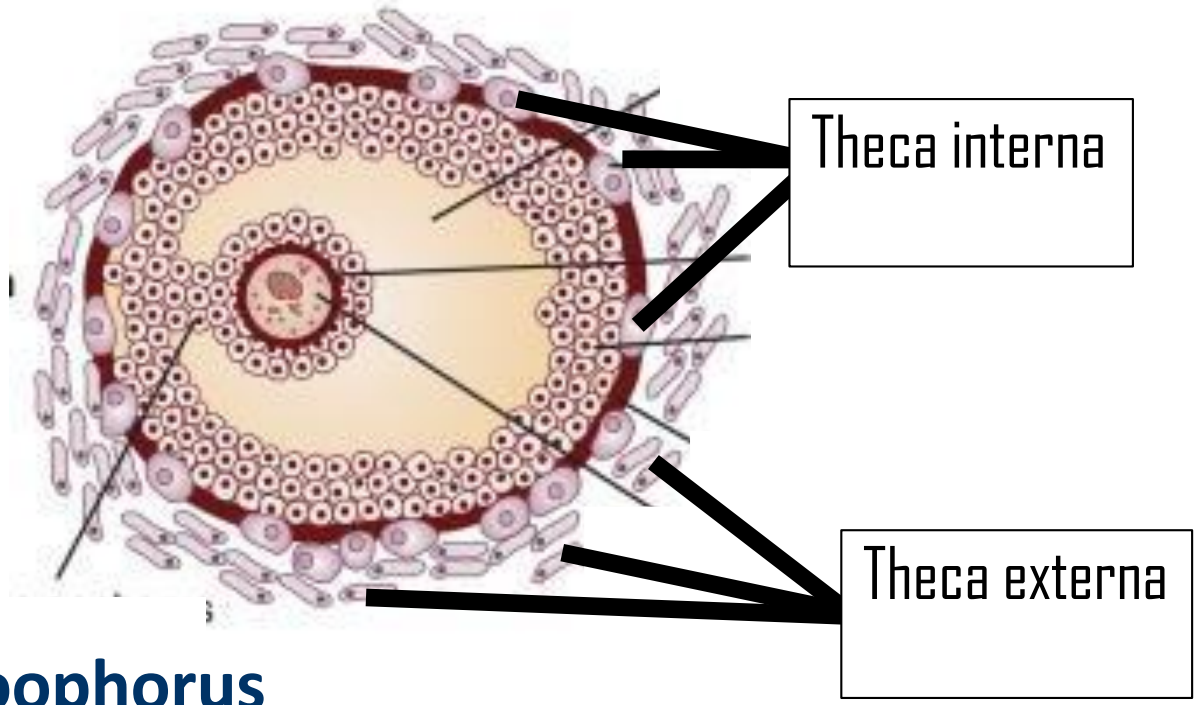
- **Granulosa cells**
  - 8-12 layers
  - Small, fluid-filled spaces
  - to single cavity = **antrum folliculi (tertiary t.)**
  - Filled with viscous fluid = **liquor folliculi**
- **Theca**
  - Theca interna --- **theca cells**
  - Theca externa --- connective tissue and smooth muscle cells

Theca interna and externa

Stromal cells form an outer covering = theca

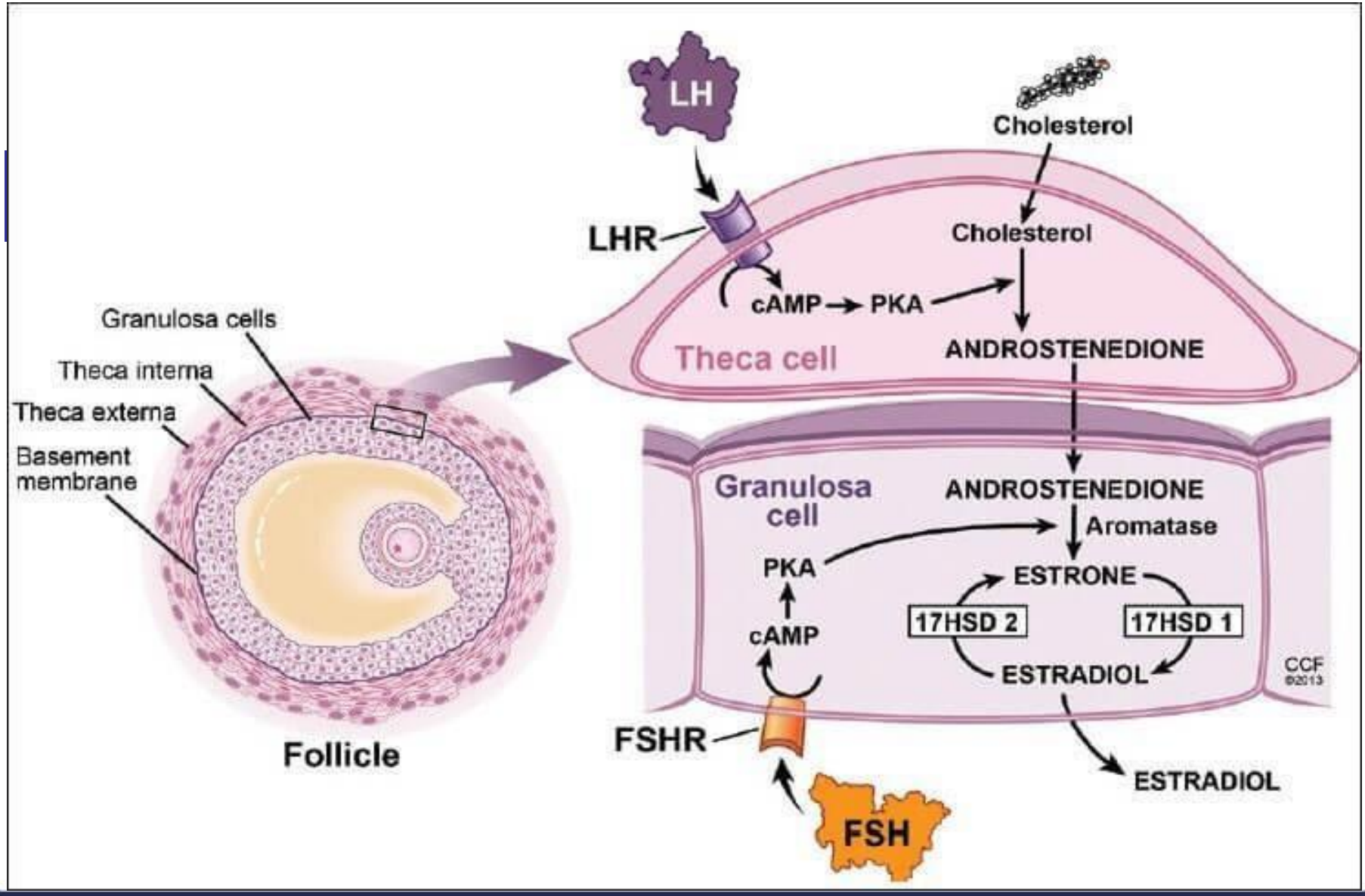
Theca interna: more vascularized, steroid producing cells

Theca externa: fibroblasts and smooth muscles



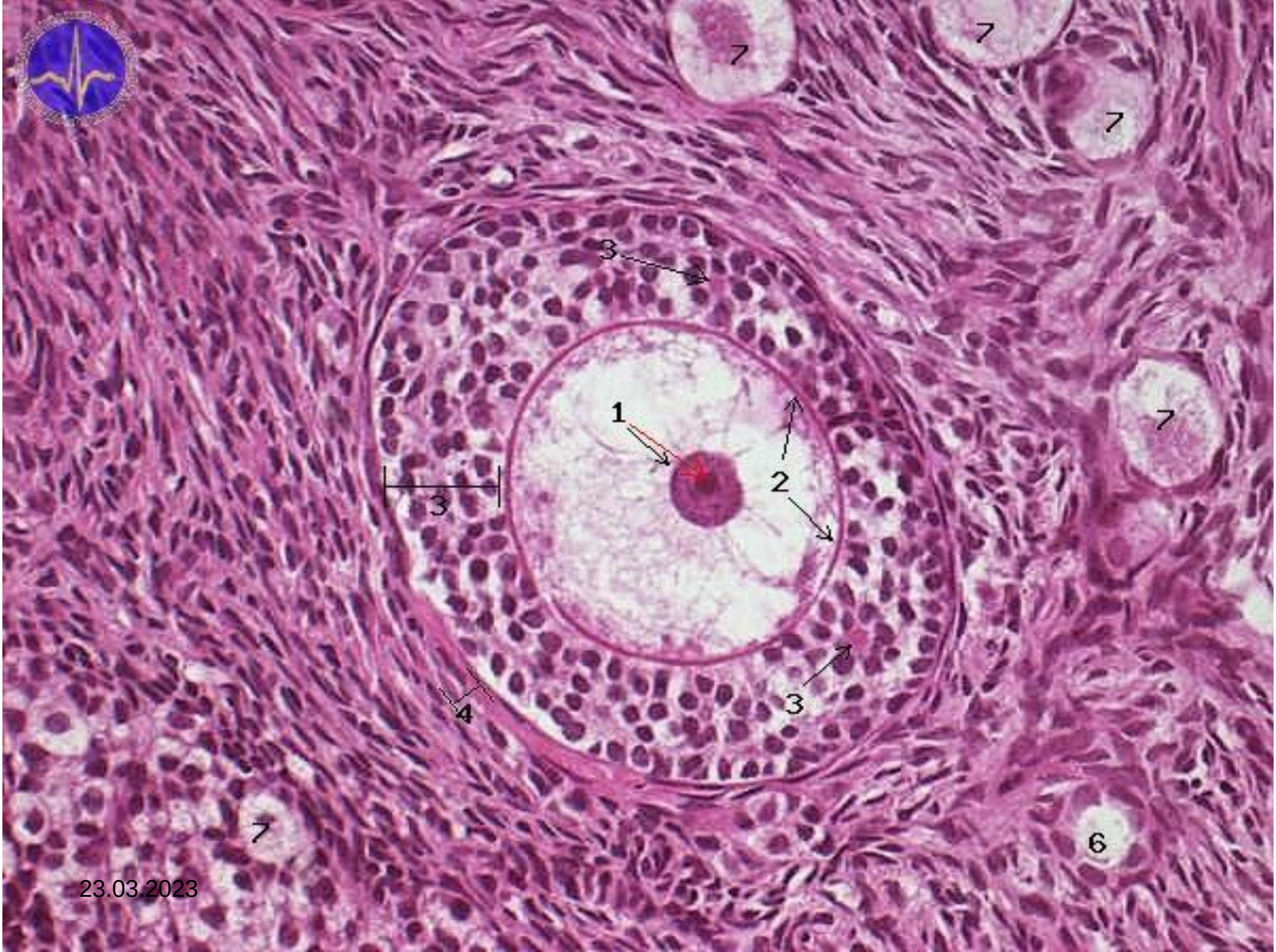
cumulus oophorus

Theca interna and externa



1.- secondary follicle
2.- follicular (granulosa) cells
3.- oocyte
4.- zona pellucida

9 - theca interna



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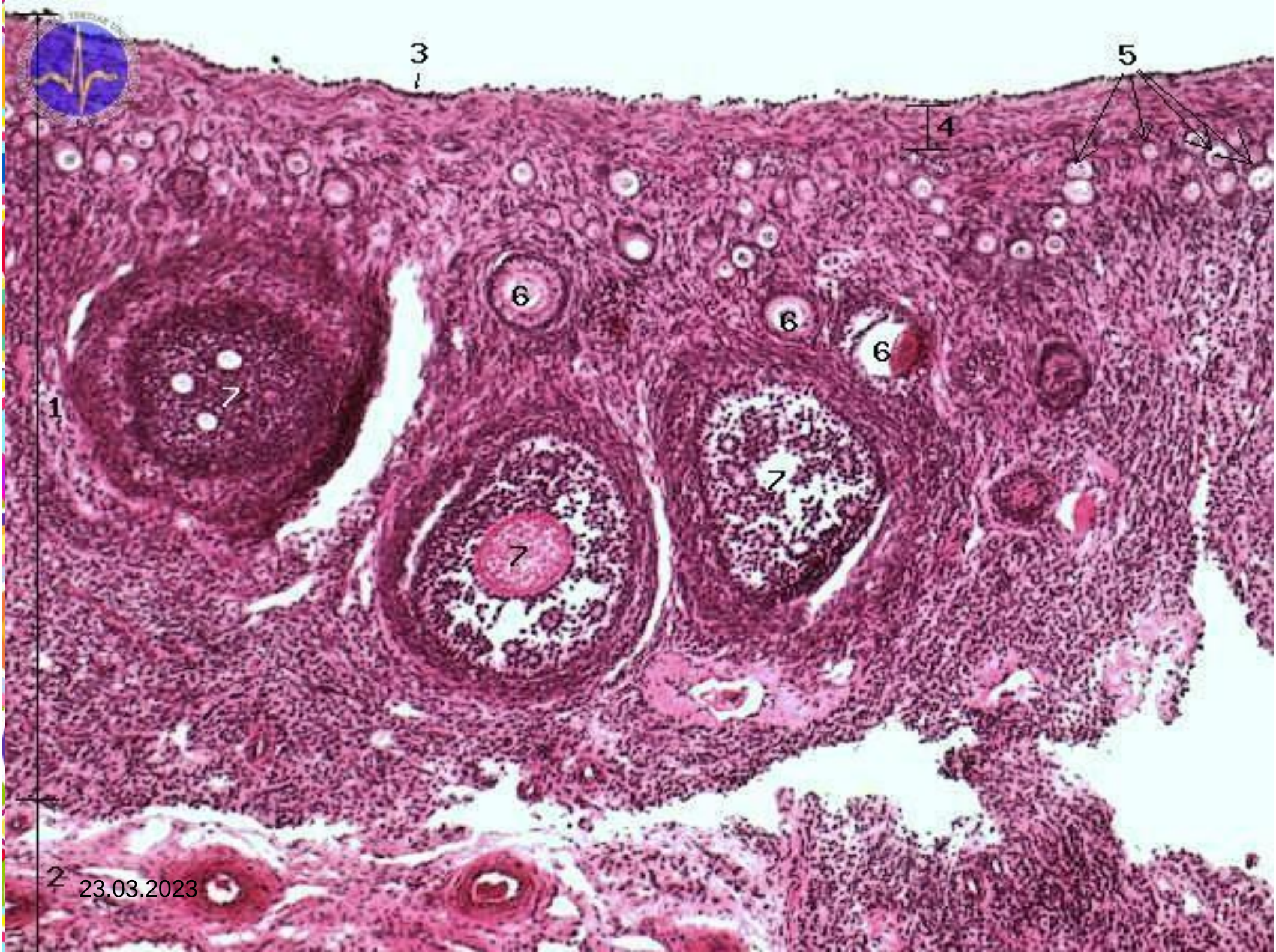

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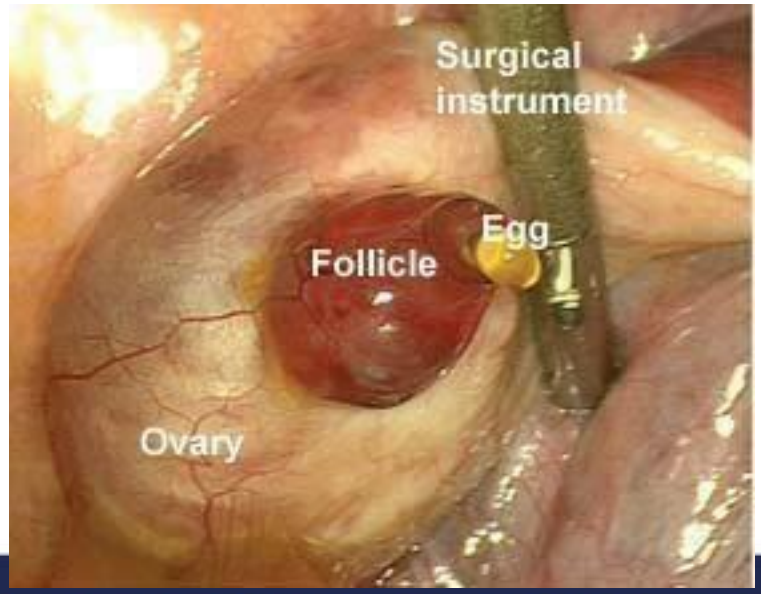
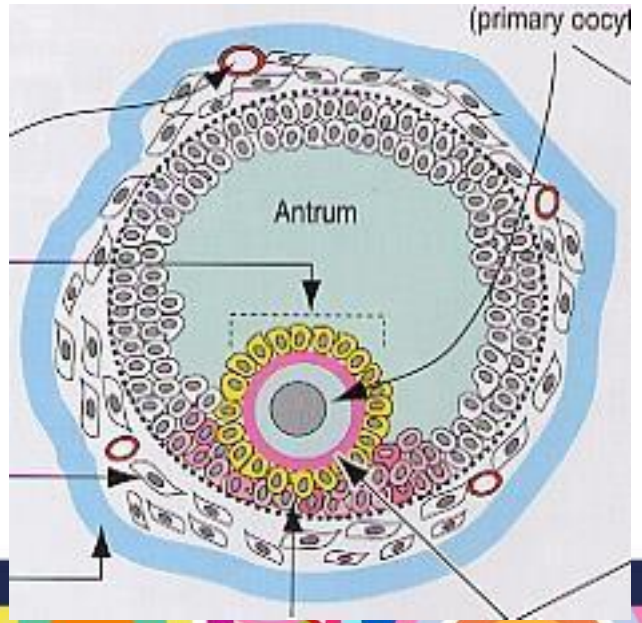
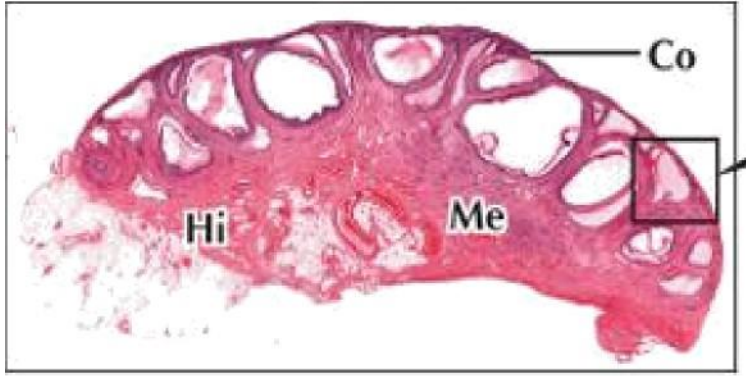
antral follicle
G
O
C
TI
TE
b

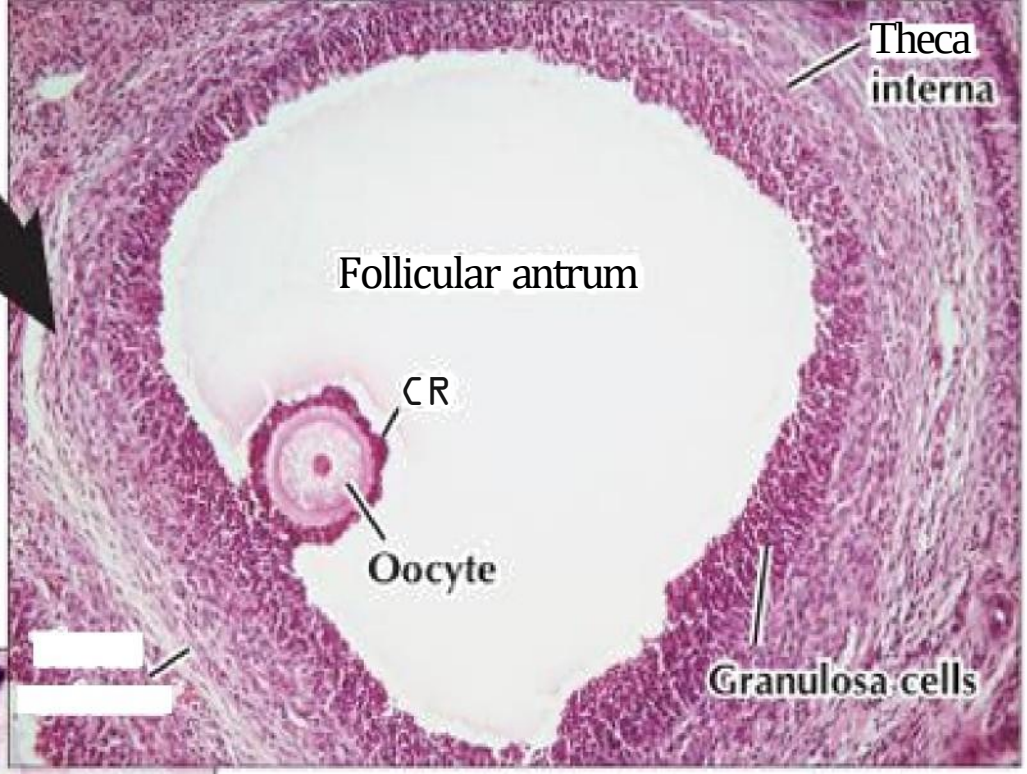
Graafian follicle

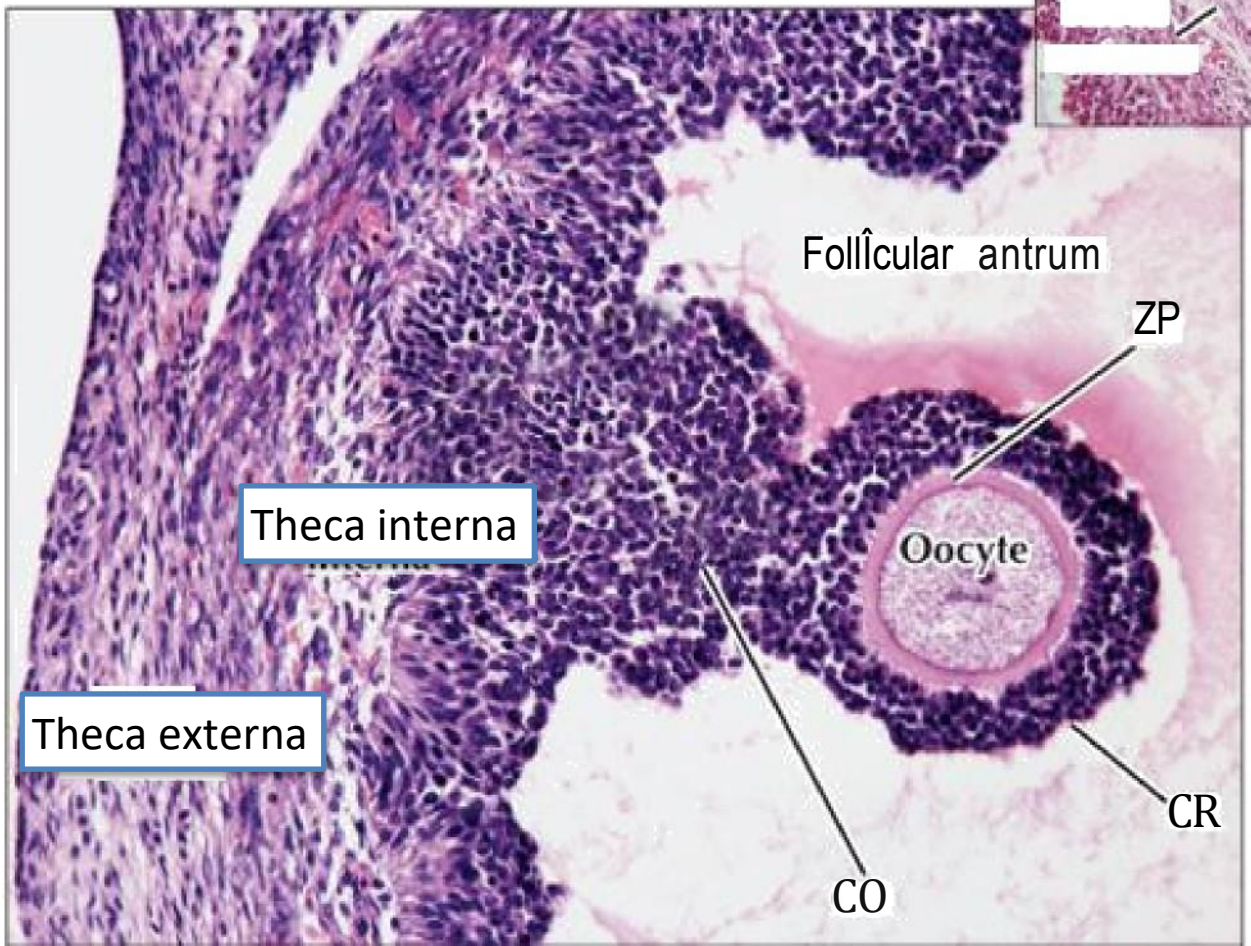
- Primary oocyte sits in **cumulus oophorus**
  = local eccentric cluster of granulosa cells
- Granulosa cells
  - Surrounding the oocyte = **corona radiata**
    - **It accompanies the oocyte during ovulation**






Co
Hi
Me

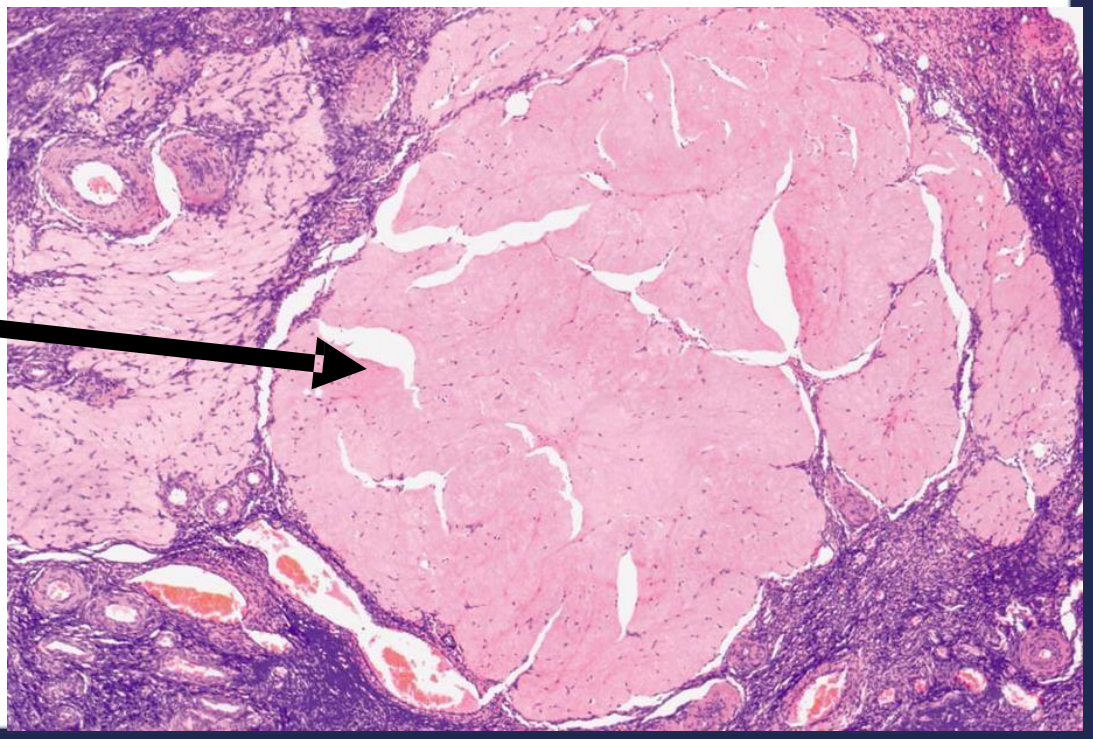

Theca interna
Follicular antrum
CR
Oocyte
Granulosa cells

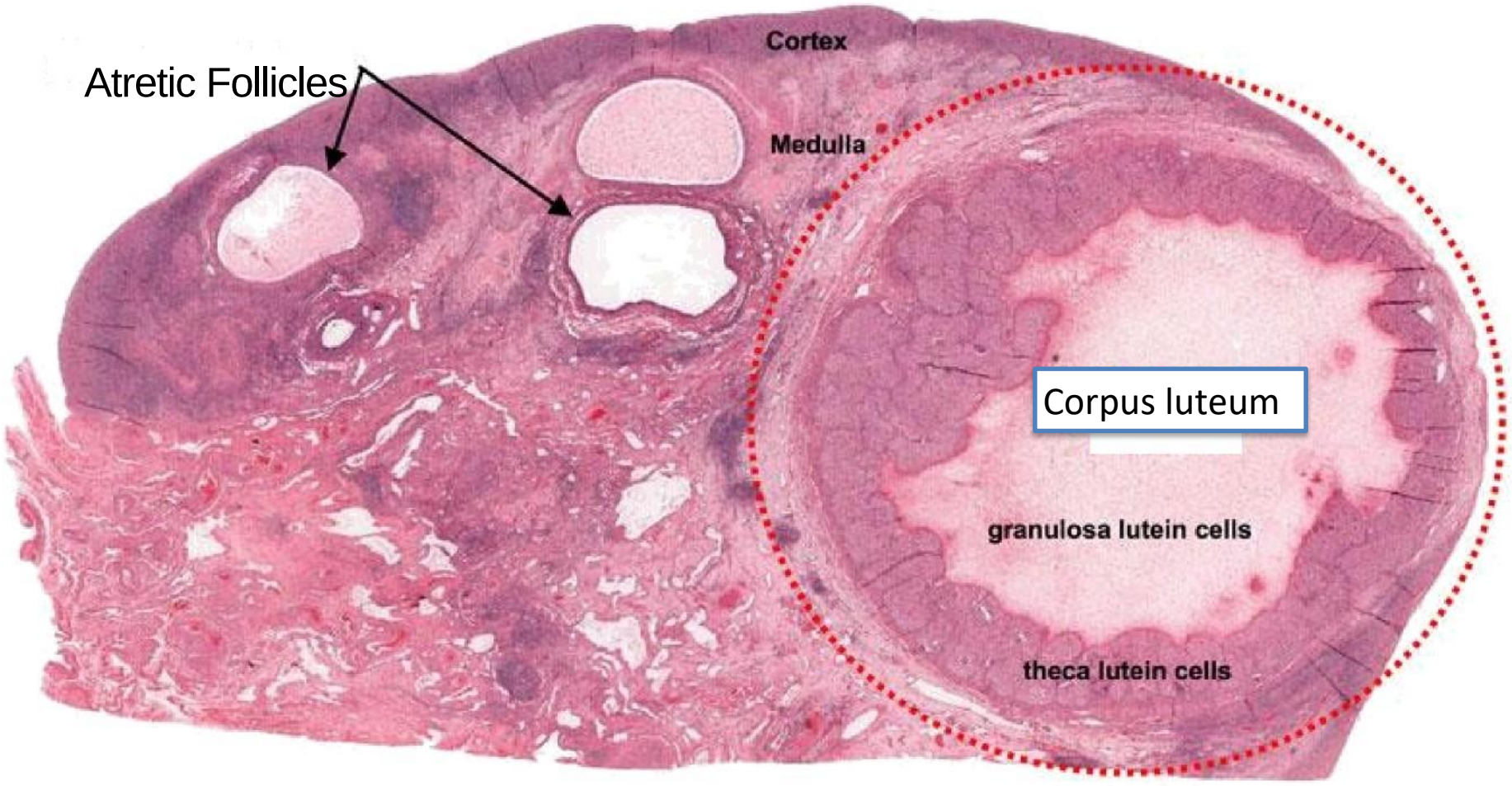

FollÎcular antrum
ZP
Theca interna
Oocyte
Theca externa
CR
CO

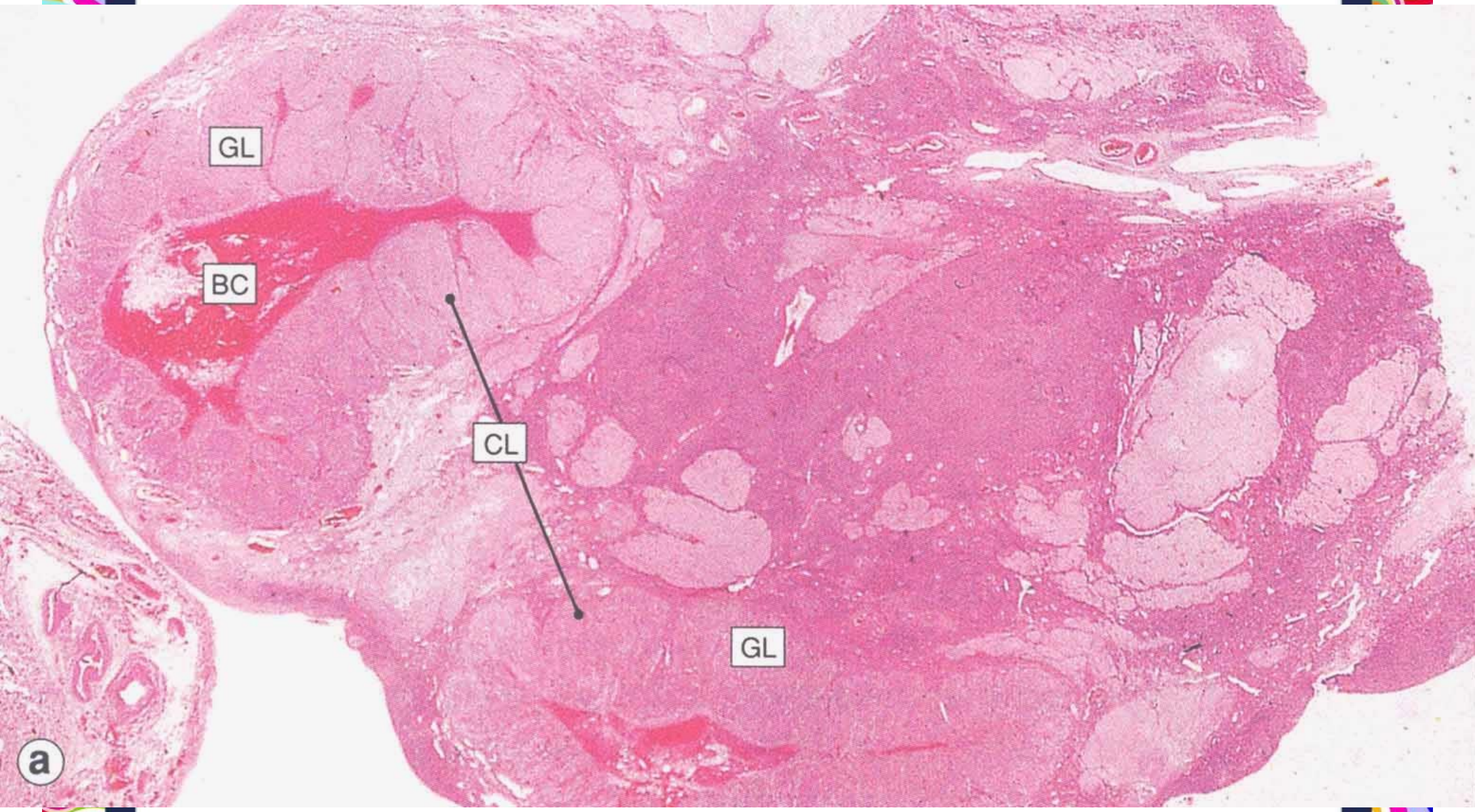
Corpus luteum

- Colapsed, infolded follicular remnant
- Antral space filled with fluid (fibrin) and blood --- coagulation --- **fibrous scar tissue**

Corpus albicans




Atretic Follicles
Cortex
Medulla
Corpus luteum
granulosa lutein cells
theca lutein cells

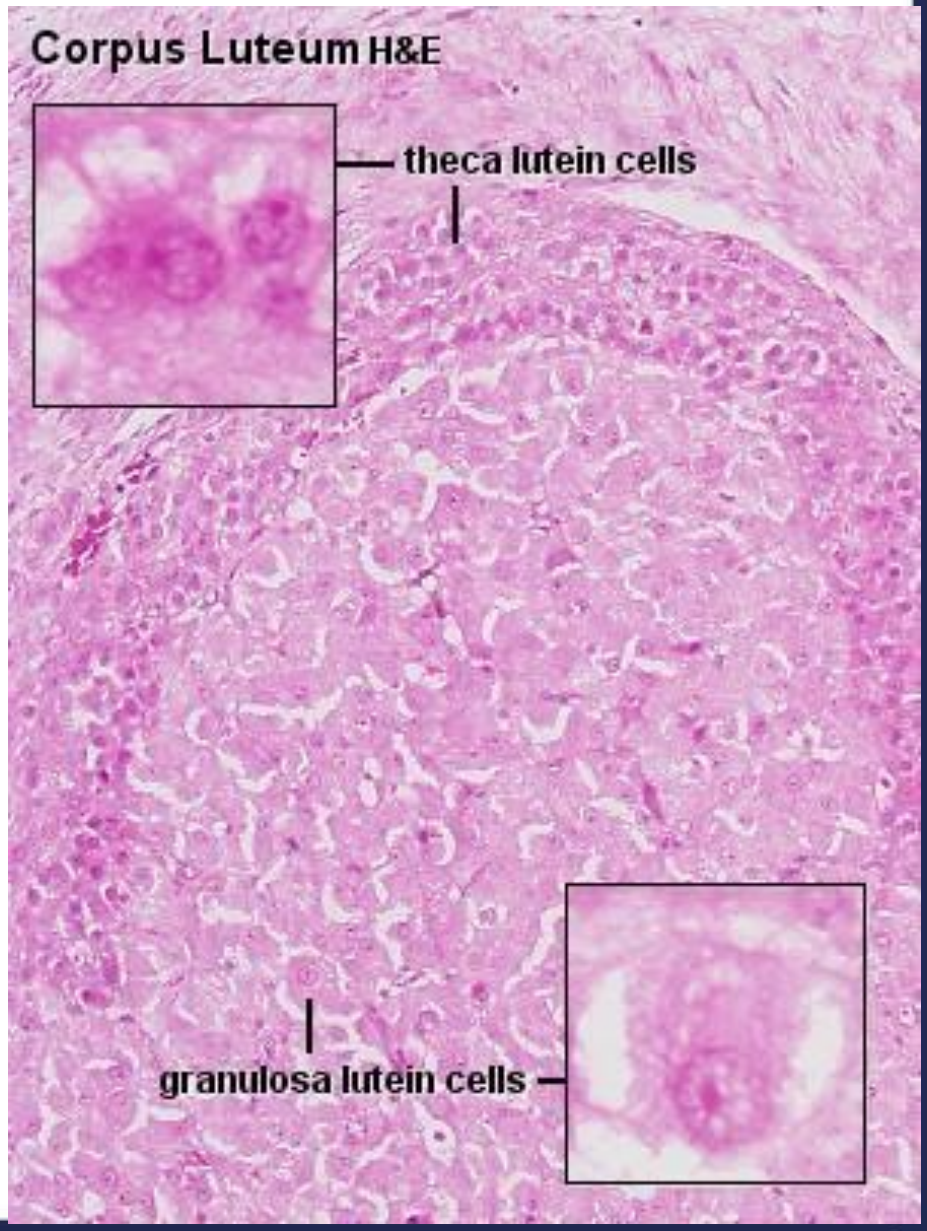


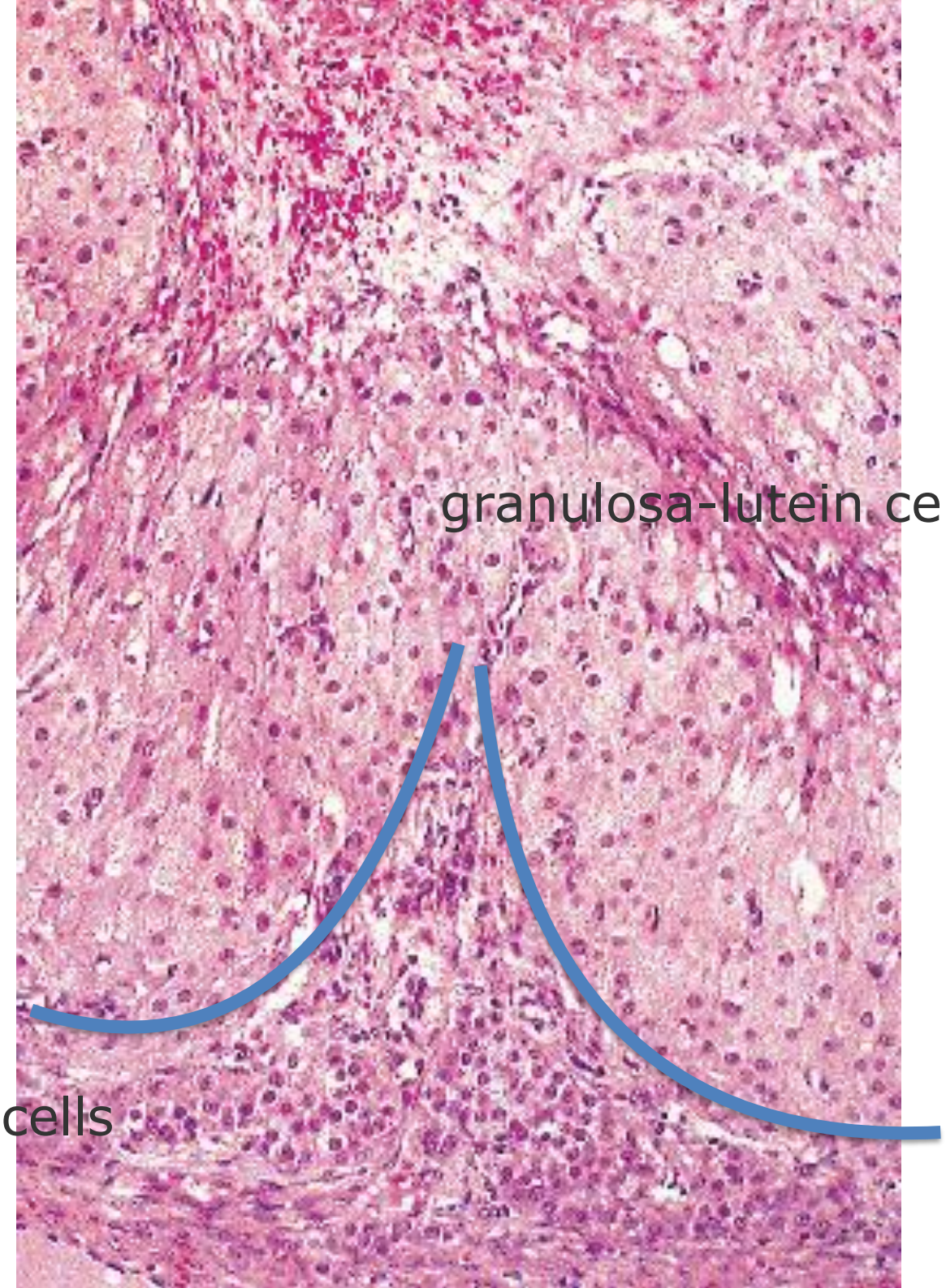
Corpus luteum

Influence of LH: Changes of granulosa and theca interna

1. Granulosa lutein cells

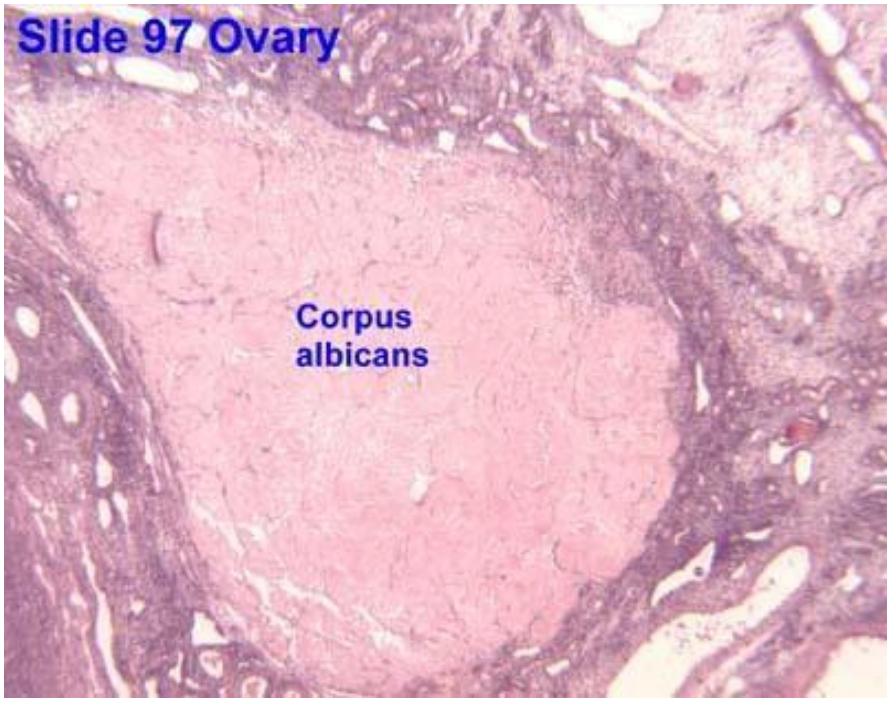
2. Theca lutein cells




granulosa-lutein cells
theca-lutein cells

Corpus luteum menstruationis

- Stops producing progesteron after 10-12 days
- Form white scar = **corpus albicans** (white body)



Corpus luteum graviditatis

- If pregnancy occurs
- Production of progesteron 8 weeks
  - Then placenta becomes major source
  - Under the influence of hCG

Ovarian cycle

- **Follicular phase** (day 1-13)
  - Follicular maturation
- **Ovulation** (day 14)
  - Follicle ruptures and releases the oocyte and corona radiata
- **Luteal phase** (day 15-28)
  - Corpus luteum

Hormonal direction

- **FSH** (follicle stimulating hormone)
  - anterior lobe of hypophysis
  - growth of follicles, maturation of dominant follicle, production of estrogens
- **LH** (luteinizing hormone)
  - terminal maturatoin of primary oocyte and beginning of the second meiotic division
  - triggering of ovulation, yellow body formation, progesteron production
- releasing is directed by **GnRH** (gonadotropin-releasing hormone)
  - hypothalamus

Maturation of follicles

- growth of follicles (3-6 months) – from primordial to tertiary follicle (gonadotropin-independent)
- maturation (gonadotropin-dependent)
  - theory of the dominant follicle
  - 10-20 early tertiary follicles influenced by FSH mature →
  - 1 selected (exceptionally 2) with higher sensitivity to FSH → production of estrogens inhibits FSH production (negative feedback) + inhibin production (also inhibits FSH) → decreasing level of FSH preserves only the most sensitive follicle, other disappear
- atresia of follicles
  - 5^{th} month: 7,000,000 follicles
  - birth: 1,000,000 follicles
  - puberty: 400,000 follicles
    - adult: 1,000 follicles degenerate monthly (after 35th year more)
  - menopause: 1,000 follicles

Oogenesis

two phases:

multiplication (mitotic divisions)

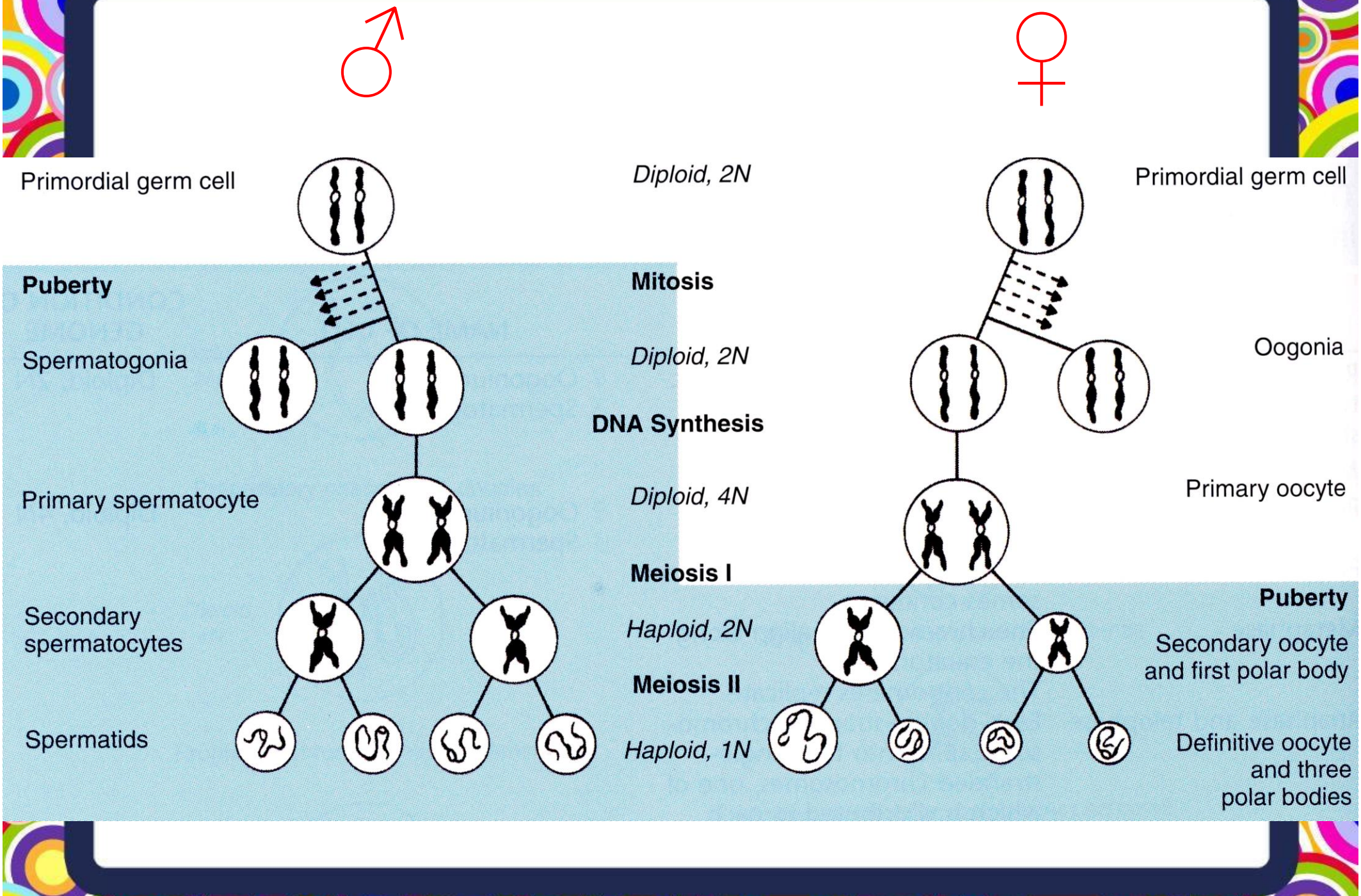
maturation (meiotic divisions)

asynchronous → various follicular developmental stages in ovaries

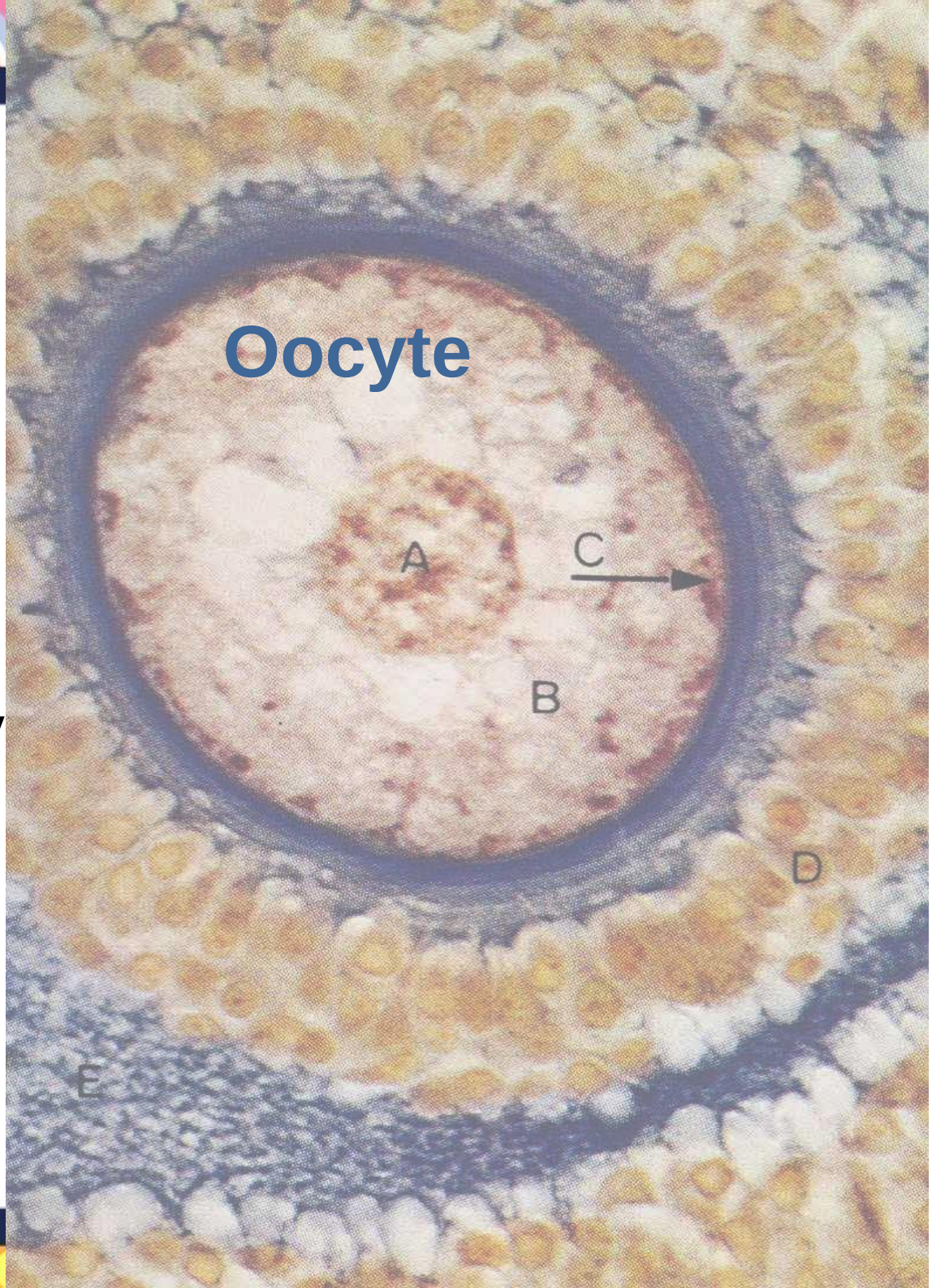
primordial germ cells in medullary cords divide and differentiate into oogonia

before birth oogonia increase and change to primary oocytes

they enter the 1st meiotic division still before birth and stop their division at the end of prophase

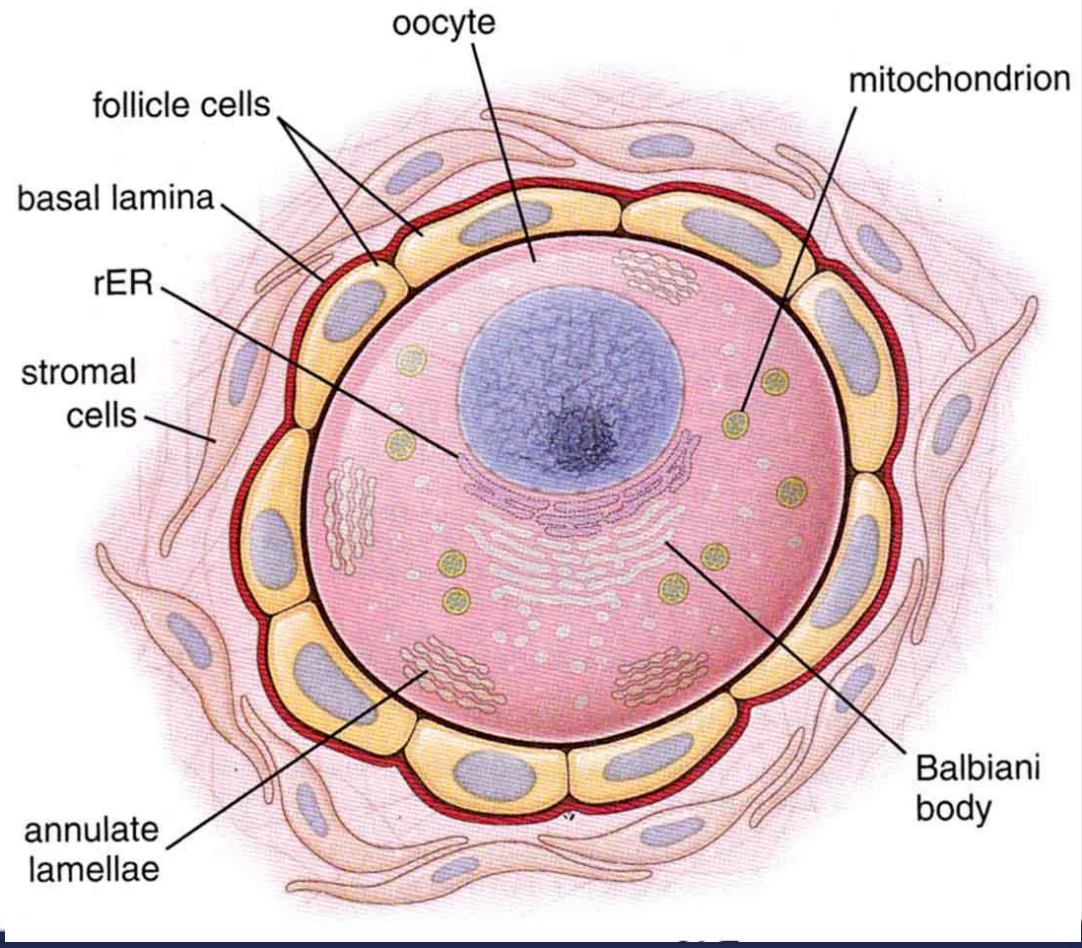

♂
♀
Primordial germ cell
Diploid, 2N
Primordial germ cell
Puberty
Mitosis
Spermatogonia
Diploid, 2N
Oogonia
DNA Synthesis
Primary spermatocyte
Diploid, 4N
Primary oocyte
Meiosis I
Puberty
Secondary spermatocytes
Haploid, 2N
Secondary oocyte and first polar body
Meiosis II
Spermatids
Haploid, 1N
Definitive oocyte and three polar bodies

- oligolecithal (few yolk inclusions)
- isolecithal (yolk inclusions equally distributed)
- holoblastic (it cleaves totally and equally)

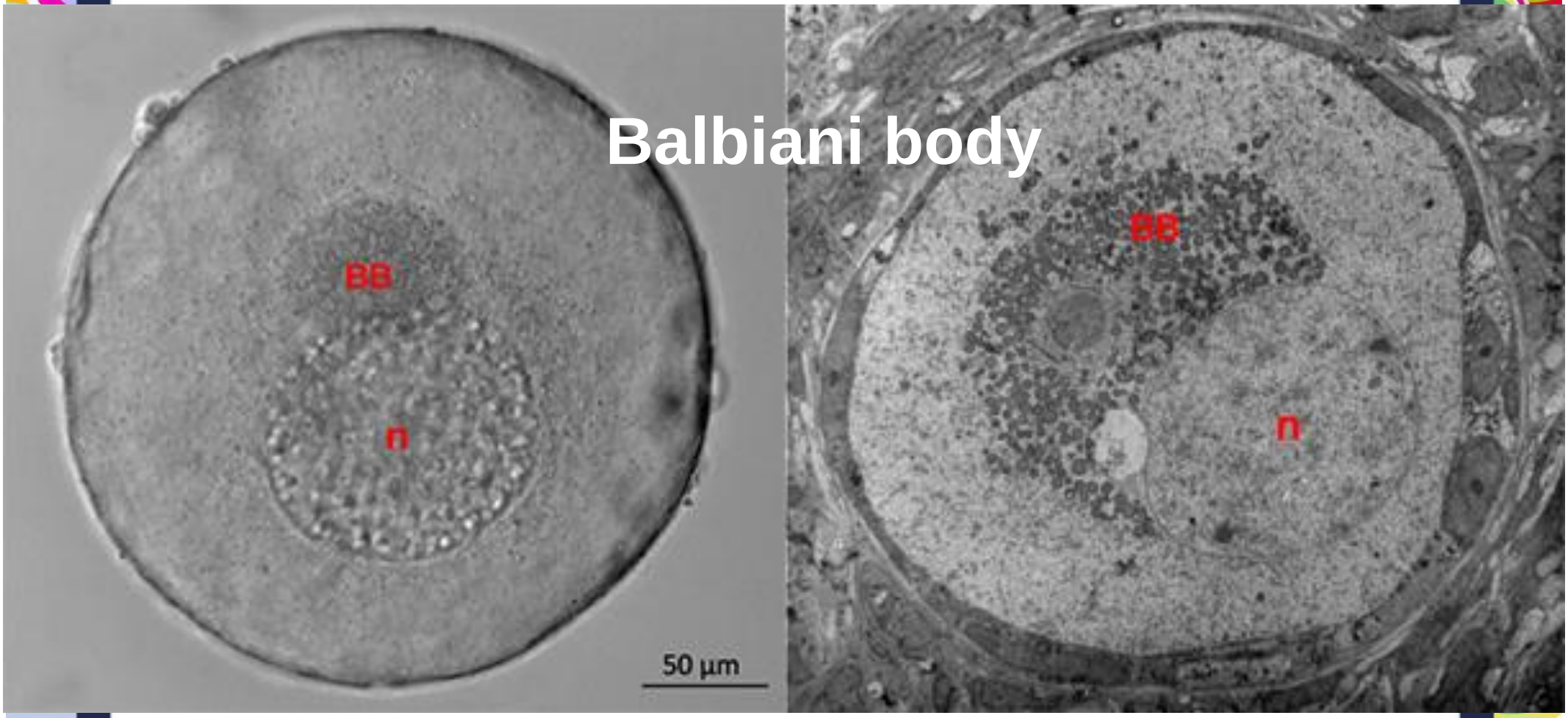


Balbiani body – cluster of organelles (mitochondria, GA, ER, ribosomes)

Membranae annulatae – membranes arranged like in nuclear envelope



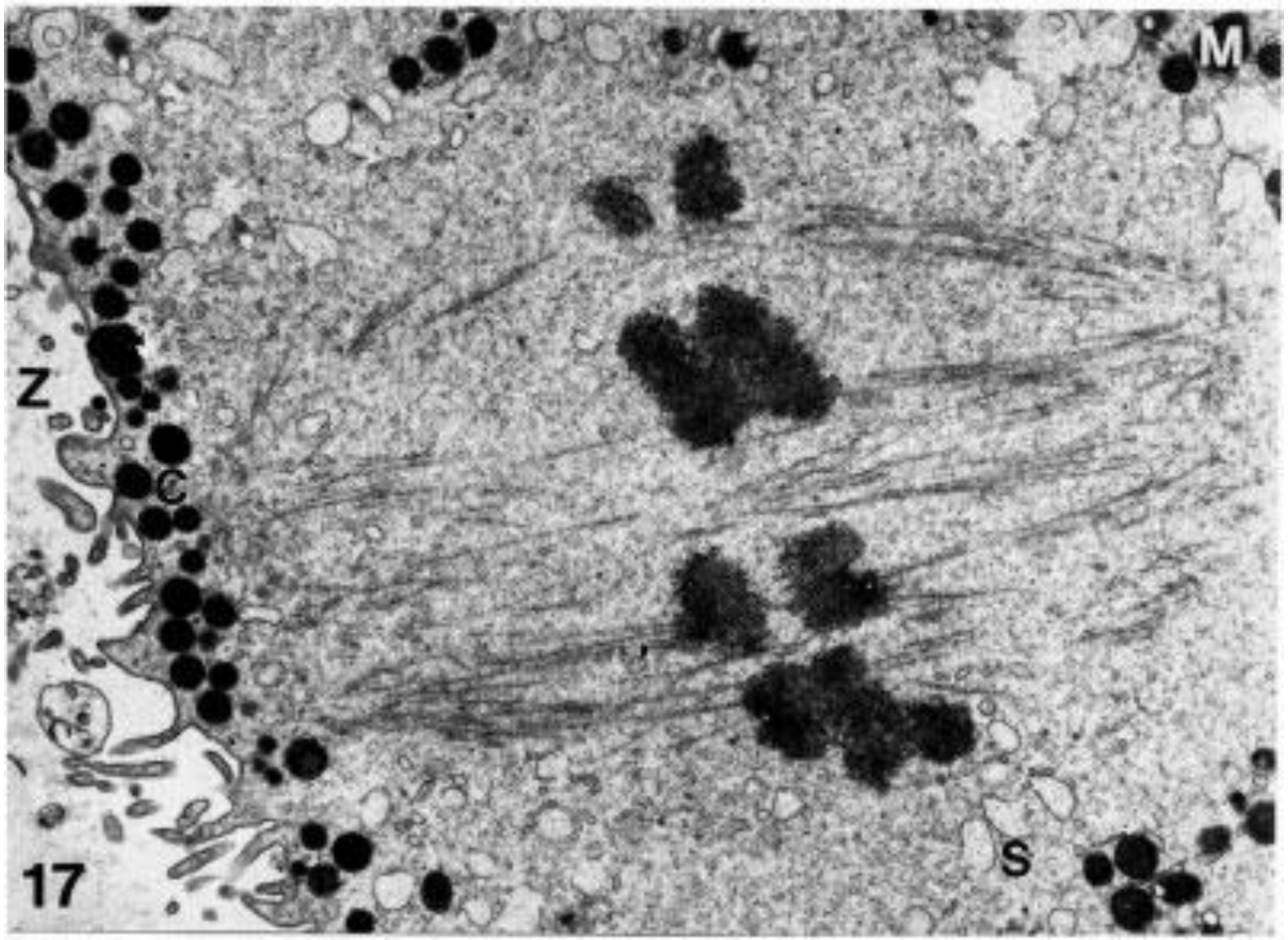
Balbiani body



Balbiani's vitelline body consists of a juxtanuclear centrosome (CS) surrounded by a condensation of mitochondria, Golgi complexes, endoplasmic reticulum, and lysosomes

•by completing prophase of the first meiotic division, centrioles dwindle

•meiotic spindles of both first and second meiotic divisions assemble as acentriolar



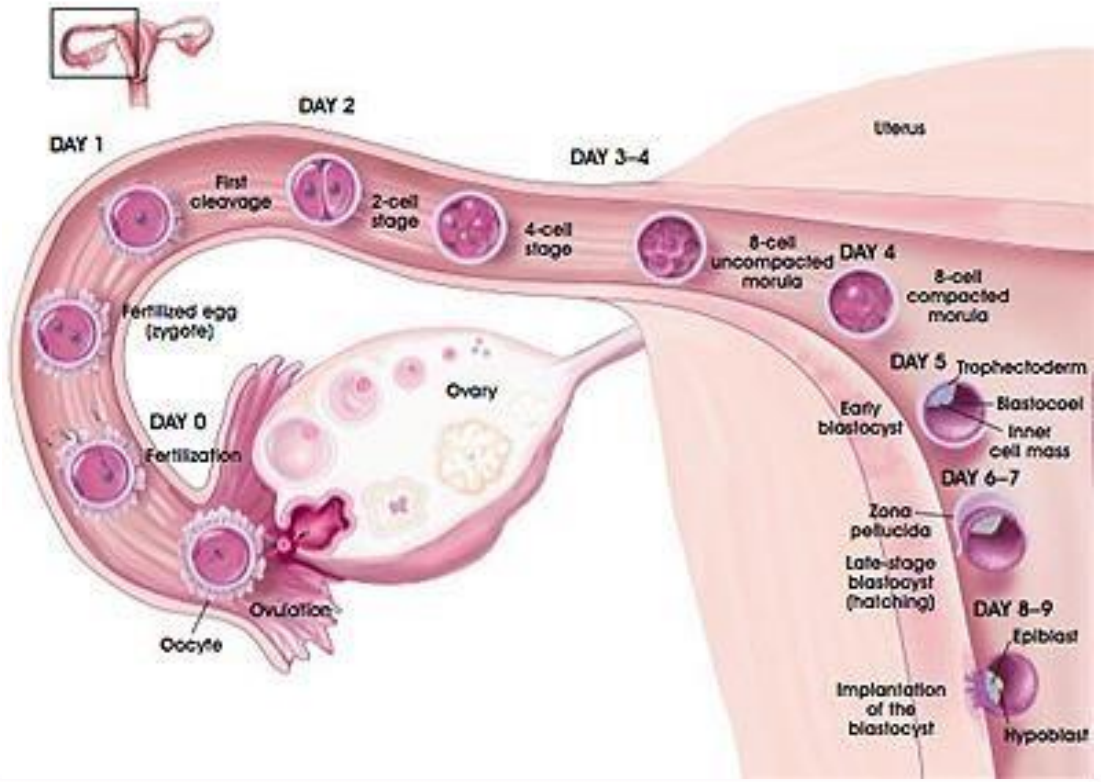
Fallopian tubes

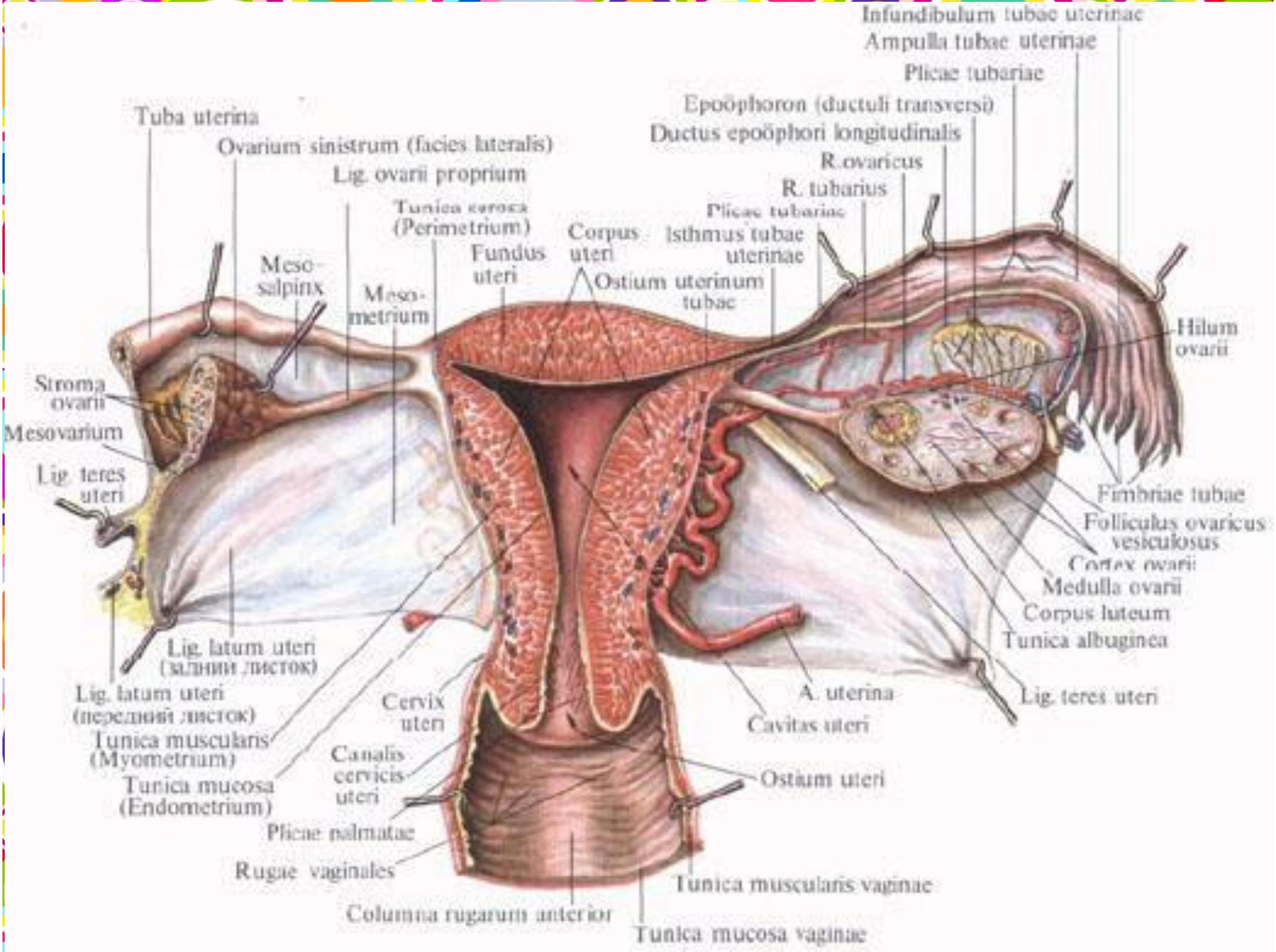
- 12-15 cm long muscle tubes suspended by mesosalpinx
- Opens into peritoneal cavity (infundibulum)

- Transport, fertilization, initial embryonic development

Fallopian tubes

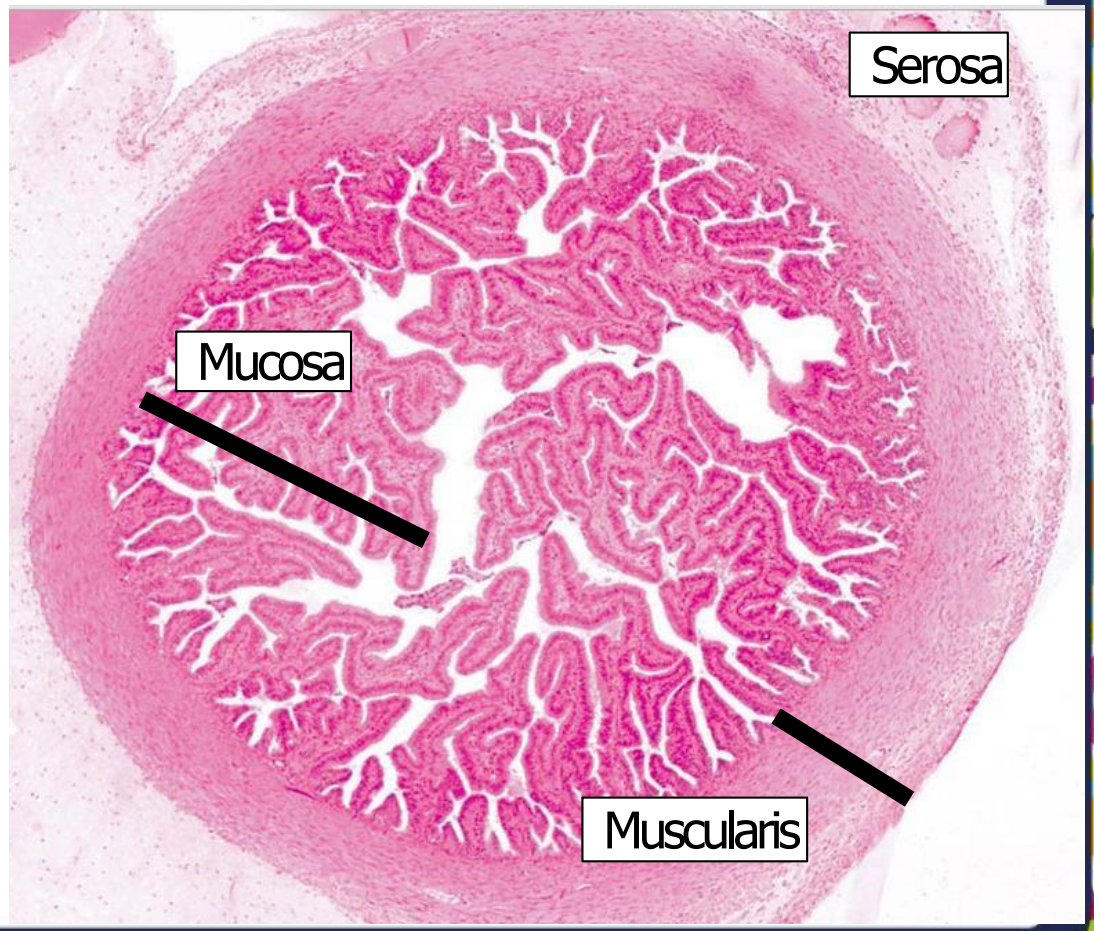
- **Infundibulum**
- **Ampulla**
- **Isthmus**
- **Intramural part**




Infundibulum tubae uterinae
Ampulla tubae uterinae
Plicae tubariae
Epoöphoron (ductuli transversi)
Ductus epoöphori longitudinalis
R. ovaricus
R. tubarius
Plicae tubariae
Tuba uterina
Ovarium sinistrum (facies lateralis)
Lig. ovarii proprium
Tunica serosa (Perimetrium)
Isthmus tubae uterinae
Corpus uteri
Fundus uteri
Meso-salpinx
Meso-metrium
Ostium uterinum tubae
Hilum ovarii
Stroma ovarii
Mesovarium
Lig. teres uteri
Fimbriae tubae
Folliculus ovaricus vesiculosus
Cortex ovarii
Medulla ovarii
Corpus luteum
Tunica albuginea
Lig. latum uteri (задний листок)
Lig. latum uteri (передний листок)
A. uterina
Lig. teres uteri
Cervix uteri
Cavitas uteri
Tunica muscularis (Myometrium)
Canalis cervicis uteri
Ostium uteri
Tunica mucosa (Endometrium)
Plicae palmatae
Rugae vaginales
Tunica muscularis vaginae
Columna rugarum anterior
Tunica mucosa vaginae

Fallopian tubes

- **Tunica mucosa**
- **Tunica muscularis**
- **Tunica serosa**

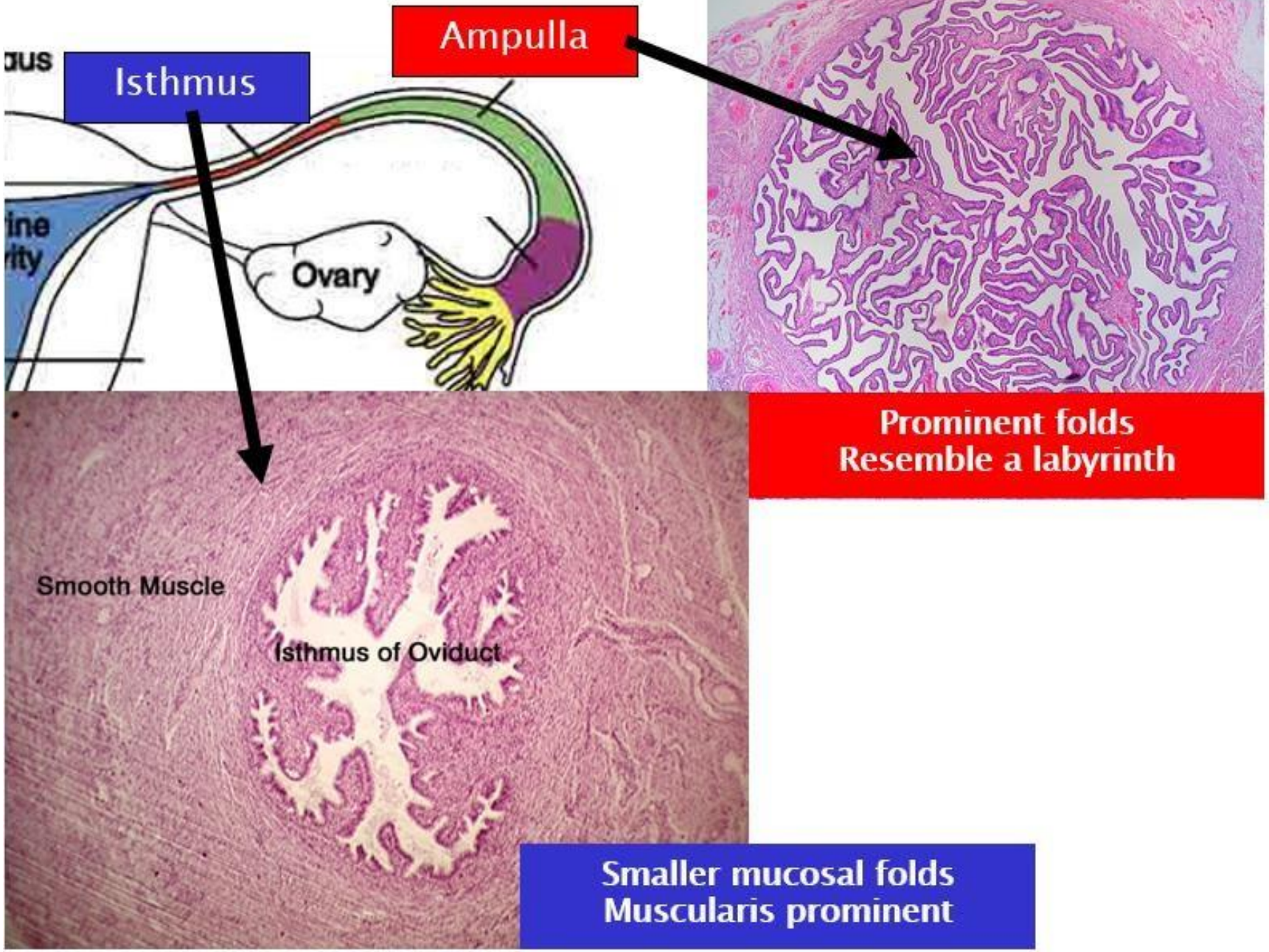


Tunica mucosa

- Longitudinal **folds** increase surface area
  - Decrease toward the uterus
- **Simple columnar epithelium**
  - **Ciliated cells**
    - Ciliary motility and oocyte transport
  - **Secretory cells**
    - GP to provide nutrients to oocyte

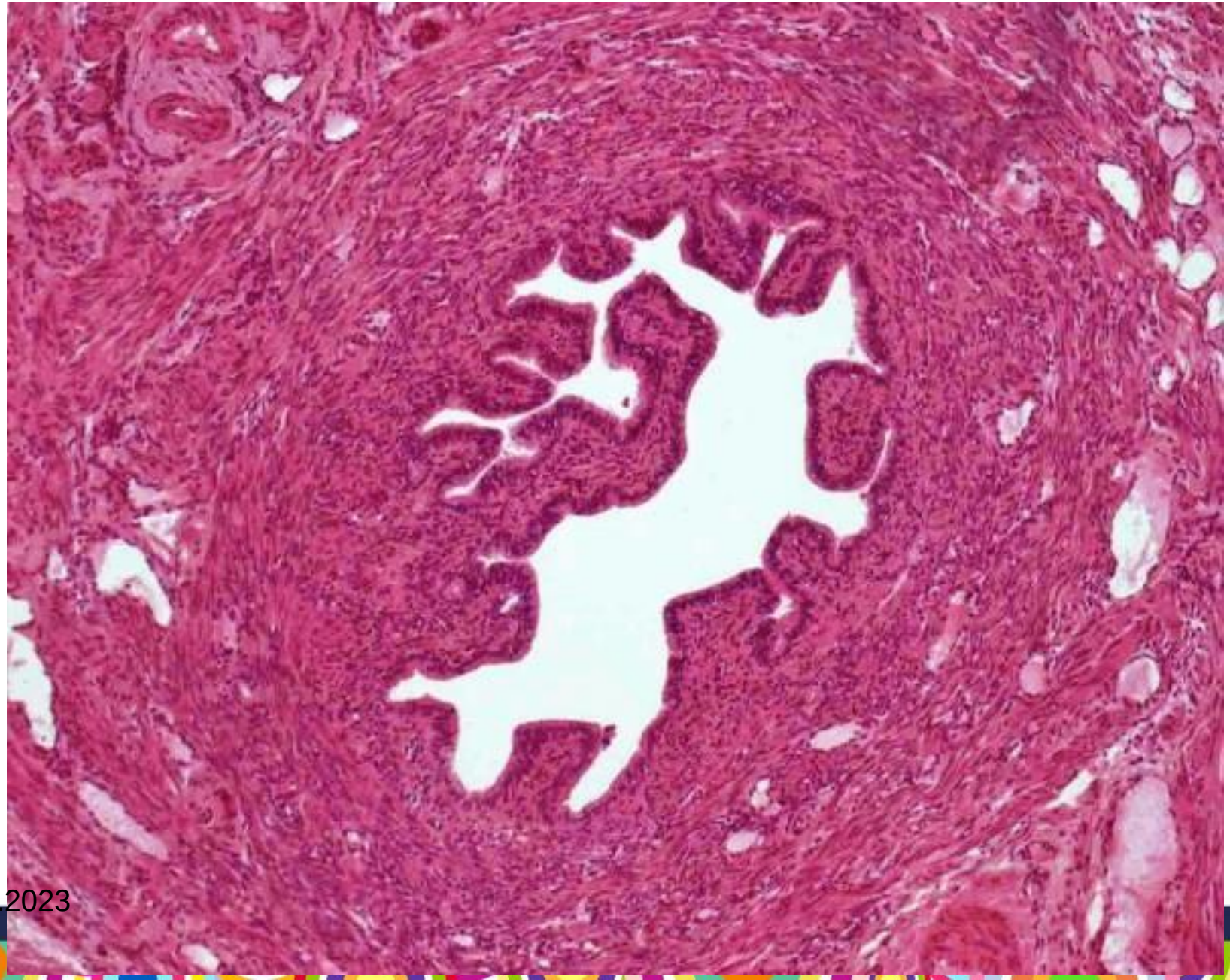
Tunica muscularis

- Two/three indistinct layers of smooth muscle
- (innermost spiral layer)
- Inner **circular**
- Outer **longitudinal**


Ampulla
Isthmus
Ovary
Prominent folds
Resemble a labyrinth
Smooth Muscle
Isthmus of Oviduct
Smaller mucosal folds
Muscularis prominent

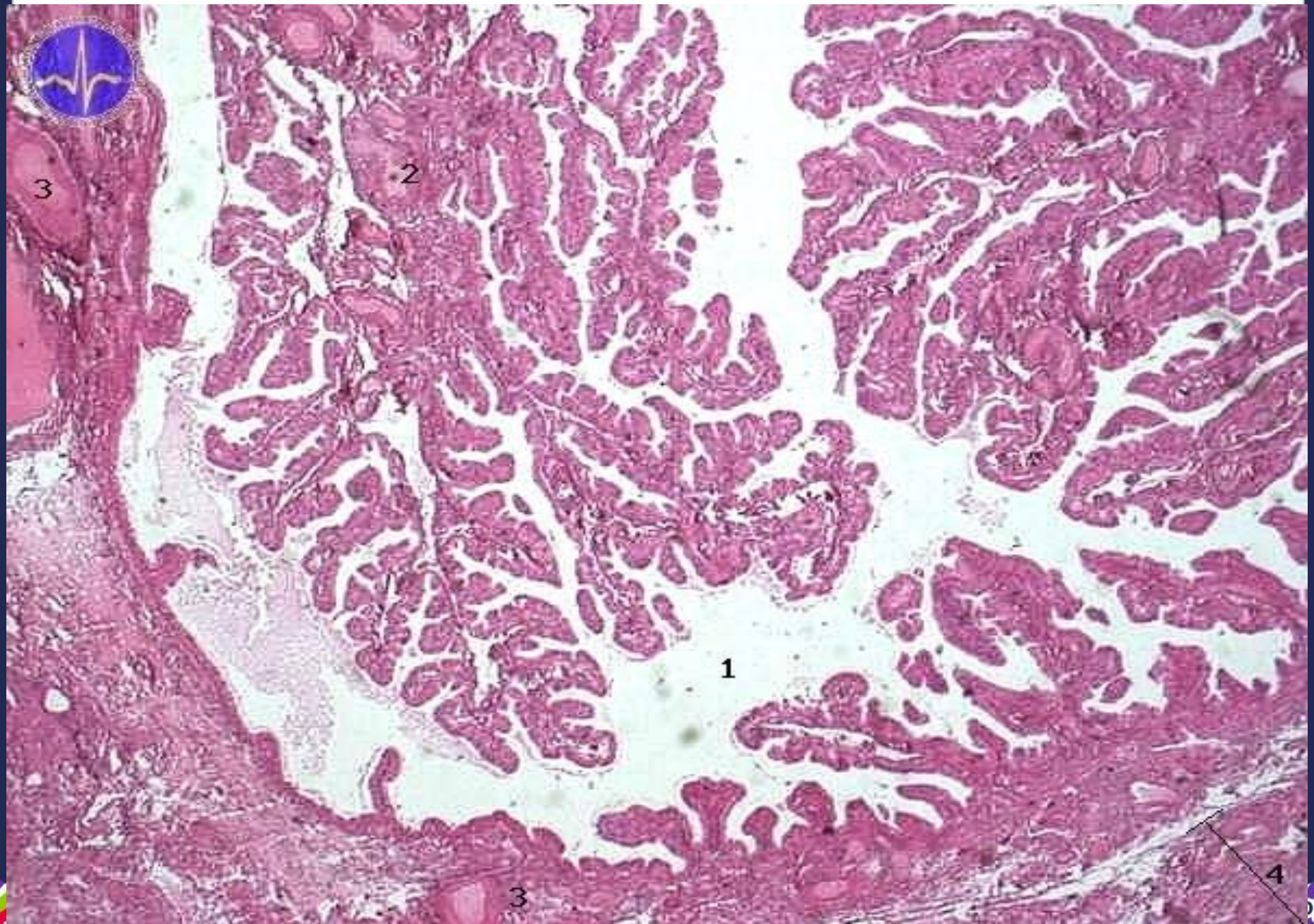
	Folds	Ciliated cells	Secretory cells	Smooth muscle
Infundibulum	+++	+++	+	+
Ampulla	+++	+++	++	++
Isthmus	++	++	+++	+++
Pars intramuralis	+	+	+++	+++

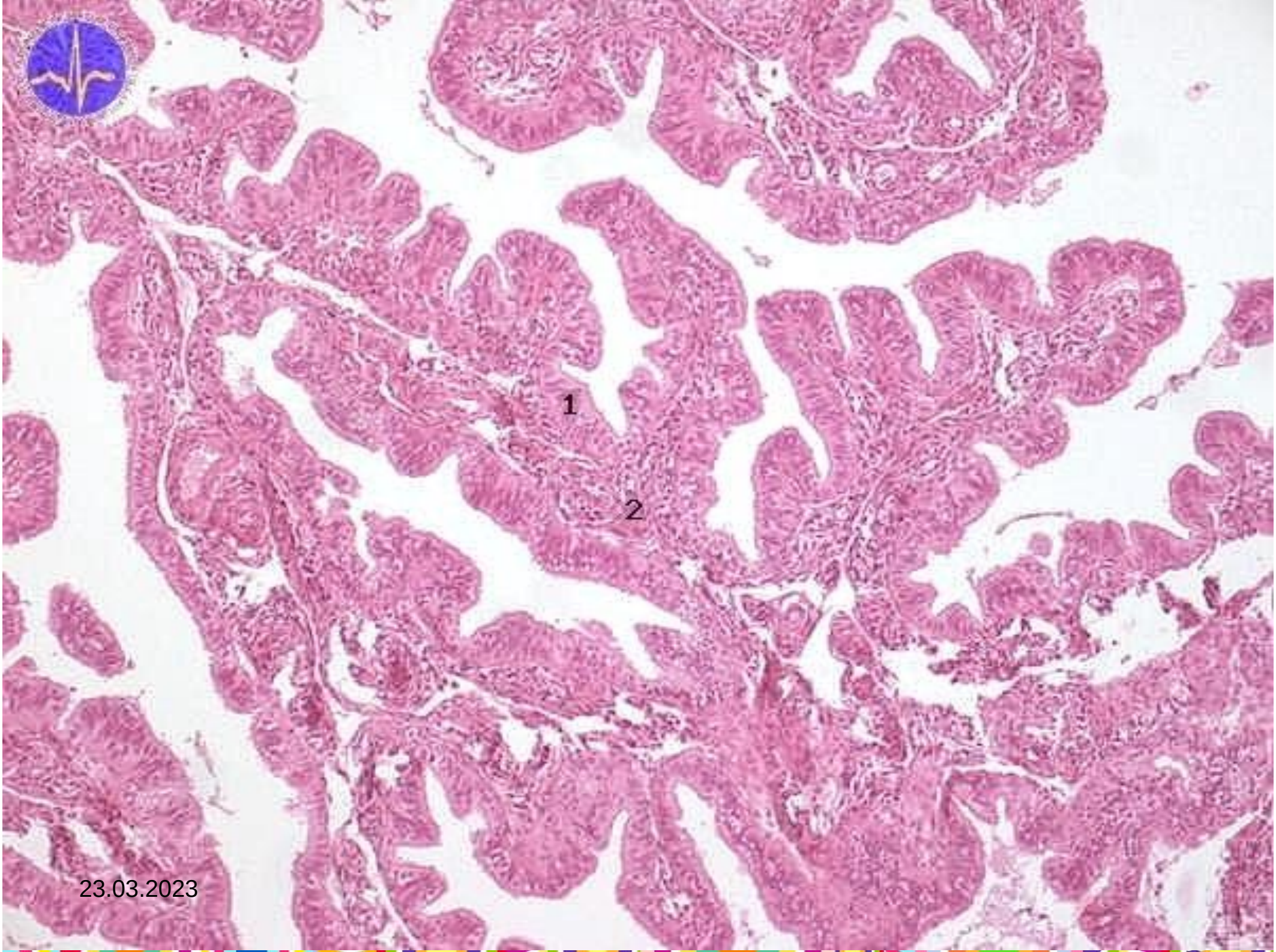
Isthmus tubae uterinae



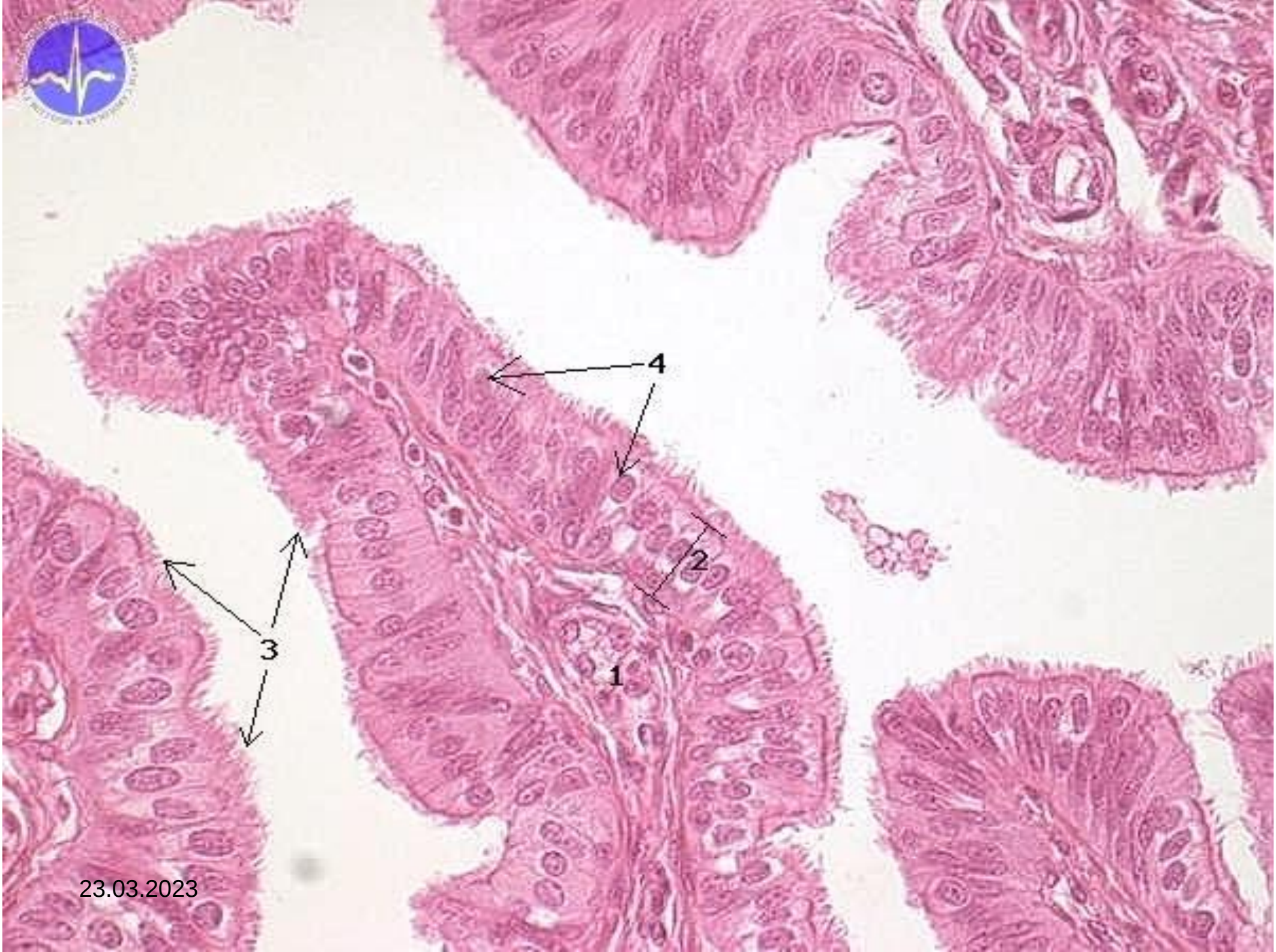

1
2
3
4
4
23.03.2023

Ampulla





23.03.2023

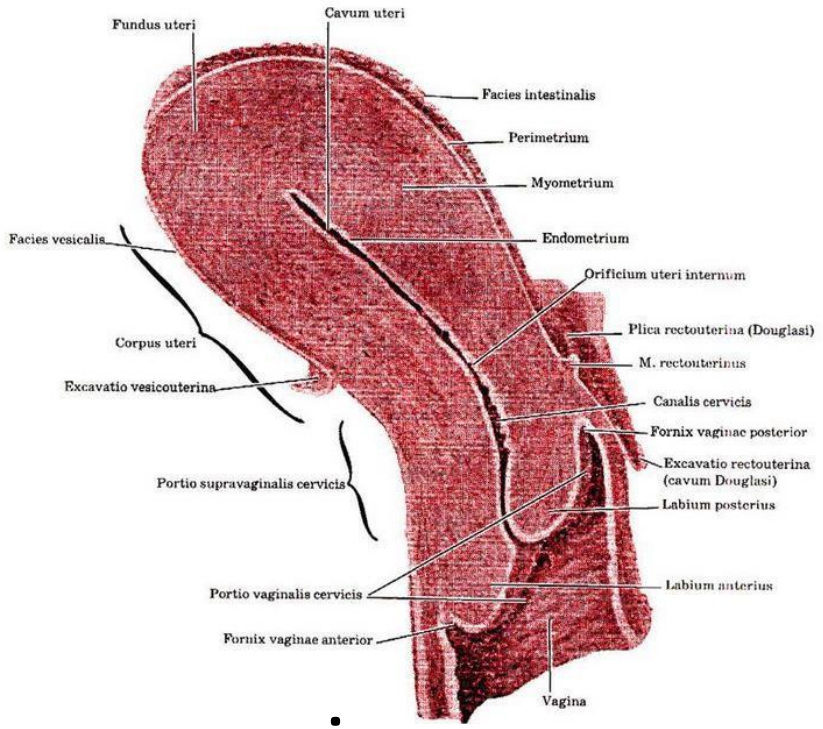


23.03.2023

This high-power photomicrograph of tubal epithelium shows numerous ciliated cells with a compressed secretory cell nucleus above the level of the ciliated cells. The cell with clear cytoplasm (lower left) is probably a lymphocyte.

Uterus

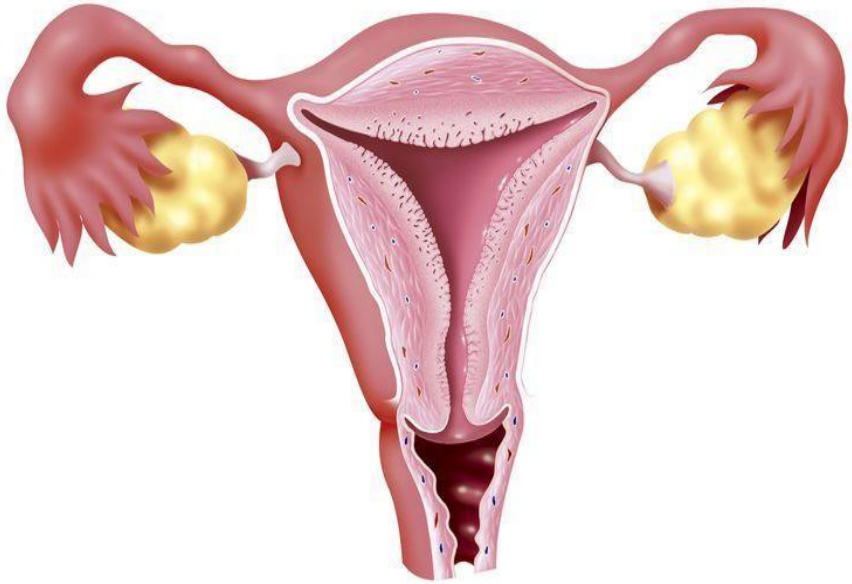
- Hollow pear-shaped organ
- Thick muscular wall

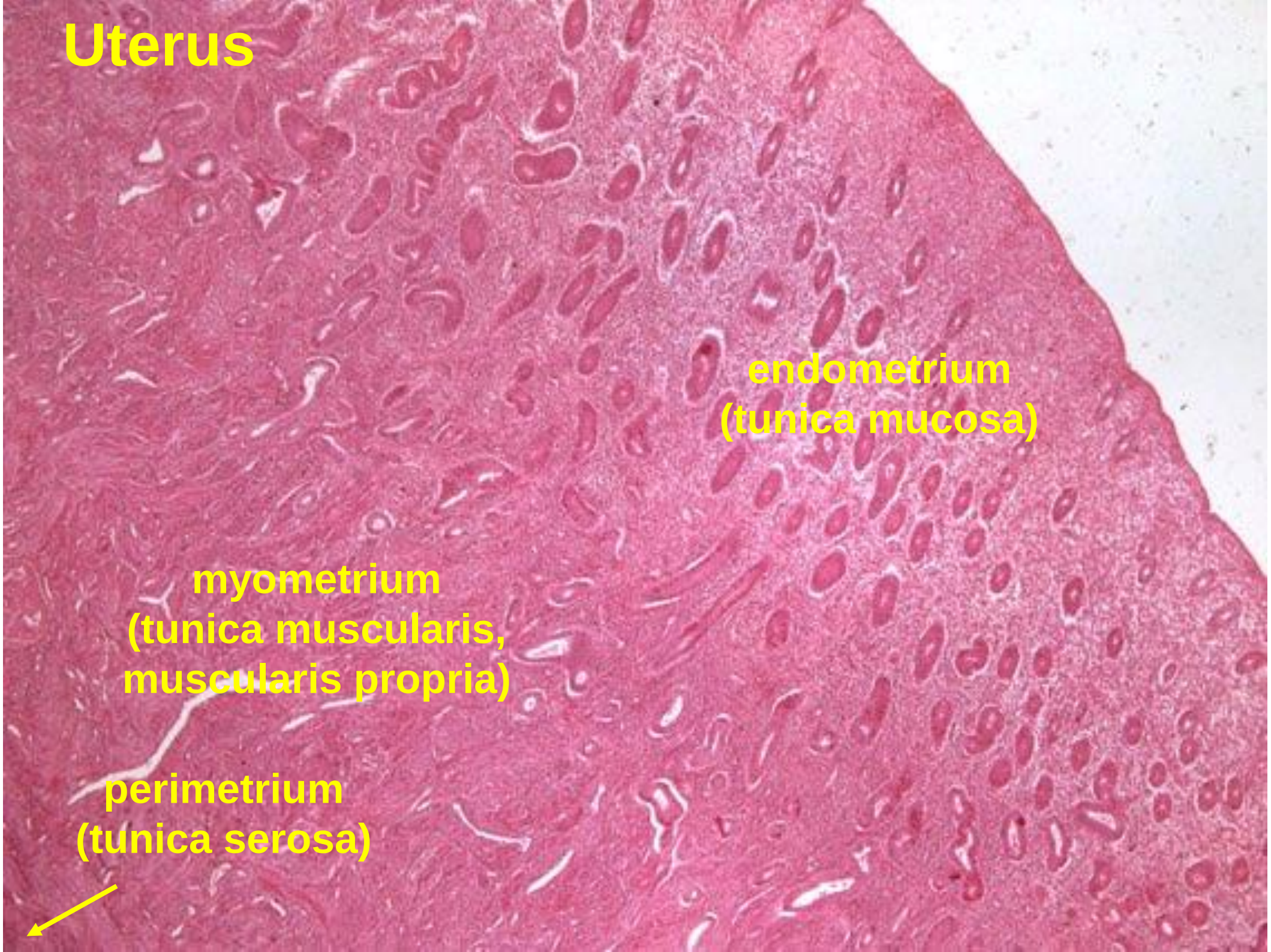


- Corpus, fundus, isthmus, cervix
- Cavitas uteri, canalis cervicis

Uterus

- **Endometrium - tunica mucosa**
- **Myometrium- tunica muscularis**
- **Perimetrium- tunica serosa**
- **Parametrium- tunica adventitia**

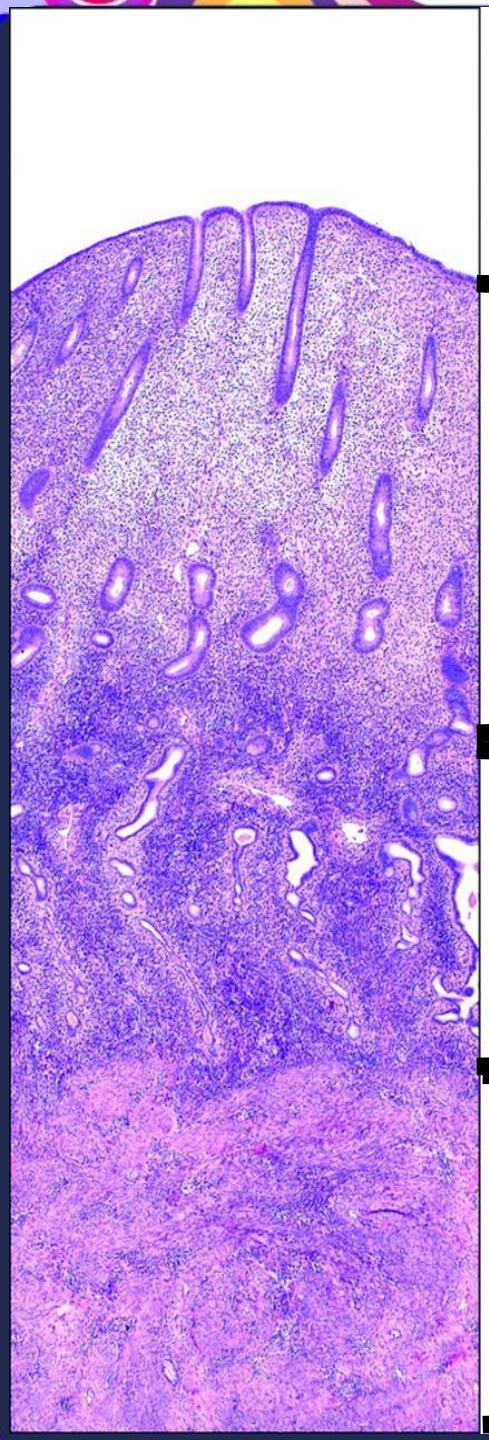



Uterus
endometrium
(tunica mucosa)
myometrium
(tunica muscularis,
muscularis propria)
perimetrium
(tunica serosa)

Endometrium

- **Lamina epithelialis**
  - Simple columnar epithelium
- **Lamina propria mucosae**
  - Highly cellular endometrial stroma
  - Simple tubular uterine glands
- **Stratum functionale**
  - Cyclic changes during the menstrual cycle
- **Stratum basale**
  - Renewal of the cells

Endometrium



Stratum functionale

Changes during menstruation

Stratum basale

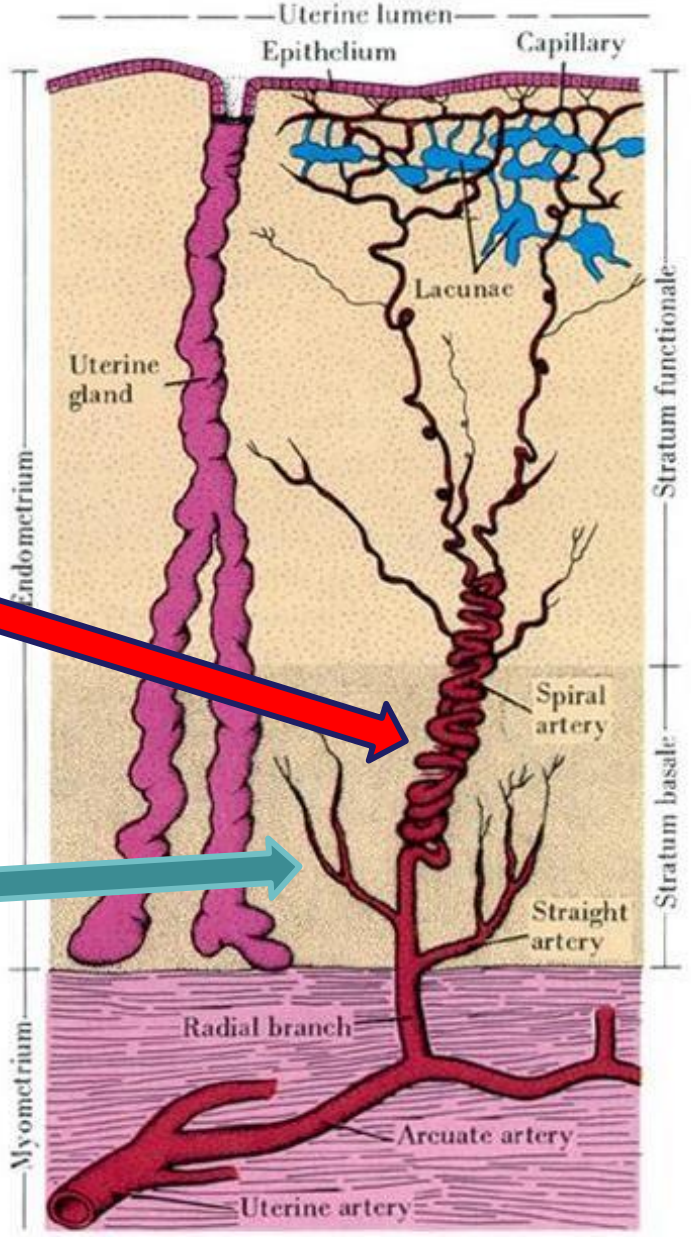
Restoration of endometrium after menstruation

Myometrium

Endometrium

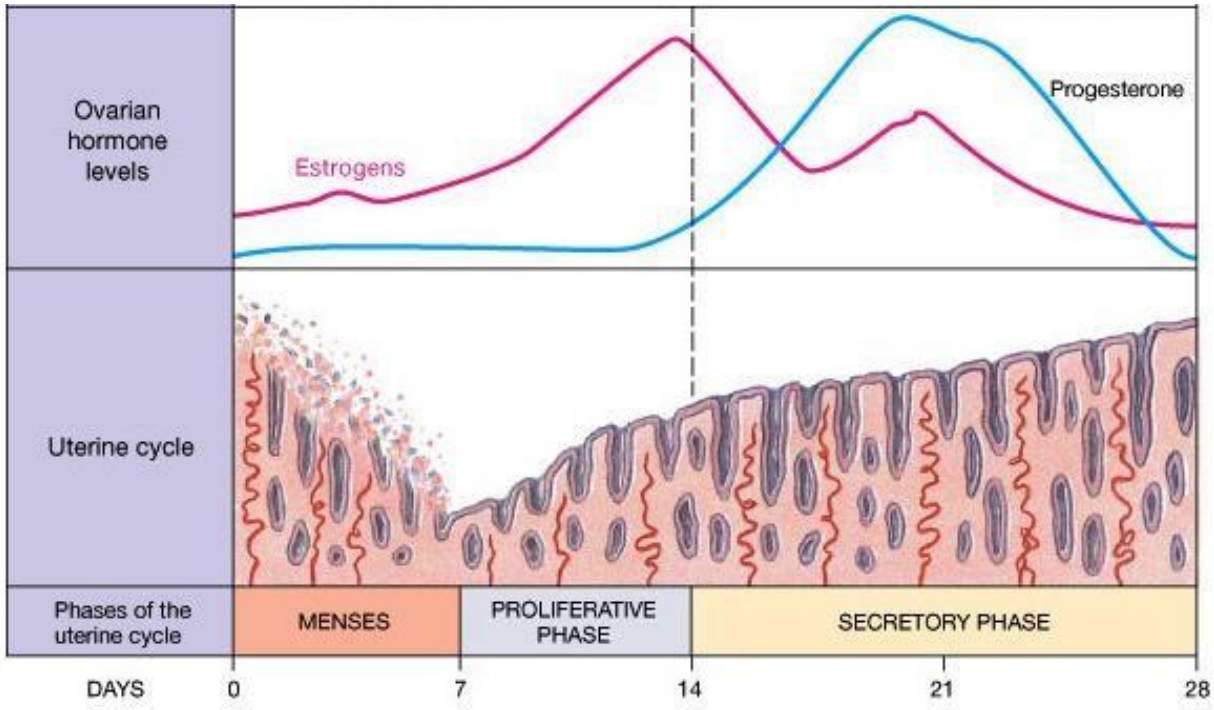
Vascular supply

- Spiral arteries
  - Supply functional layer of endometrium
- Straight arteries
  - Supply basal layer of endometrium



Menstrual cycle

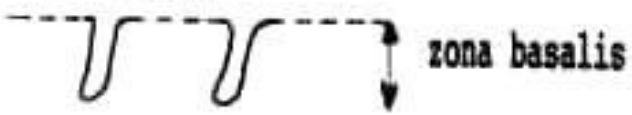
- **Menstrual phase** (1.-4.)
- **Proliferative phase** (5.-14.)
- **Secretory phase** (15.-27.)
- **(Ischemic phase)** (28.)



MENSTRUAL CYCLE

1 – menstrual phase

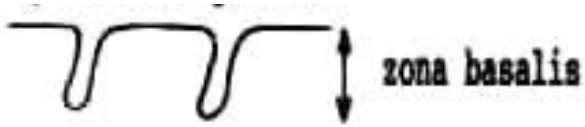
days 1- 4



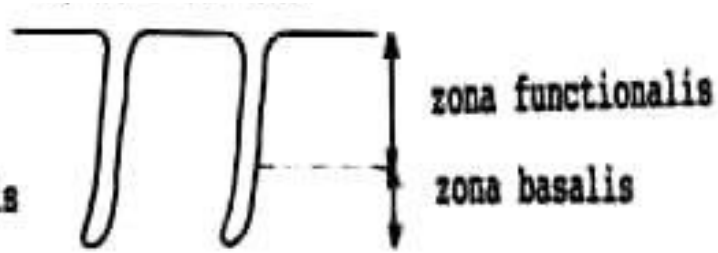
2 – proliferative (follicular) phase

a) day 5

surface re-epithelisation



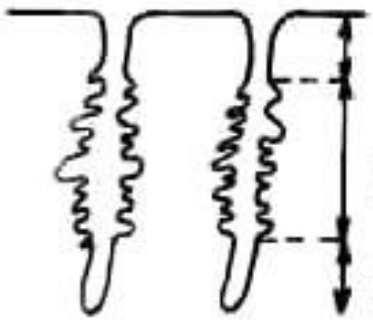
b) days 6 - 15



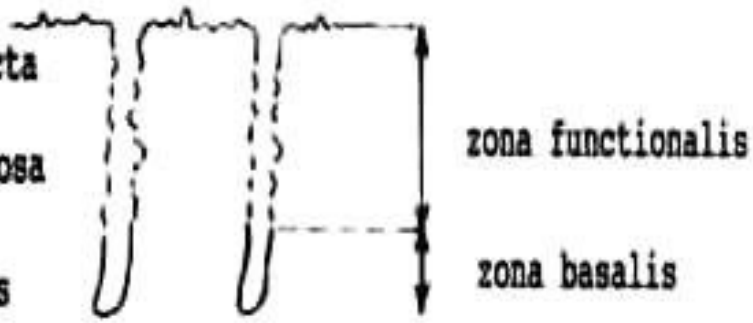
3 – secretory (luteal) phase

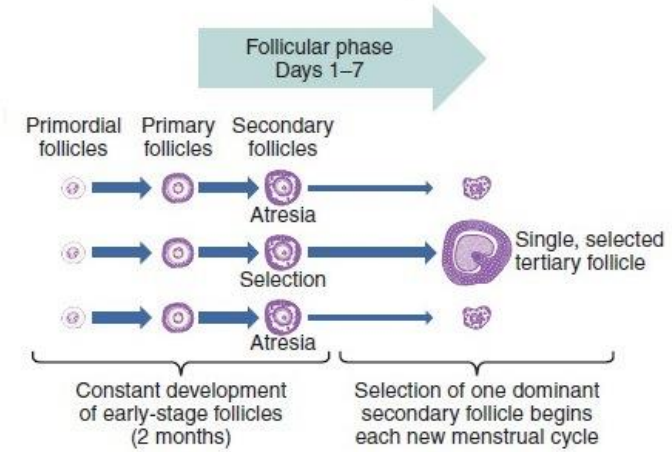
4 – ischemic phase

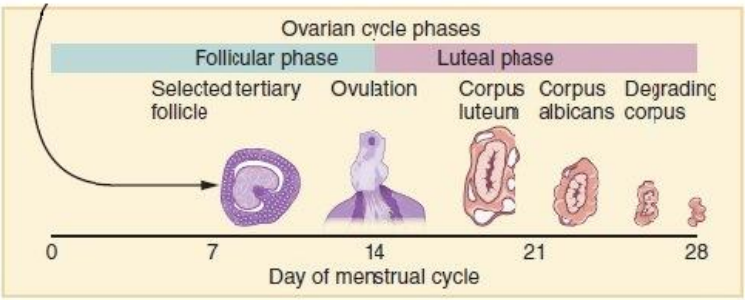
days 16 - 28

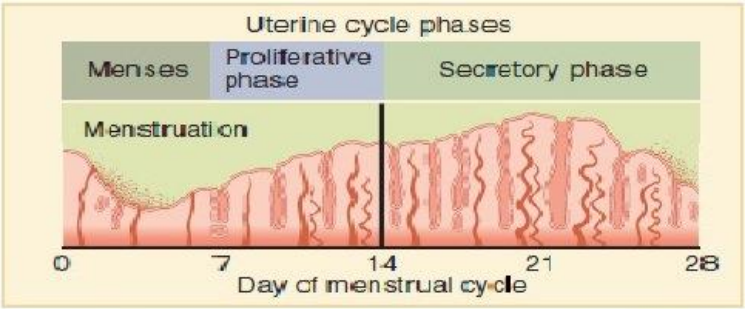


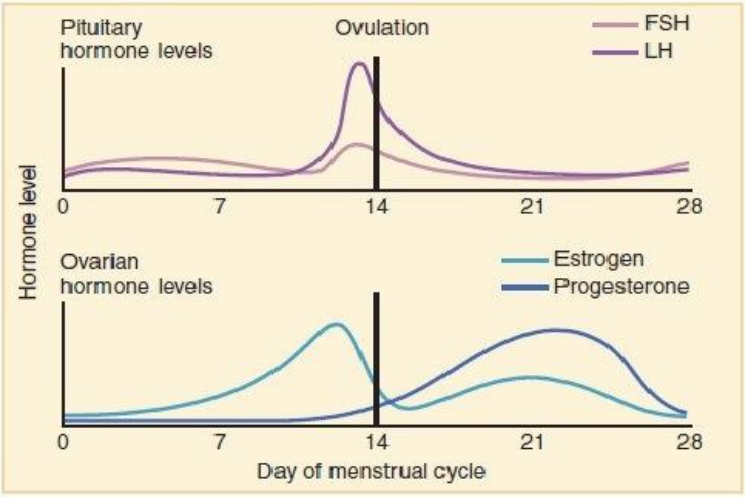
day 28







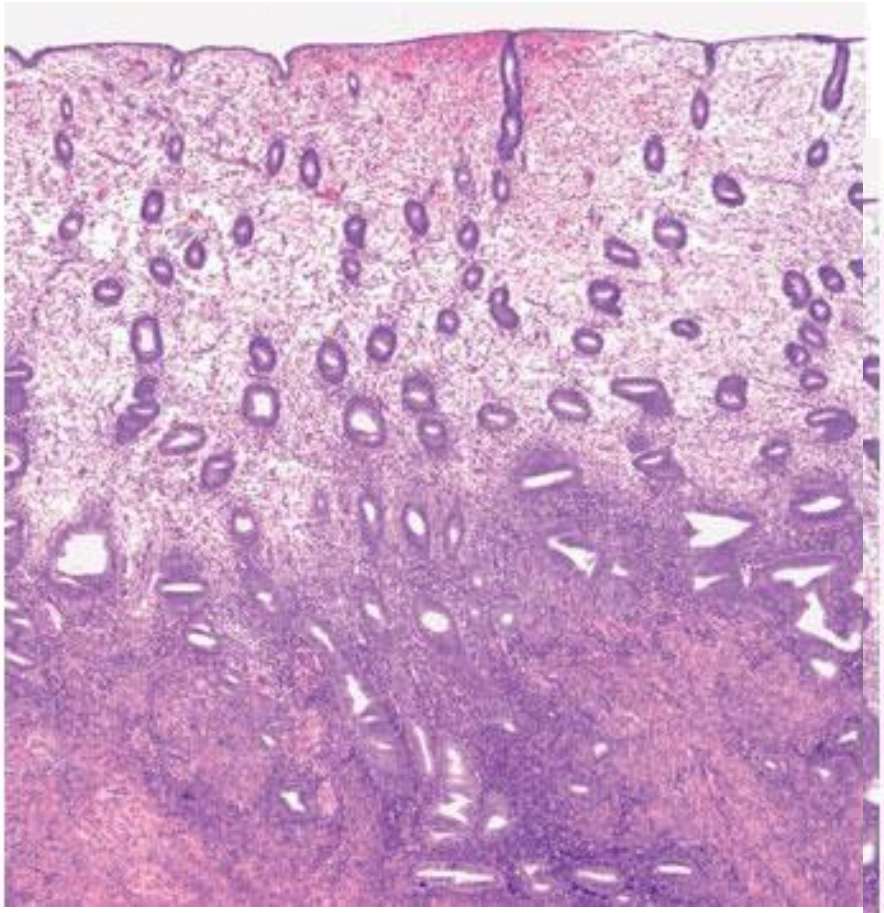


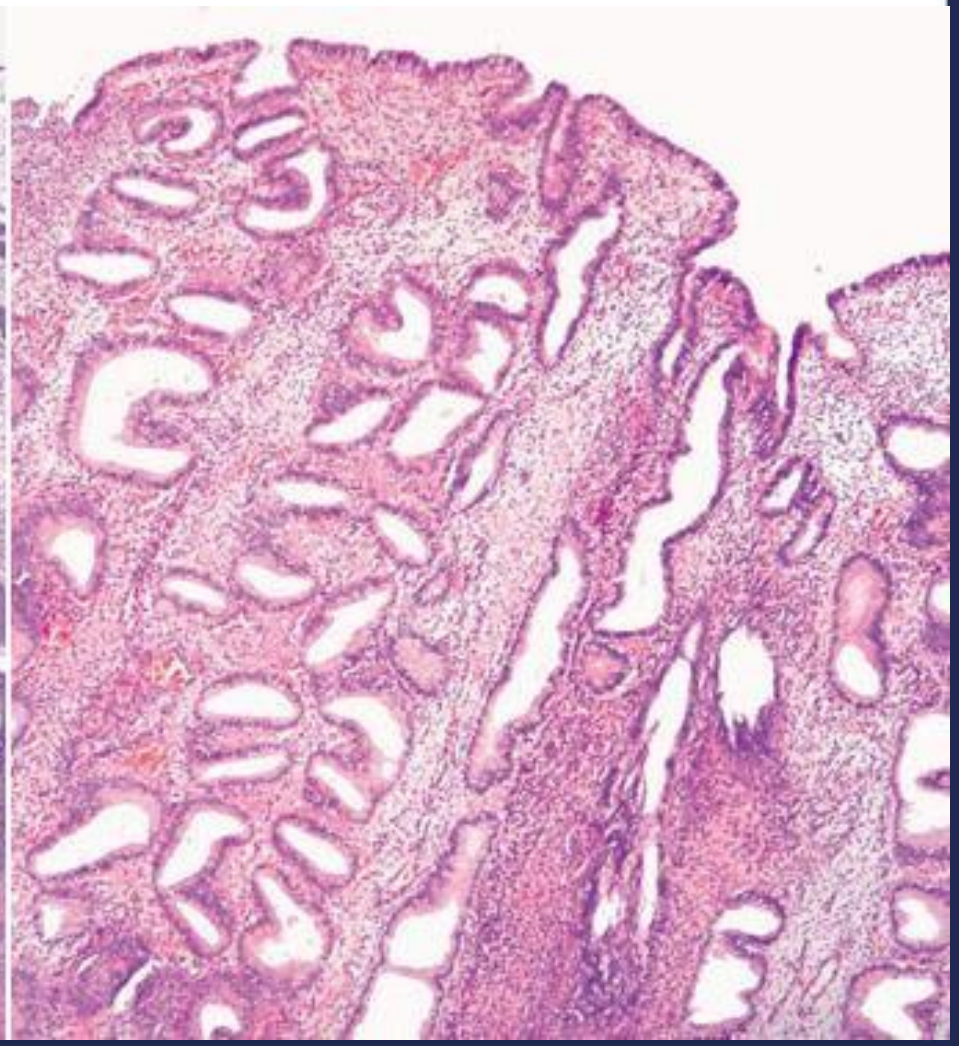


Menstrual phase

- Menstrual bleeding
- Result of ischemia of the functional layer of the endometrium
- *Stratum basale* is preserved to restore the endometrium

Proliferative phase





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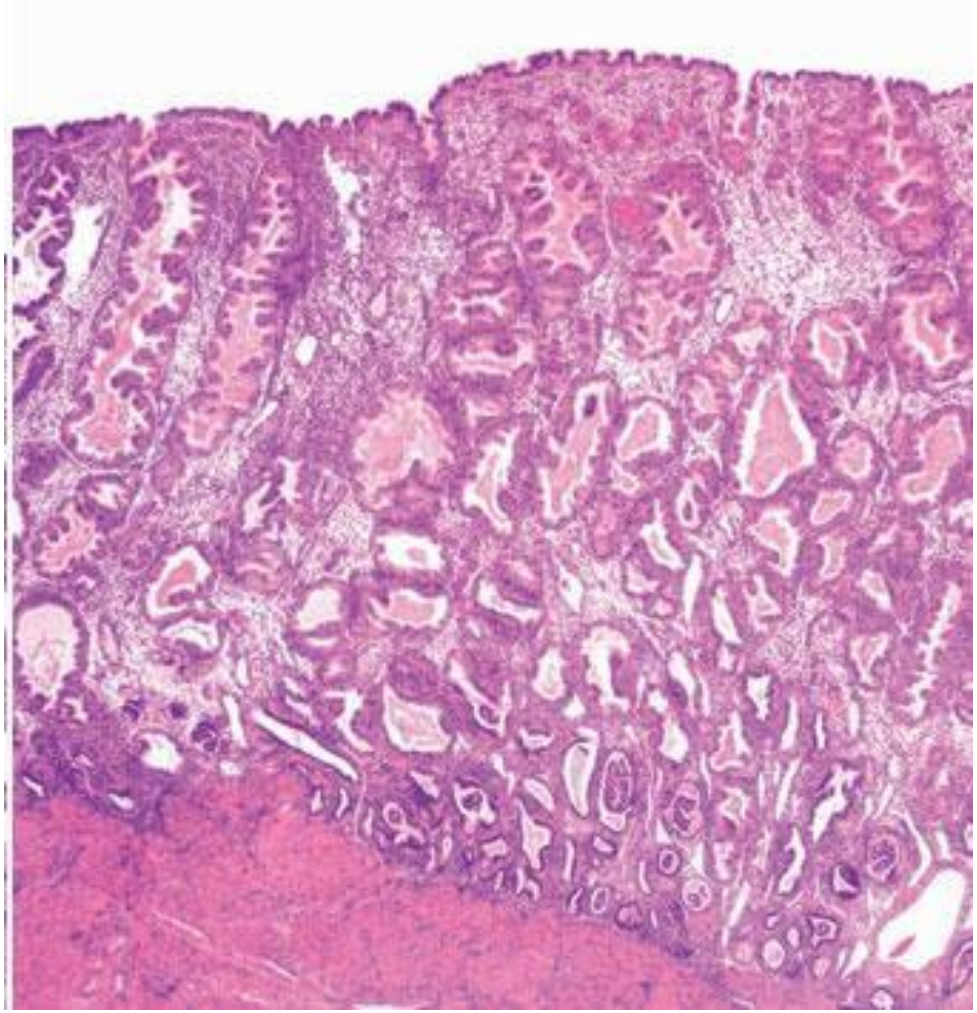
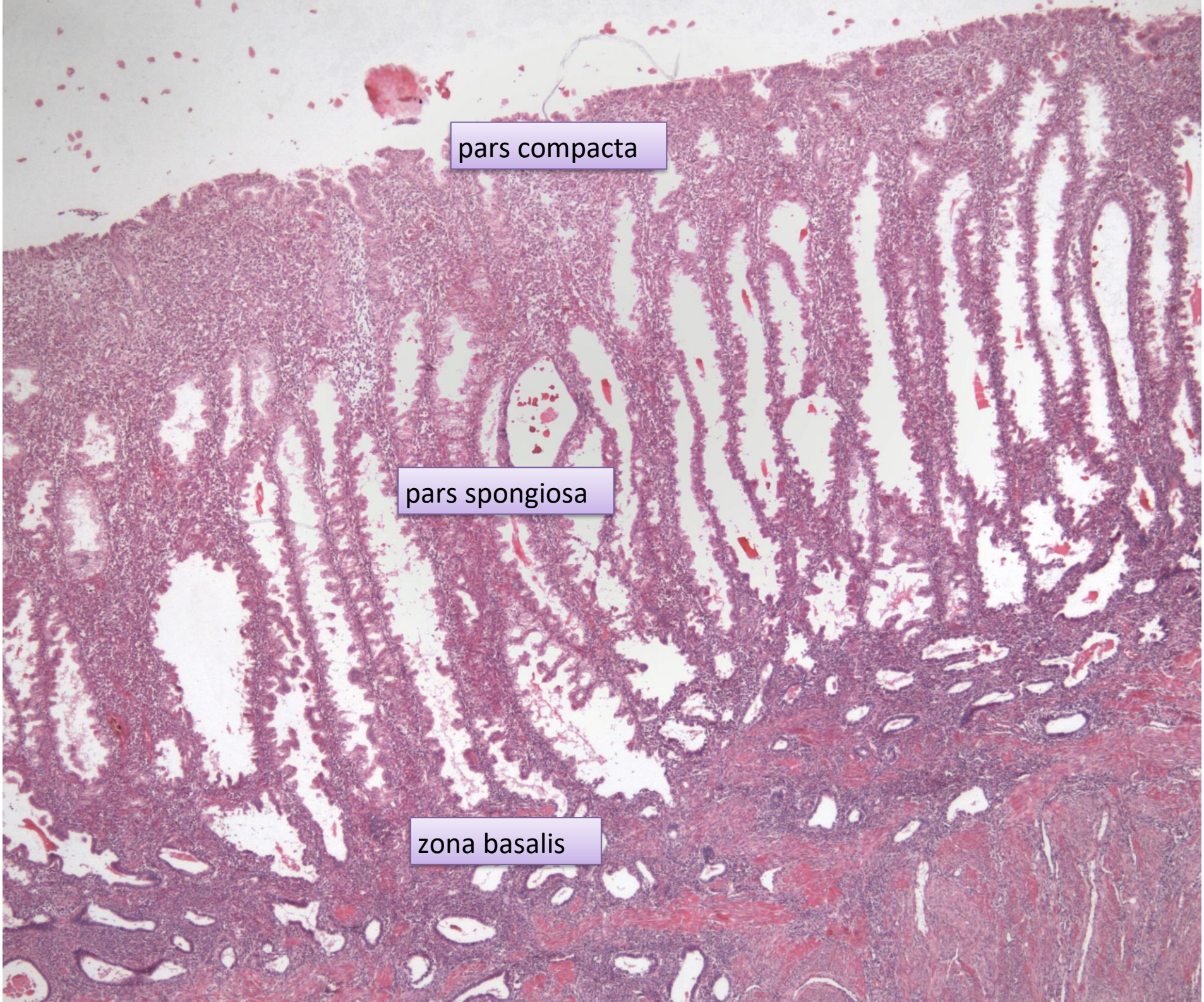
Secretory phase

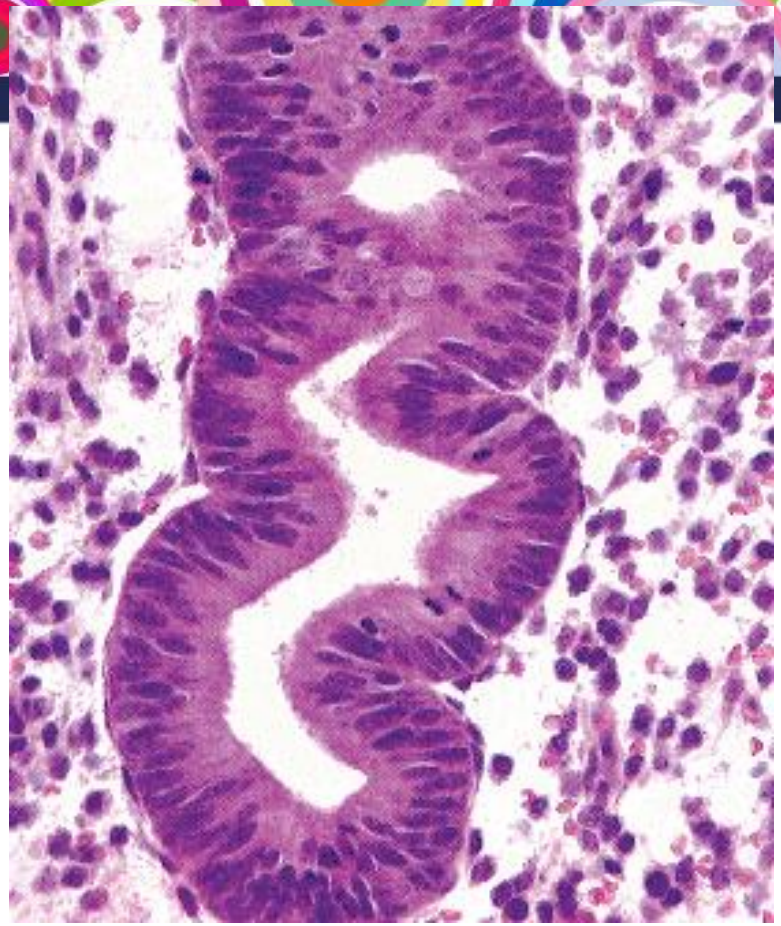


Glands become coiled

Secretion of glycogen and glycoproteins

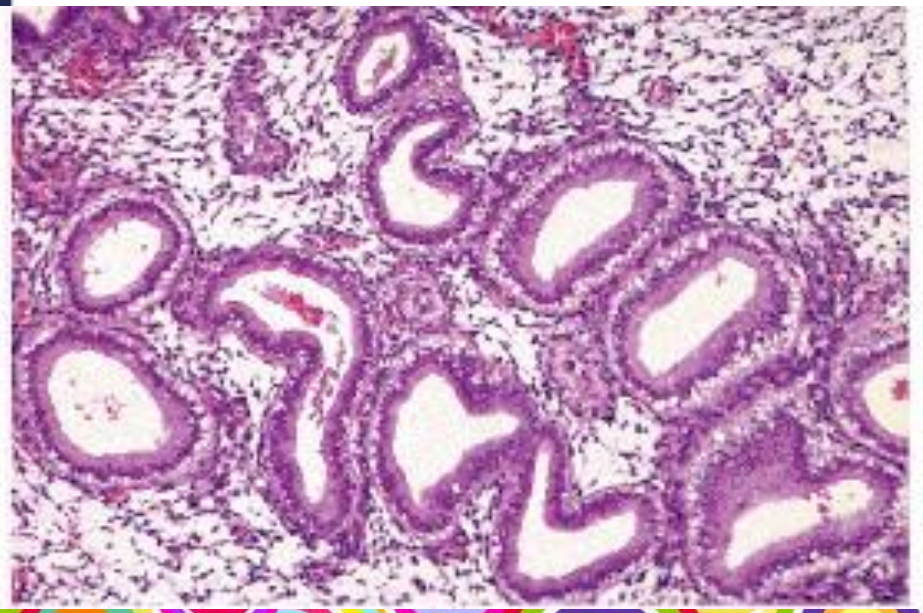
Nutrition for the embryo

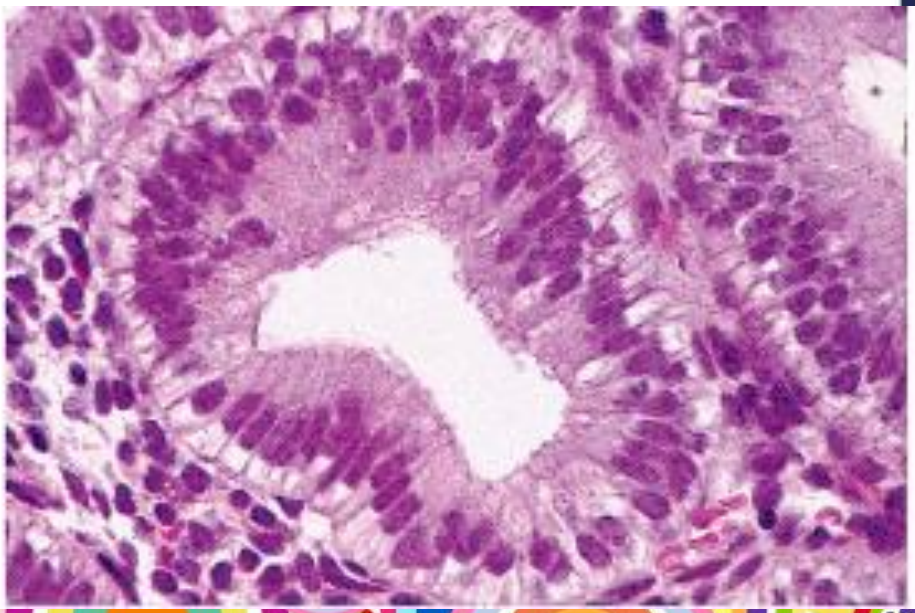

pars compacta
pars spongiosa
zona basalis



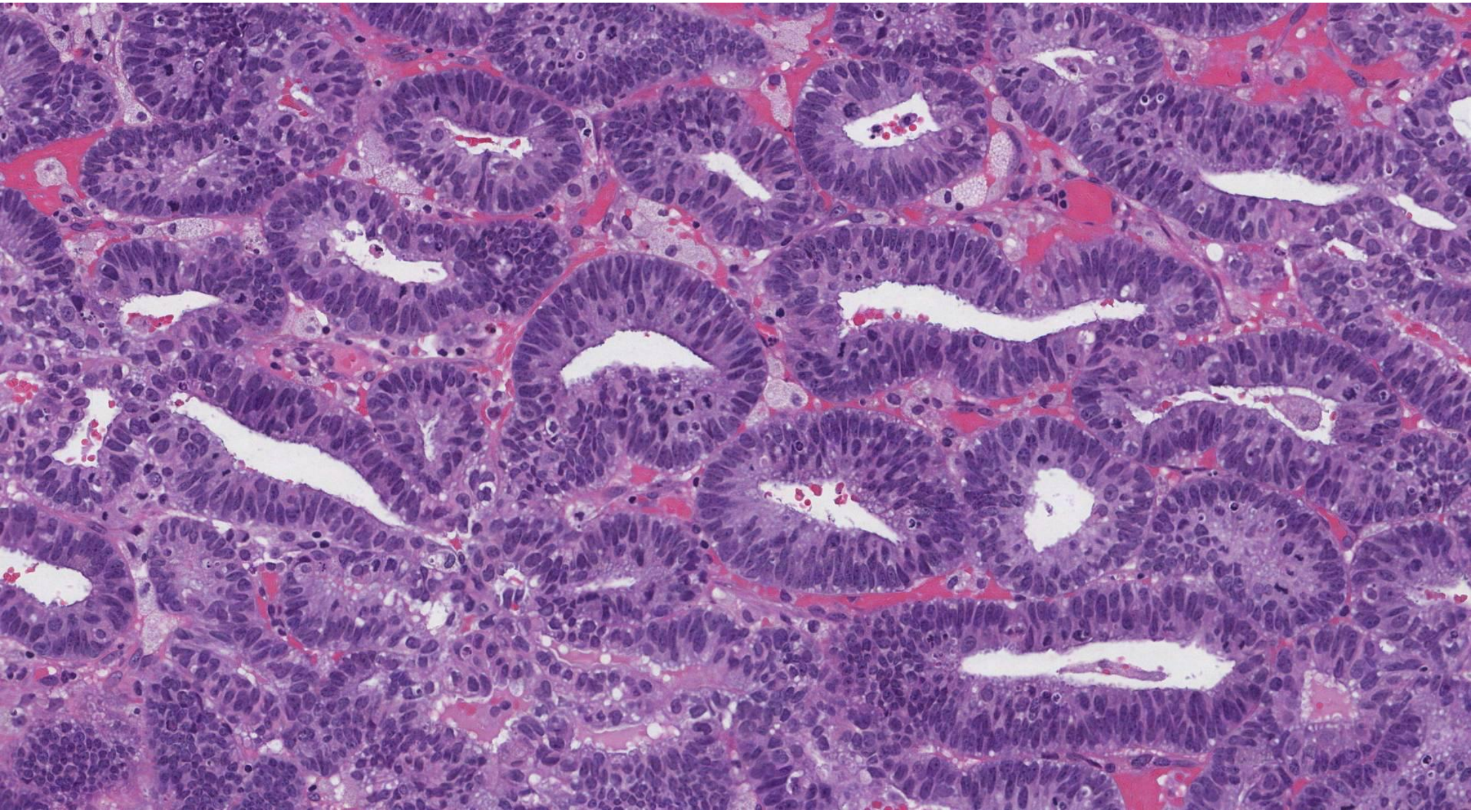
Proliferative phase

Secretory phase





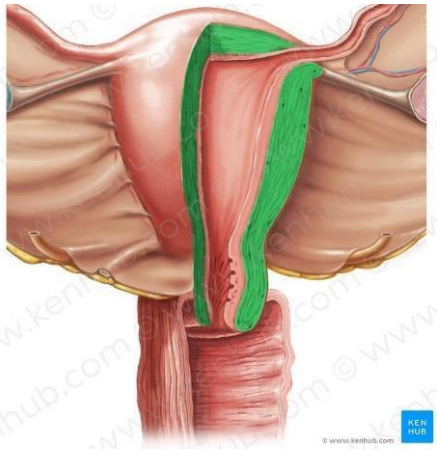
Endometroid carcinoma



Myometrium

- 4 poorly defined layers of smooth muscle
- Inner layers arranged more spirally
- Outer layer arranged more longitudinaly

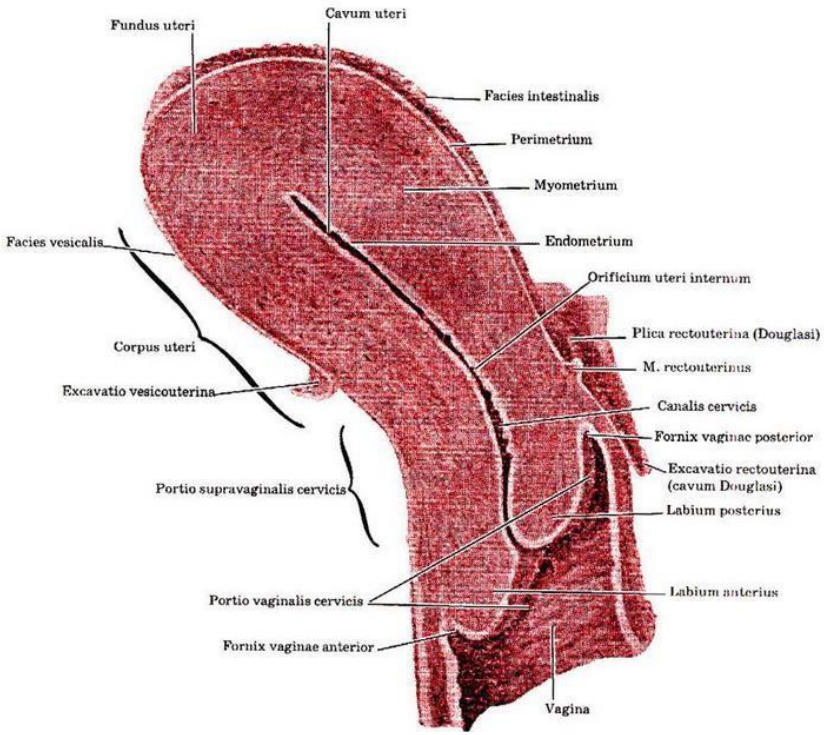
- Isthmus – less smooth muscle, more fibrous tissue

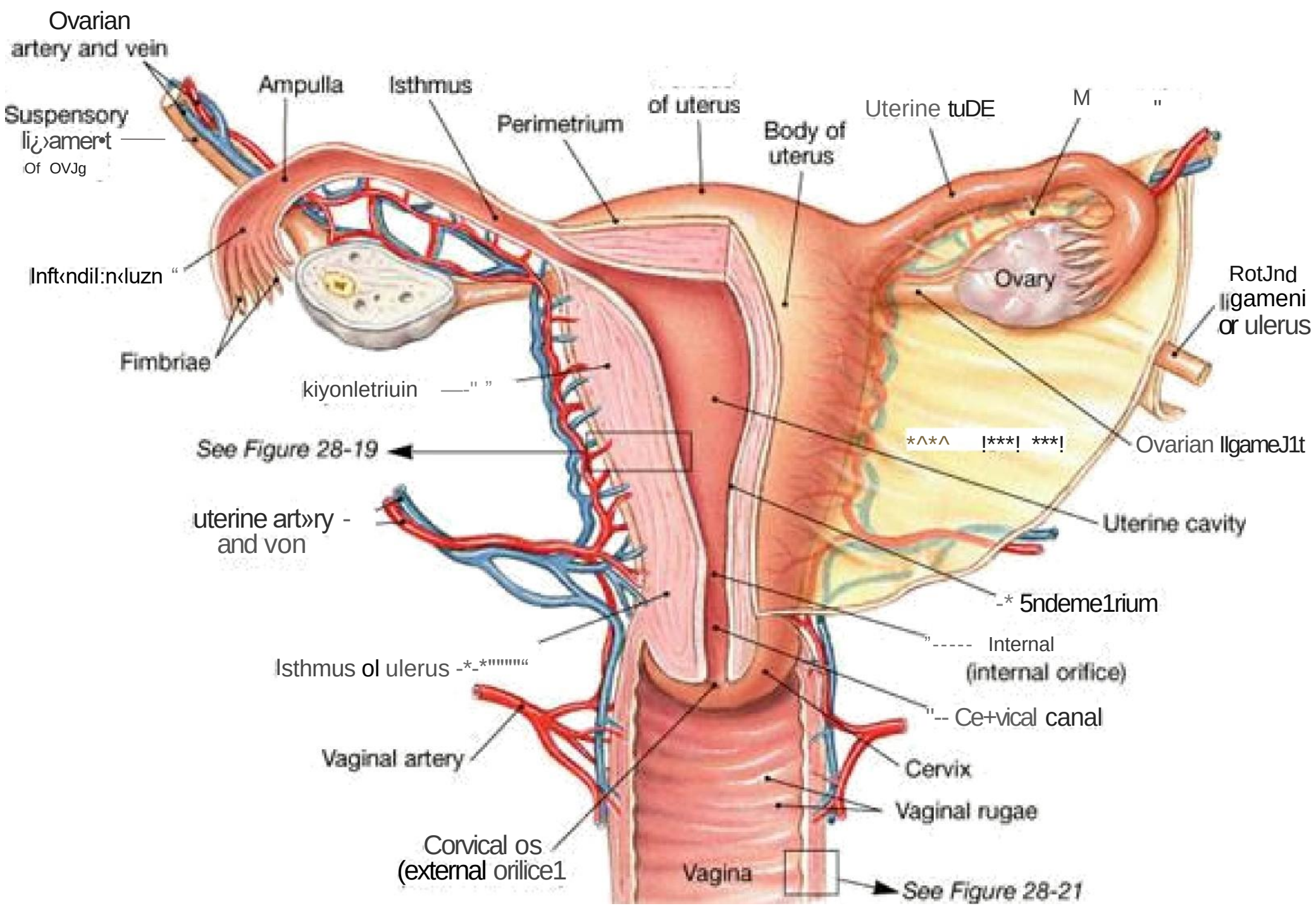


Cervix uteri

= inferior portion of the uterus

- **Portio supravaginalis cervicis** / cervical canal
- **Portio vaginalis cervicis**





{c) Posterl›or view

Portio supravaginalis cervicis

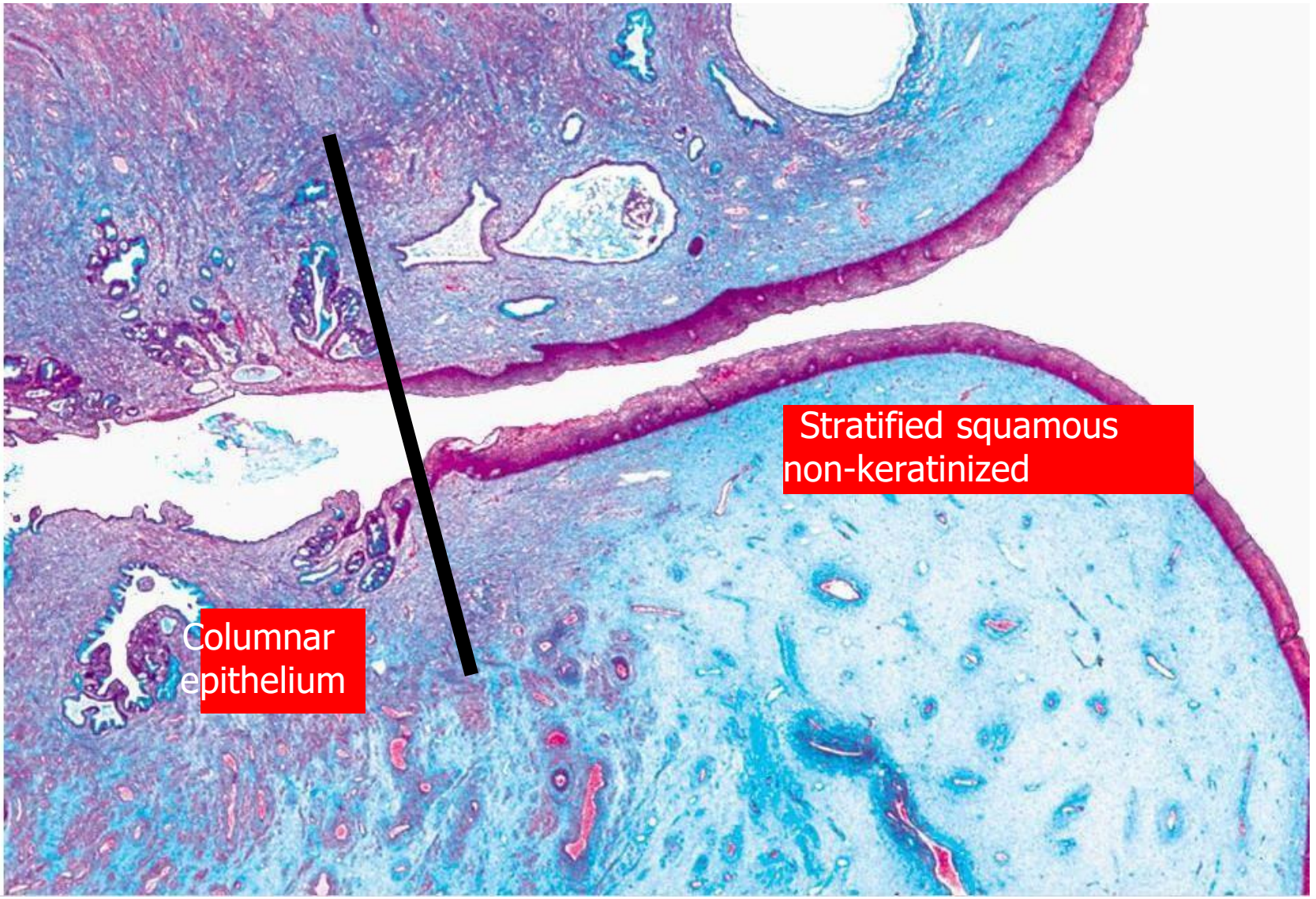
- **Simple columnar epithelium**

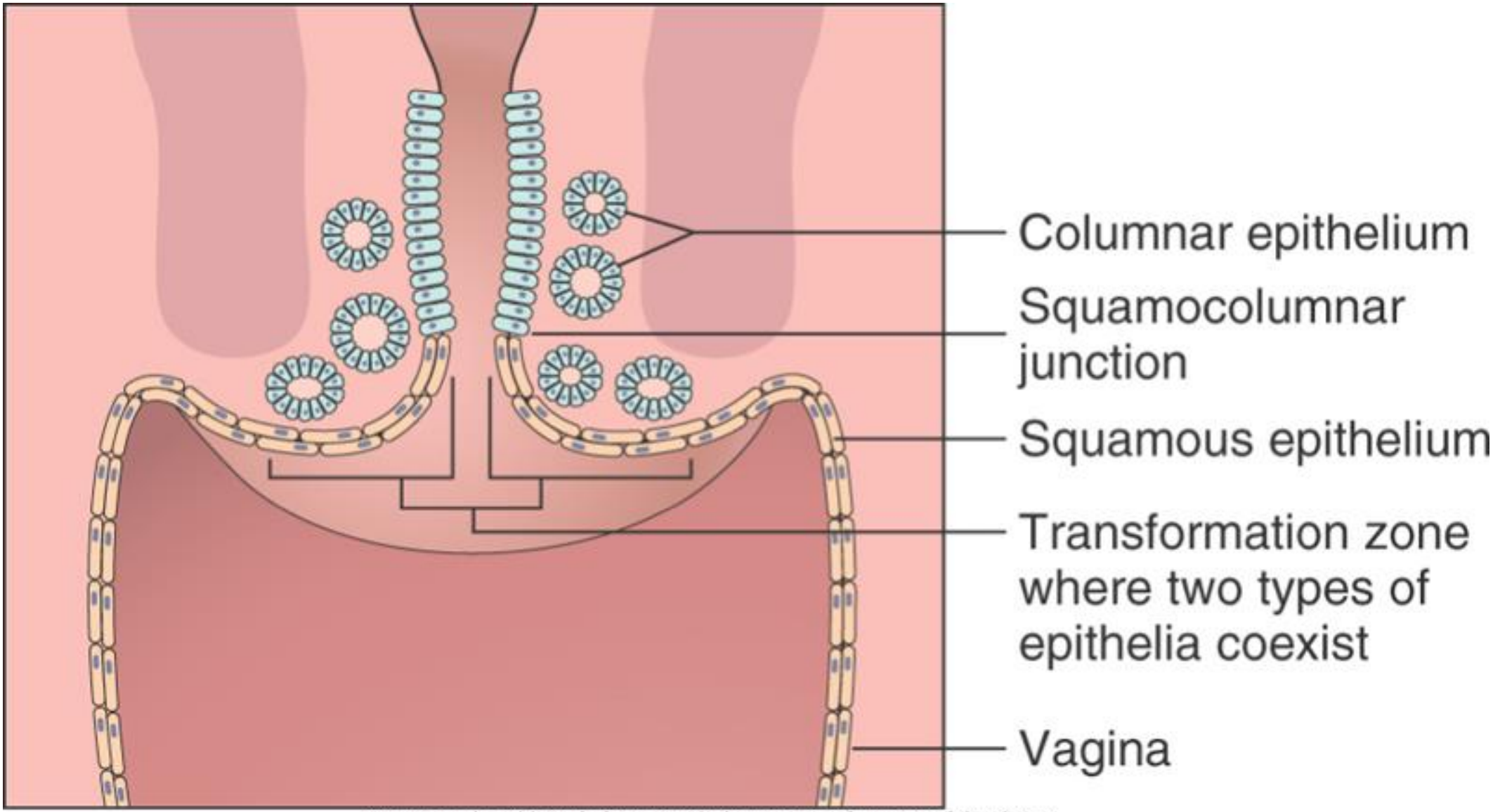
- **Glandulae cervicales uteri** (mucus-secreting)
  - Simple/branched tubular glands (crypts)
  - Occluded and dilated = Nabothian cyst

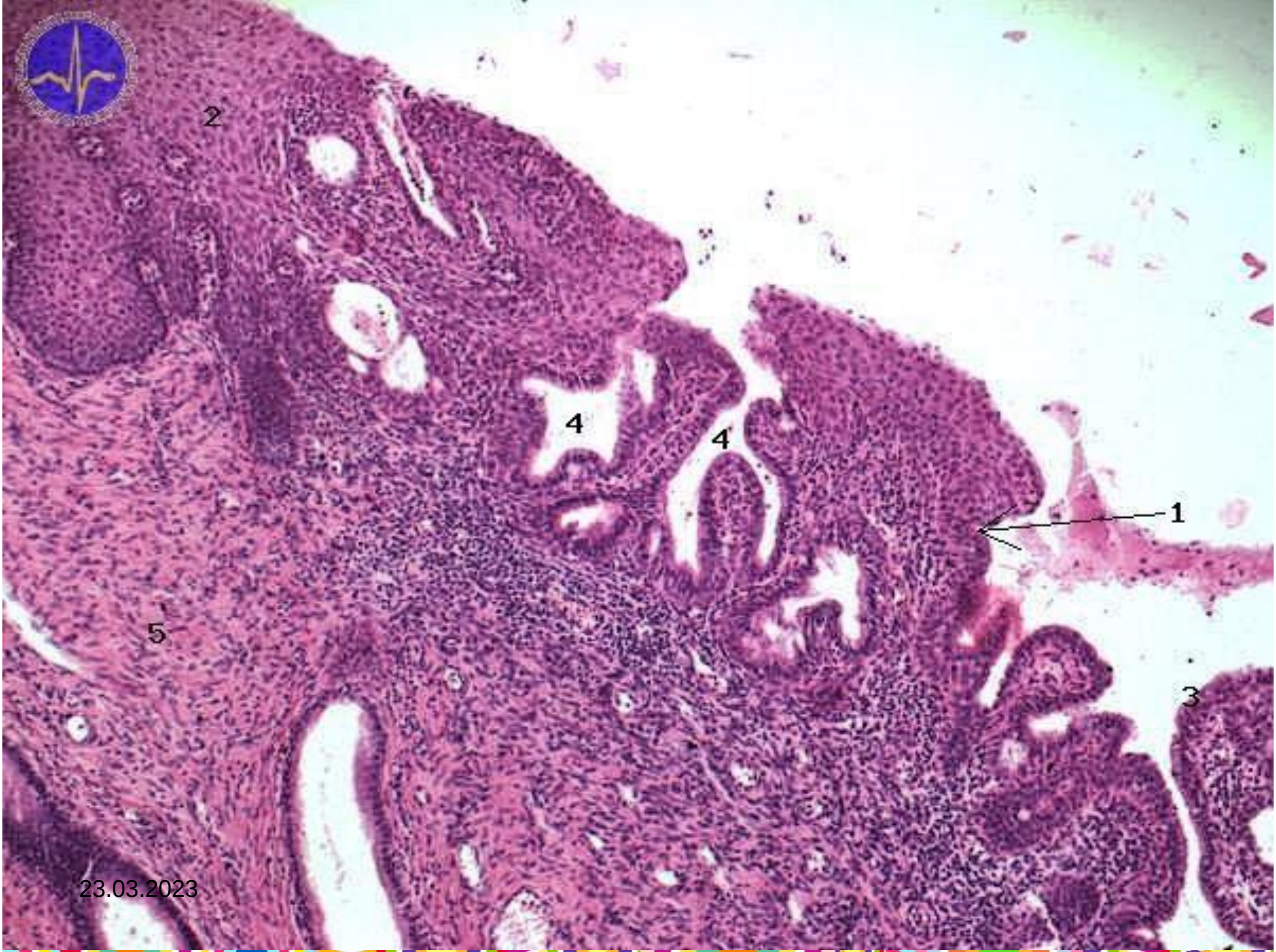
Portio vaginalis cervicis

- **Nonkeratinized stratified squamous epithelium**
  - Cervicovaginal junction
    - Prepubertal junction inside of cervical canal
    - In fertile age junction is outside of the canal (ectropium)
    - **Metaplasia** (= transformation of simple columnar epithelium into normal stratified squamous epithelium) = transformational zone

Cervicovaginal junction







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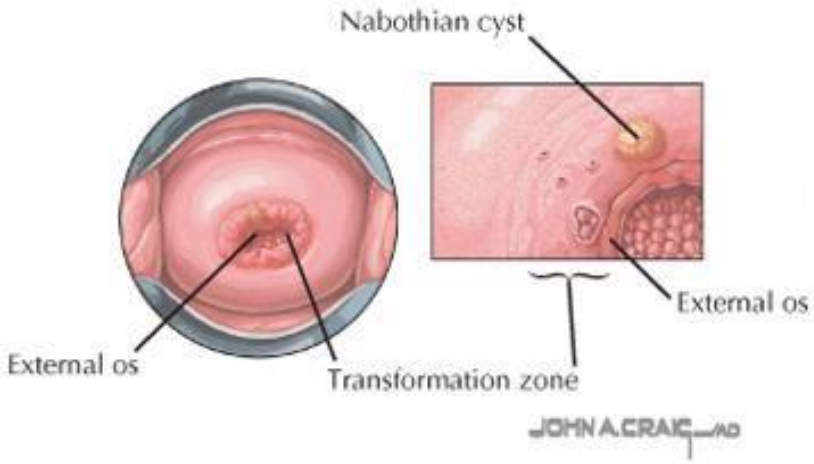
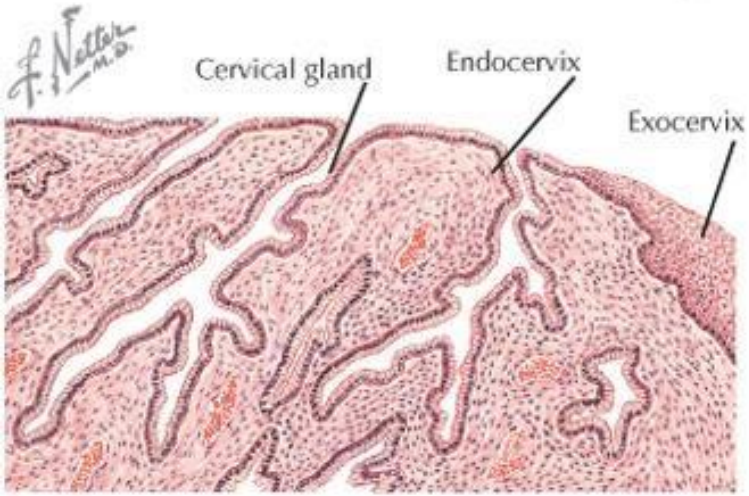
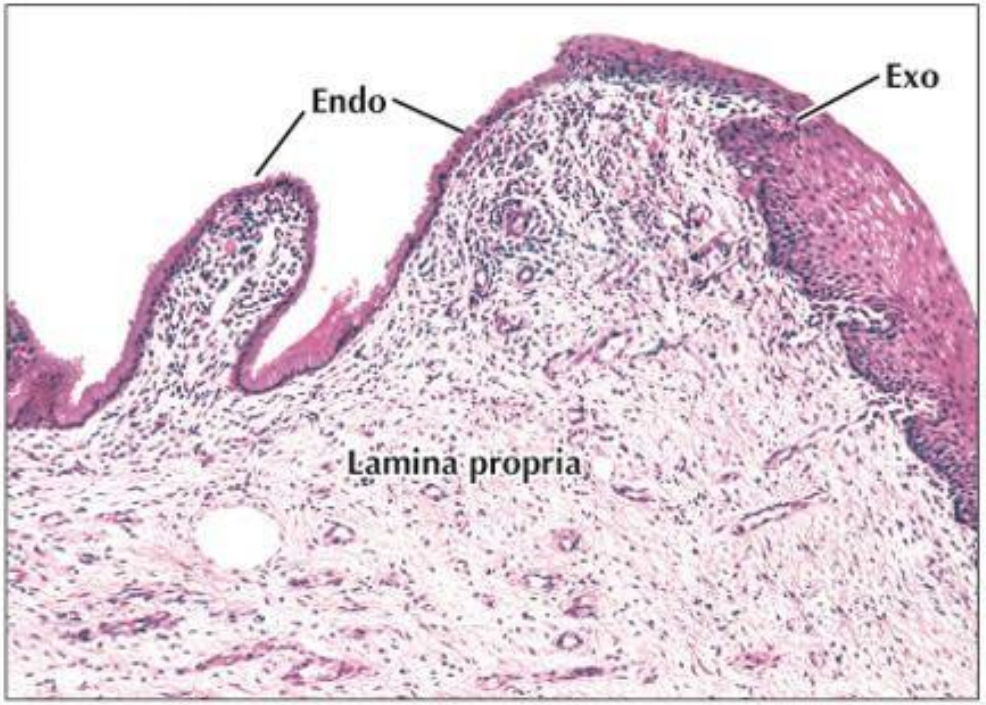
▼ **Low- and high-power colposcopic views of the normal transformation zone.**



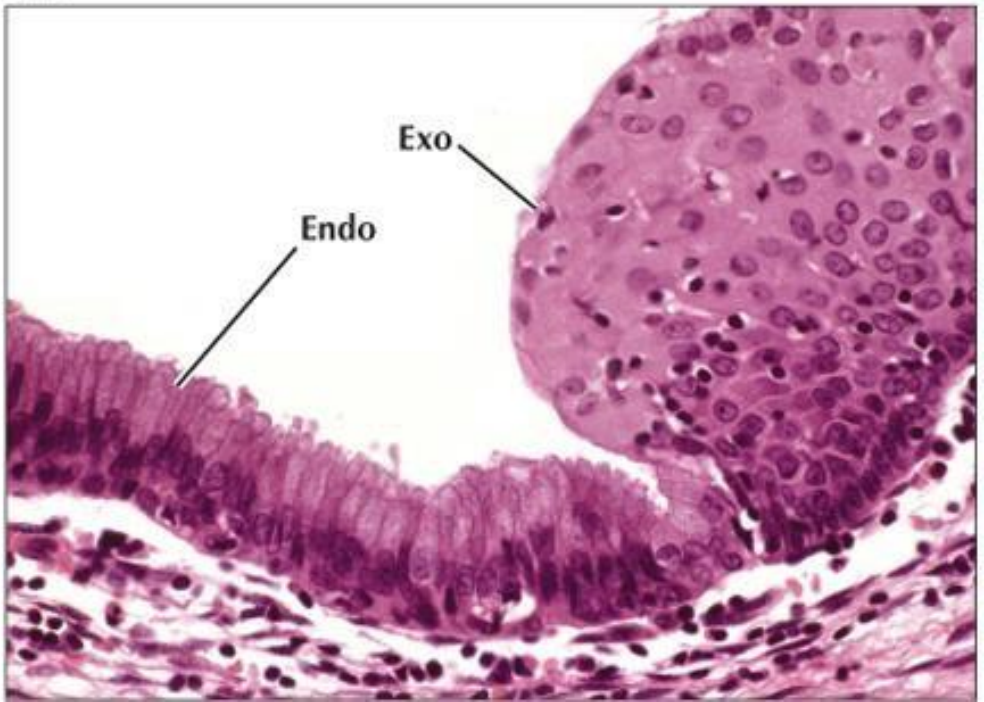


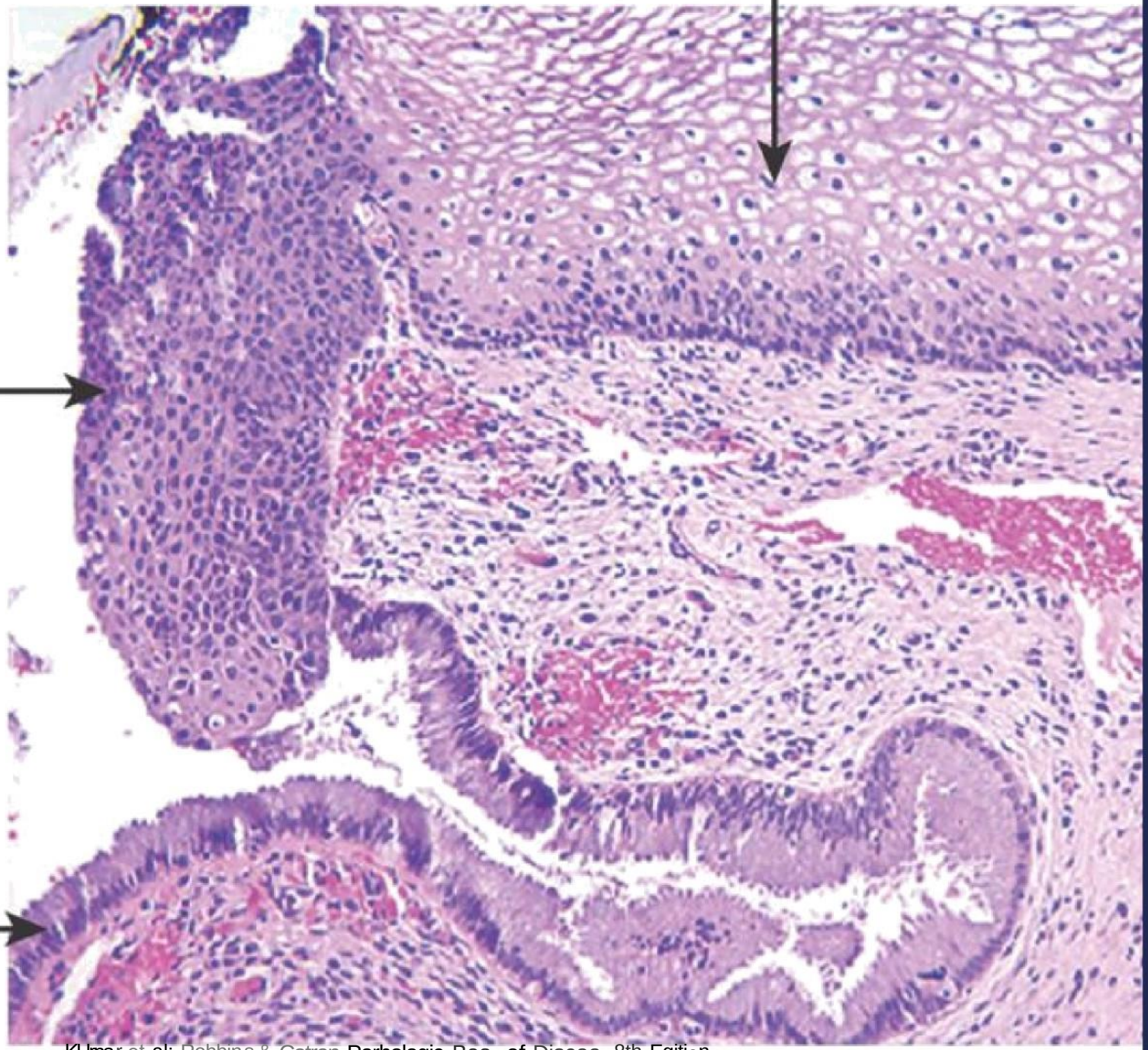
▲ **Schematic of the cervical squamocolumnar junction.**

► **Higher magnification LM of the cervical squamocolumnar junction.** The endocervix (**Endo**) is lined by simple columnar epithelium with tall mucus-secreting cells. The epithelium abruptly changes to a nonkeratinized stratified squamous type in the exocervix (**Exo**). 290×. *H&E.*

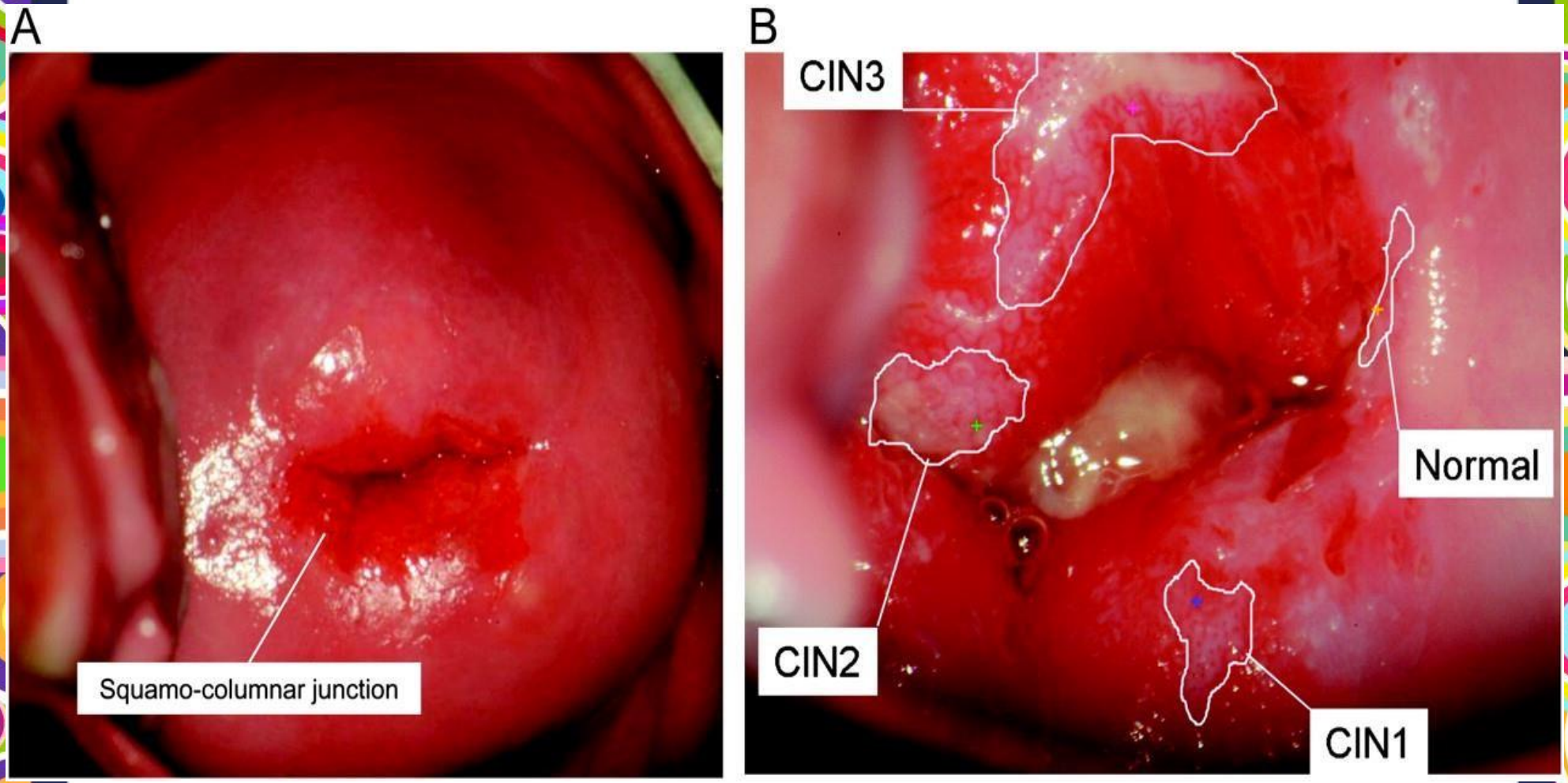


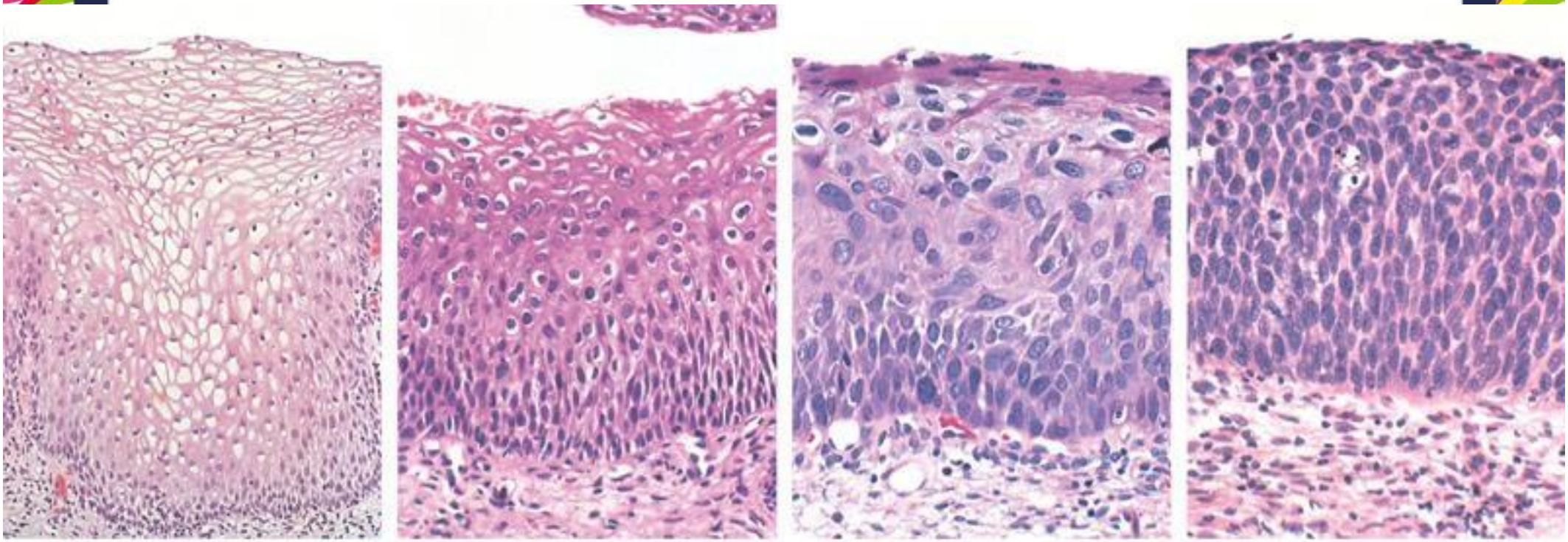
▲ **Low-magnification LM of the mucosa of the uterine cervix.** The simple epithelium of the endocervix (**Endo**) is highly folded and continuous with stratified epithelium of the exocervix (**Exo**). Underlying lamina propria is richly cellular. 96×. *H&E.*

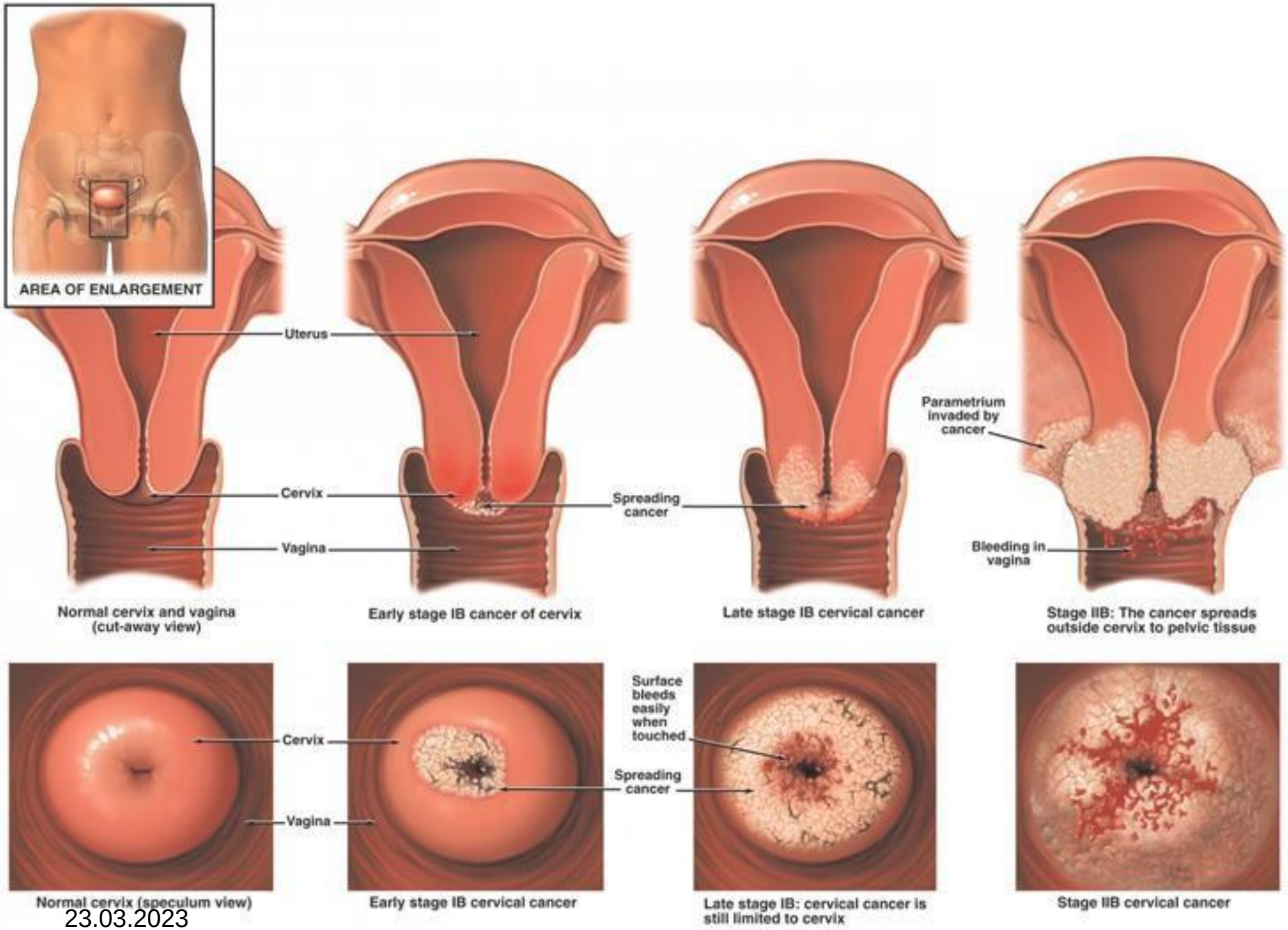




Cervical metaplasia

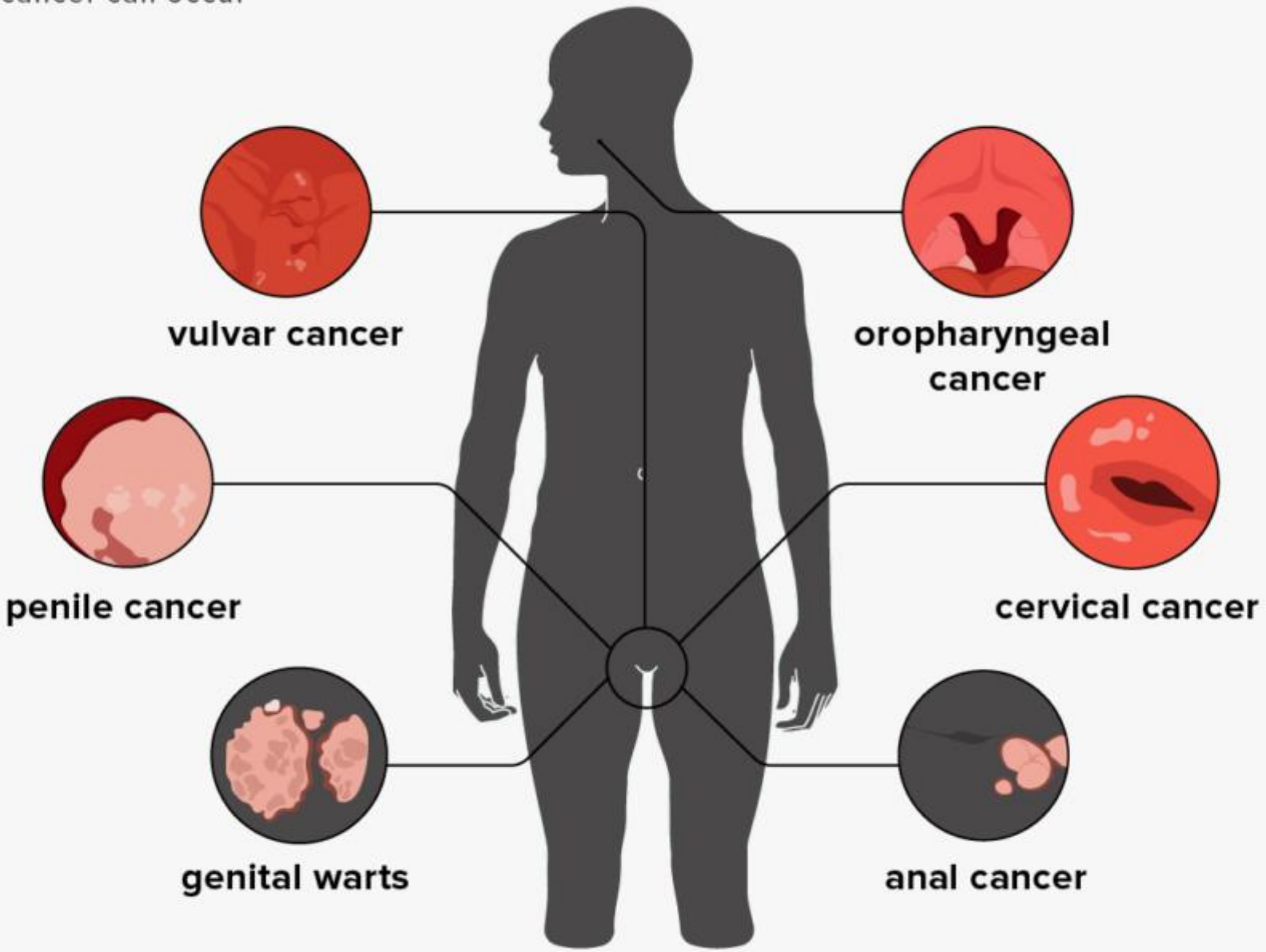





AREA OF ENLARGEMENT
Uterus
Cervix
Vagina
Spreading cancer
Parametrium invaded by cancer
Bleeding in vagina
Normal cervix and vagina (cut-away view)
Early stage IB cancer of cervix
Late stage IB cervical cancer
Stage IIB: The cancer spreads outside cervix to pelvic tissue
Cervix
Vagina
Surface bleeds easily when touched
Spreading cancer
Normal cervix (speculum view)
Early stage IB cervical cancer
Late stage IB: cervical cancer is still limited to cervix
Stage IIB cervical cancer

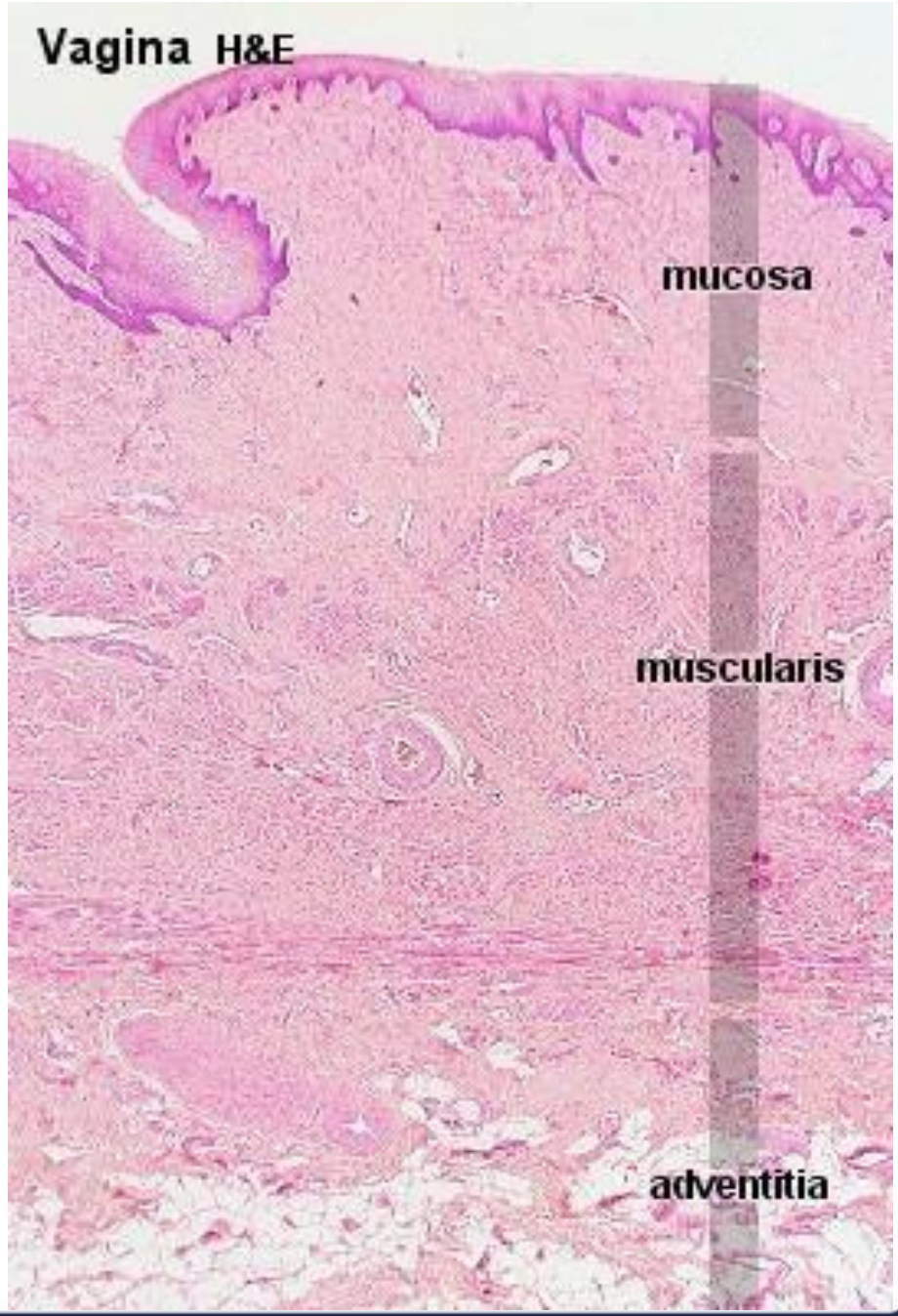
High Risk Papilomavirus (HPV)

Where cancer can occur



Vagina

- **Tunica mucosa**
- **Tunica muscularis**
  - Smooth muscle
    - inner(circular)
    - outer (longitudinal)
- **Tunica adventitia**



Mucosa

- Nonkeratinized stratified squamous epithelium
- Lamina propria mucosae

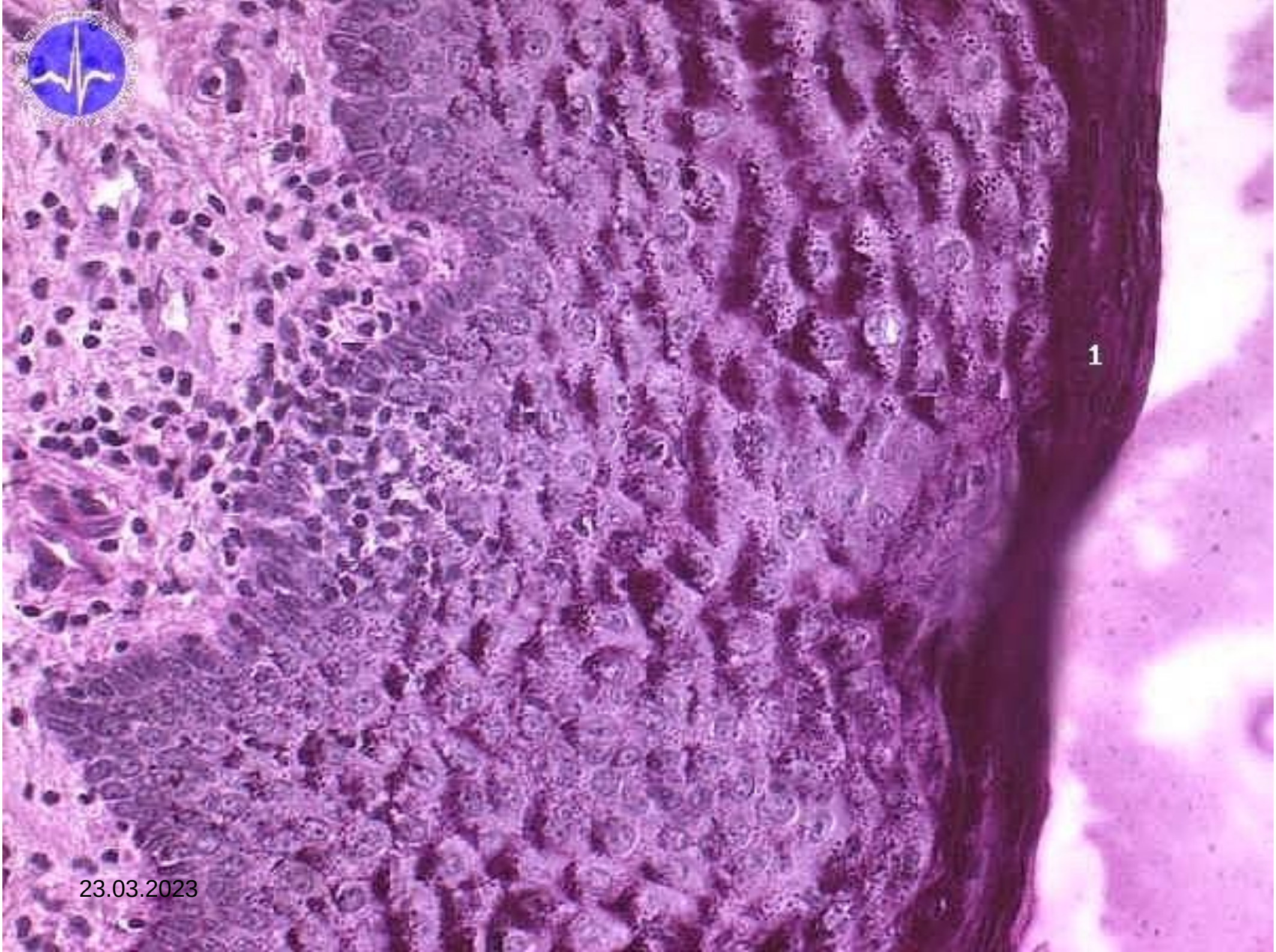
- **NO GLANDS!!!**

23.03.2023

23.03.2023

Mucosa

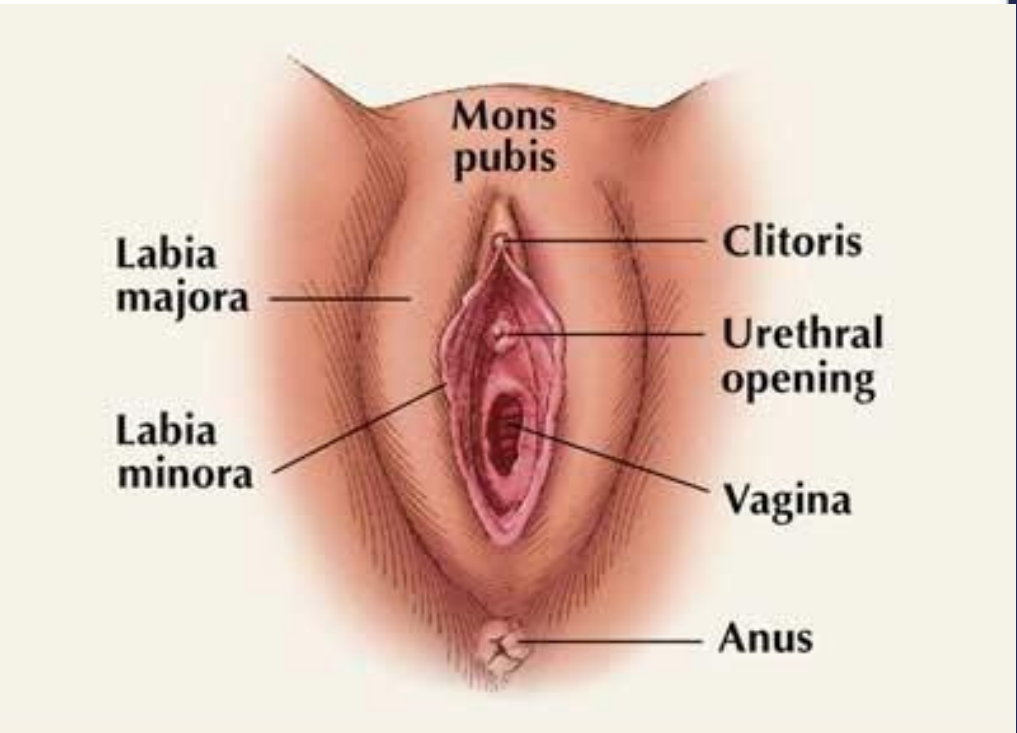
- Transverse folds = rugae
- Epithelial cells
  - Cytoplasmatic storage of glycogen
  - Glycogen = nutrition for microbial flora (Döderlein‘s bacillus)
  - Causes the acidofied enviroment (pH 4-5)

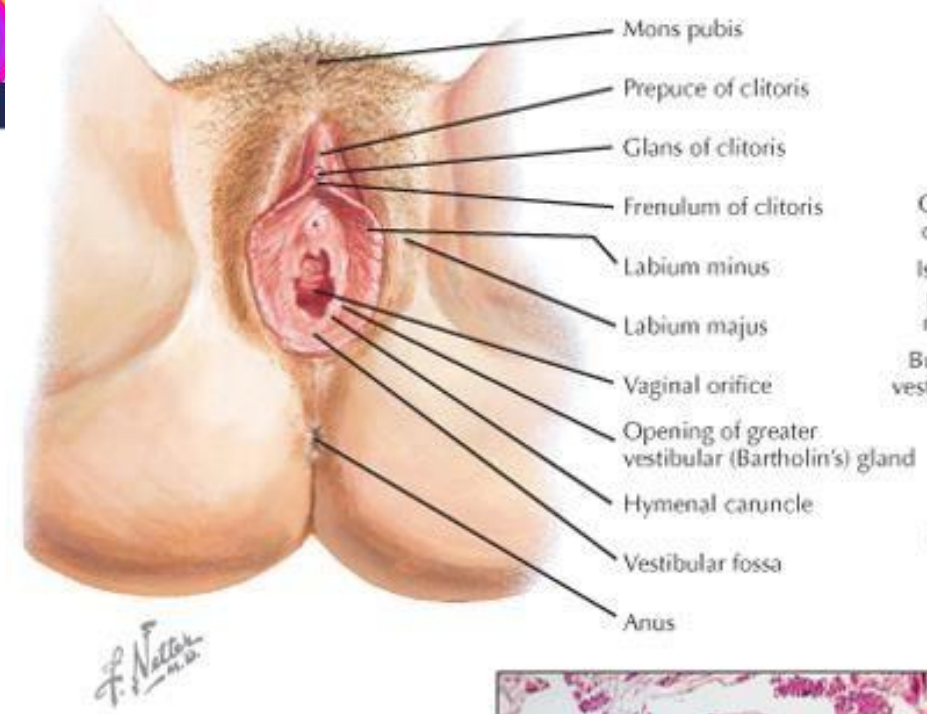


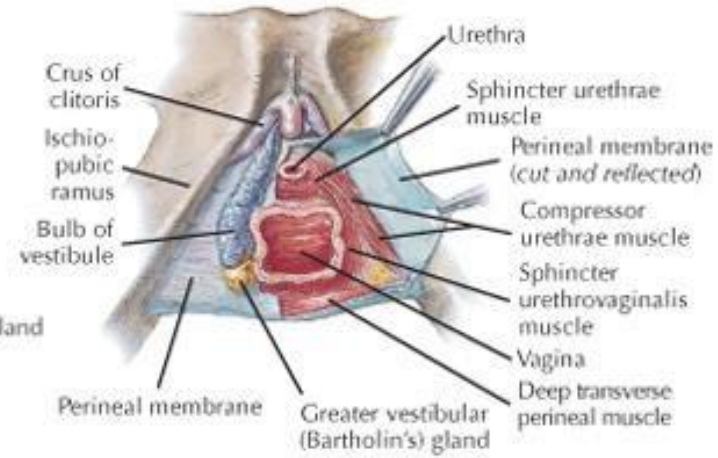
23.03.2023

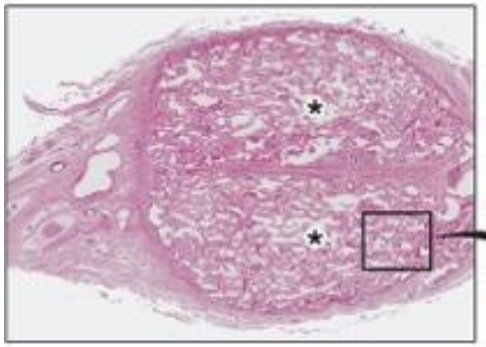
Vulva

- Clitoris
- Labia minora
- Labia majora
- Vestibulum vaginae

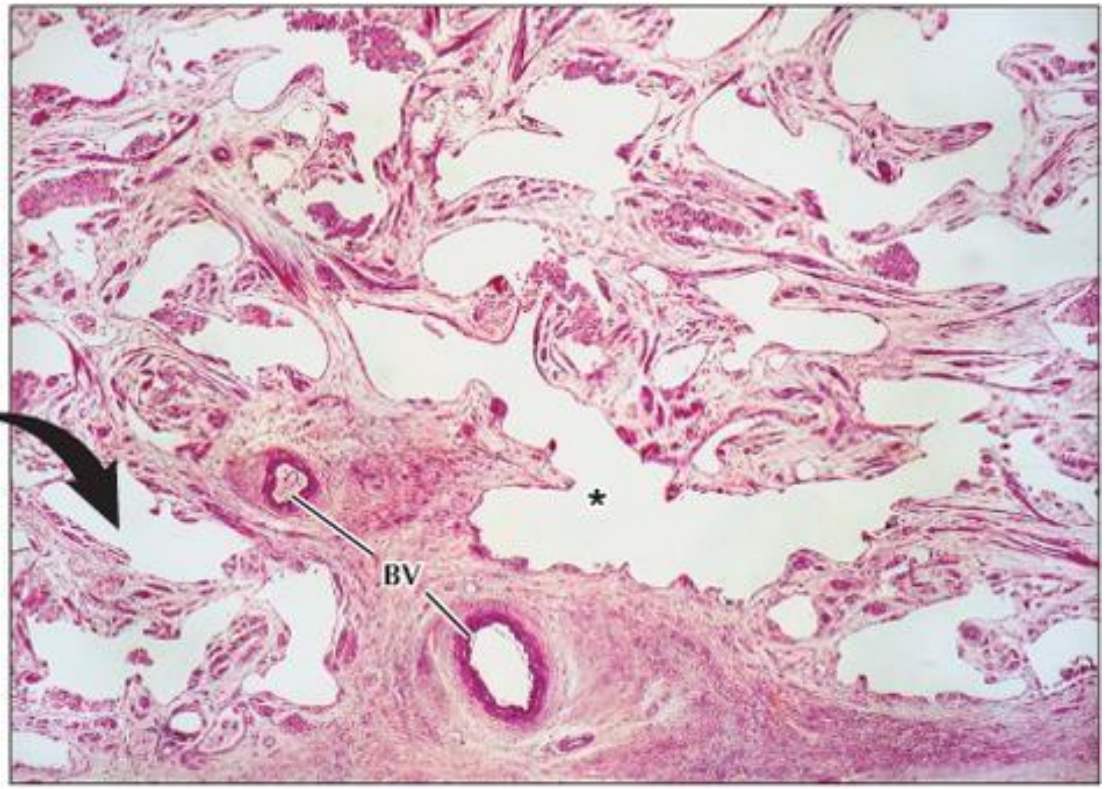




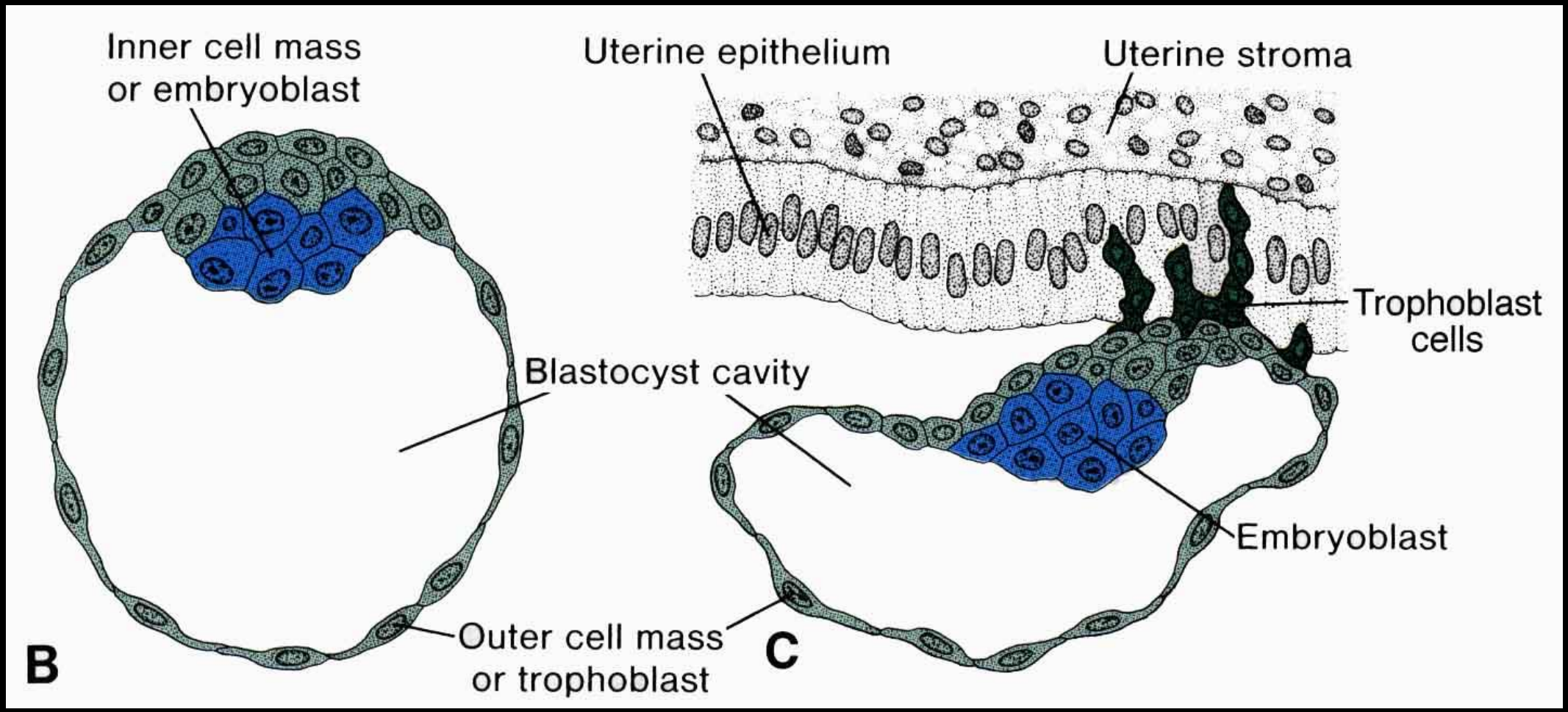




▲ **Low-magnification LM of the clitoris in transverse section.** The organ comprises two corpora cavernosa (•). They contain erectile tissue, which accounts for the spongy appearance. 3×. *H&E.*



▲ **Higher magnification LM of erectile tissue of the clitoris.** An anastomotic network of many thin-walled vascular channels (•) makes up the erectile tissue. Surrounding connective tissue contains blood vessels (**BV**) with thicker walls. 30×. *H&E.*

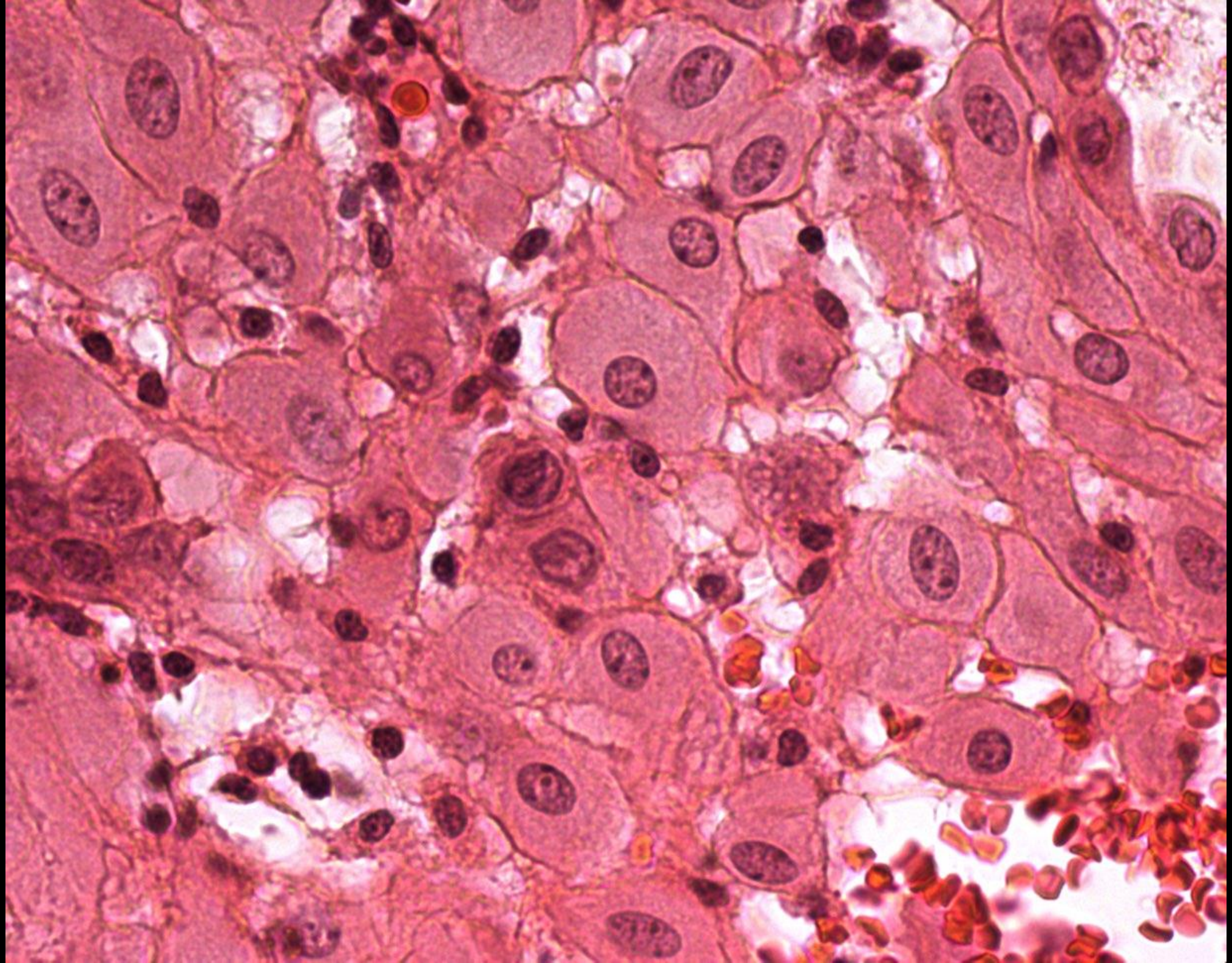


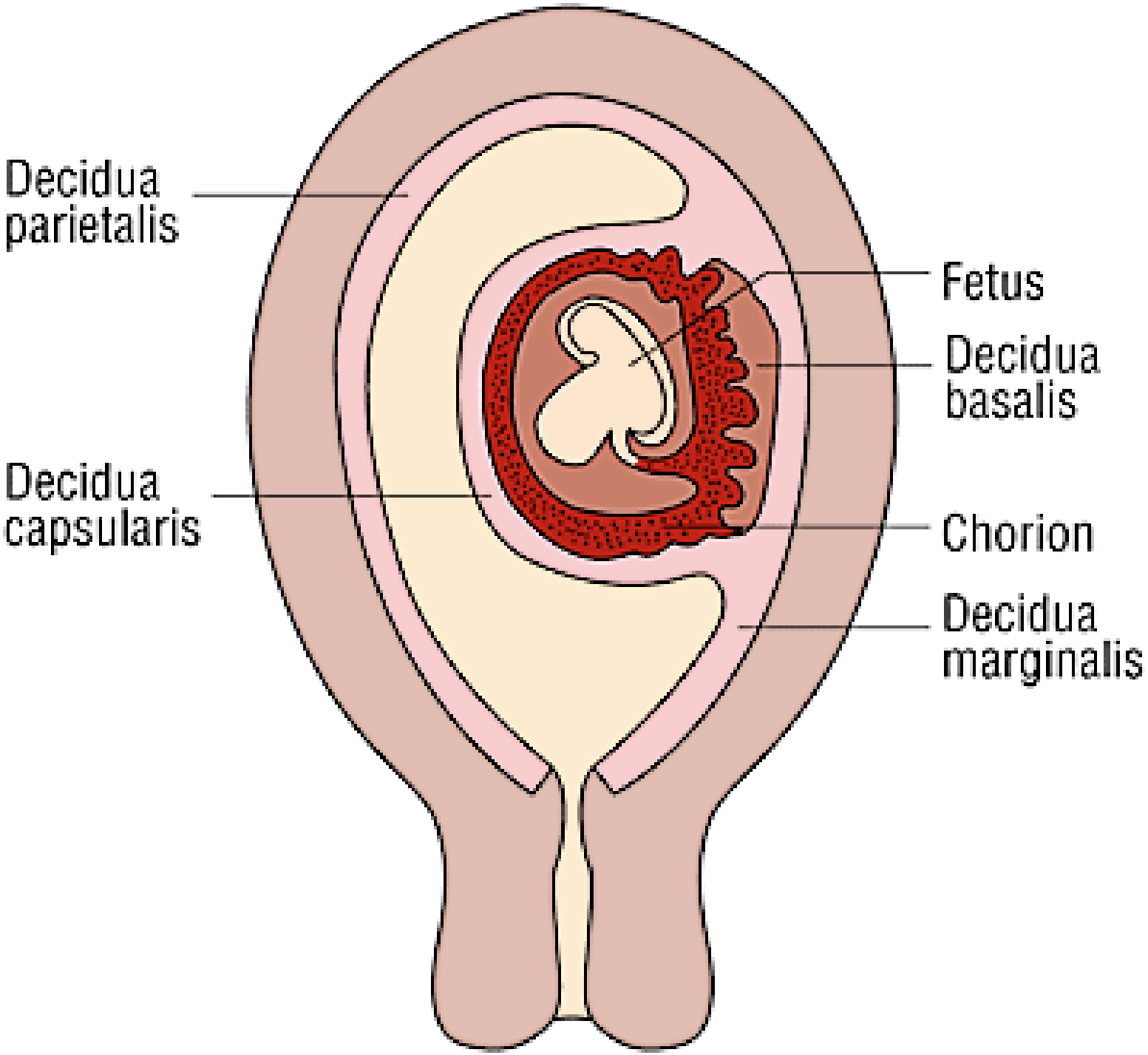
4.5 days

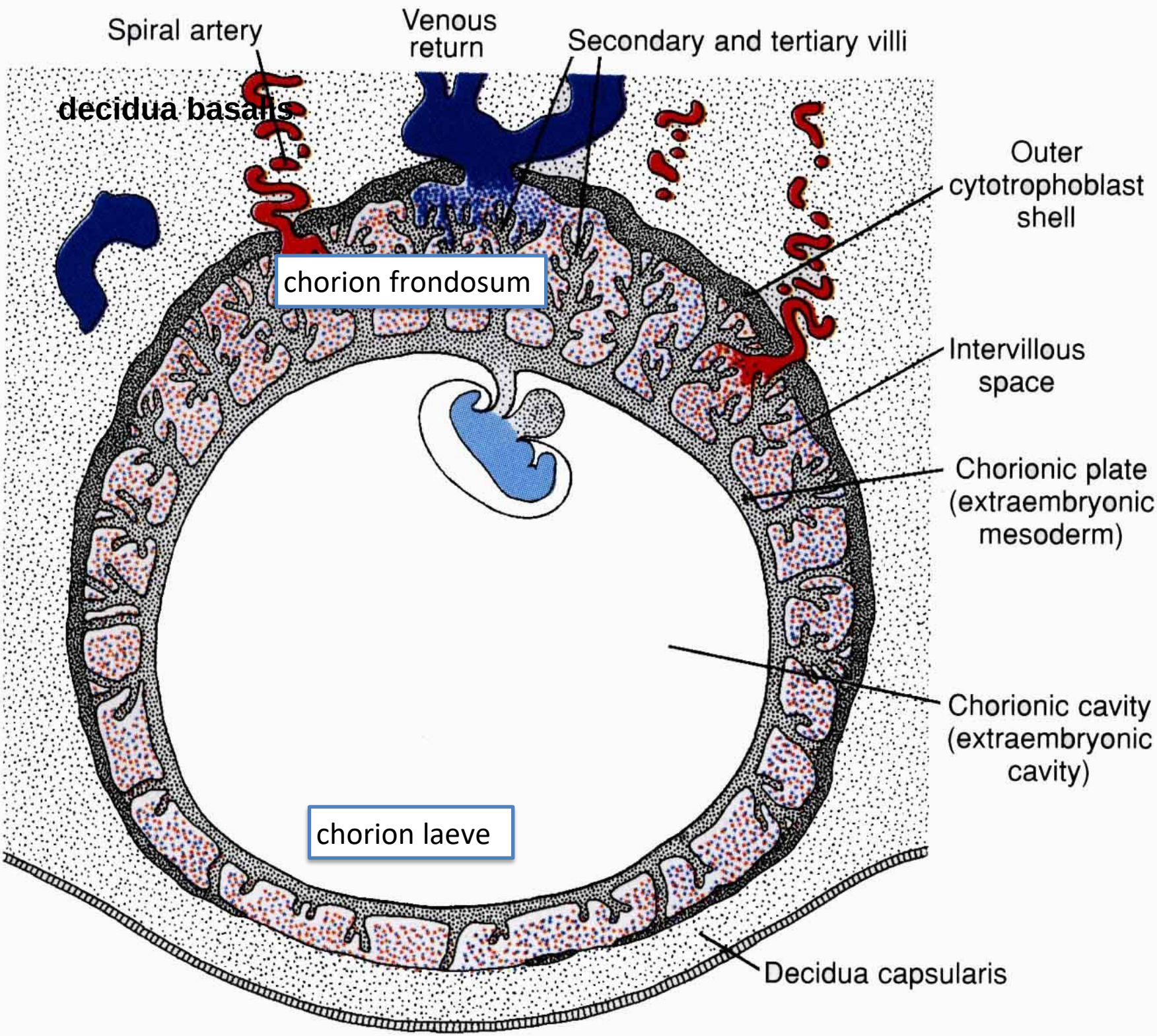
6 days

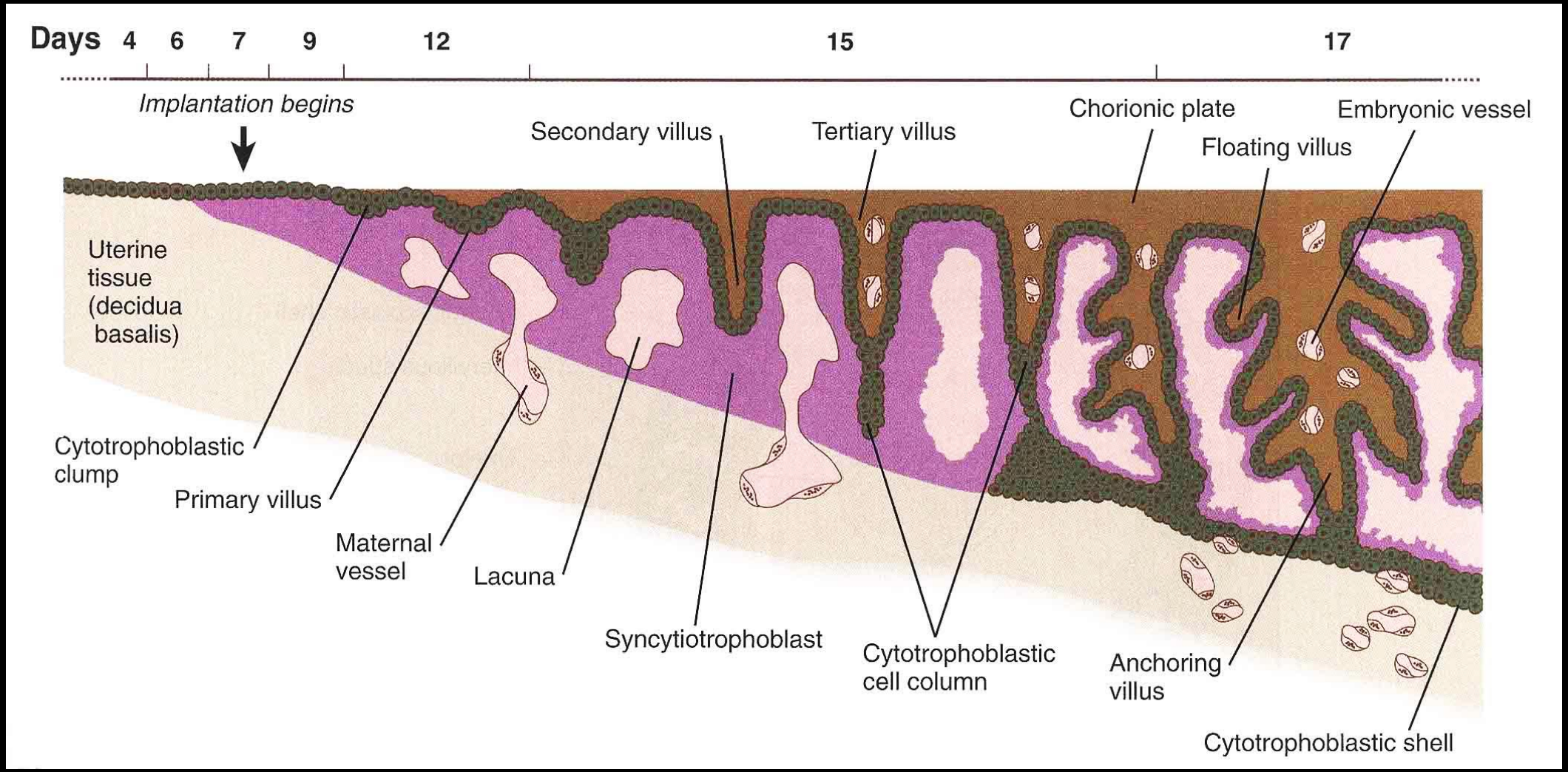
Decidual reaction of endometrium

- ***decidua*** – uterine mucosa at the end of secretory phase and during the whole pregnancy
- multiplication of vessels – sinusoids
- acclerated function of uterine glands
- decidual cells (*cellulae deciduales)*
  - cells of the endometrial connective tissue react to the syncytiotrophoblast by decidual transformation
  - shape is changing from spindle to polyedric
  - storage of **lipids** and **glycogen**
  - cells are incorporating by syncytiotrophoblast for the embryo nutrition

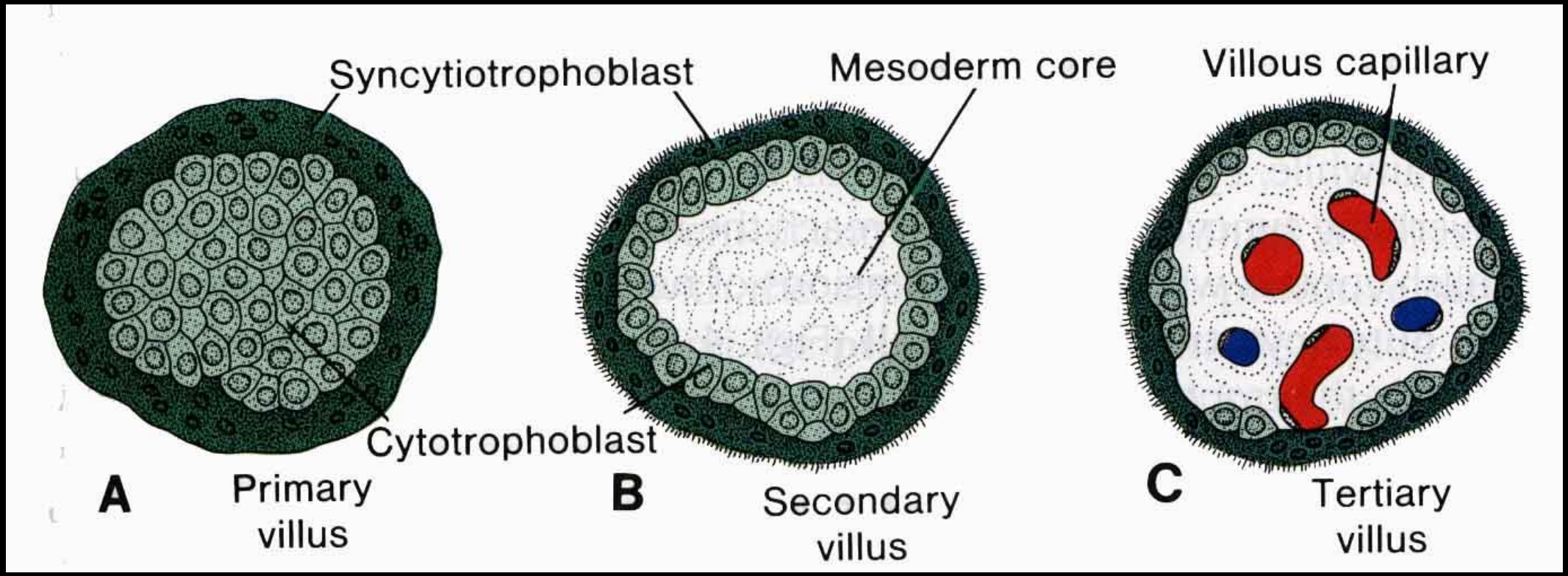


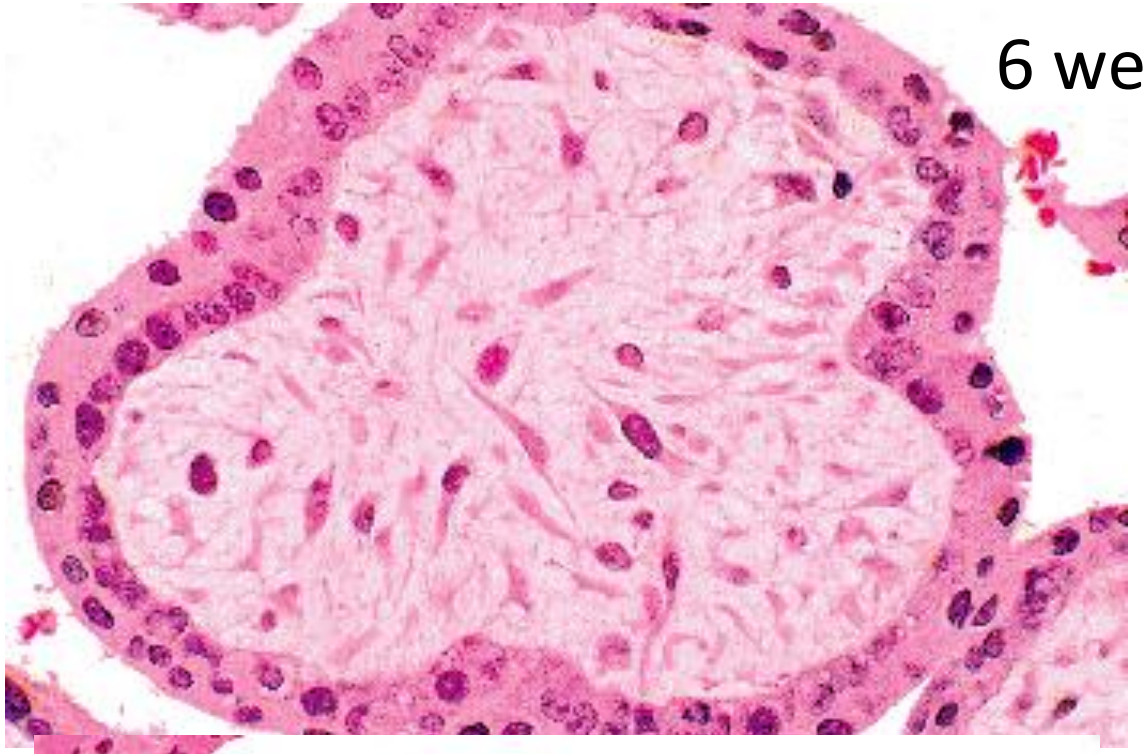

Decidua parietalis
Decidua capsularis
Fetus
Decidua basalis
Chorion
Decidua marginalis


Spiral artery
Venous return
Secondary and tertiary villi
decidua basalis
Outer cytotrophoblast shell
chorion frondosum
Intervillous space
Chorionic plate (extraembryonic mesoderm)
Chorionic cavity (extraembryonic cavity)
chorion laeve
Decidua capsularis

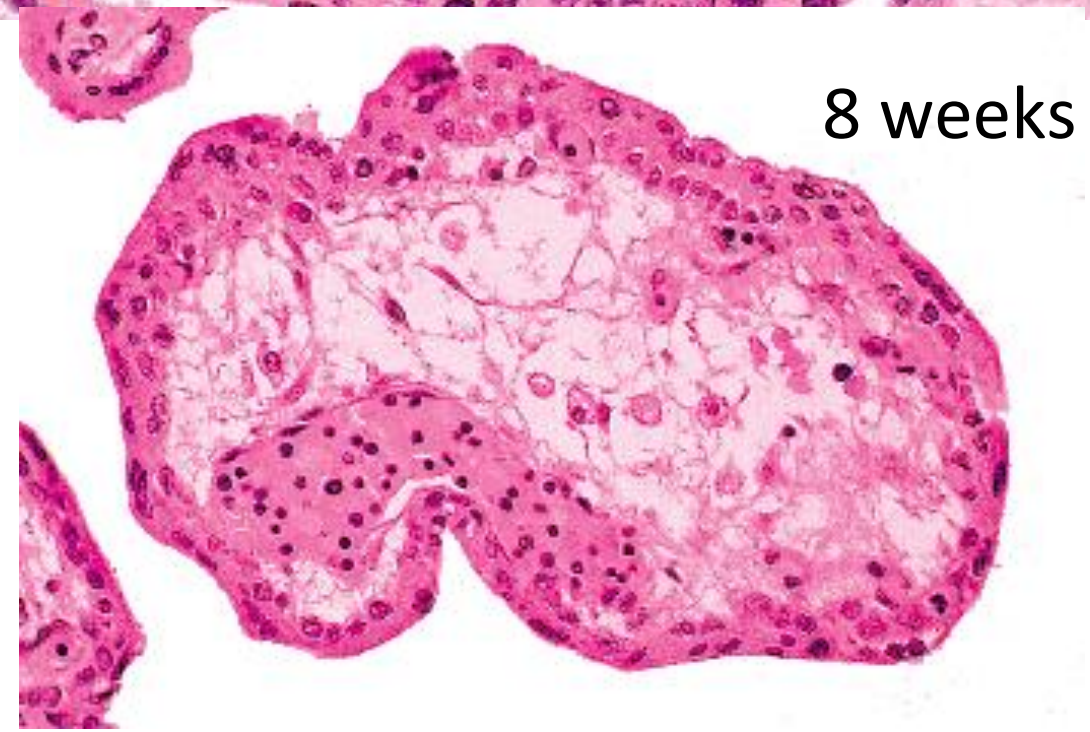


Carlson, B.M.: Human embryology and developmental biology. 4th ed. Mosby, Elsevier, Philadelphia 2009.


Syncytiotrophoblast
Cytotrophoblast
A
Primary villus
Mesoderm core
B
Secondary villus
Villous capillary
C
Tertiary villus

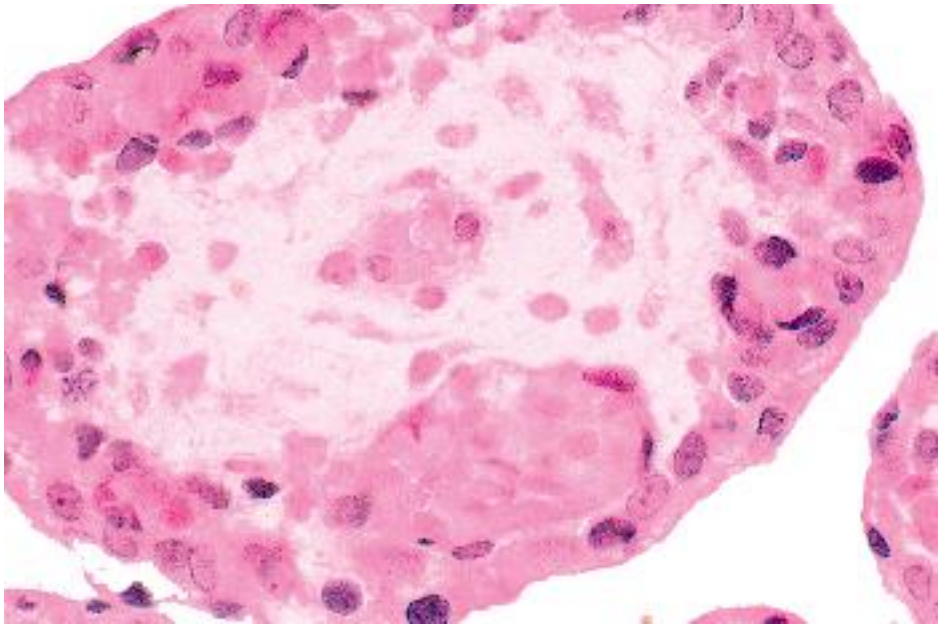


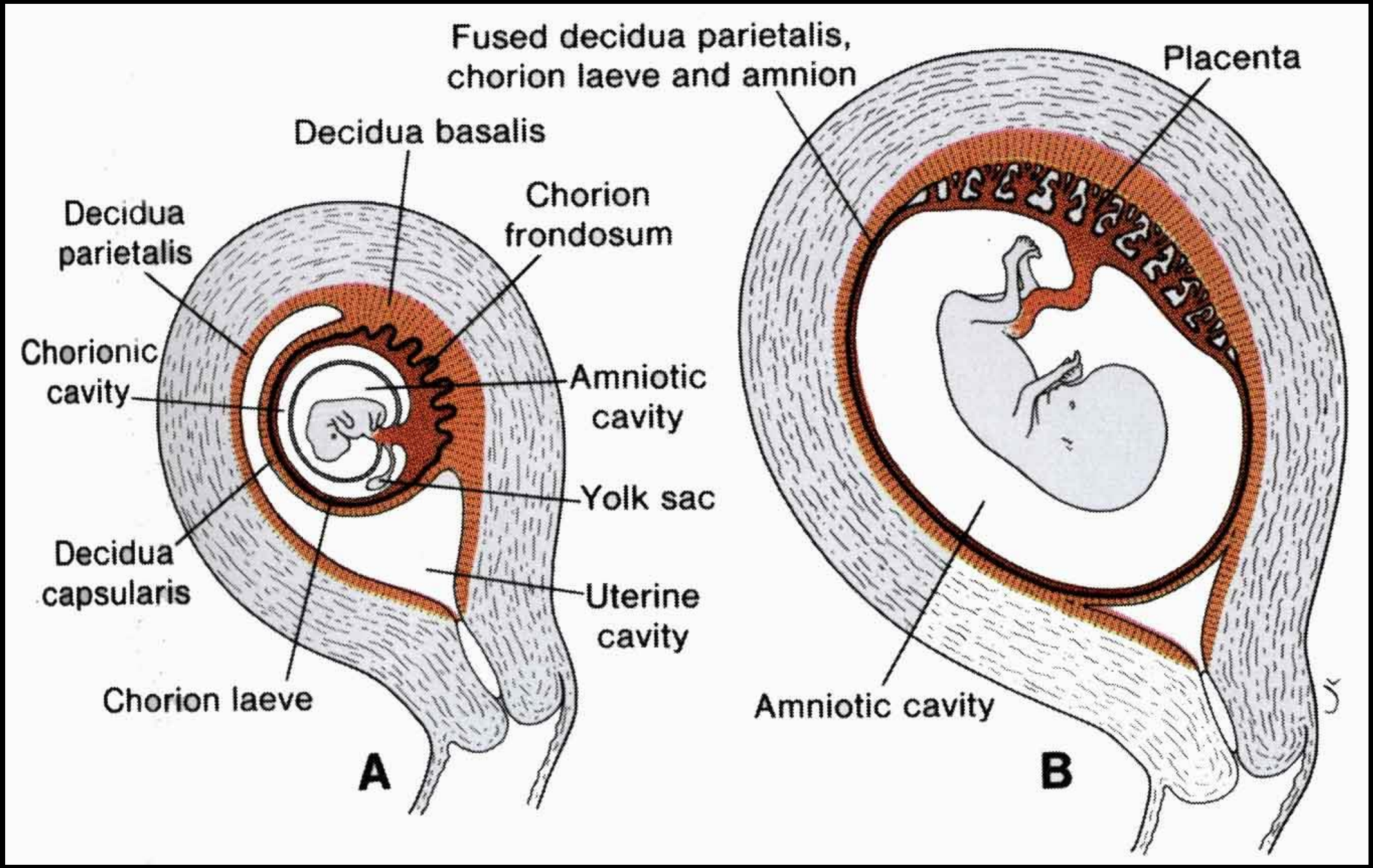
6 weeks



8 weeks

12 weeks



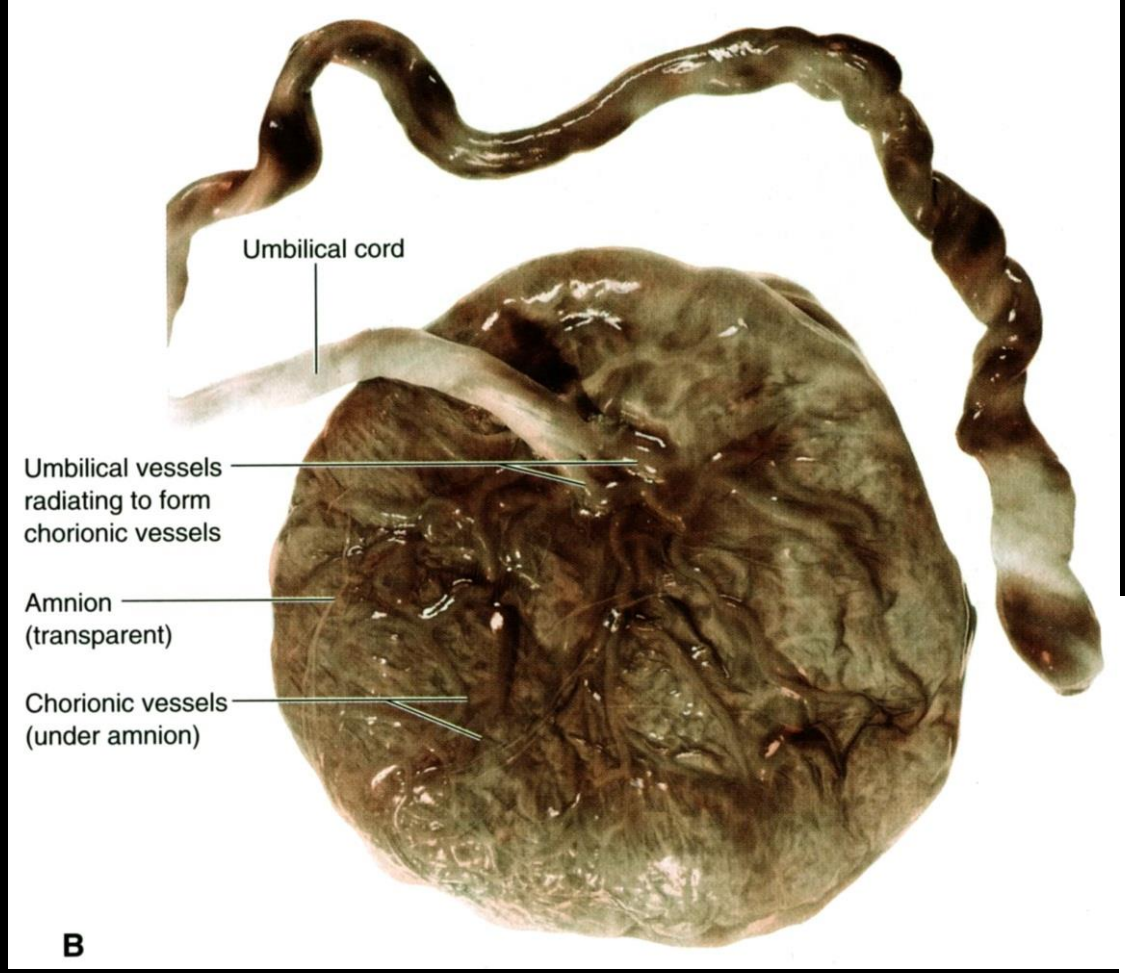


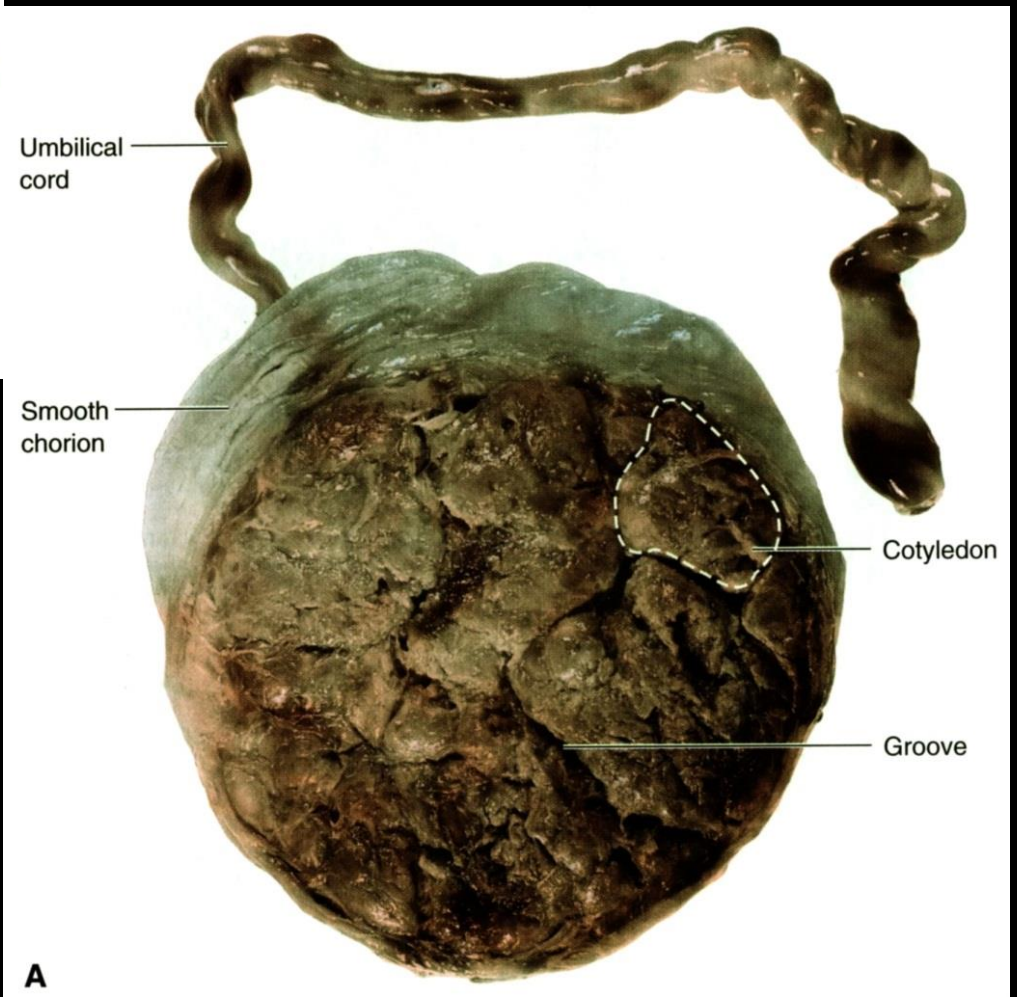
8th week

12th week

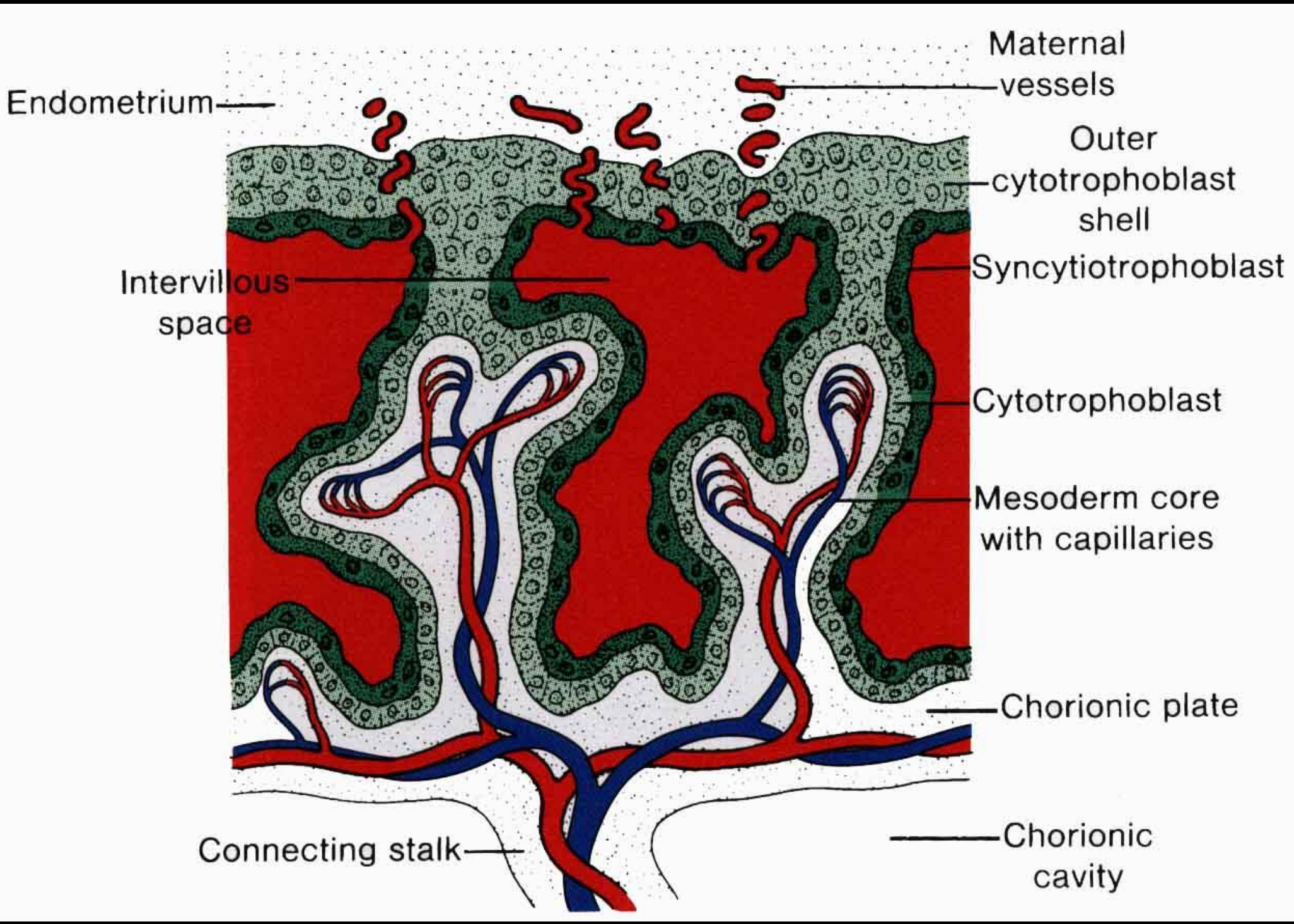
Placenta

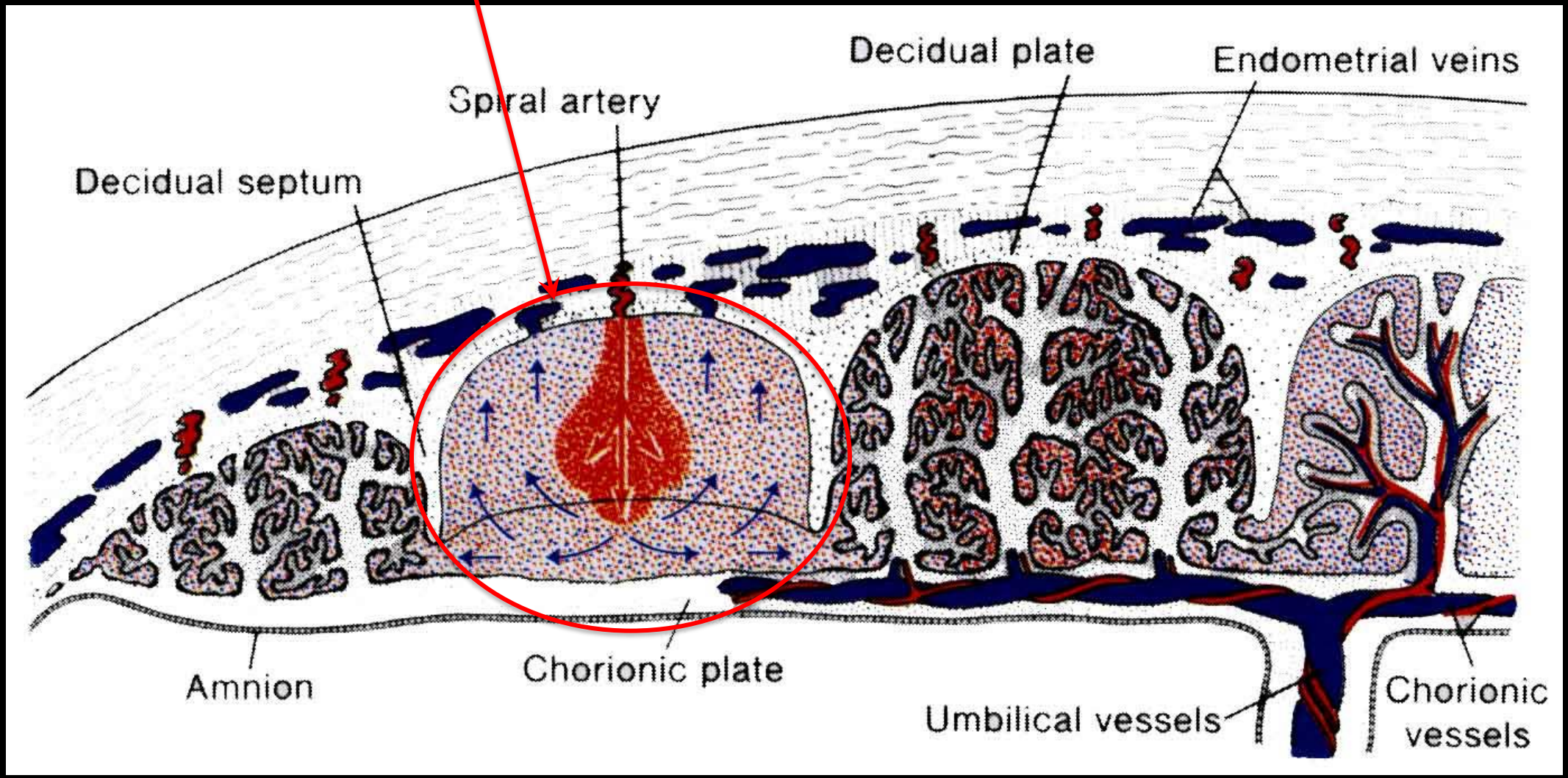
- discoid
- haemochorial
- cotyledoned

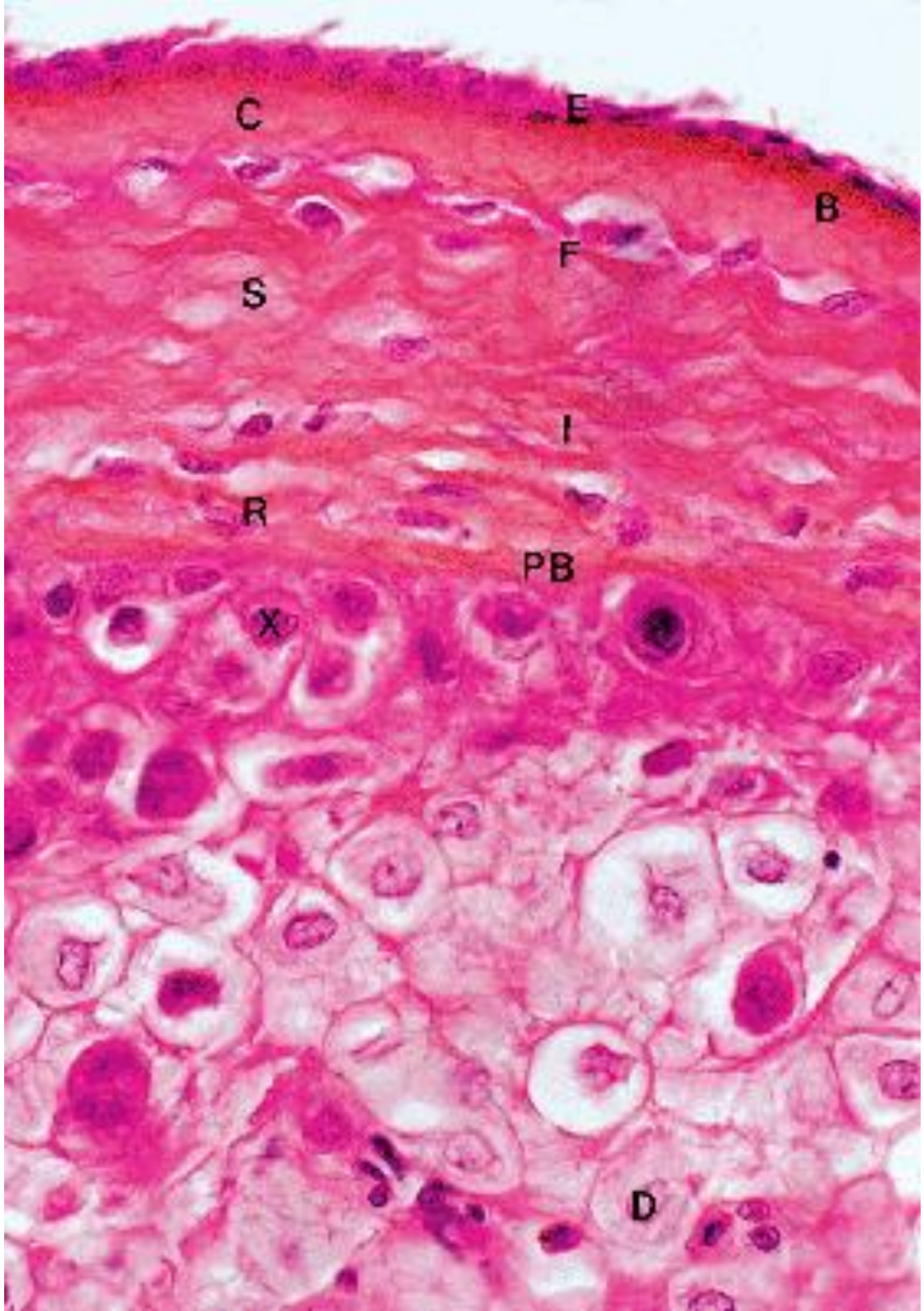




15 - 20 cm diameter
1,5 - 3 cm thick
500 g
500 ml of maternal blood / min


Maternal vessels
Endometrium
Outer cytotrophoblast shell
Syncytiotrophoblast
Intervillous space
Cytotrophoblast
Mesoderm core with capillaries
Chorionic plate
Connecting stalk
Chorionic cavity


cotyledon
Decidual plate
Endometrial veins
Spiral artery
Decidual septum
Amnion
Chorionic plate
Umbilical vessels
Chorionic vessels



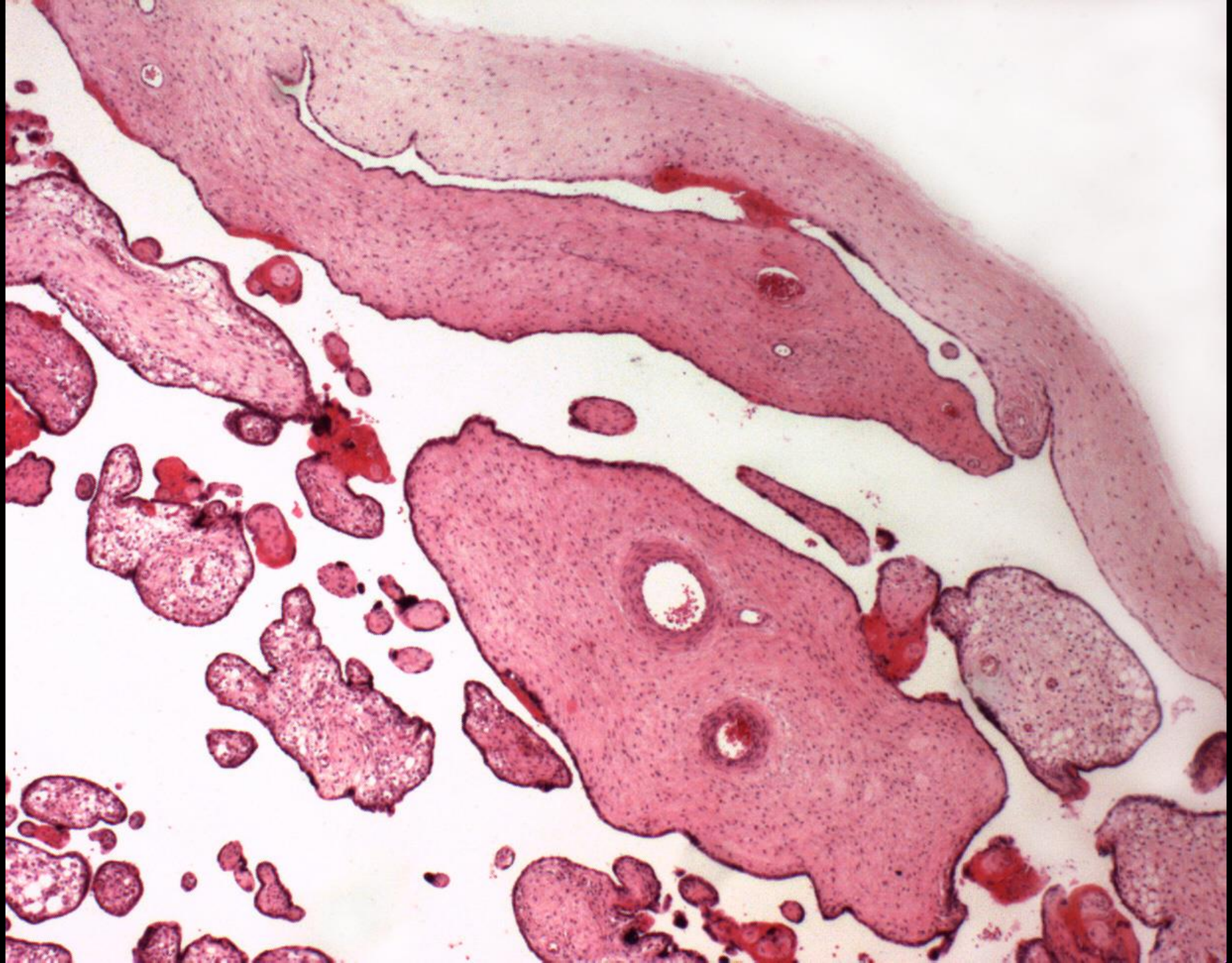
Flattened to cuboidal amnionic epithelial cells (E) adhere to their basement membrane (B).

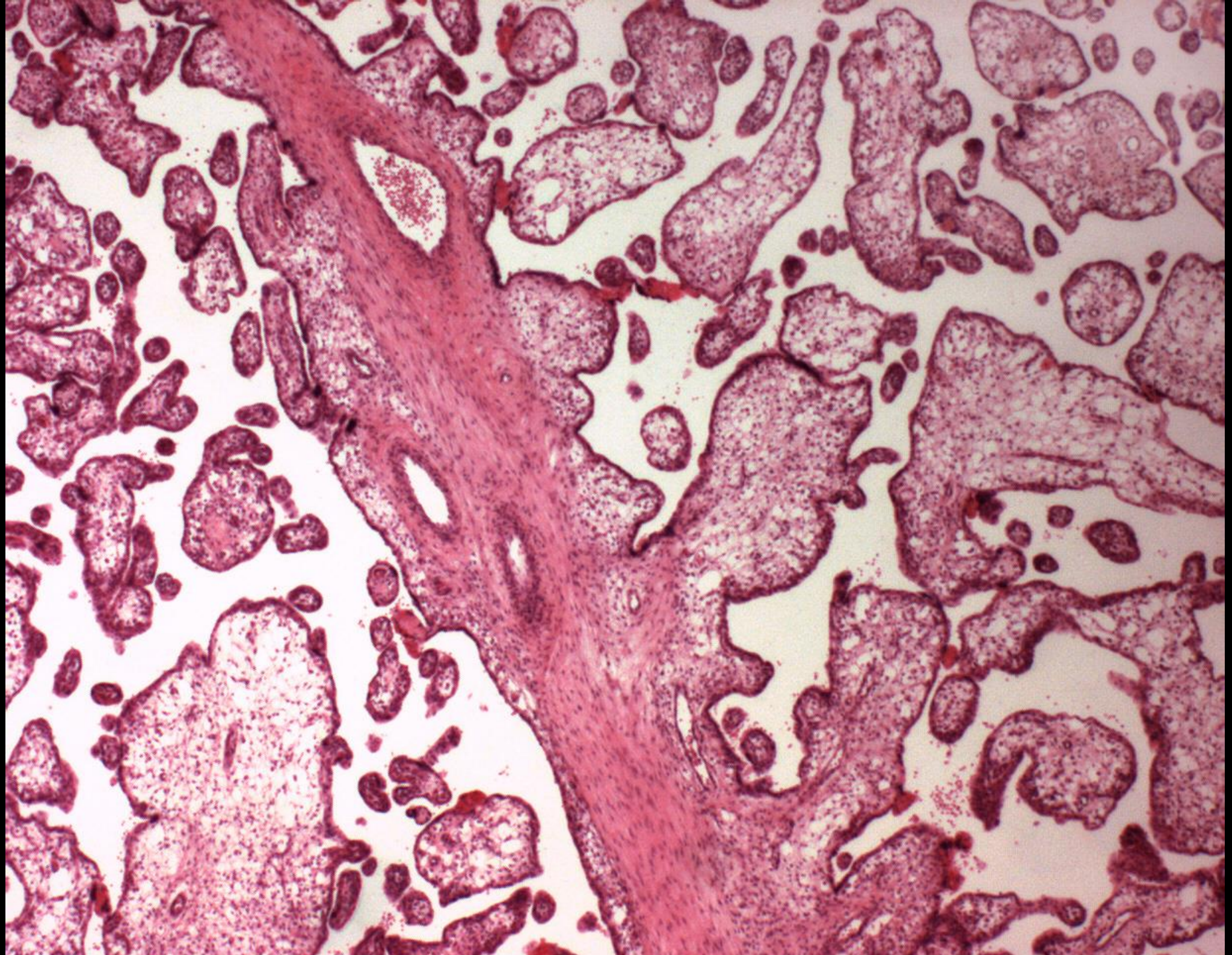
compact layer of the amnion (C), which is acellular and may form a barrier to PMNs.

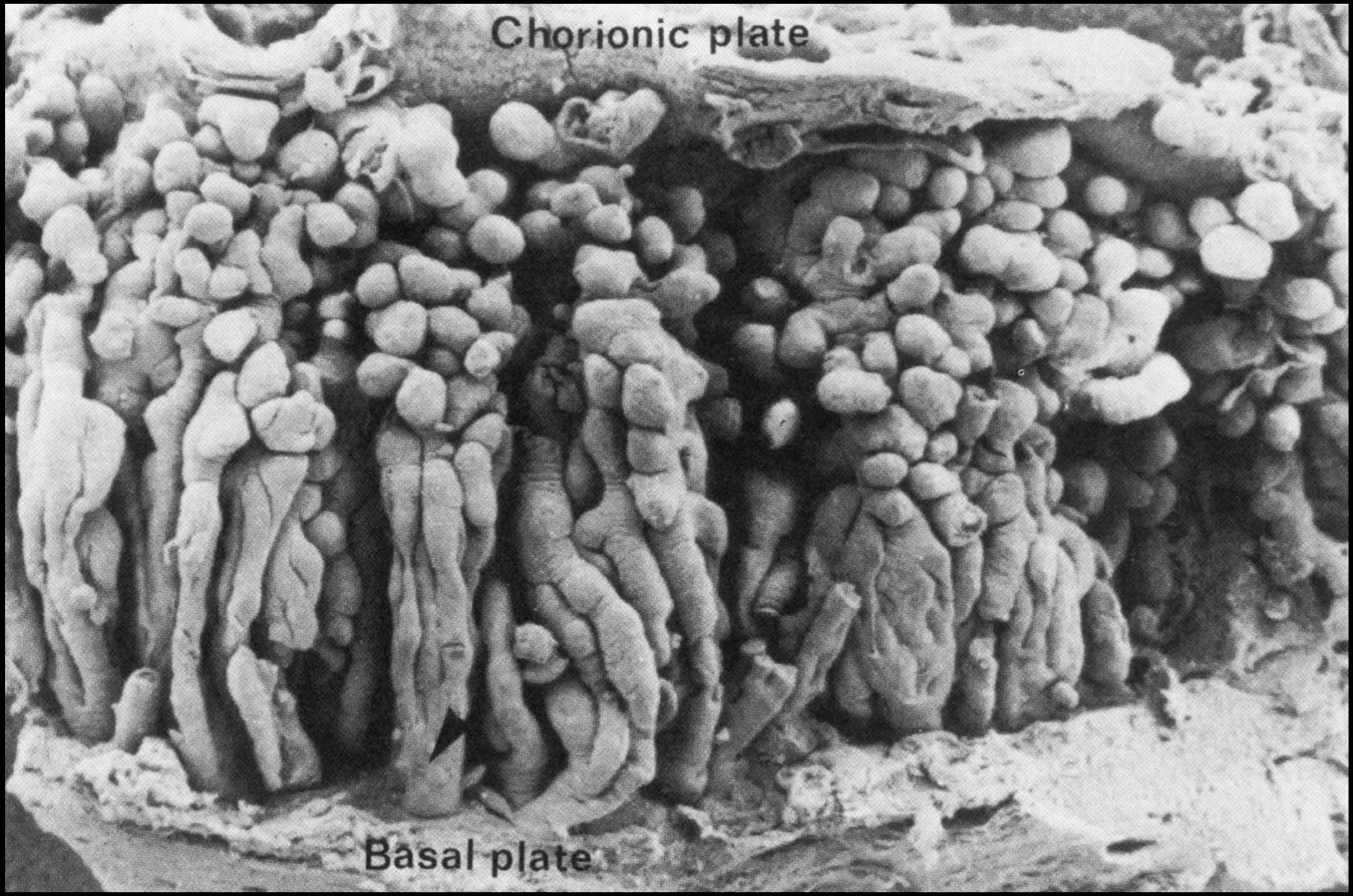
A fibroblastic layer (F) lies beneath the compact layer, and macrophages may be found.

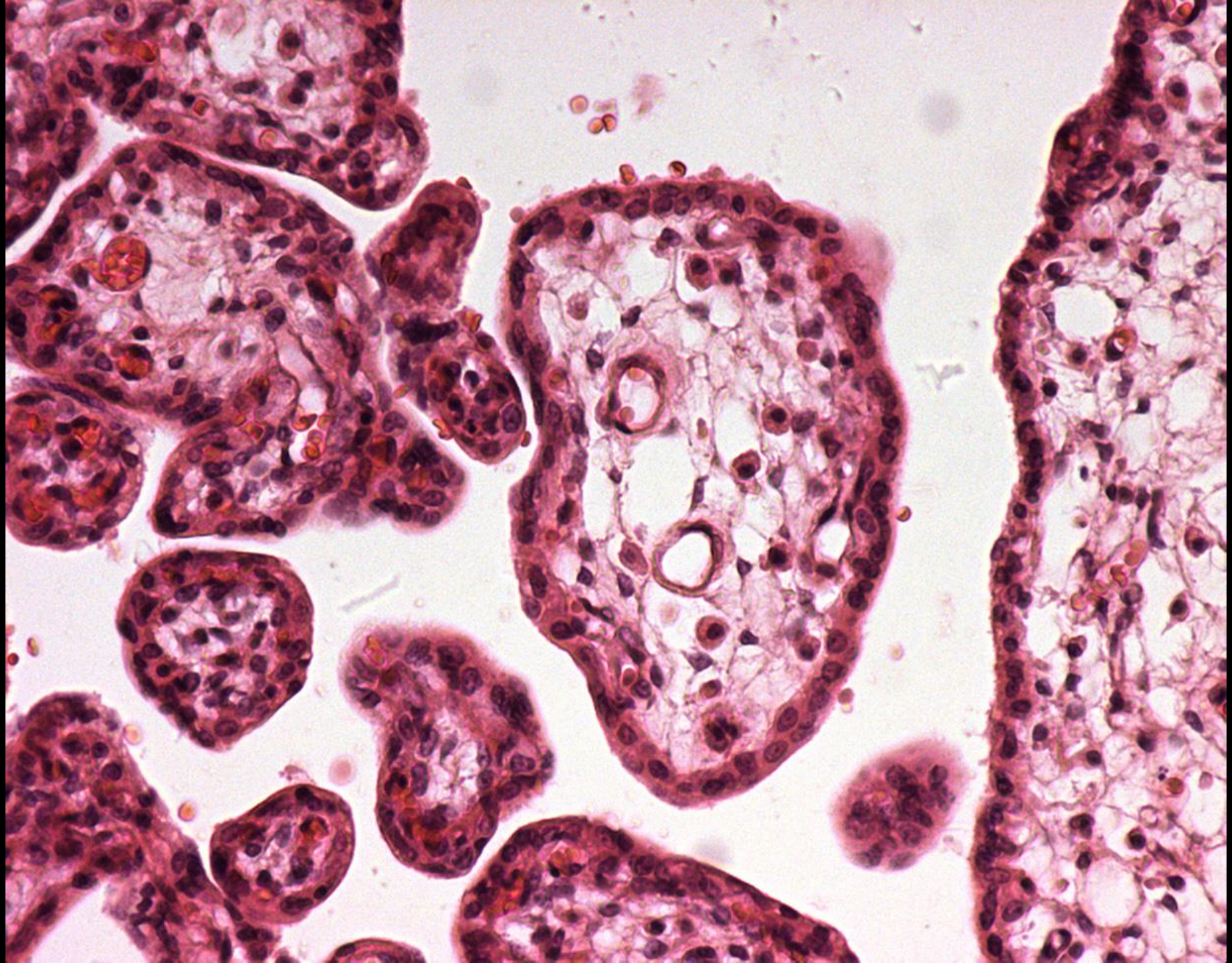
A spongy layer (S), relatively devoid of fibroblasts, separates the amnion from the
chorion, although the two may merge imperceptibly.

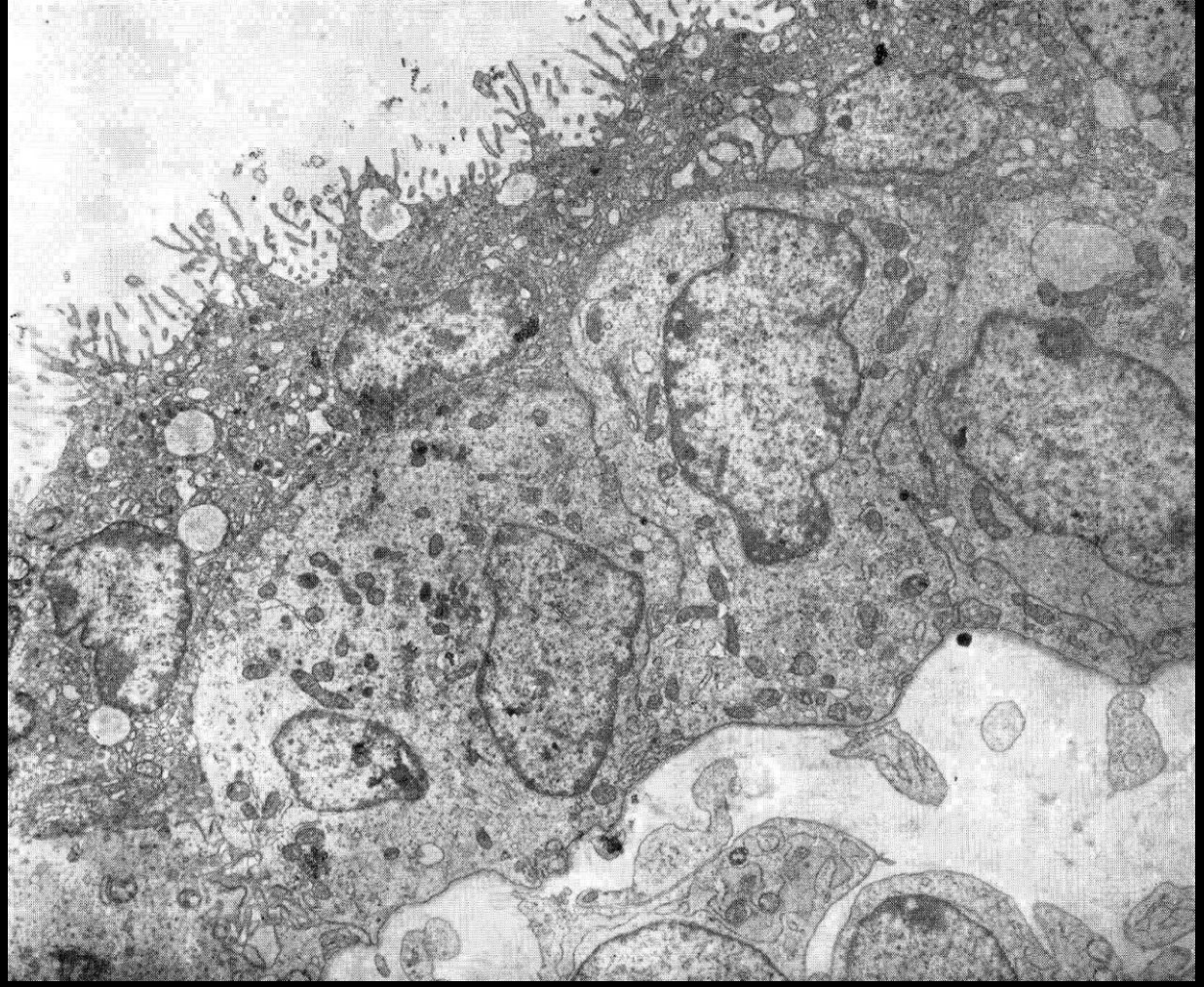
The amnion usually measures from 0.2 to 0.5 mm in thickness (1). The most superficial layer of chorion is usually an incomplete cellular zone (I) that overlies a thick reticular layer (R). This layer is composed of fibroblasts and macrophages. Beneath the reticular layer is a basement membrane (PB) overlying trophoblastic X cells (X) and then maternal decidua (D)






Chorionic plate
Basal plate

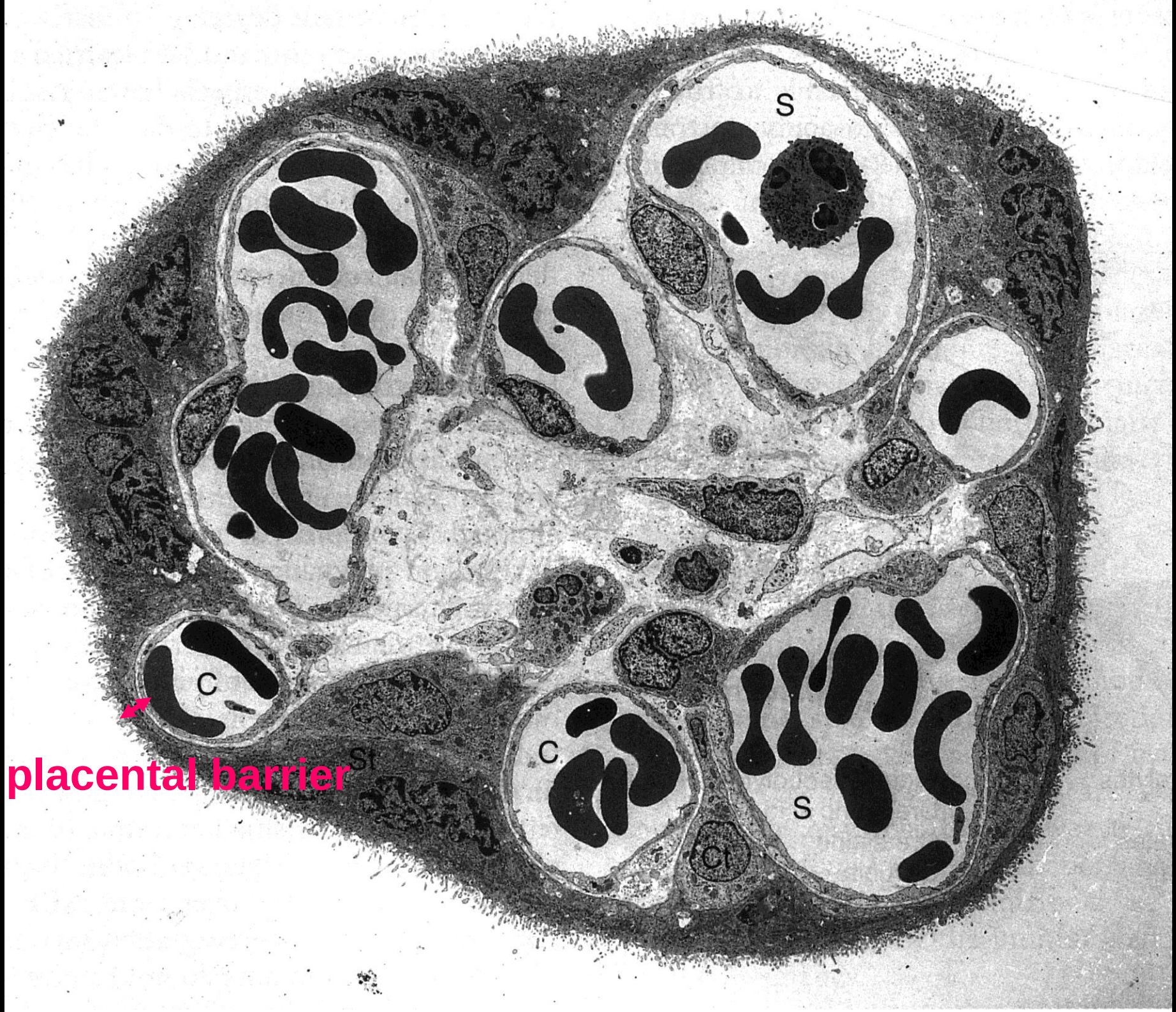




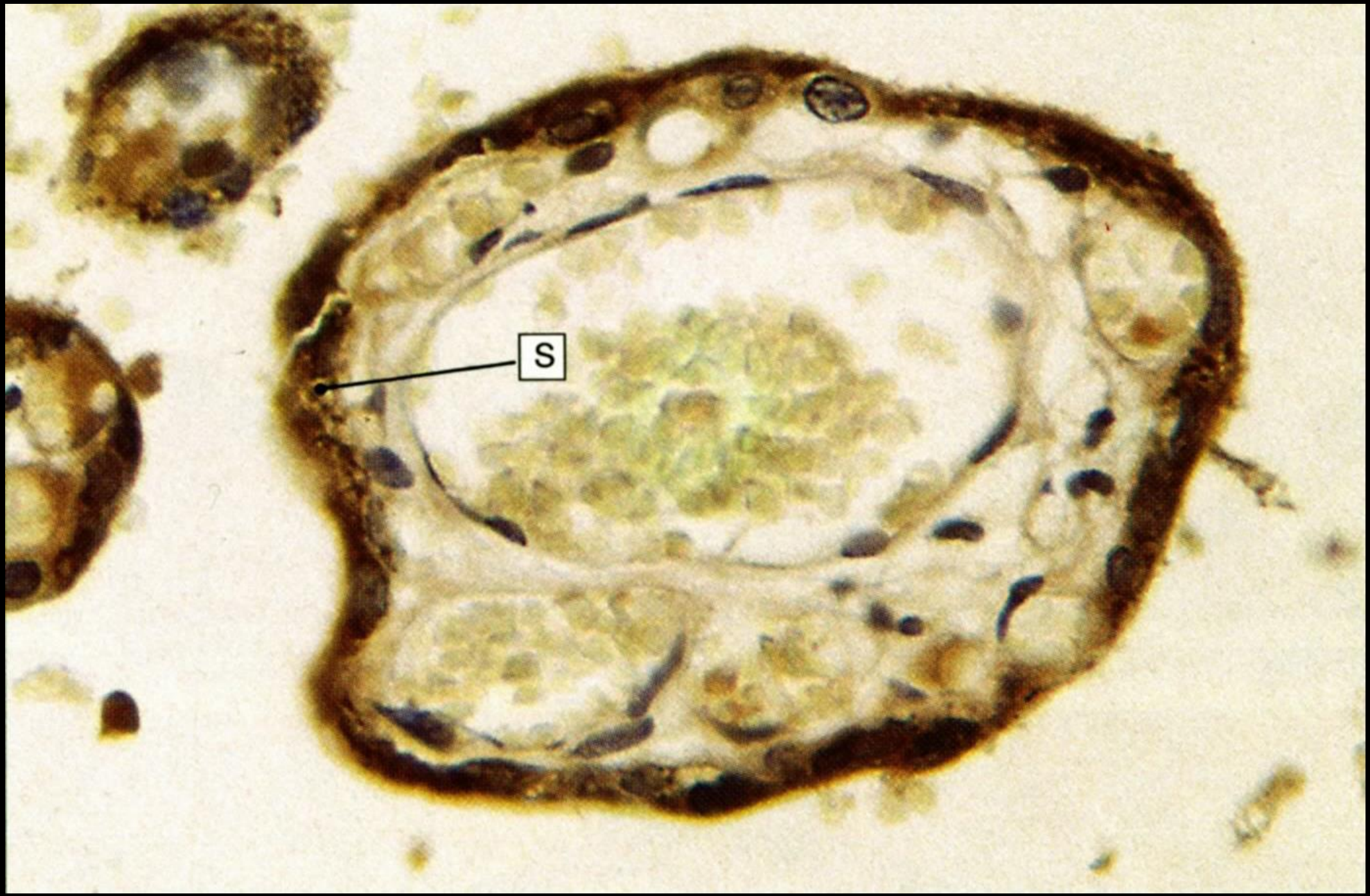
syncytiotrophoblast

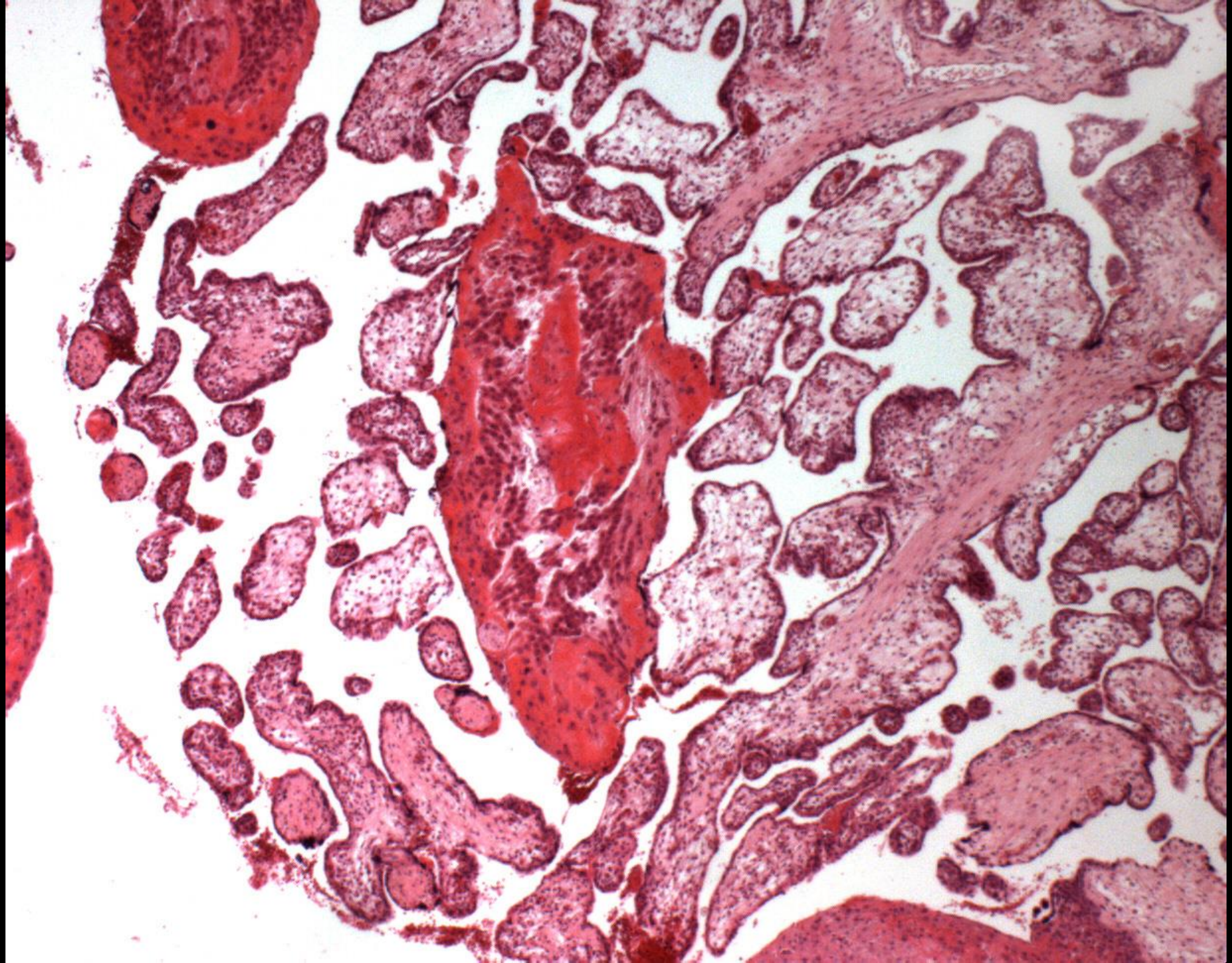
cytotrophoblast

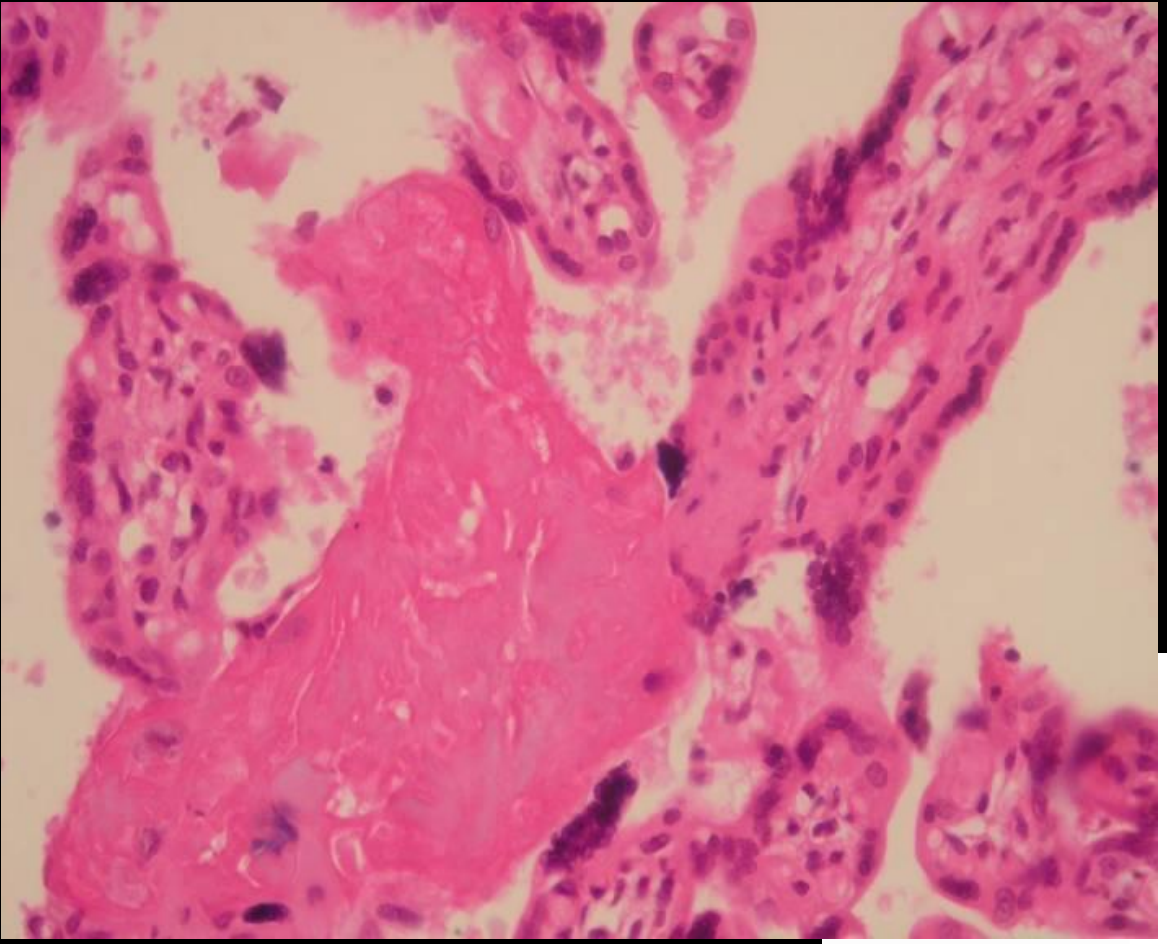
differentiation of placental barrier


S
C
C
S
Ct
St
placental barrier

production of hCG (immunohistochemistry)







Fibrinoid