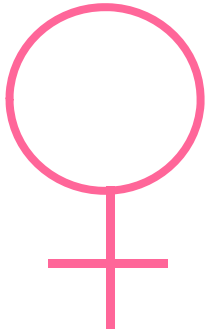
The female reproductive system

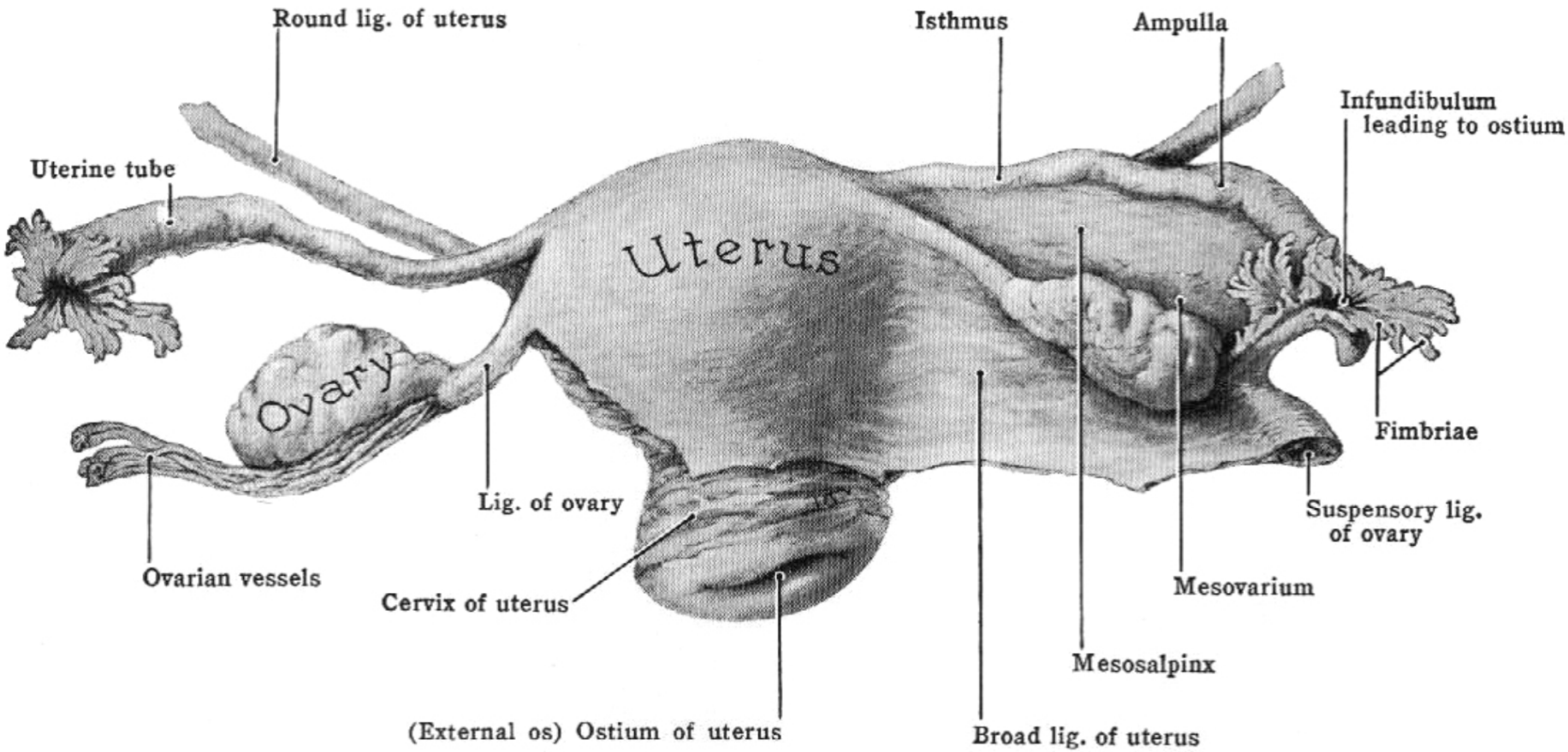
Aleš Hampl



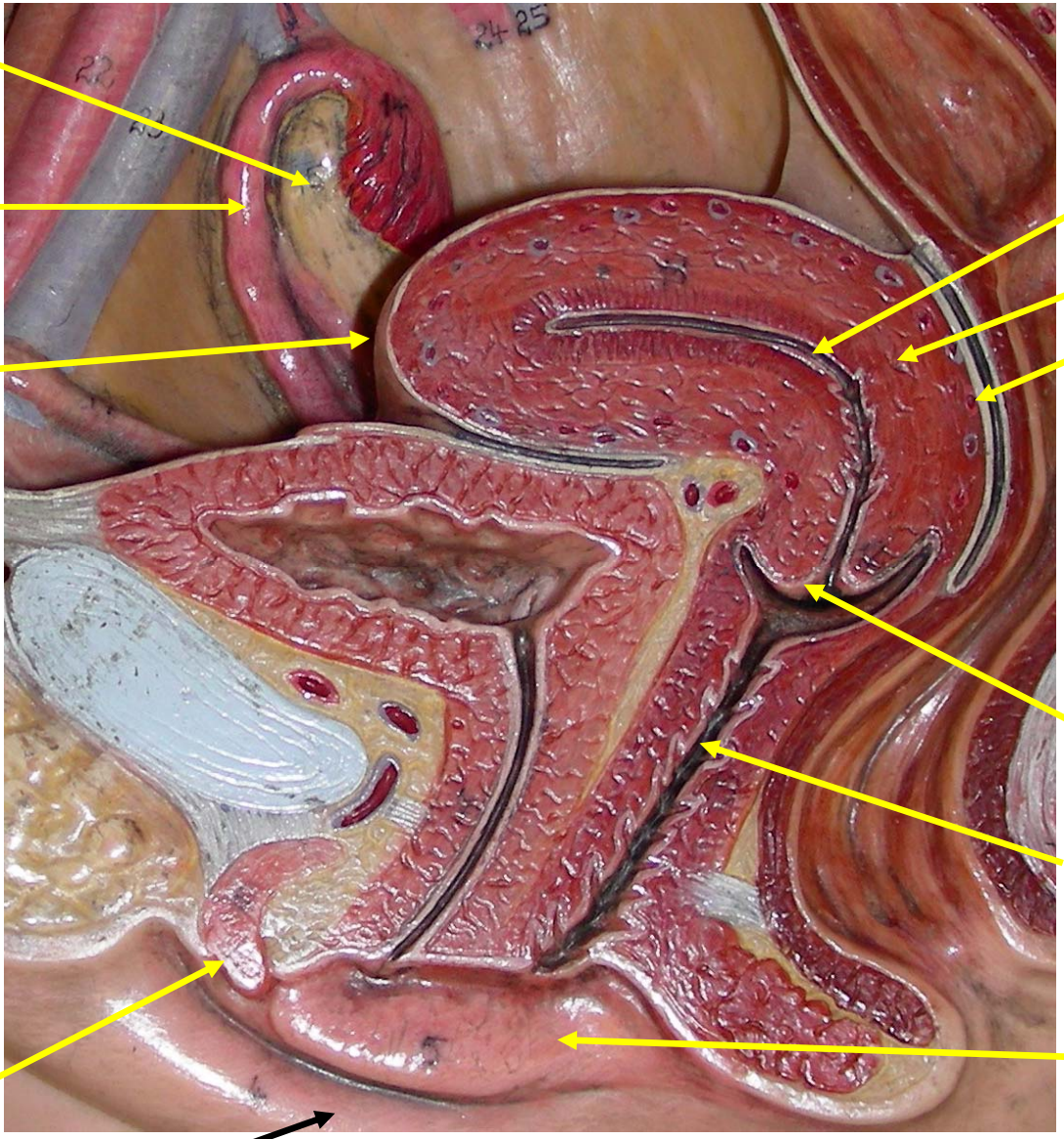
Functions of the female reproductive system

1. **Oogenesis**
2. **Copulation** – receives sperm from male
3. **Hormone production**
4. Provides sites for egg **fertilization, implantation, and development**
5. Acts as **birth canal**

Female genital organs – Gross anatomy 1

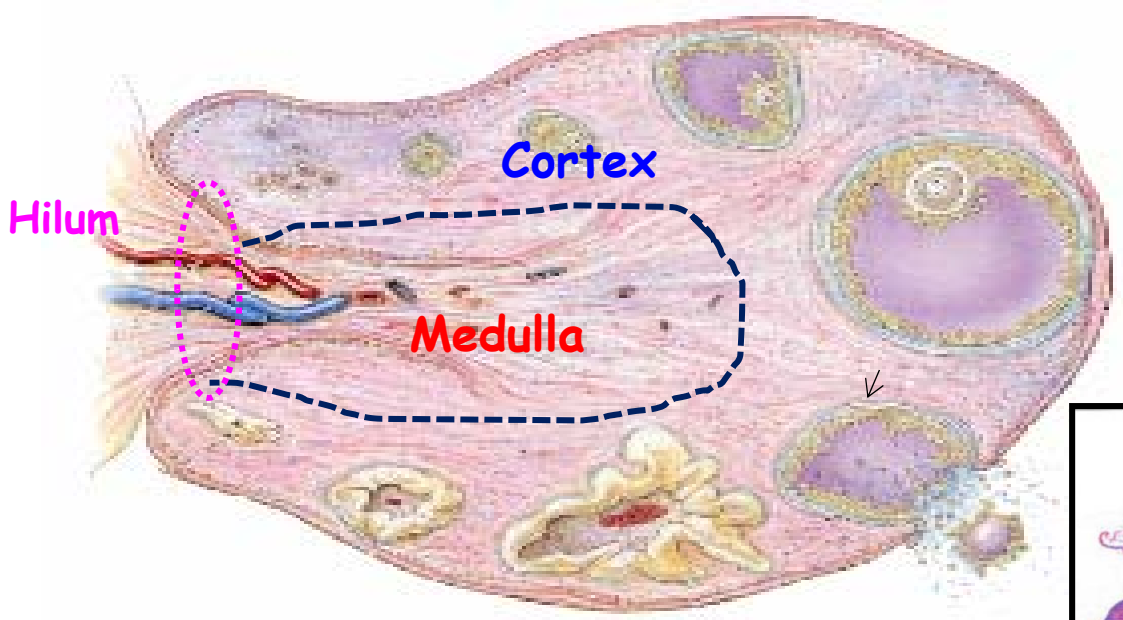


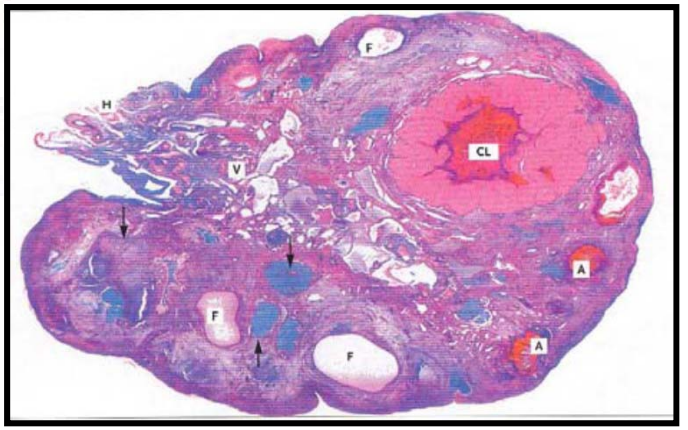
Female genital organs – Gross anatomy 2



Length – 3 cm
Width – 1.5 cm
Thickness – 1 cm

Ovary – Overall structure





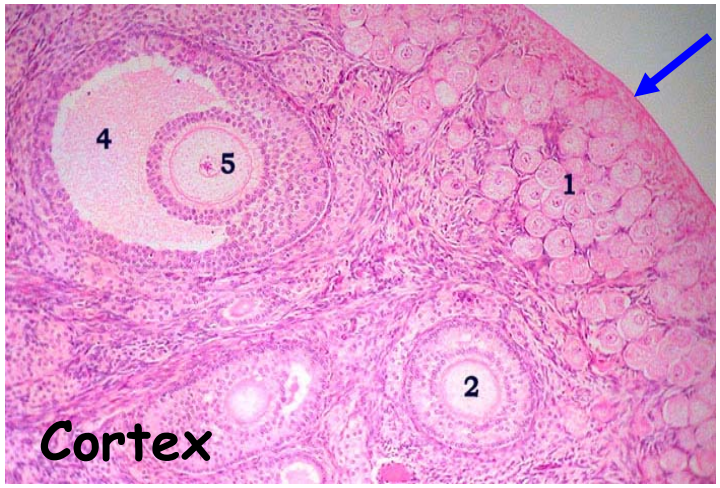
Cortex

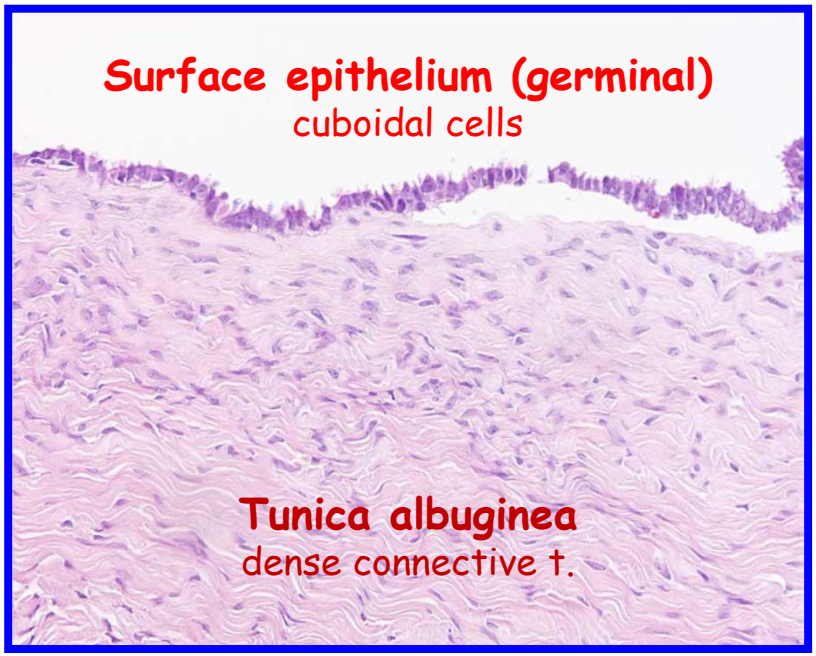
- Follicles
- Highly vascularized stroma

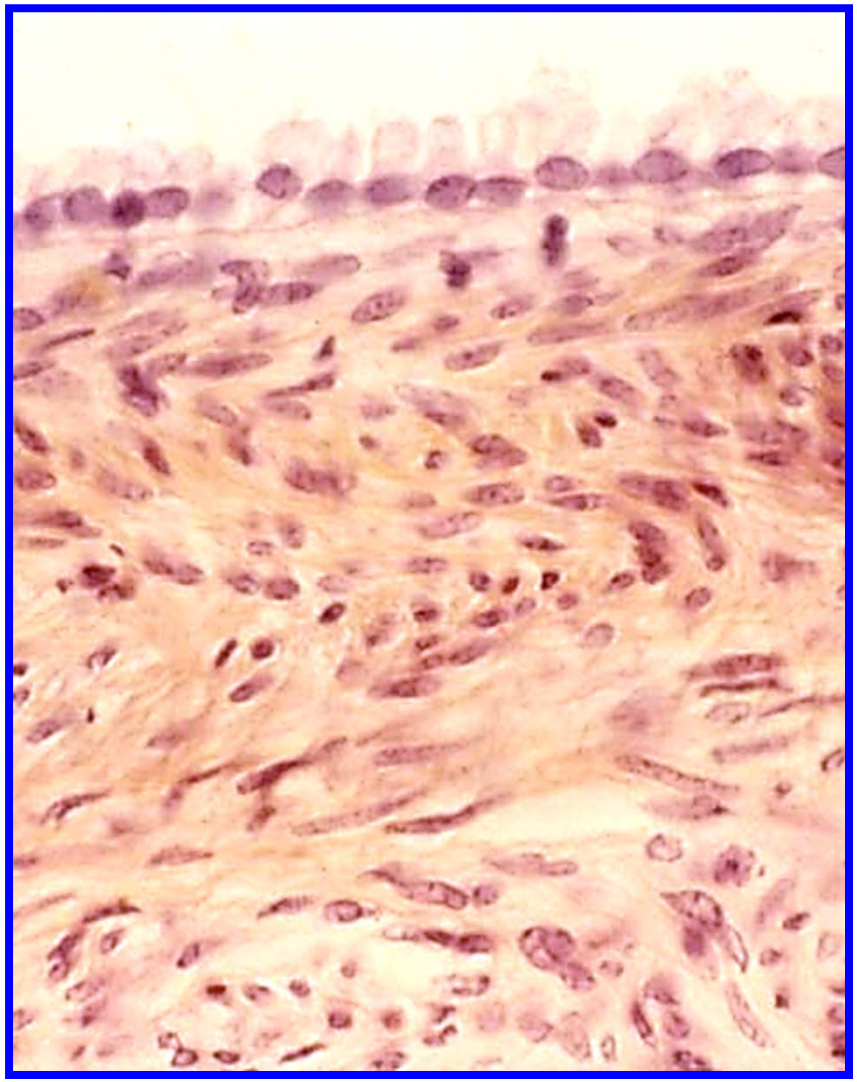
Medulla

- Vessels
- Loose connective tissue

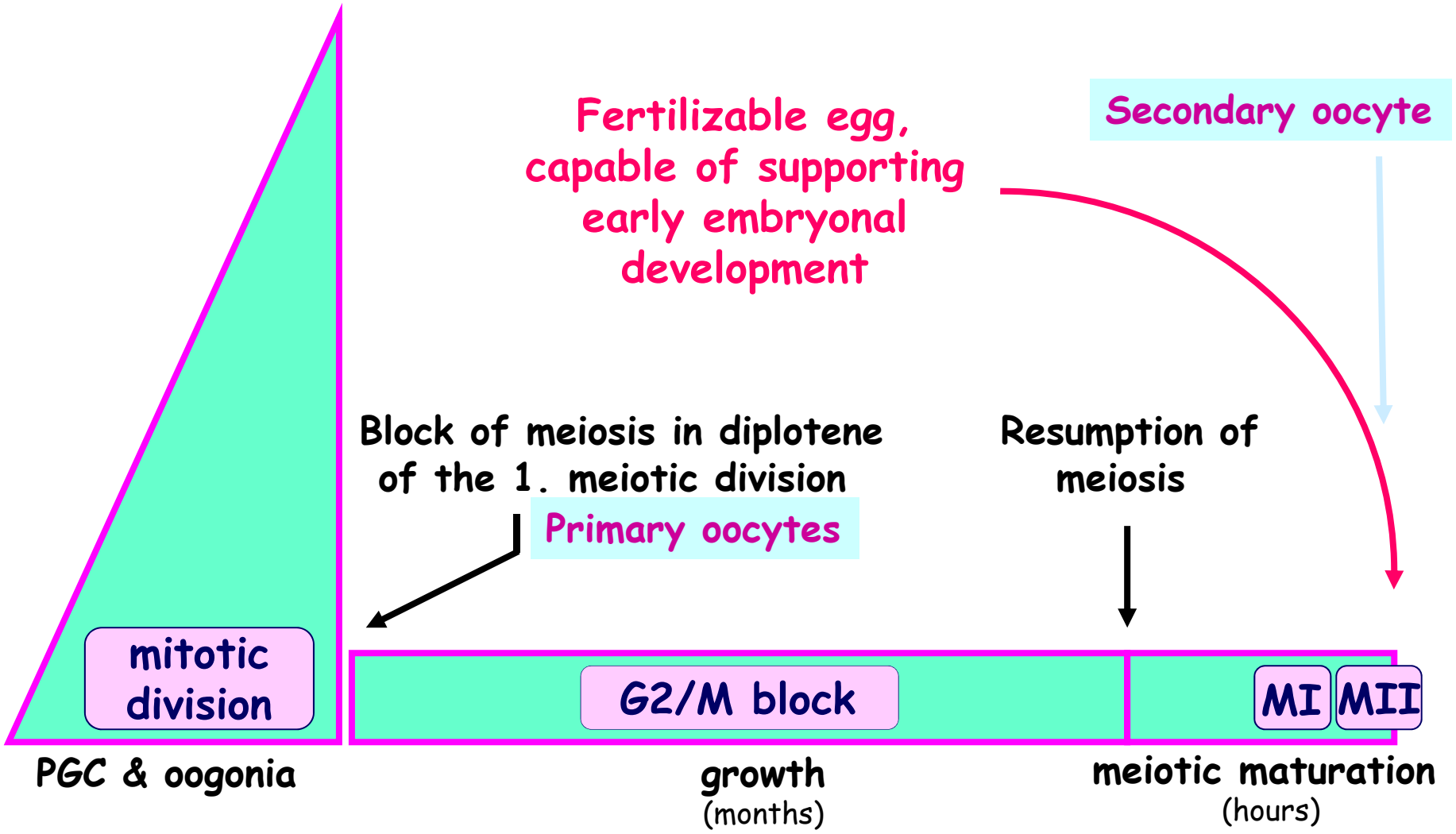
Ovary - Surface

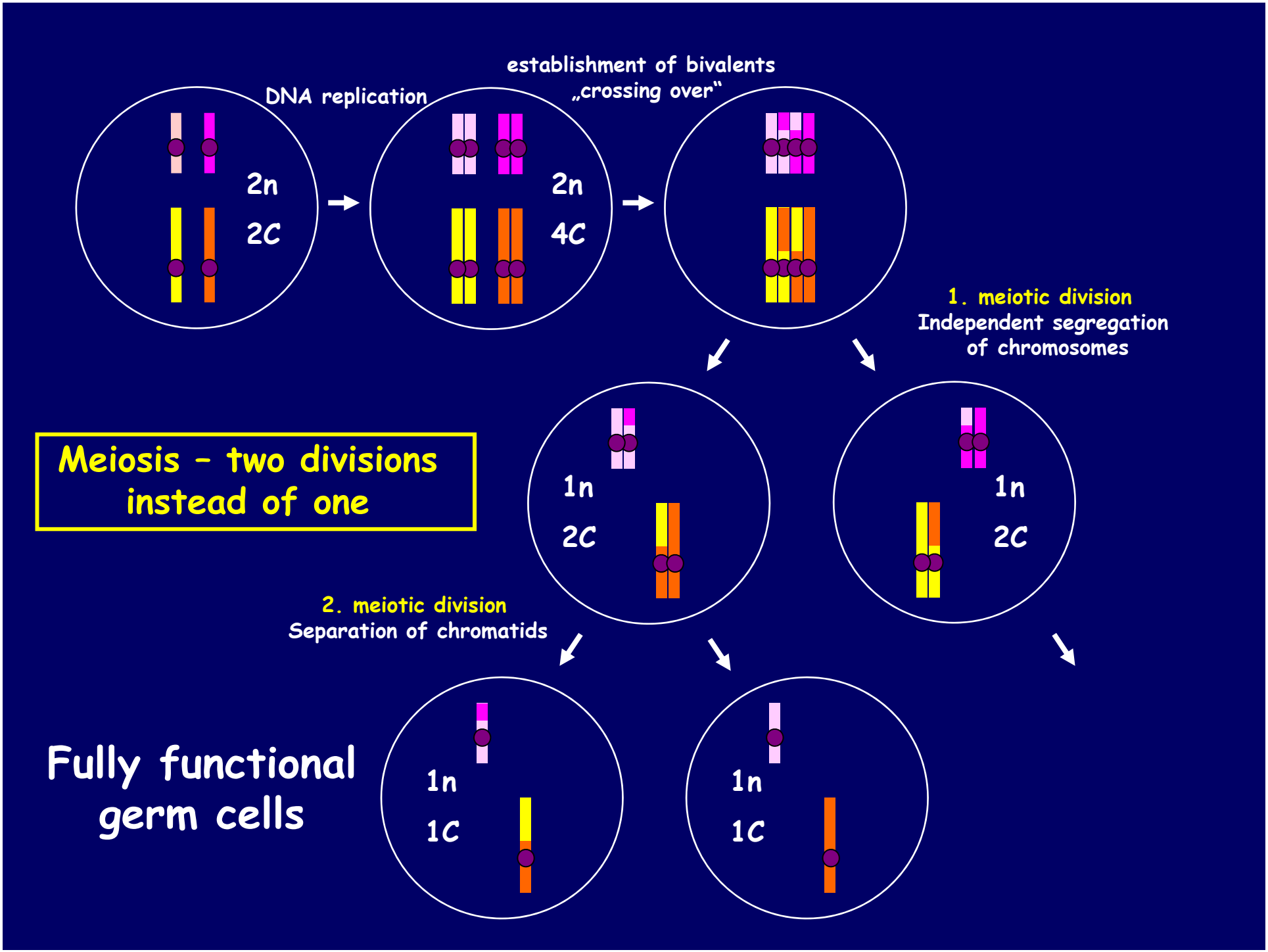






Oogenesis - Key periods




DNA replication
establishment of bivalents
„crossing over"
2n
2C
2n
4C
1. meiotic division
Independent segregation
of chromosomes
Meiosis – two divisions
instead of one
1n
2C
1n
2C
2. meiotic division
Separation of chromatids
Fully functional
germ cells
1n
1C
1n
1C

Oogenesis - Lifetime summary

At the end of 6 month of fetal development
~ 6 – 7 millions of primary oocytes

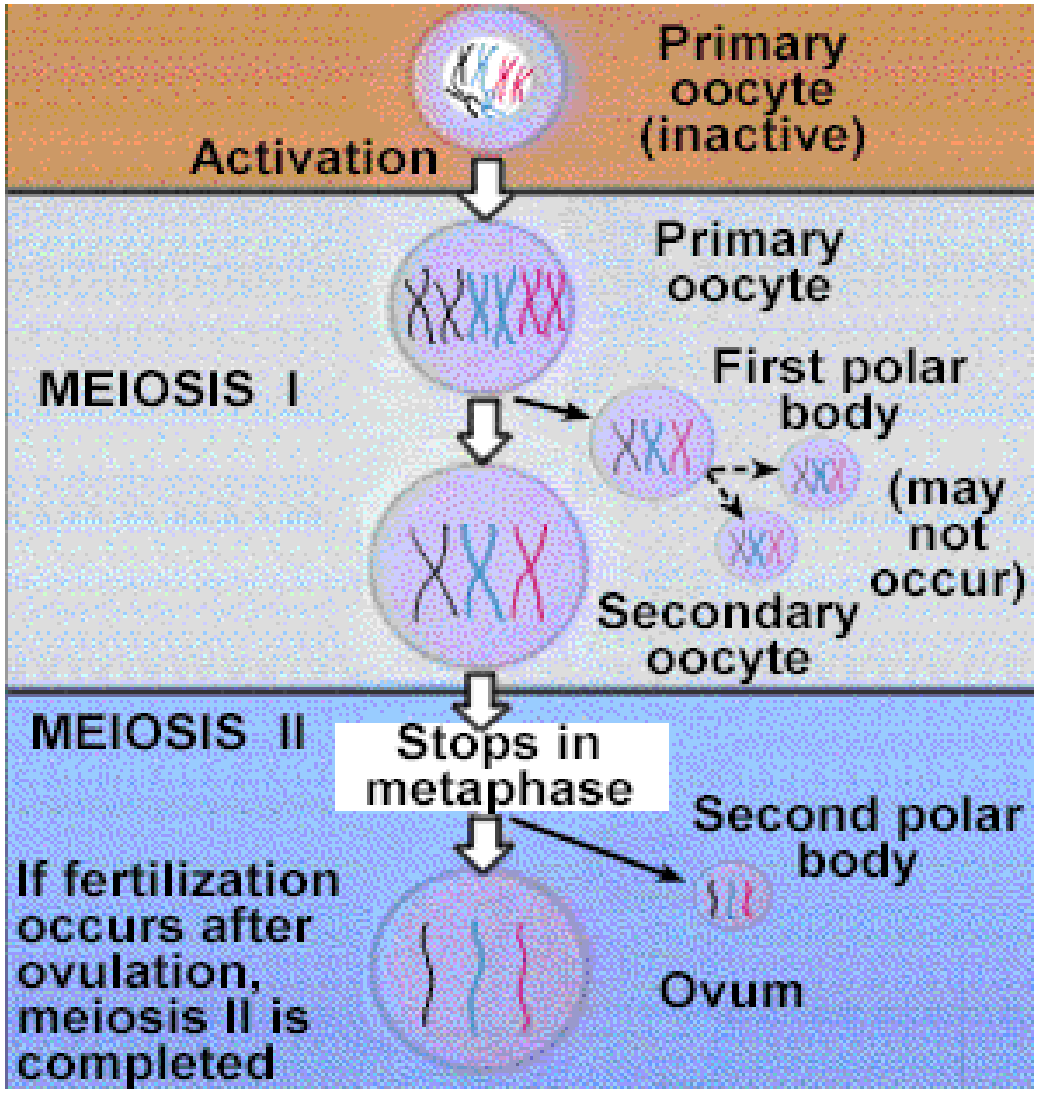
Atresia

At the time of birth
~ 500 thousands of primary oocytes

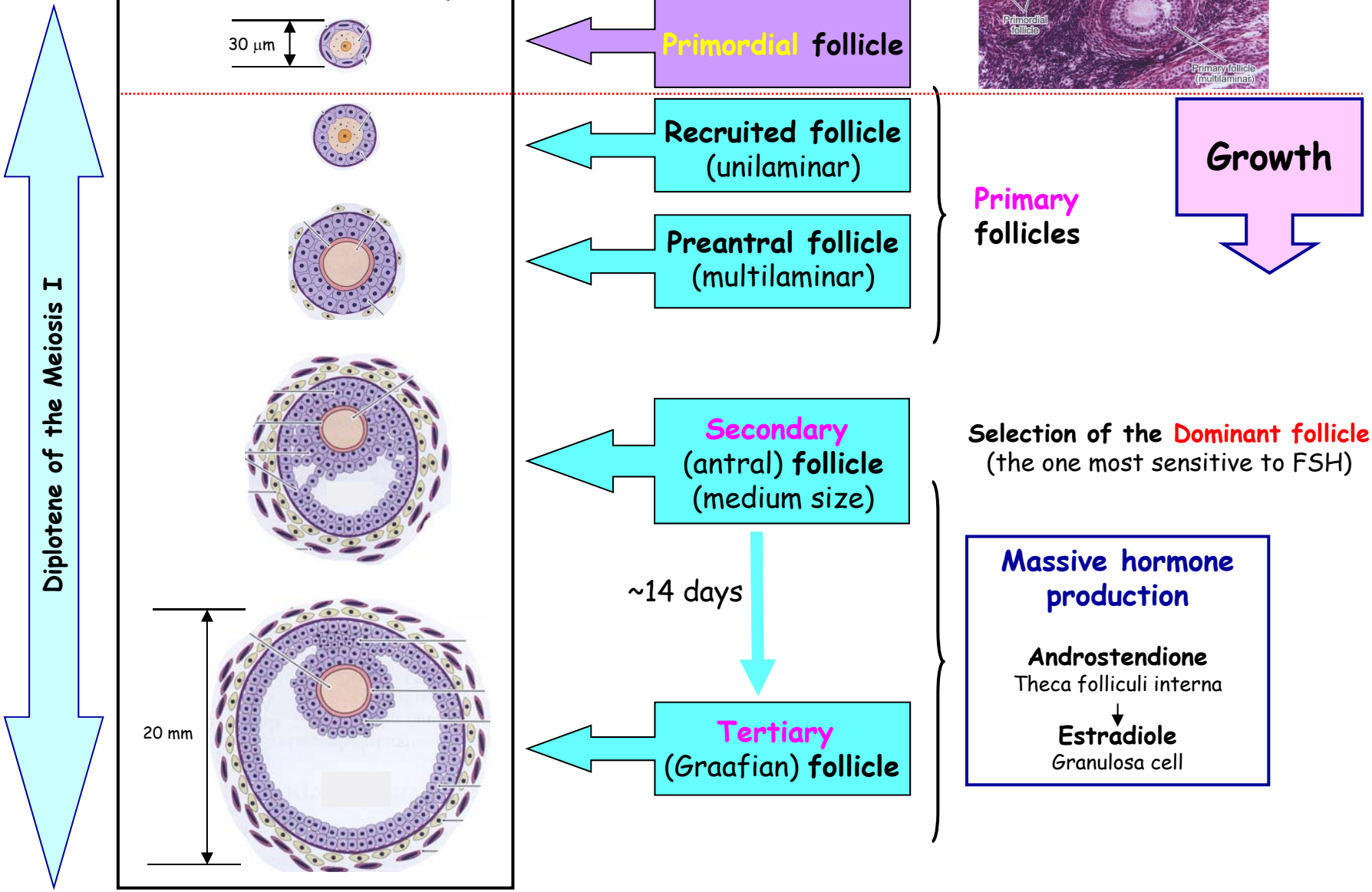
Atresia
Ovulation (~ 500 oocytes)

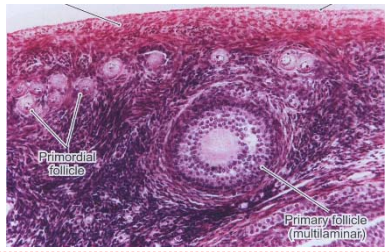
At the time of menopause
max. 100 – 1000 remaining oocytes

Oogenesis – Polar body production

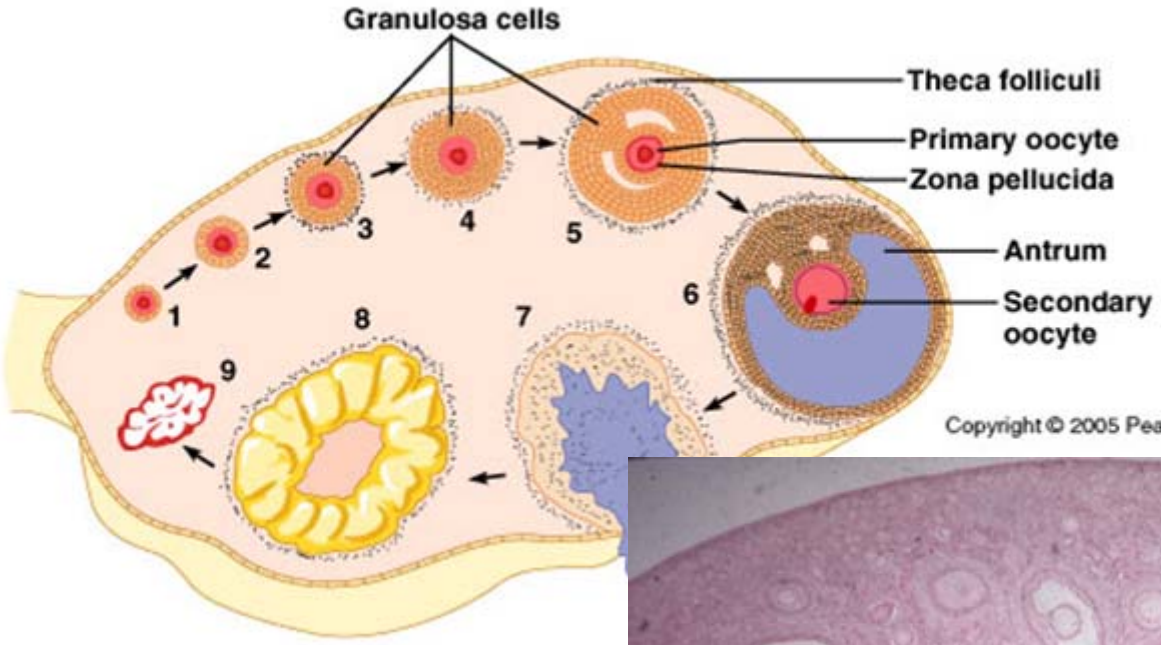


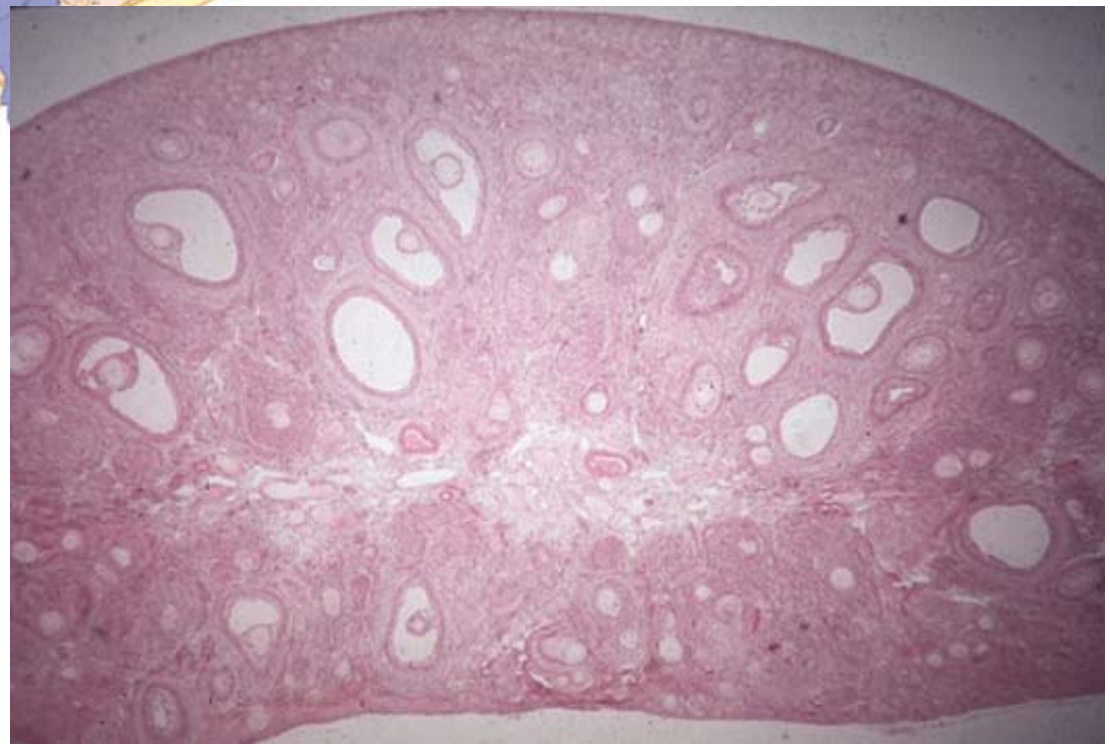
Ooogenesis – stages of the oocyte development



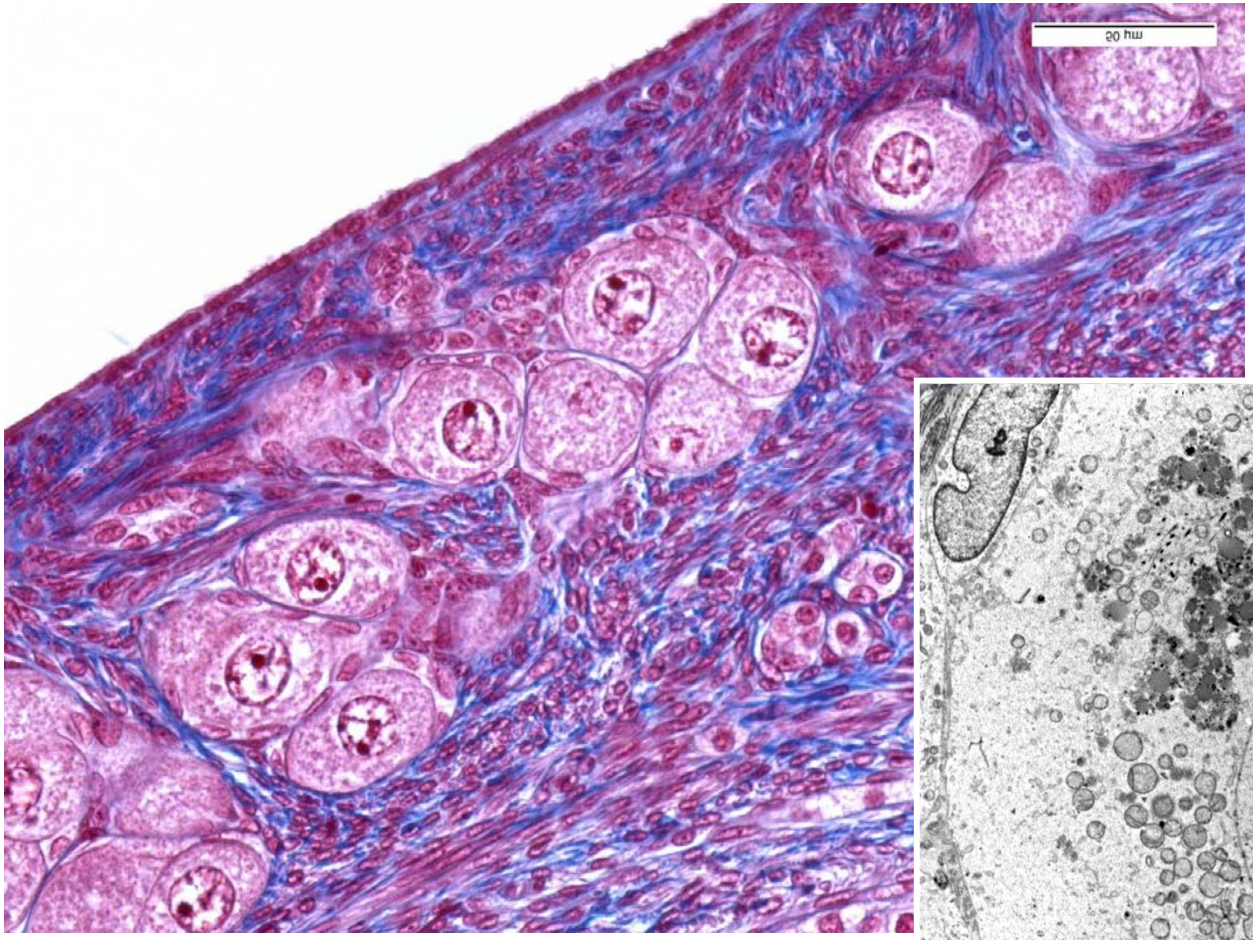


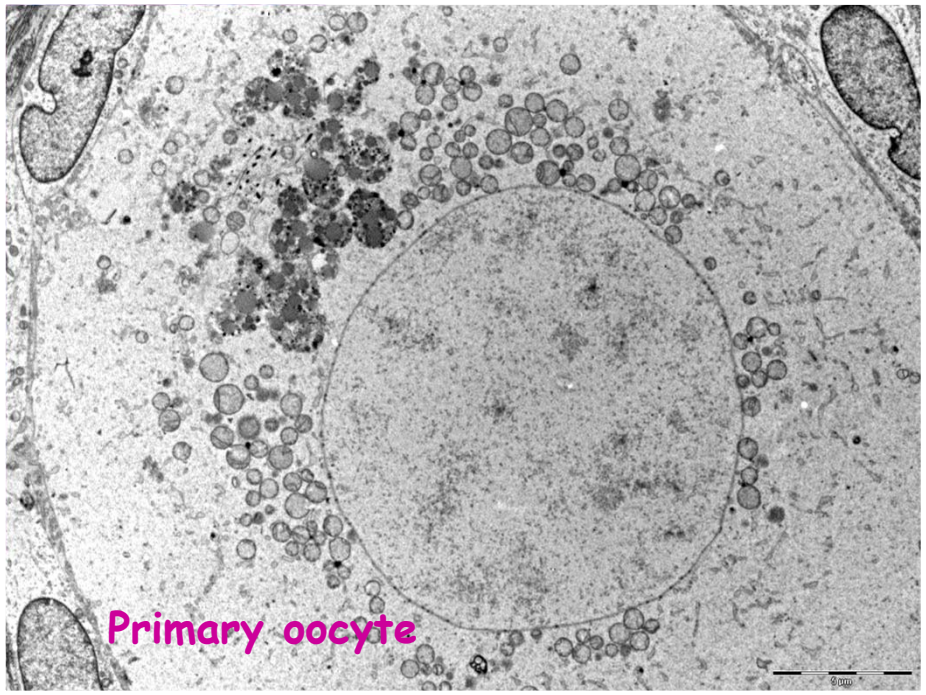
Oogenesis – Overall picture inside the ovary





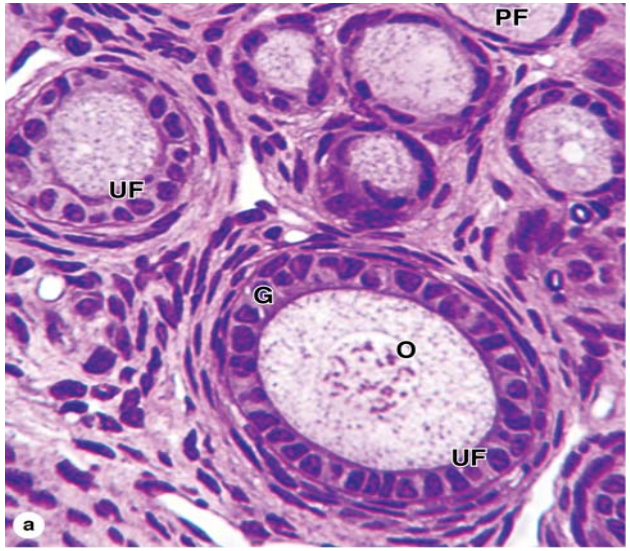
Oogenesis – Primordial follicles

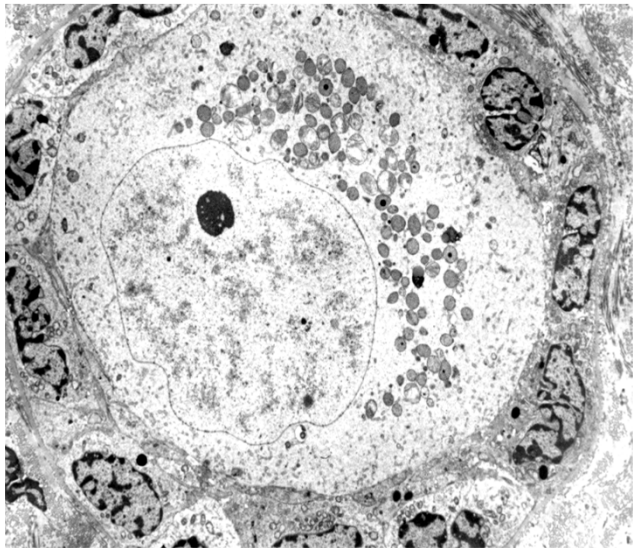




- Organelles around nucleus
- Abundant mitochondria
- Abundant RER

Oogenesis – Primary follicles

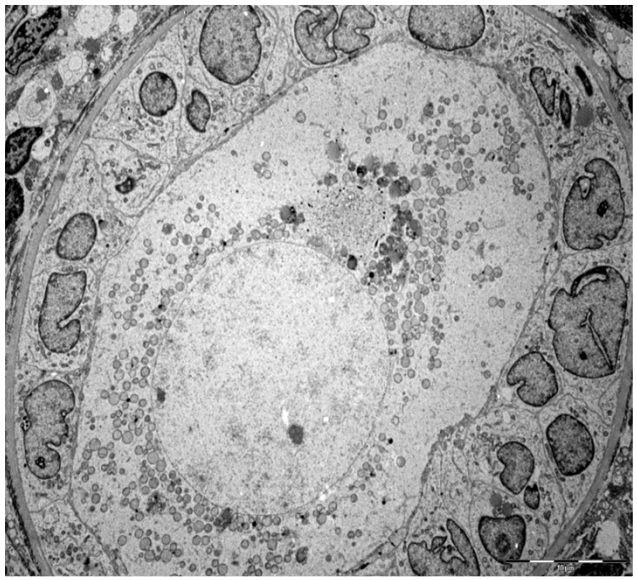




Unilaminar

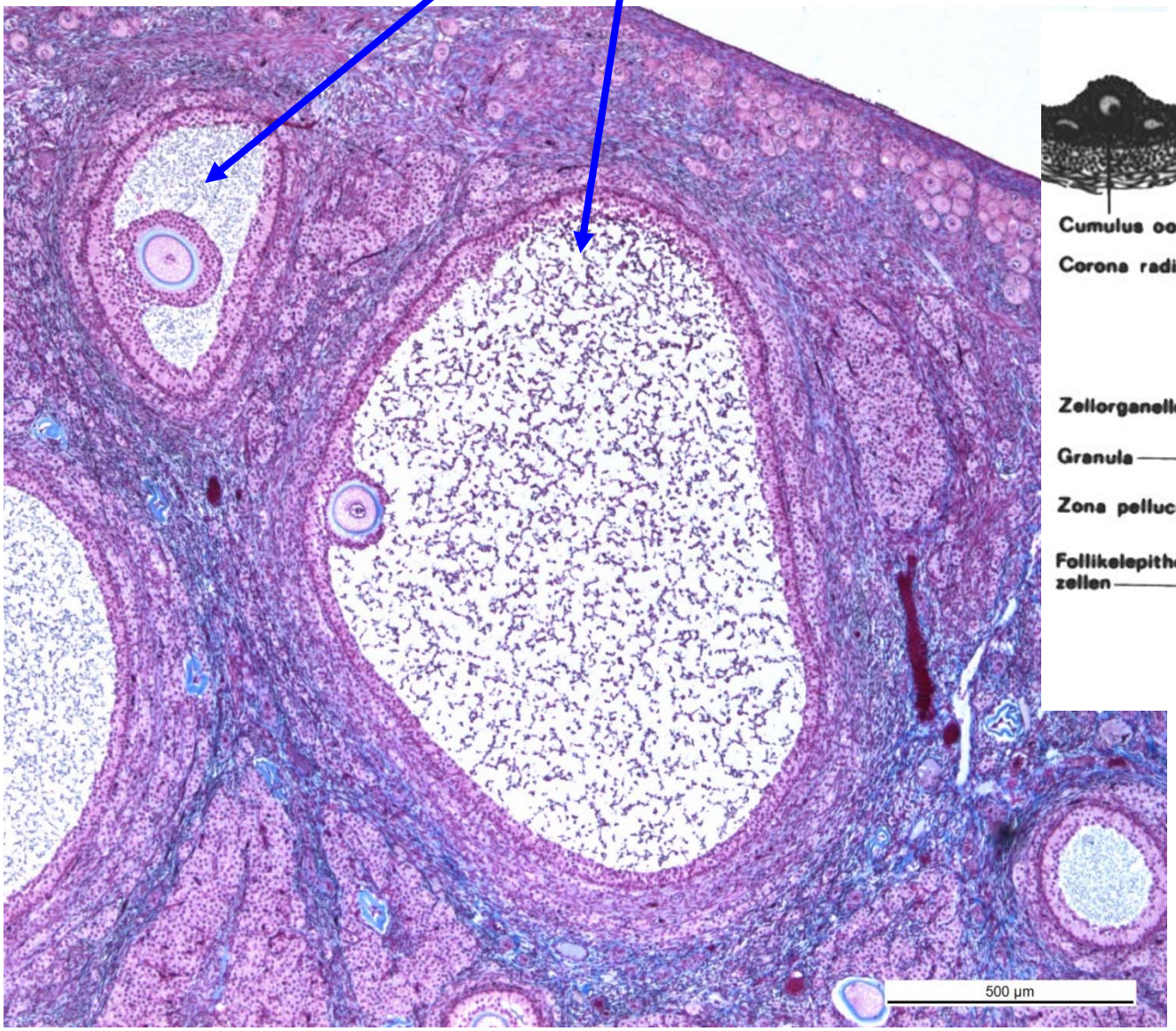
Zona pellucida
(5-10 μm)

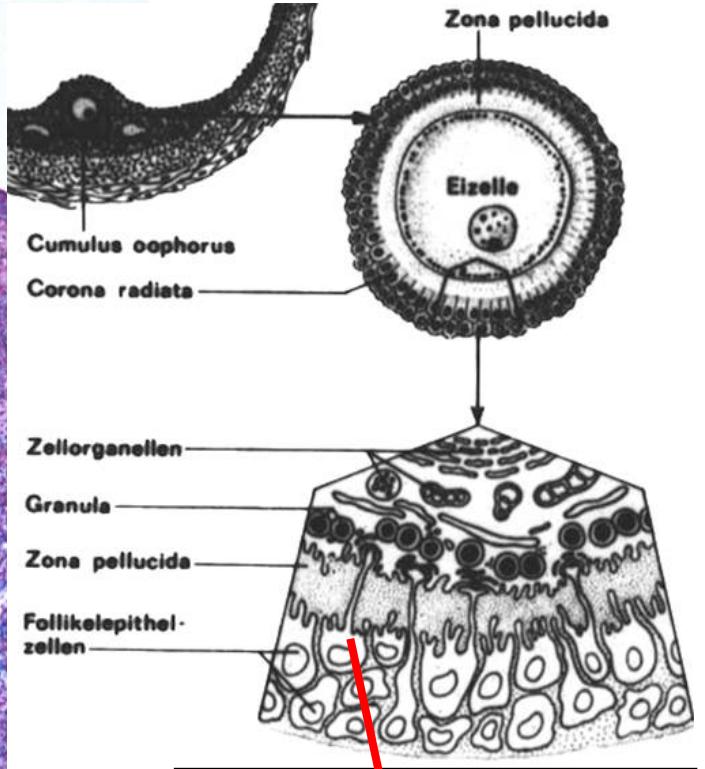
Granulosa cells

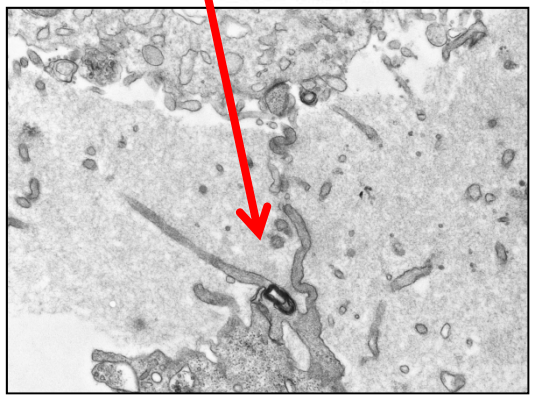


Multilaminar

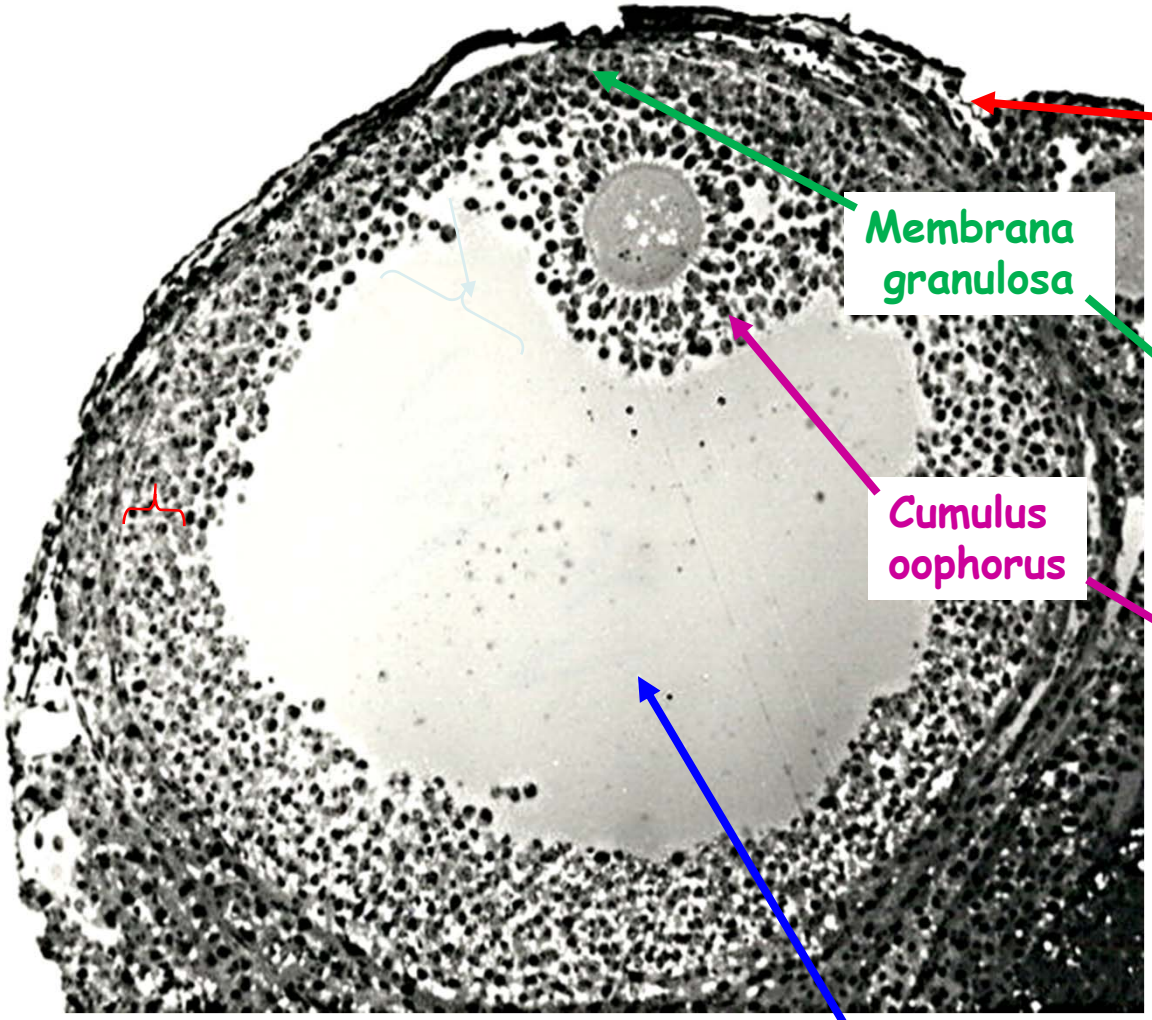
Oogenesis – Secondary (antral) follicles

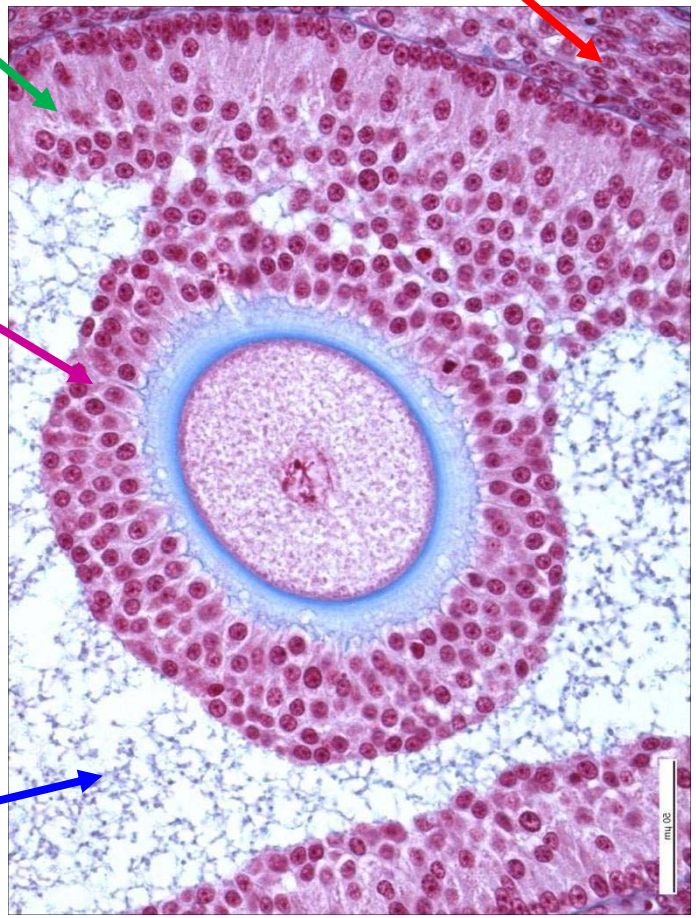




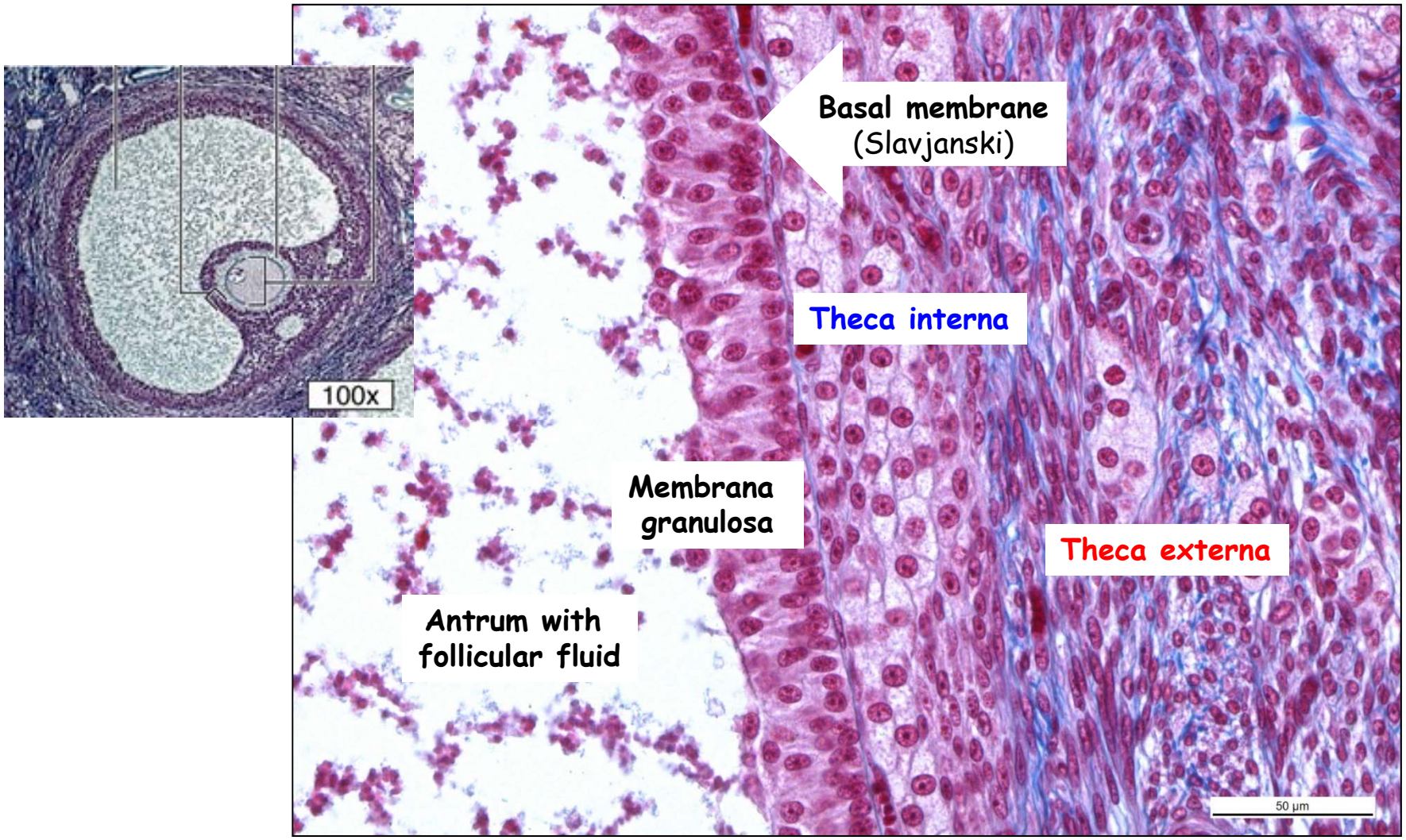


Oogenesis – Tertiary (Graafian, preovulatory) follicle





Oogenesis – Wall of tertiary follicle



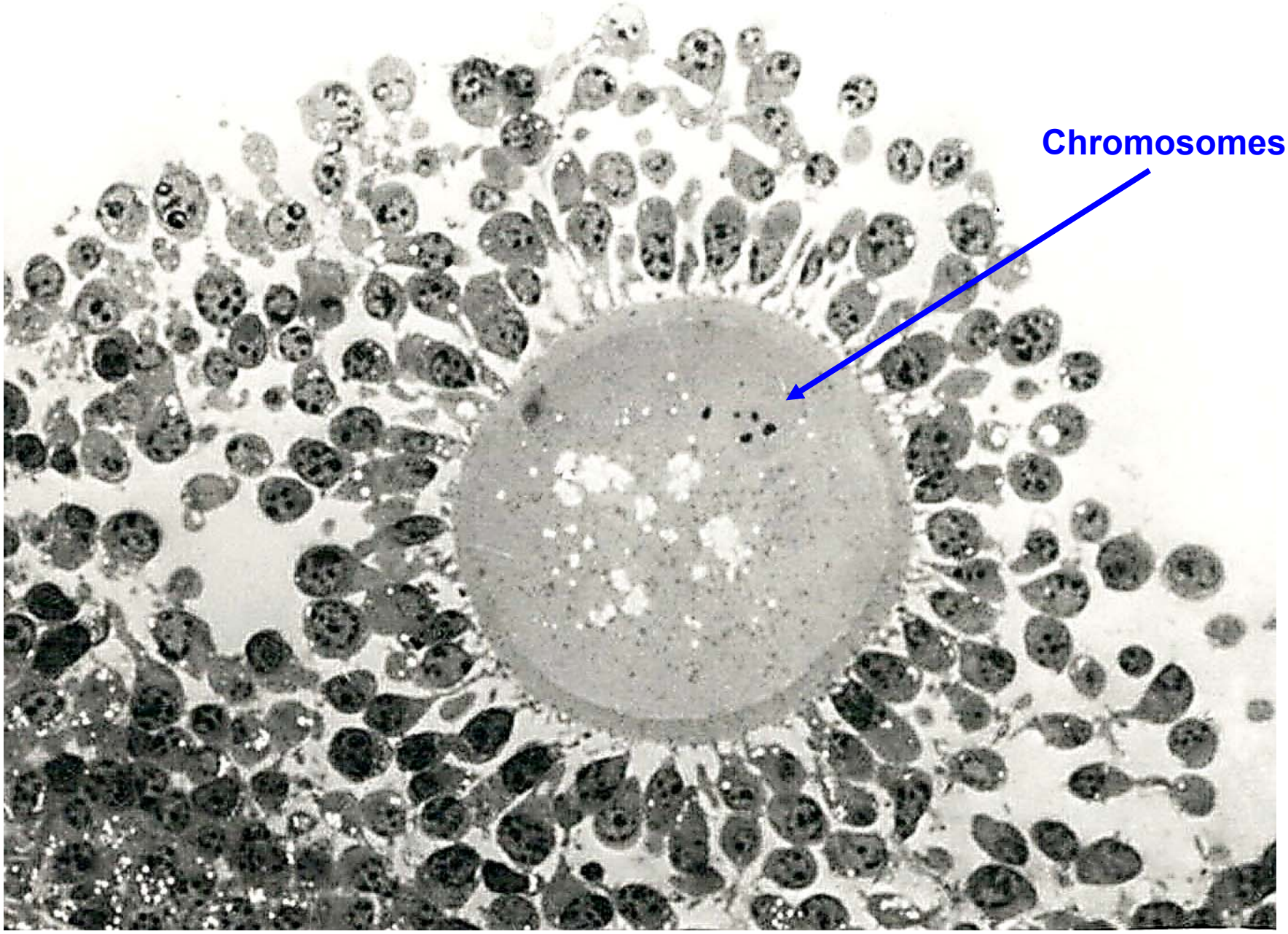
Theca interna

- Vascularized
- Androstendione to granulosa cells - estradiol

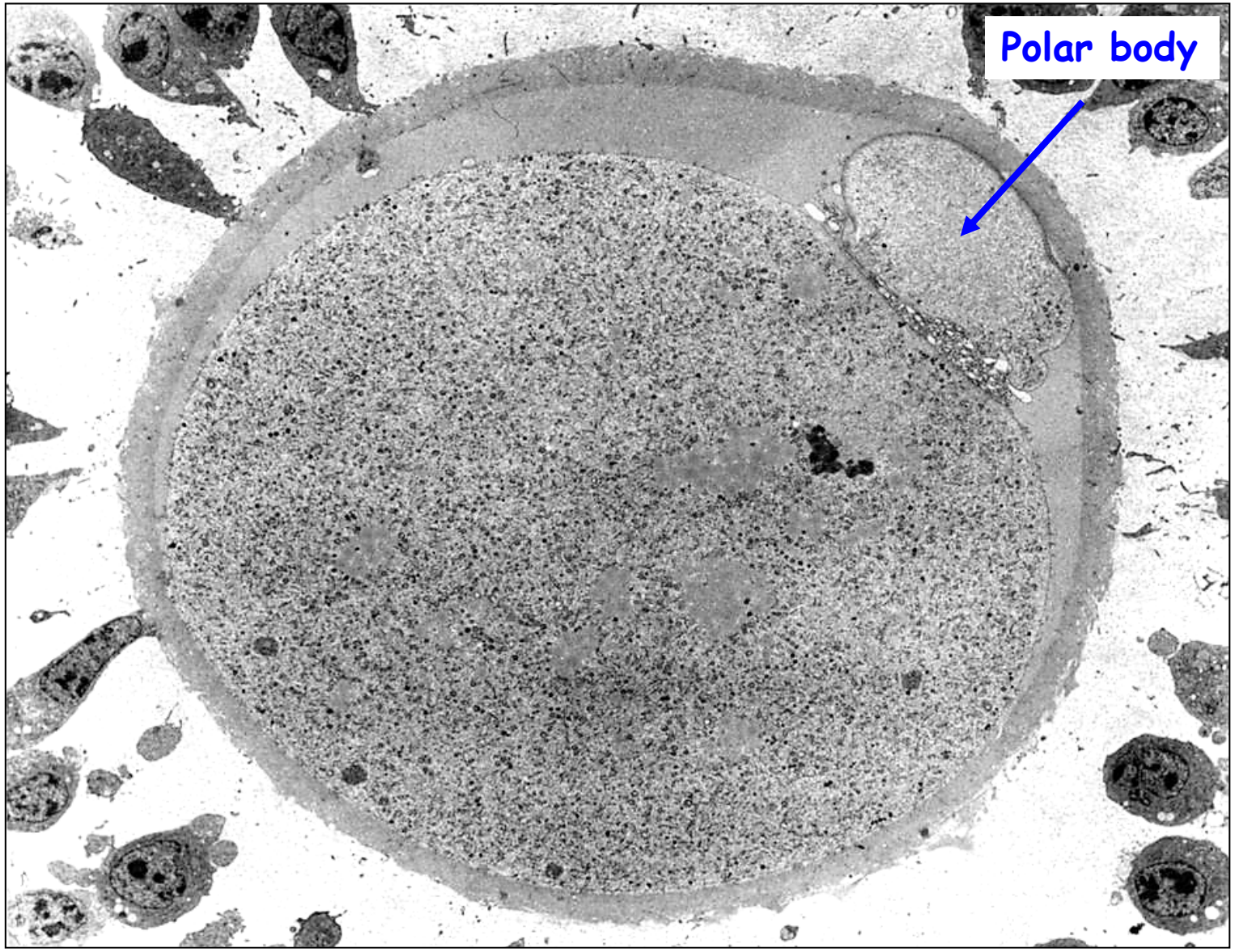
Theca externa

- Fibrous with smooth m. cells

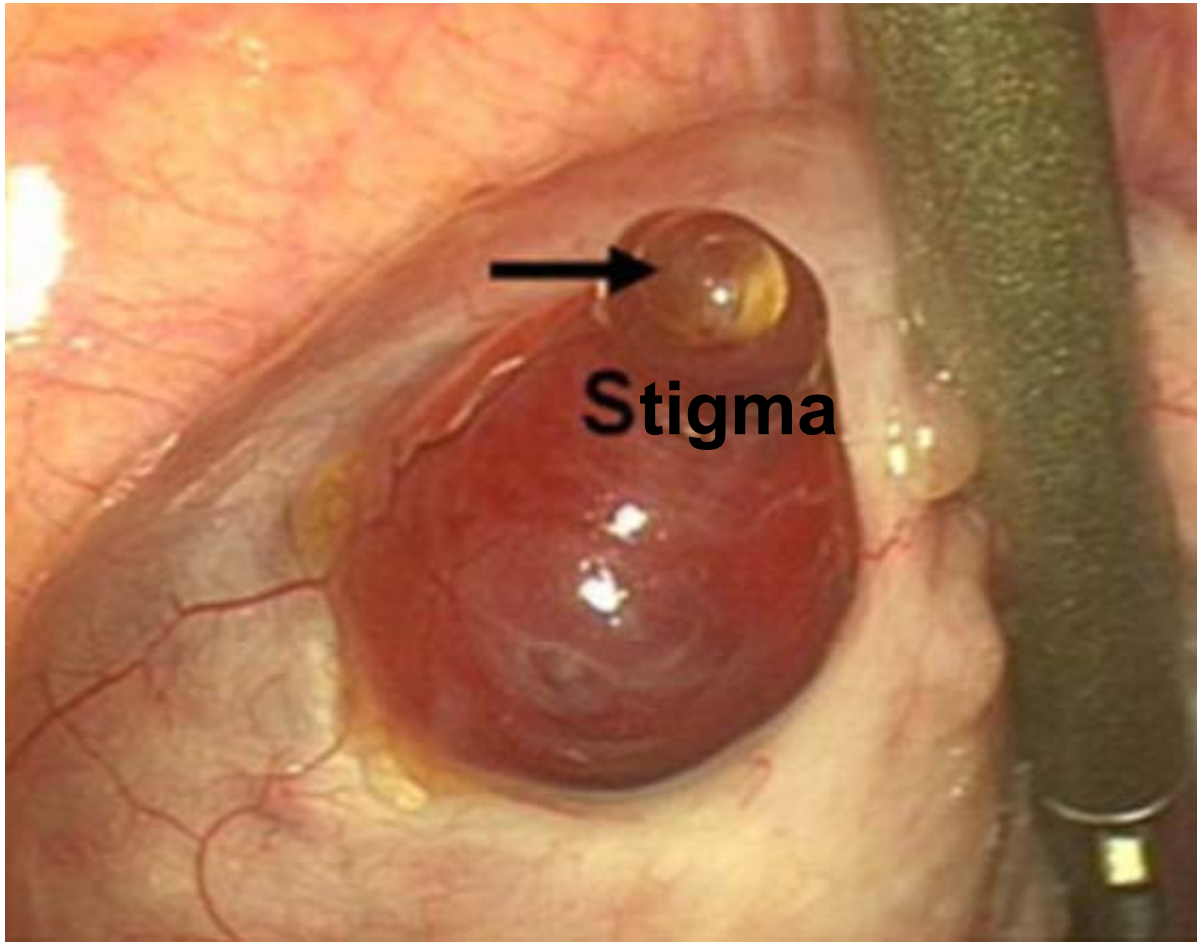
Oogenesis – MI phase oocyte surrounded by corona radiata



Oogenesis – MII phase oocyte

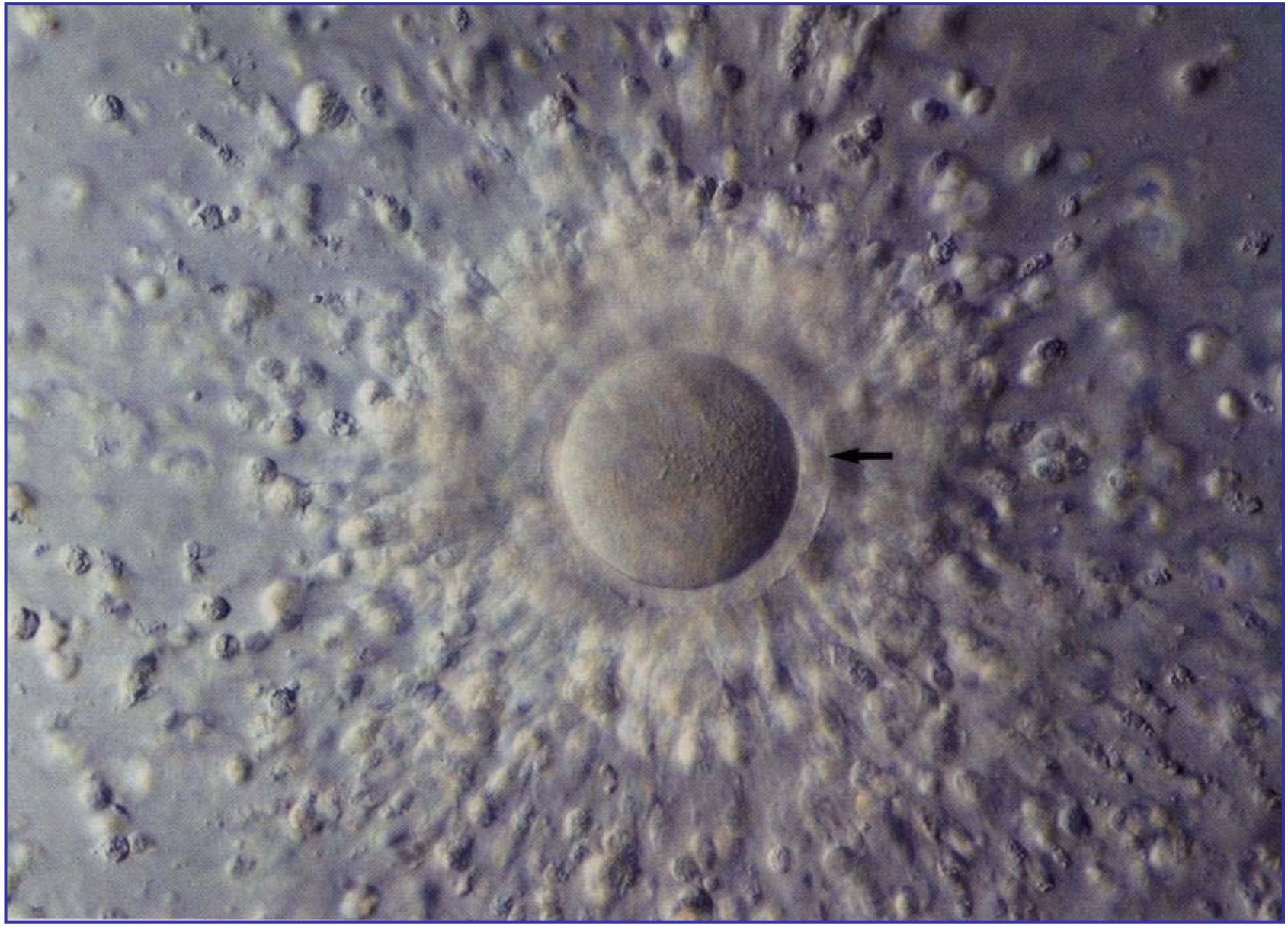


Oogenesis – Ovulation

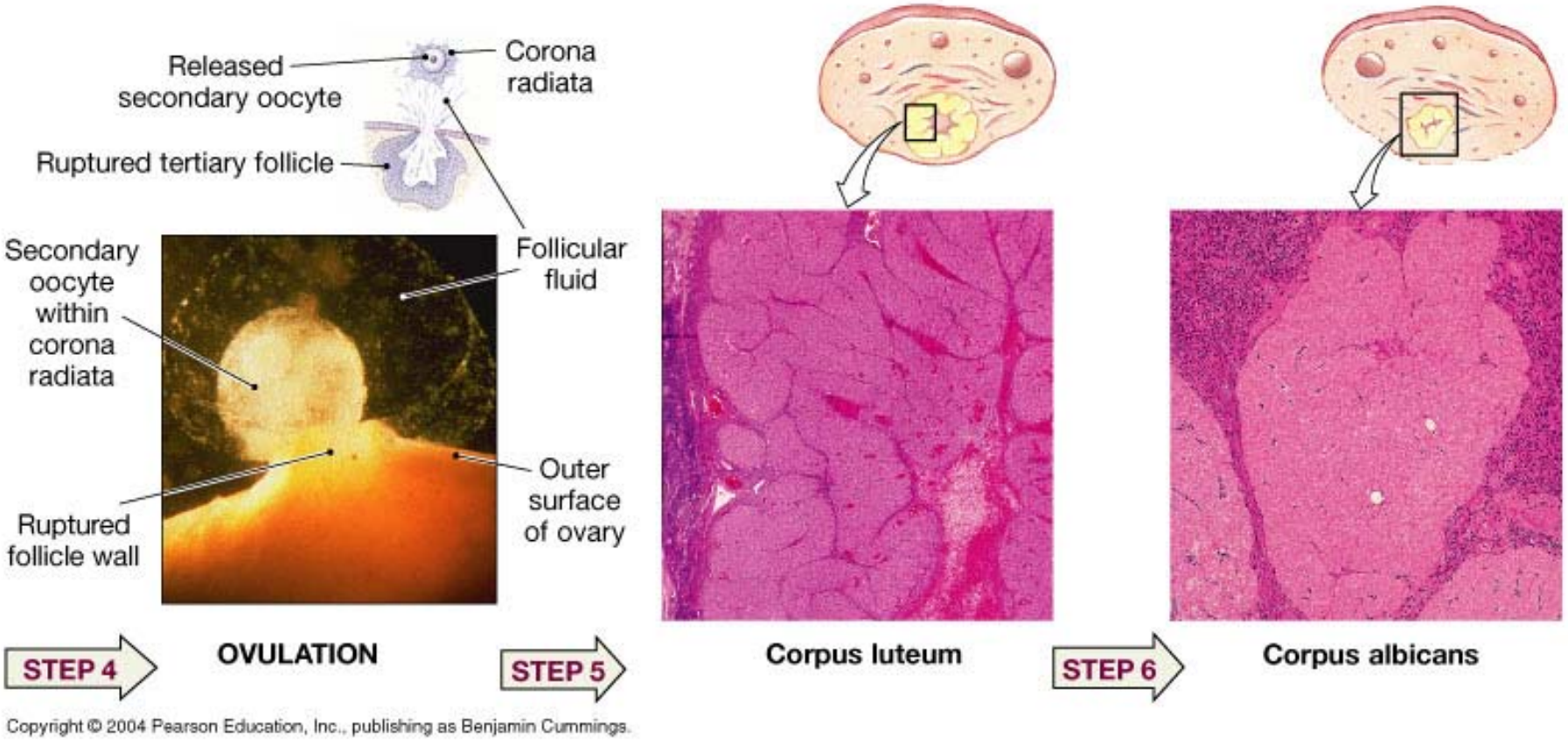


- initiated by LH surge
- no blood flow at stigma – ischemia
- smooth muscle contractions - theca f. externa

Oogenesis – Ovulated oocyte



Corpus luteum 1



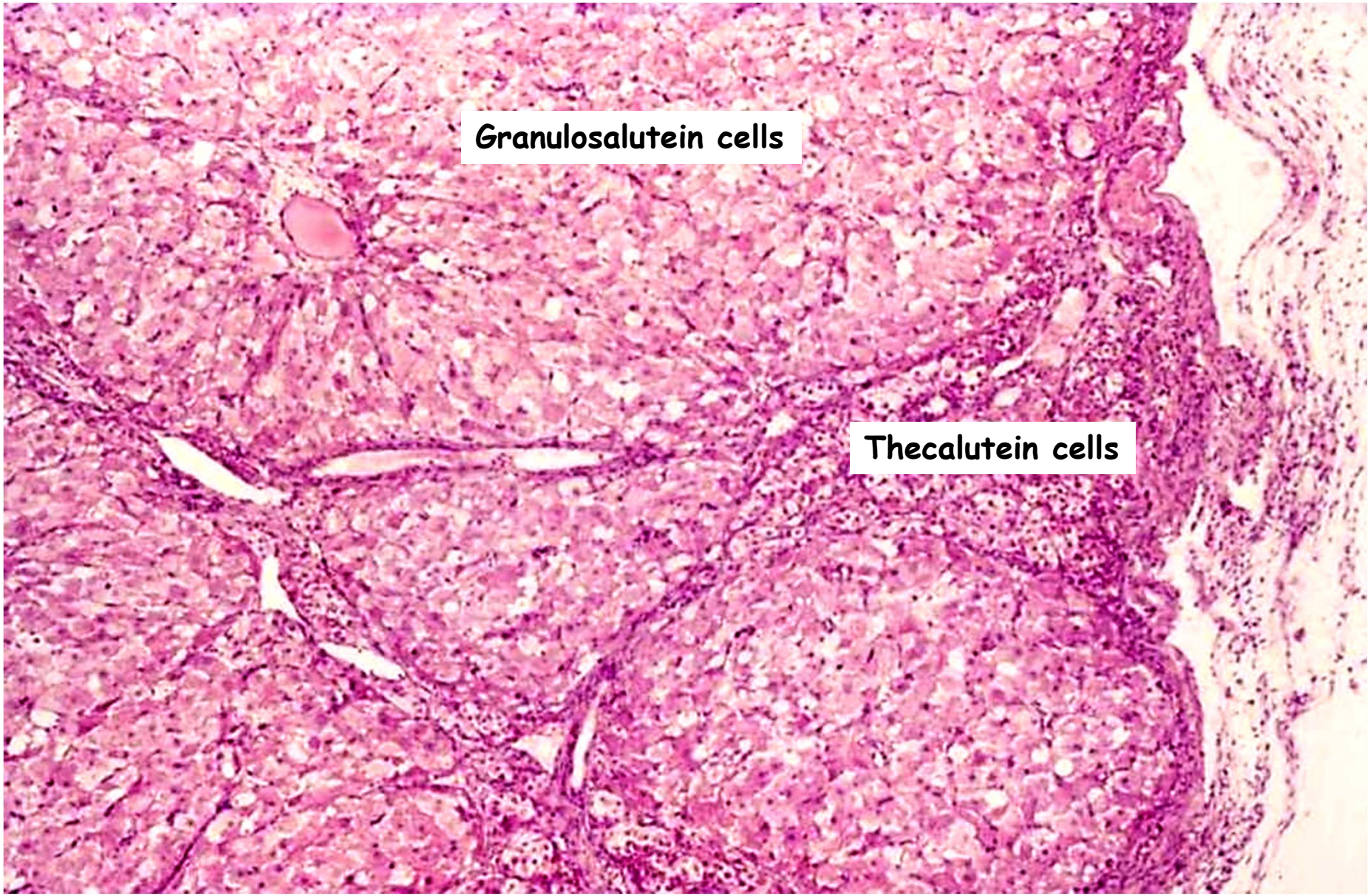
Granulosa cells – Granulosa lutein cells

- large (20-30 μm)
- 80 % of CL
- convert androstendione to estradiol

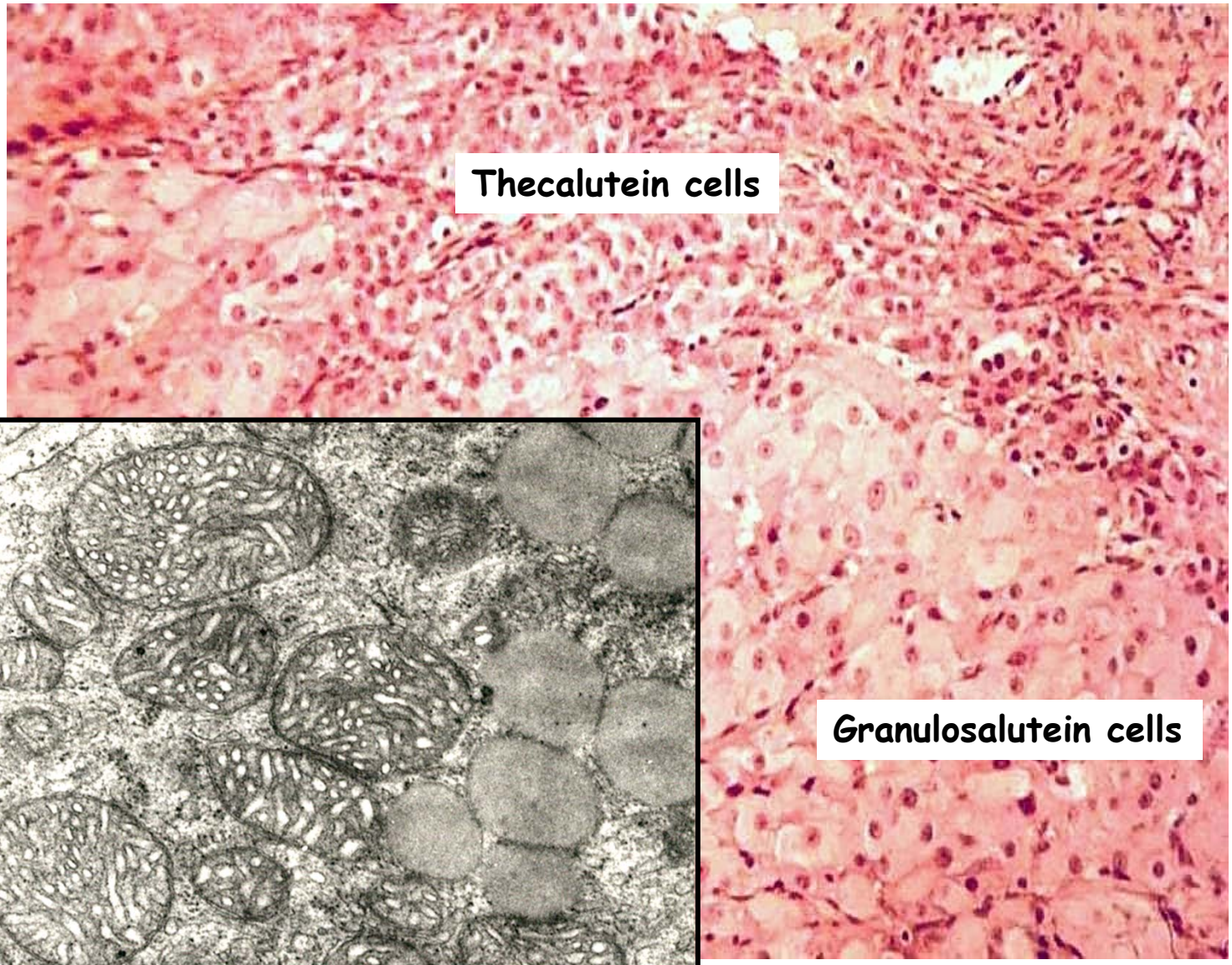
Theca interna cells – Theca lutein cells

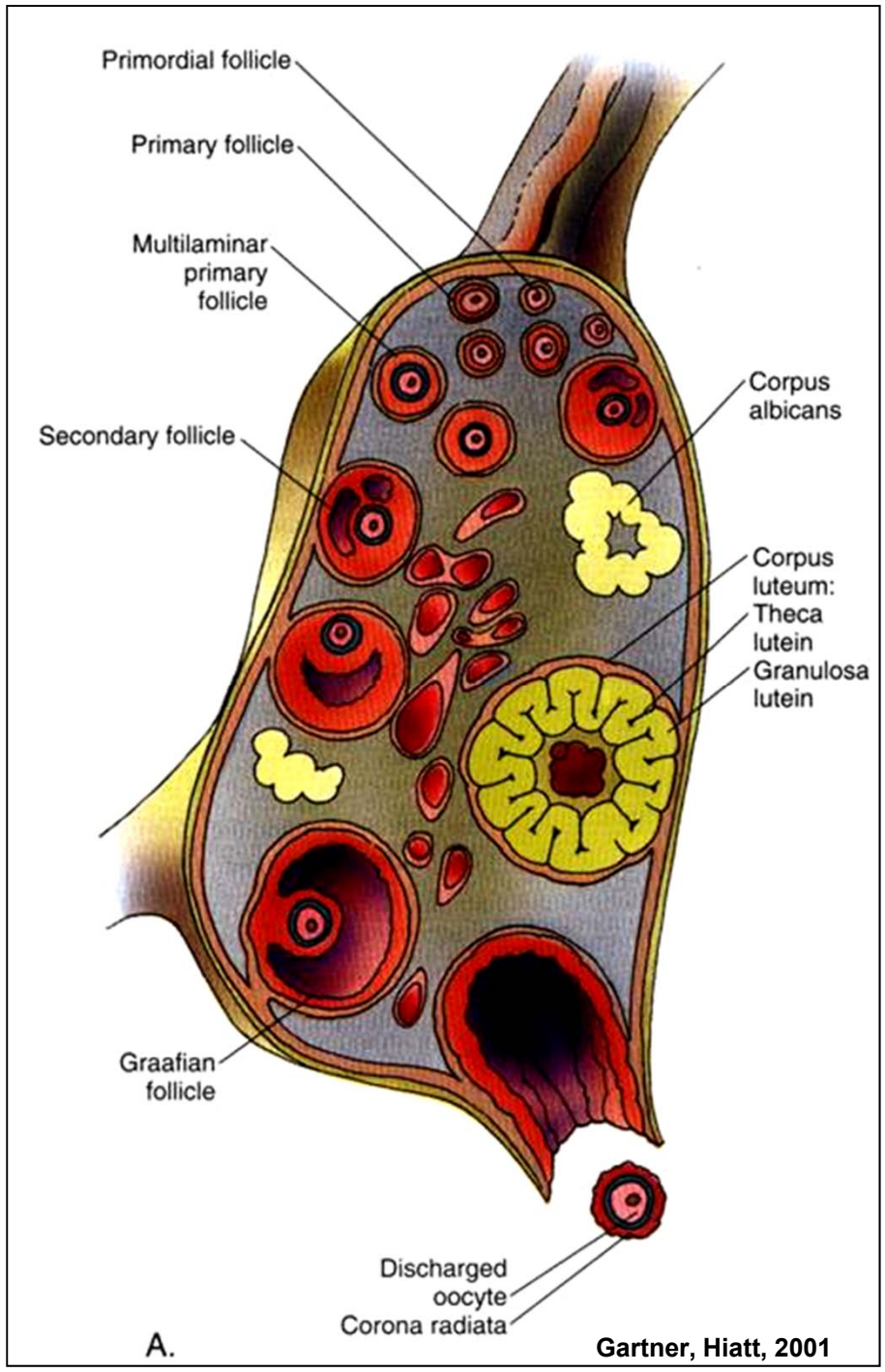
- smaller (10-15 μm)
- progesterone production
- vascularized – fenestrated caps.

Corpus luteum 2



Corpus luteum 3





Corpus luteum 4

CL graviditatis

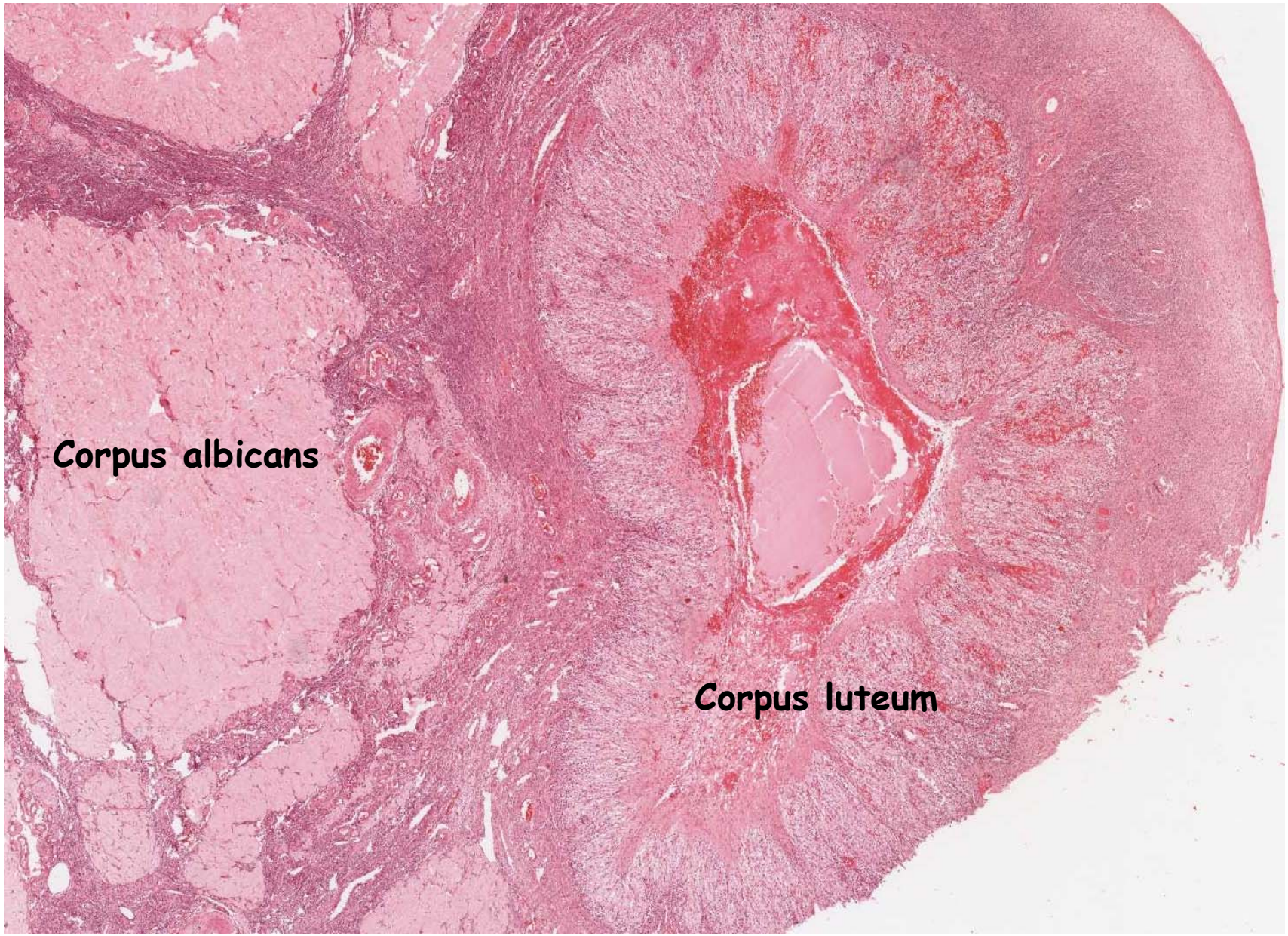
- diameter 2 – 3 cm
- maintains pregnancy
- mantained by chorionic gonadotropin (HCG)
- maximal at 2 months
- changes to c. albicans at month 4-5

CL menstruationis

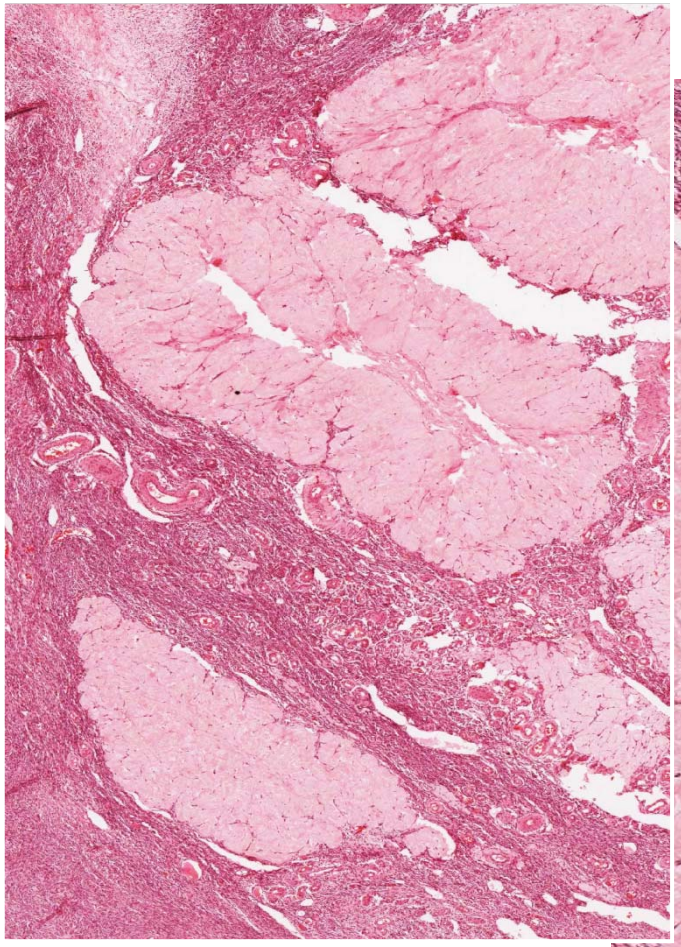
- 10 – 12 days
- changes to c. albicans

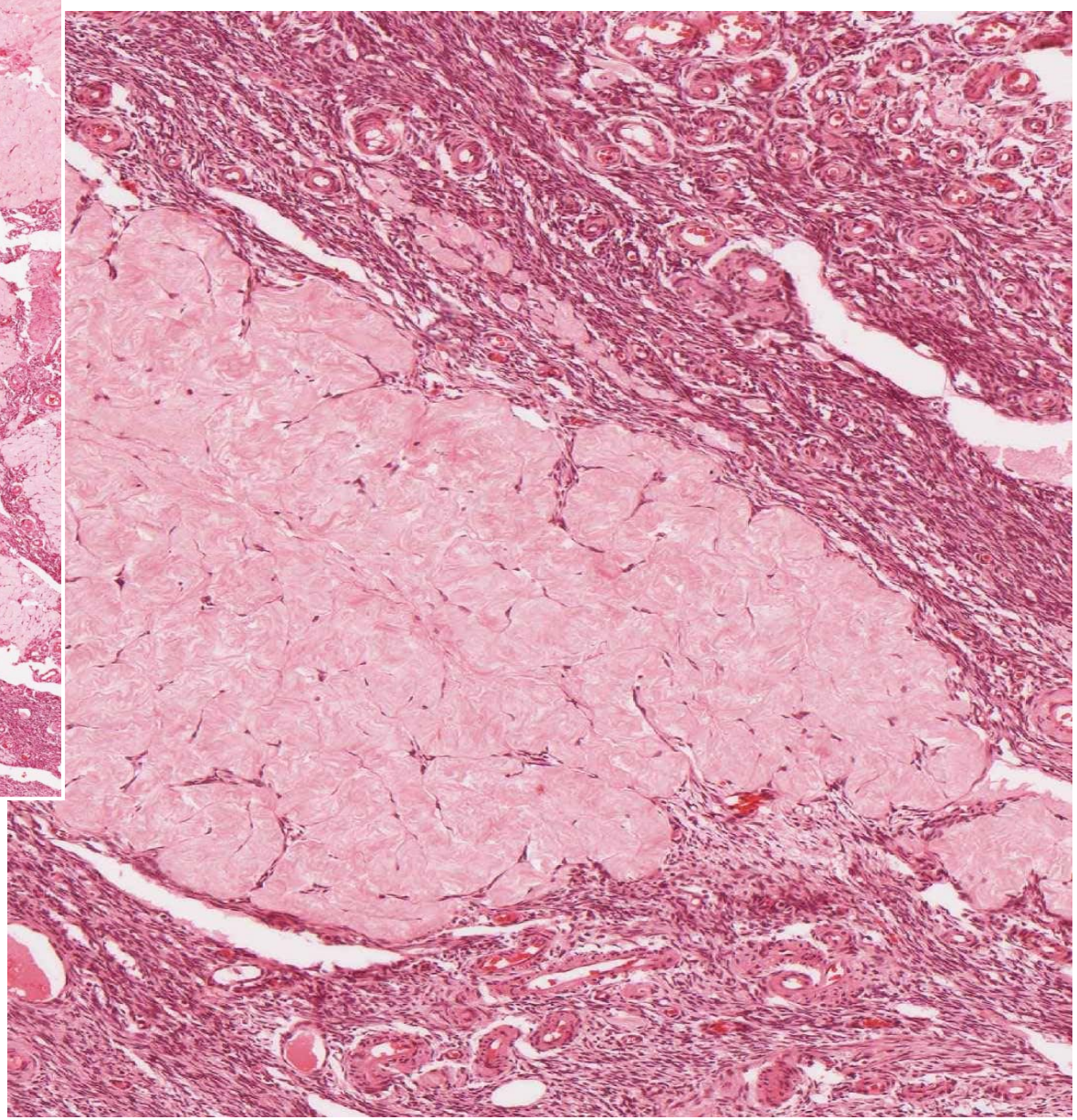
  (dense connective tissue – collagen + fibroblasts)

Corpus luteum & albicans



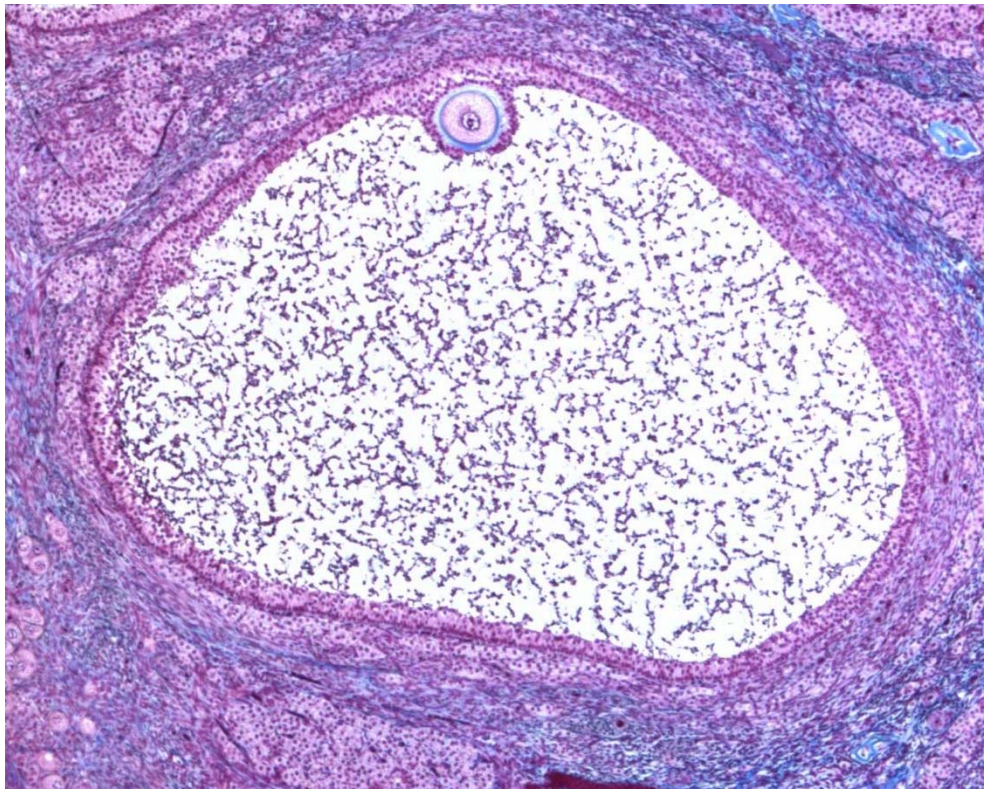
Corpus albicans

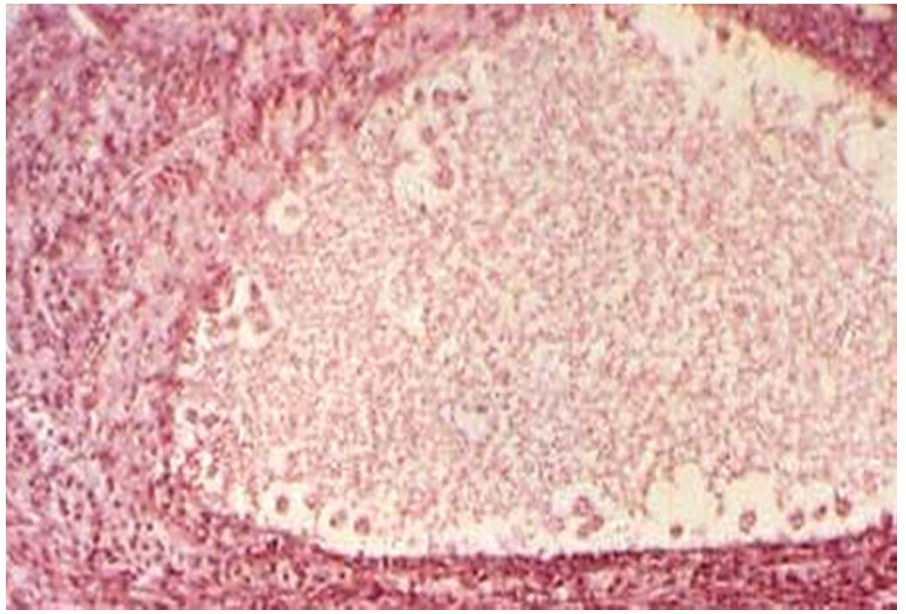


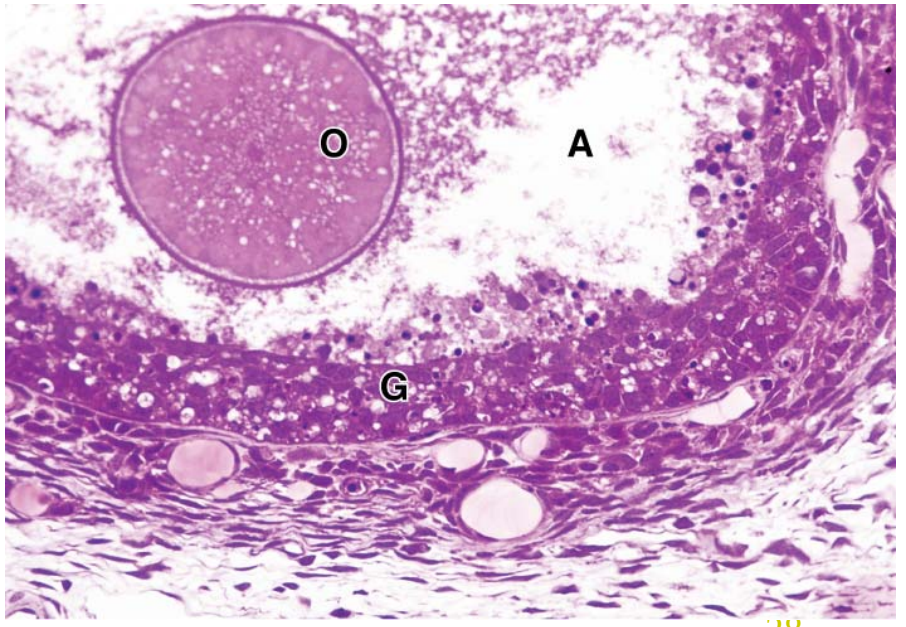


Follicular atresia

- all types of follicles
- apoptosis of follicular cells
- autolysis (autophagy) oocytes
- phagocytosis by macrophages
- zona pellucida and basal lamina persist the longest time







Mescher, 2010

Ovarian cycle – 28 days

Preovulatory phase

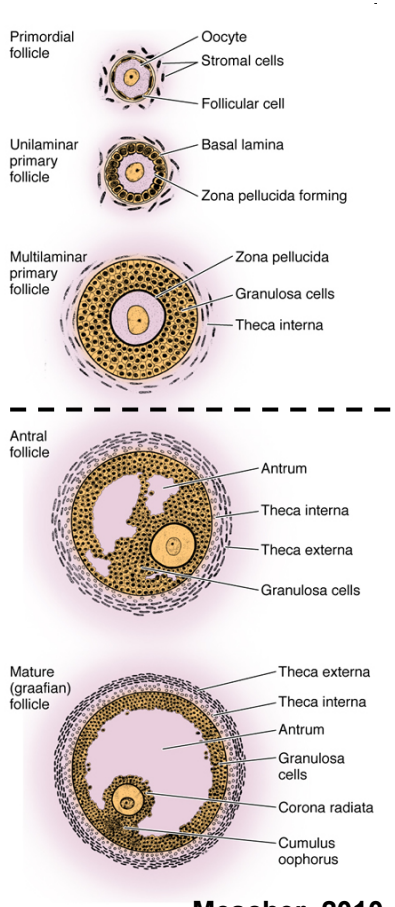
- days 1 to 14
- growth and maturation of follicles
- production of steroid hormones

Ovulation

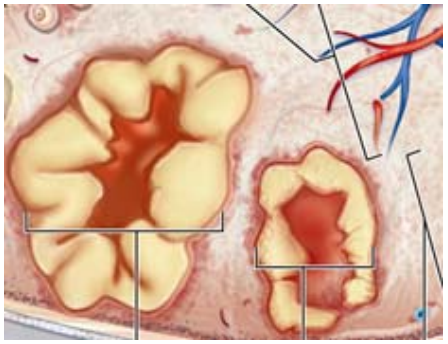
- at day 15

Postovulatory phase

- days 16 to 28
- corpus luteum
- production of progesterone

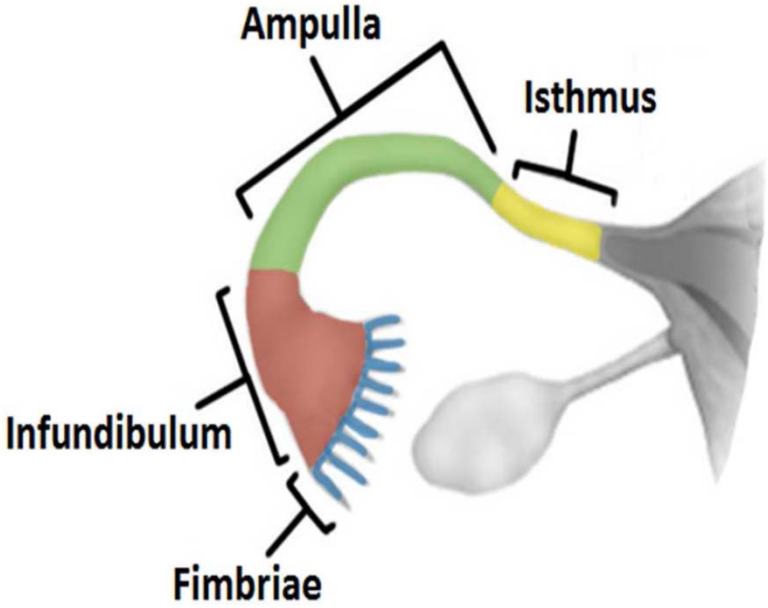


Mescher, 2010

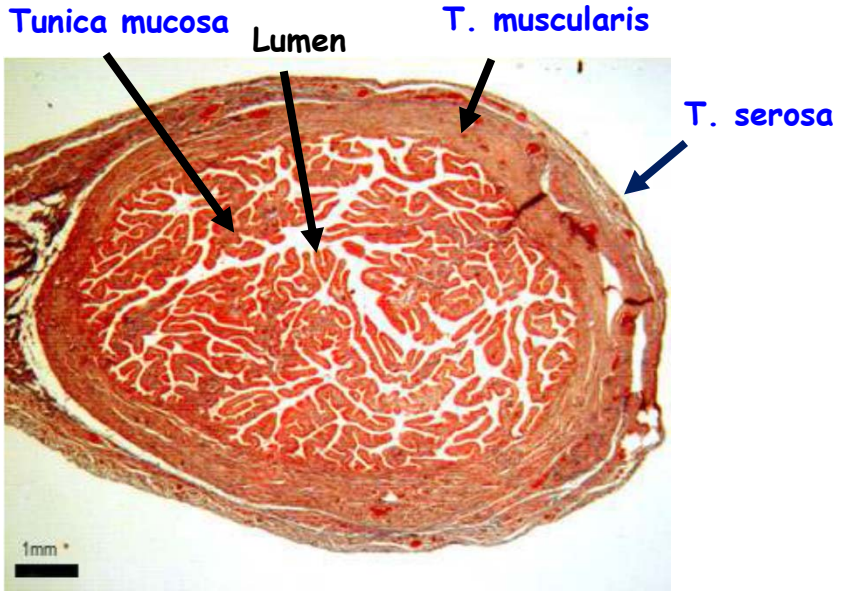


Uterine tubes = Fallopian tubes = Oviducts

- connect the ovaries to the uterus
- 12 to 15 cm long x 0.7 to 5 cm in diameter
- location of fertilization and early embryonic development

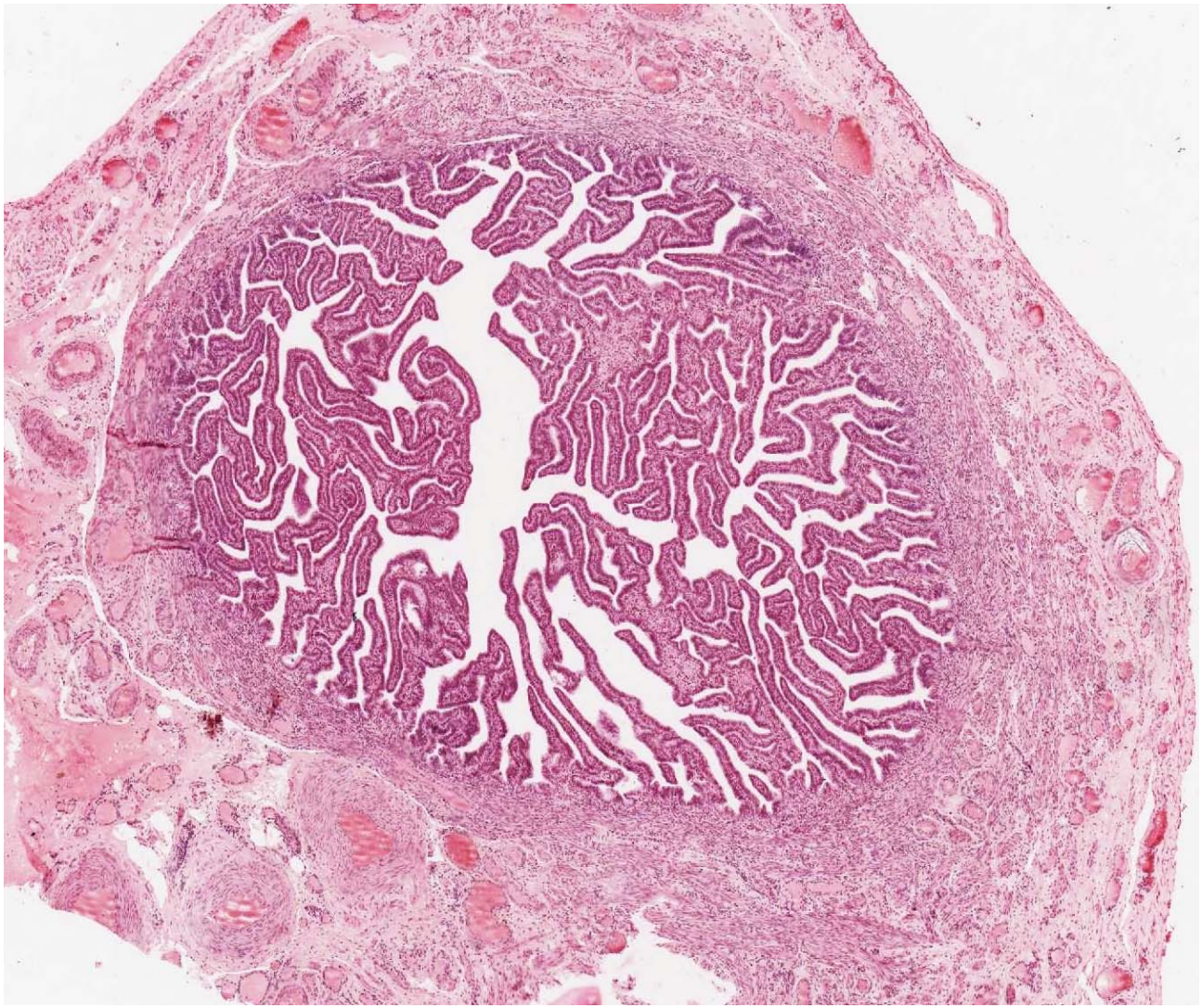


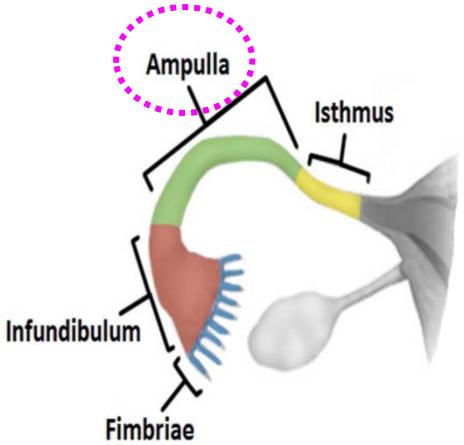
Teachmeanatomy.info



University of Leeds Histolgoy, histology.leeds.ac.uk

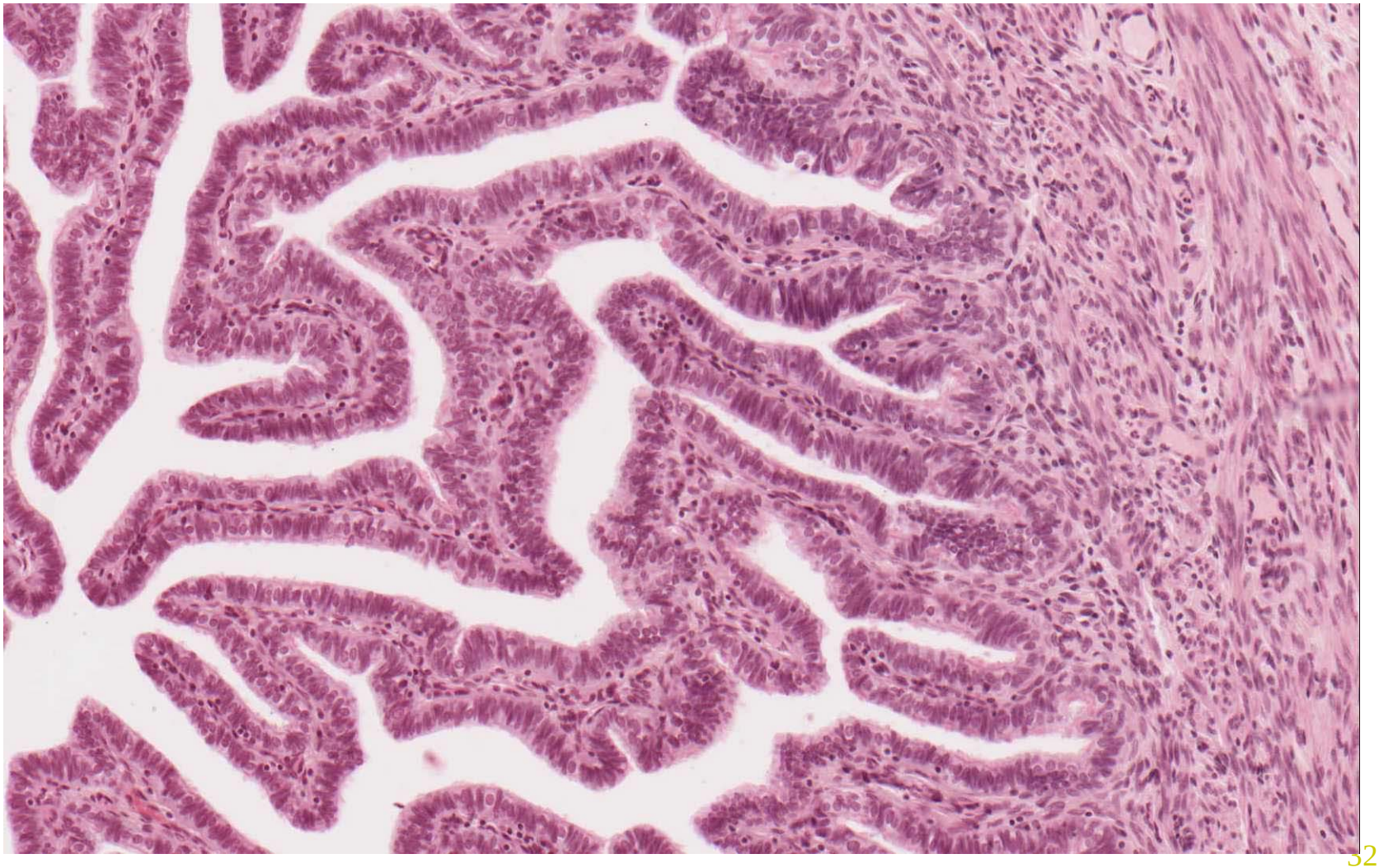
Oviduct - Ampula



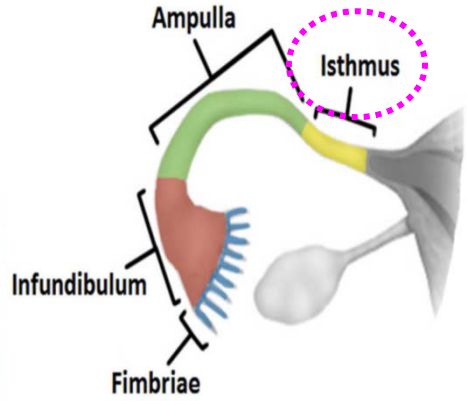


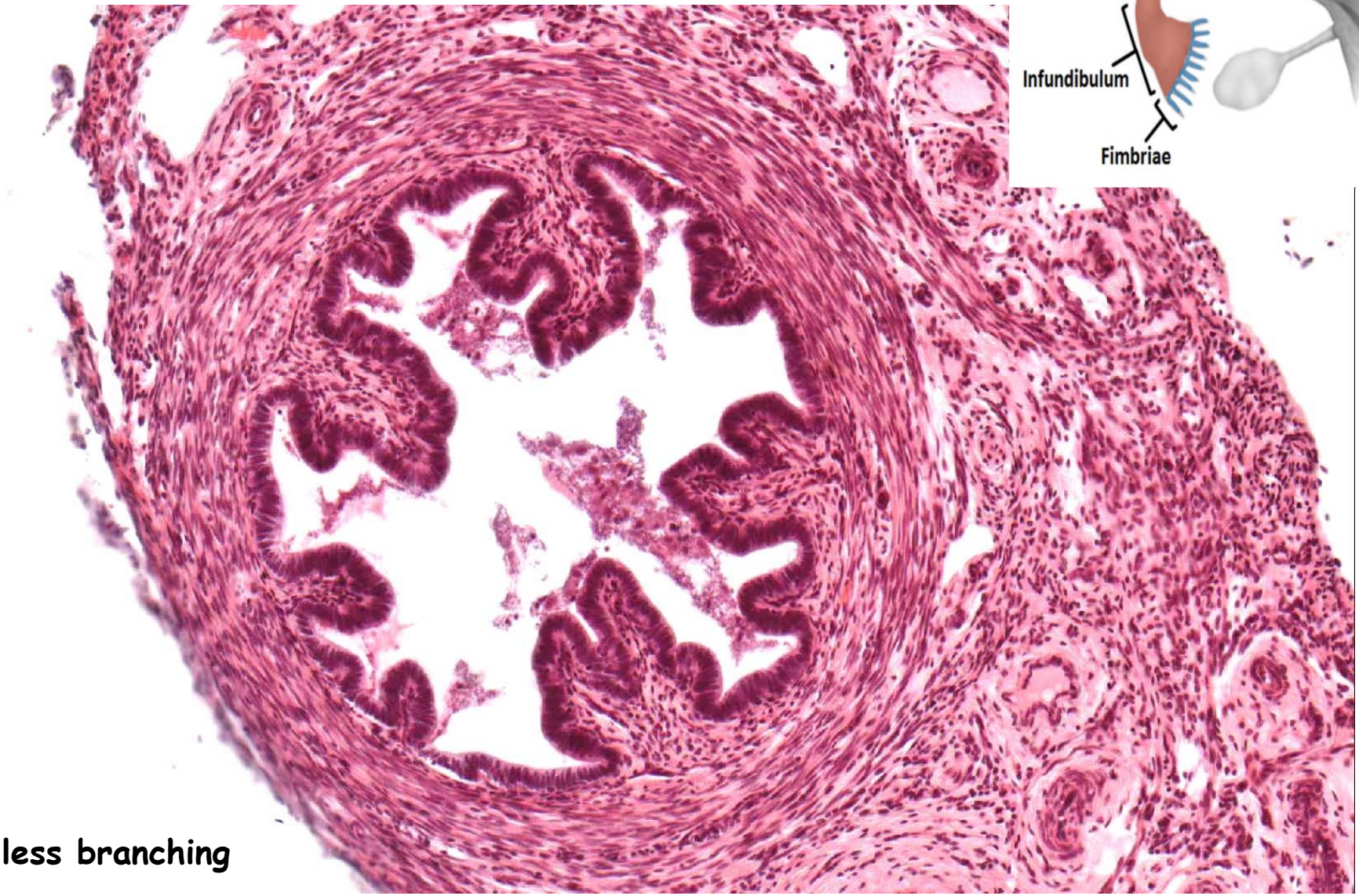
- highly branched mucosa
- longitudinal folds
- labyrinth

Oviduct - Ampula



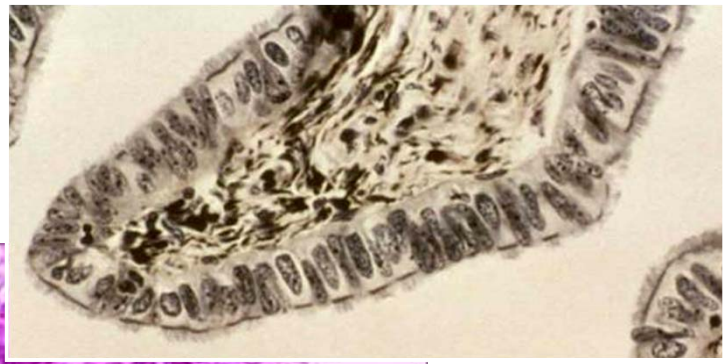
Oviduct - Isthmus

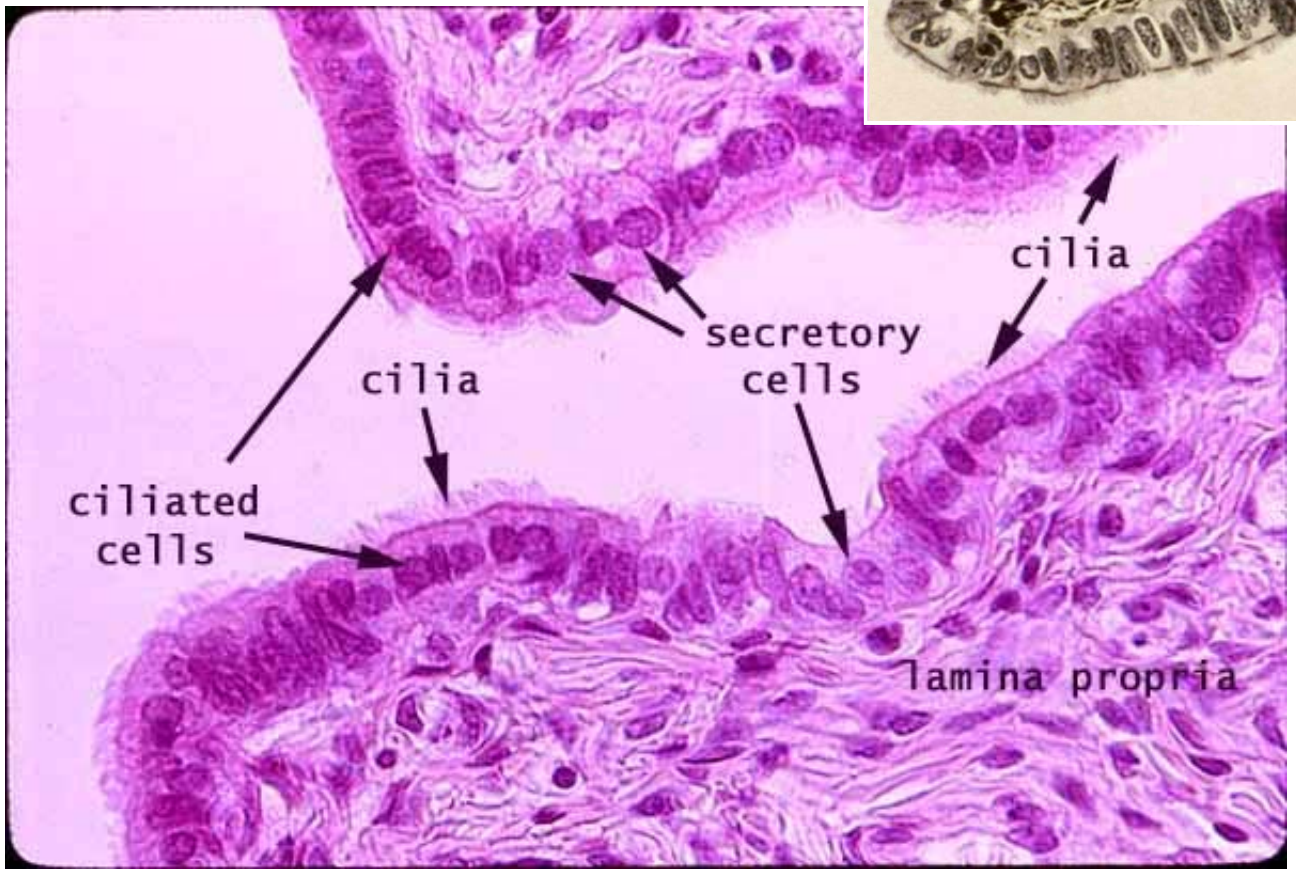




- less branching

Oviduct





Tunica mucosa

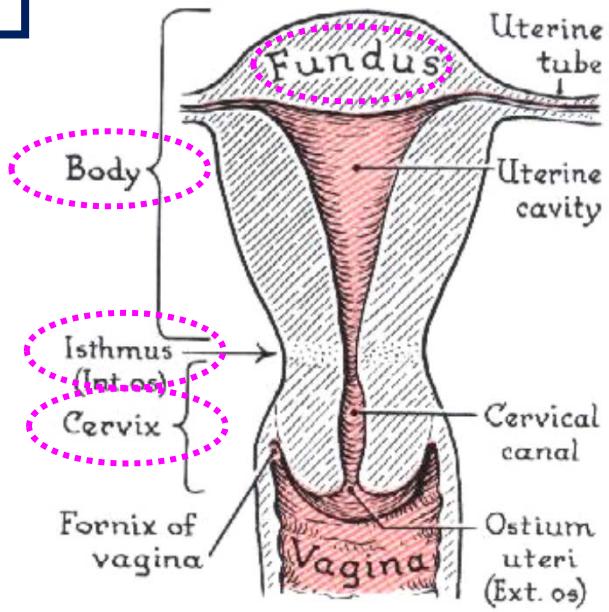
- *lamina epithelialis* – **simple columnar epithelium**

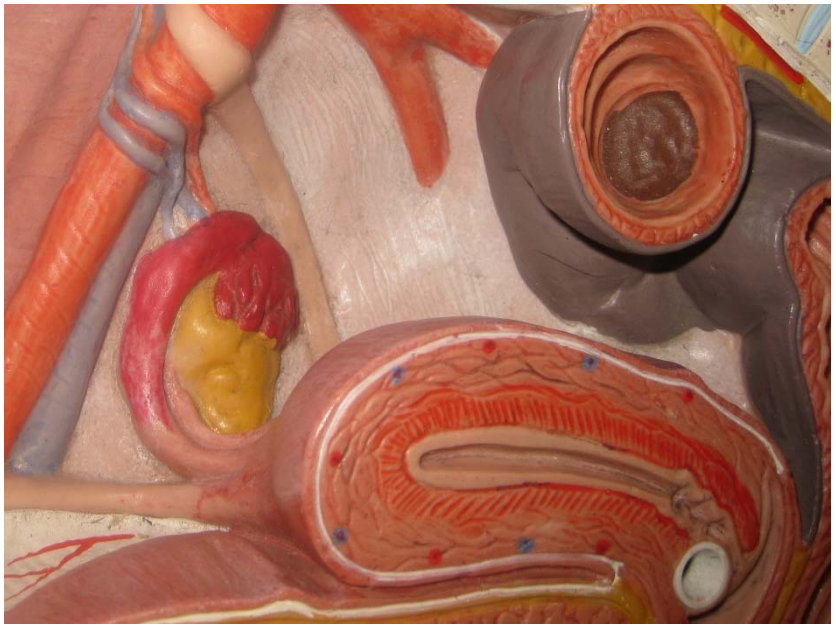
1.) **CILIATED CELLS** –possess many cilia- **transport** of the ovum and embryo

2.) **SECRETORY CELLS (PEG)** – secrete a **nutrient rich medium**

- *lamina propria* – **loose connective tissue** (is richly vascularized!)

Uterus 1



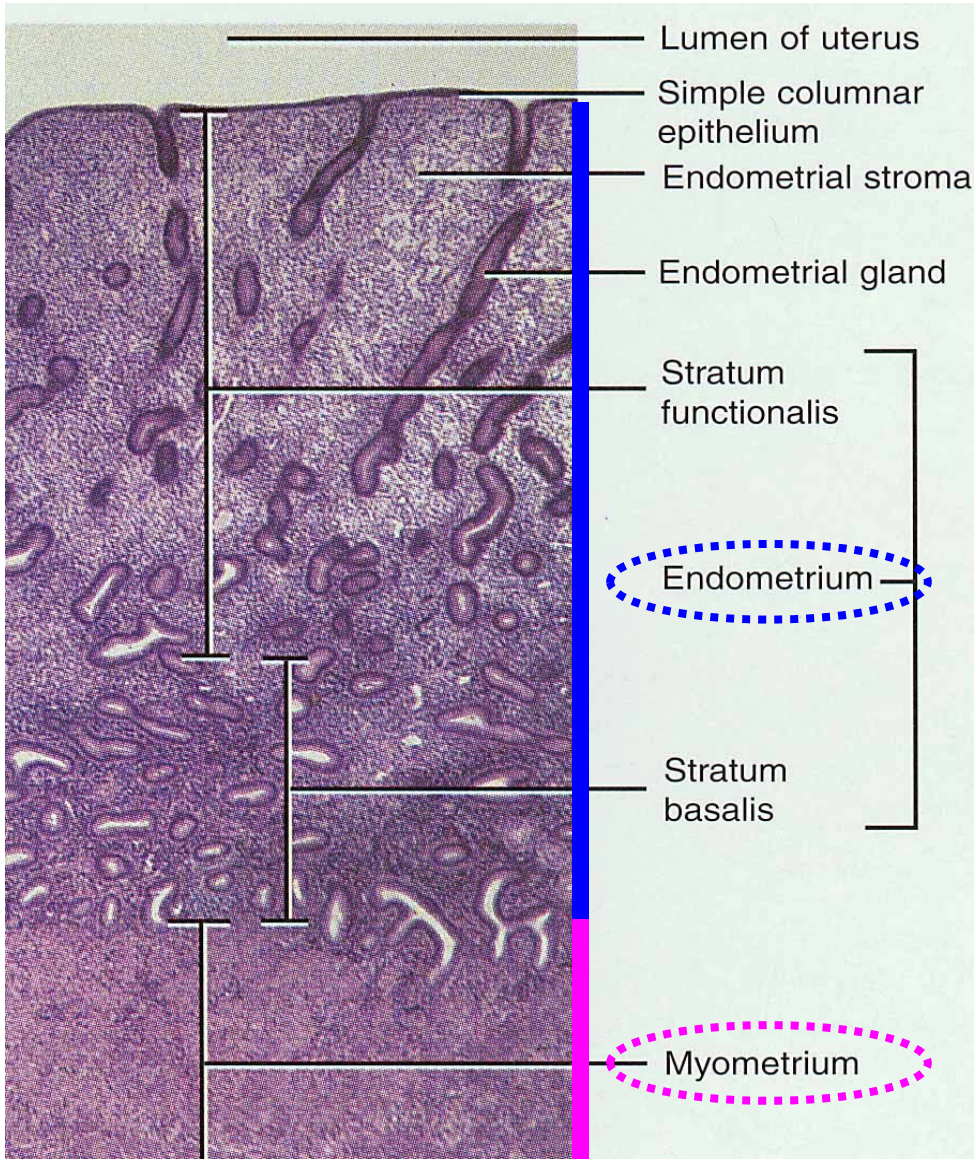


- **Mechanical protection and nutritional support to developing embryo**
- **Bends anteriorly** (anteflexion)
- **Stabilized by** broad, uterosacral, round, and lateral **ligaments**

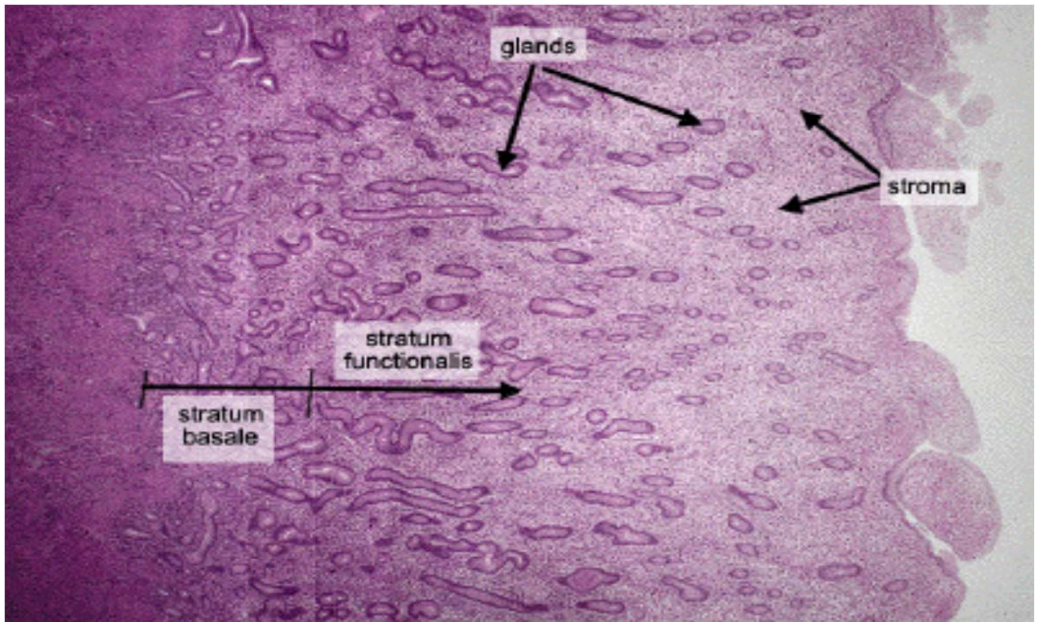
Uterus 2

Uterine wall ~ 1.5 - 2 cm

1. Endometrium – *T. Mucosa*
2. Myometrium – *T. muscularis*
3. Perimetrium – *T. Serosa*



Uterus – Endometrium 1



Dartmouth Medical School, Virtual Histology
http://www.dartmouth.edu/~anatomy/Histo

- consists of ***lamina epithelialis*** and ***lamina propria***
- epithelial lining – **simple columnar epithelium** containing **secretory and ciliated cells**
- lamina propria – **loose connective tissue** with many stellate **fibroblasts**, contains *abundant amorphous ground substance*→ **uterine glands** – ***simple tubular glands*** (covered by simple columnar epithelial cells)

1. Stratum functionalis (~ 5 mm)

- exhibit **dramatic changes during menstrual cycle** every month (hormone-driven)
- shed during menstruation !

2. Stratum basale (~ 1 mm)

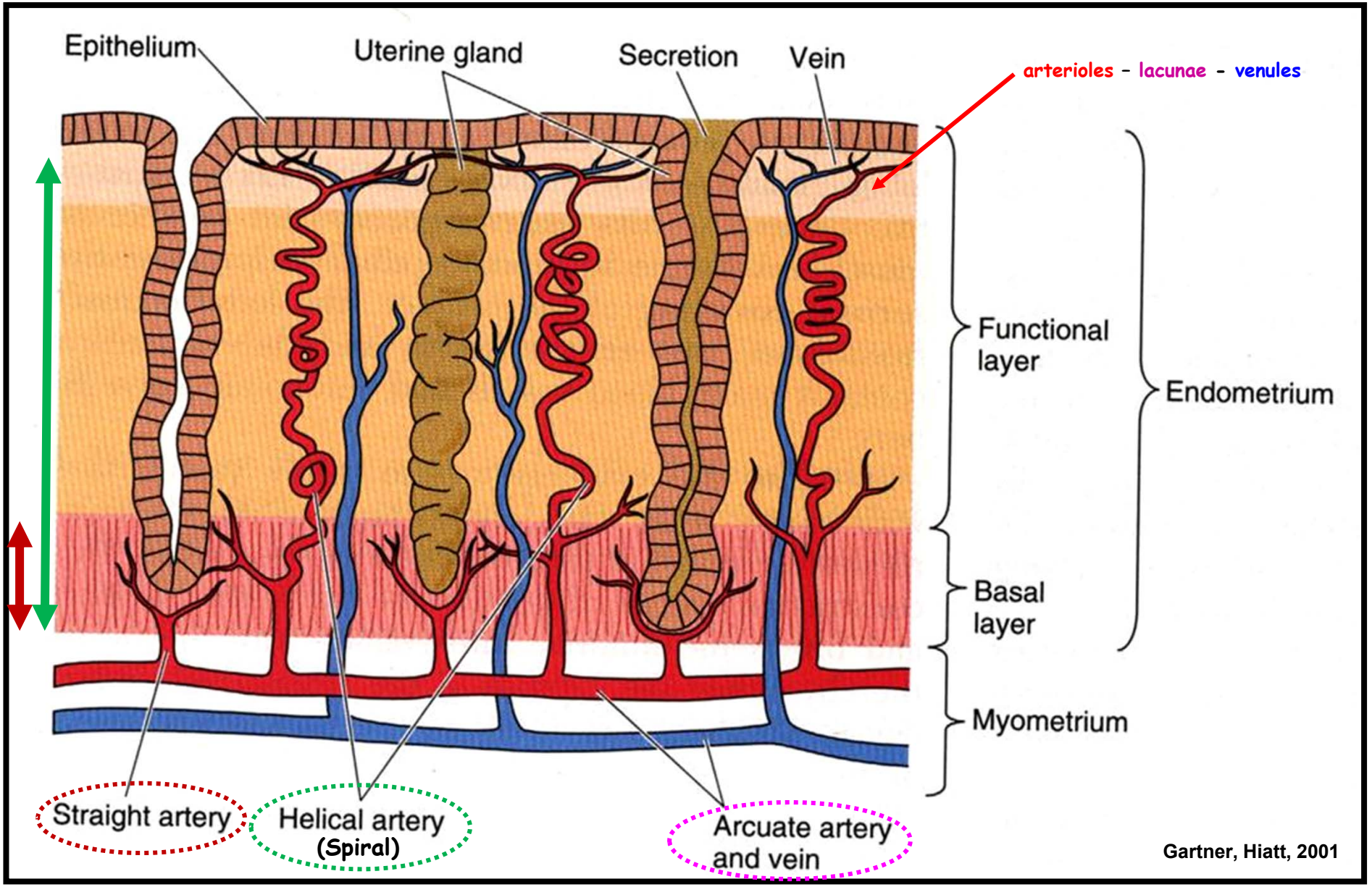
- undergoes little changes during the menstrual cycle
- **not shed during menstruation !**
- **provides a new epithelium and lamina propria for the renewal of the endometrium!**

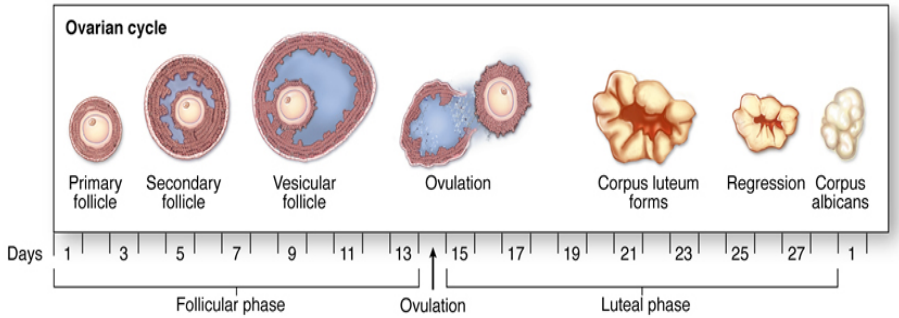
Uterus – Endometrium 2

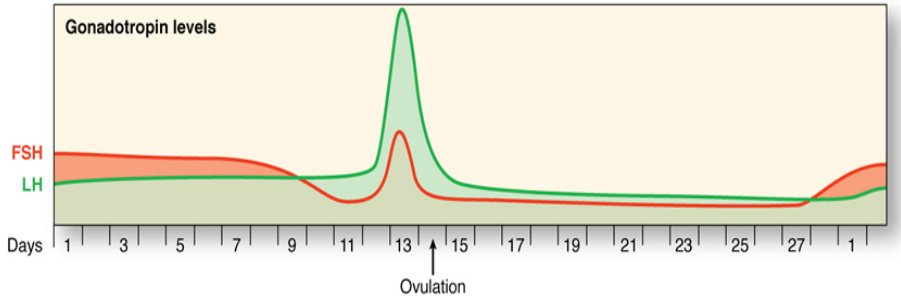
Simple columnar epithelium

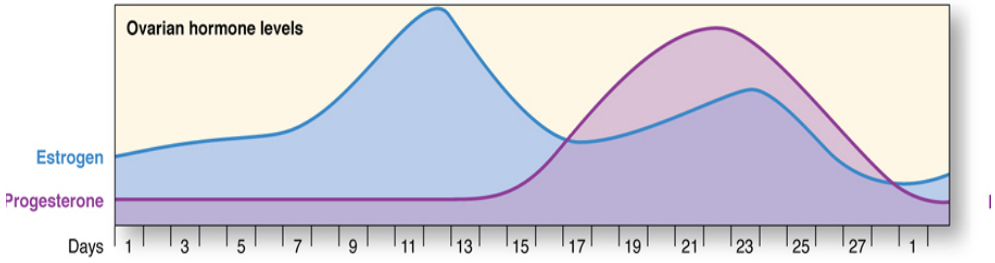
Endometrial glands

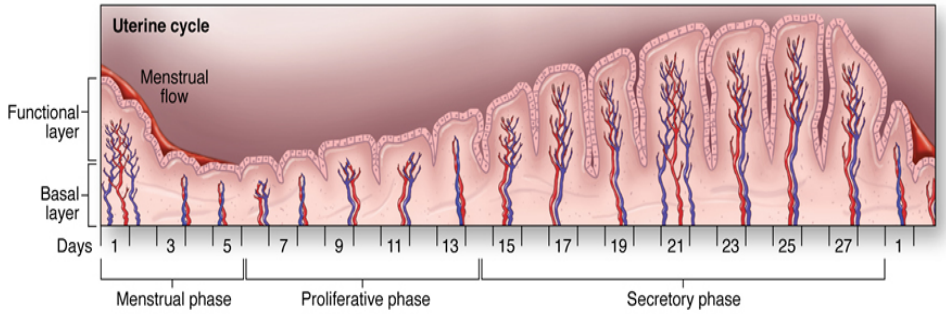
Uterus – Endometrium – Blood supply











Uterus – Menstrual cycle

(28 days)

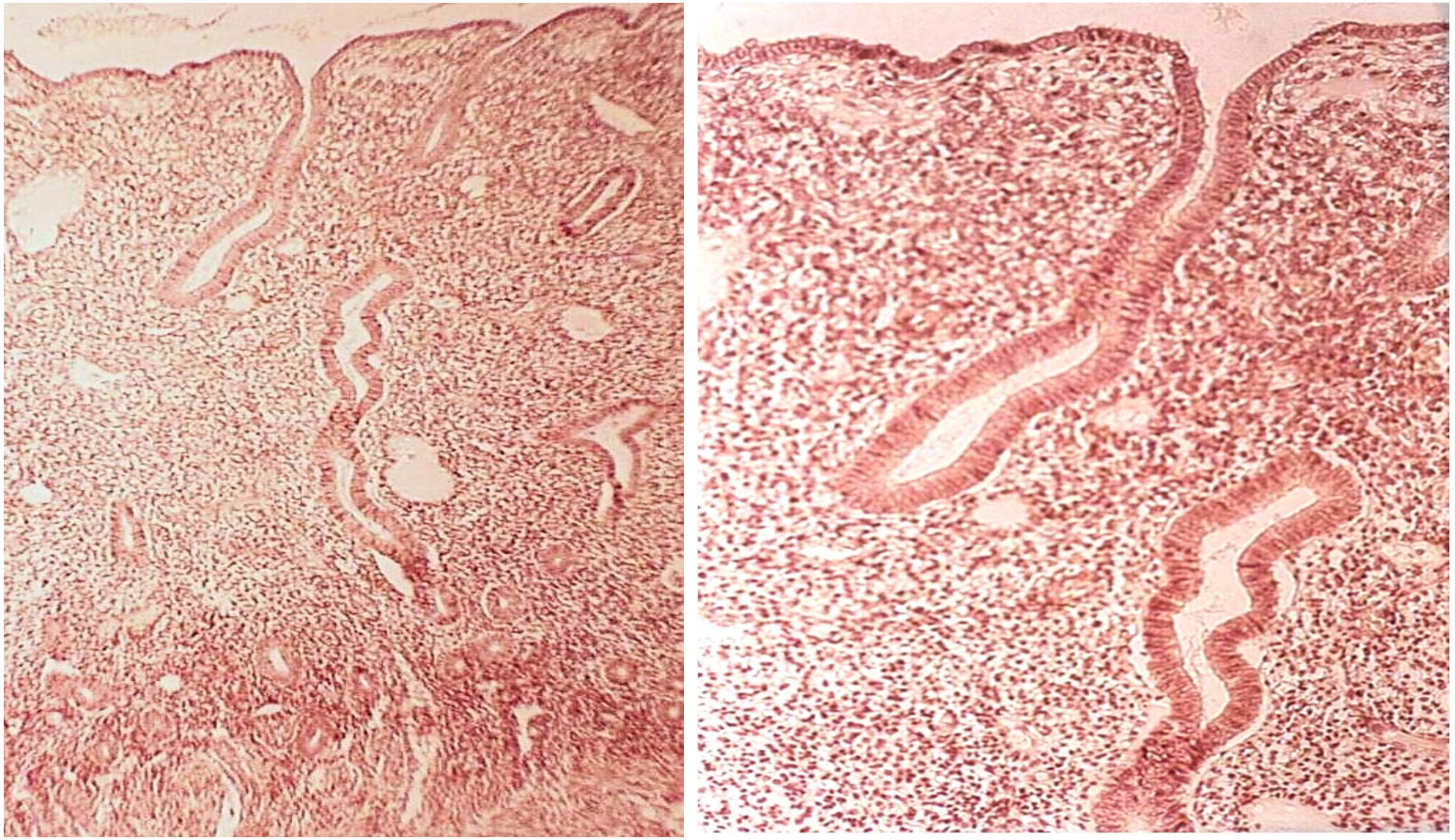
Menstrual phase (days 1 – 4)

Proliferative phase (days 5 – 15)
(driven by estrogens)

Secretory phase (days 16 – 27)
(driven by progesteron)

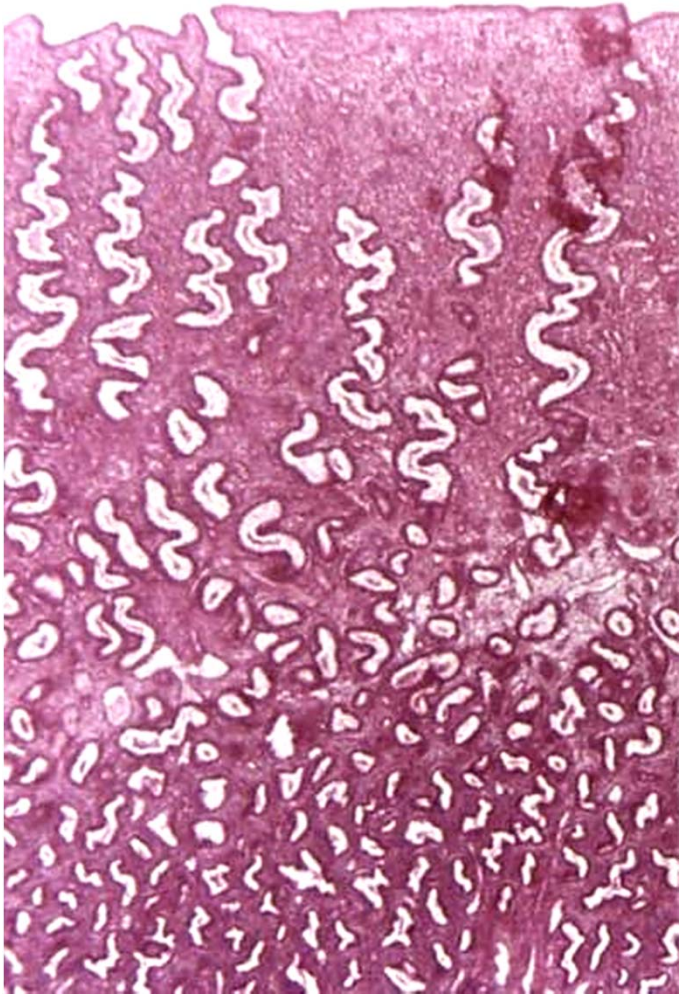
Ischemic phase (day 28)

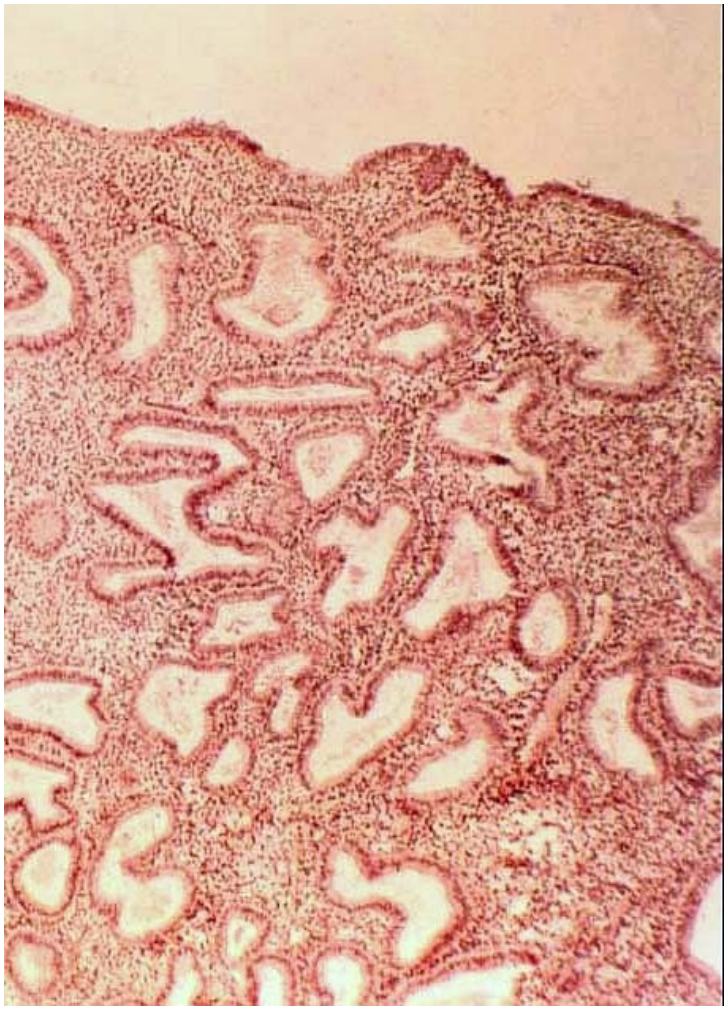
Endometrium – Proliferative phase



- rising estrogen from the developing follicles
- the stratum basalis is regrowing the stratum functionalis – new glands form
- long and straight uterine glands which are not yet functional

Endometrium – Secretory phase

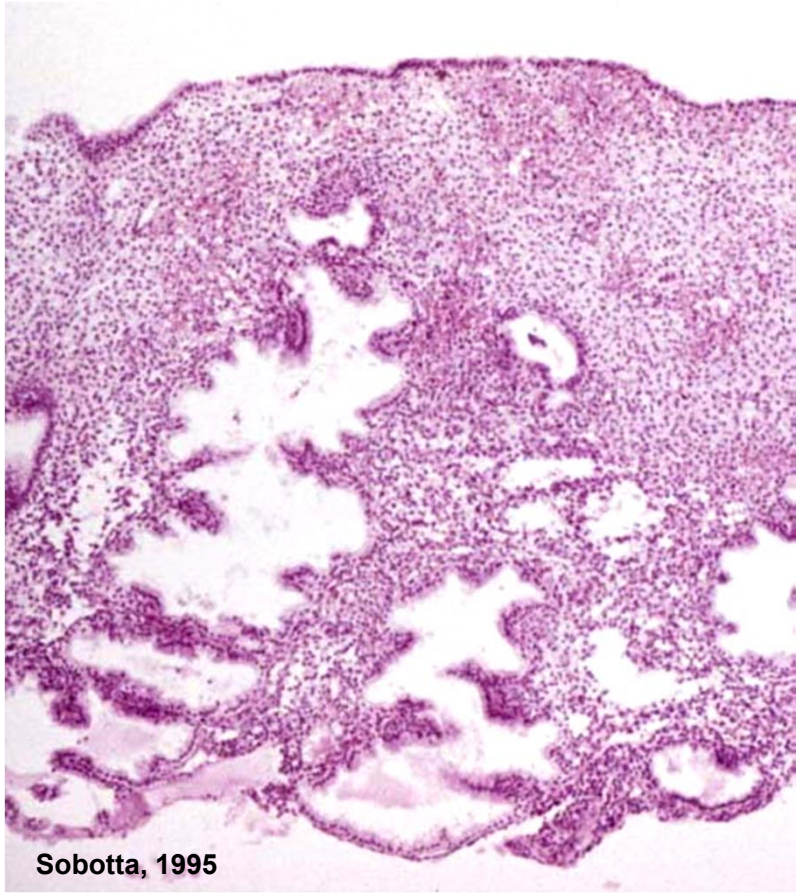


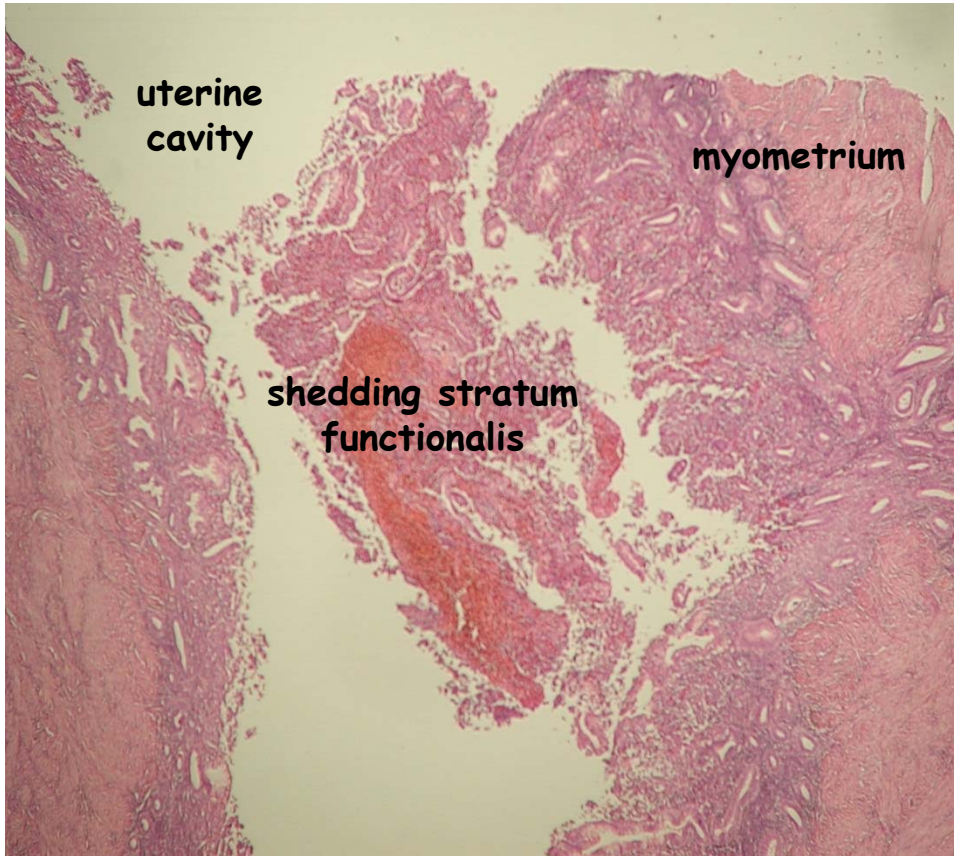


Sobotta, 1995

- under the control of estrogen and progesterone from the corpus luteum
- the uterine glands of the stratum functionalis begin to function, producing glycogen
- the curvy and dilated glands and elongated spiral arteries

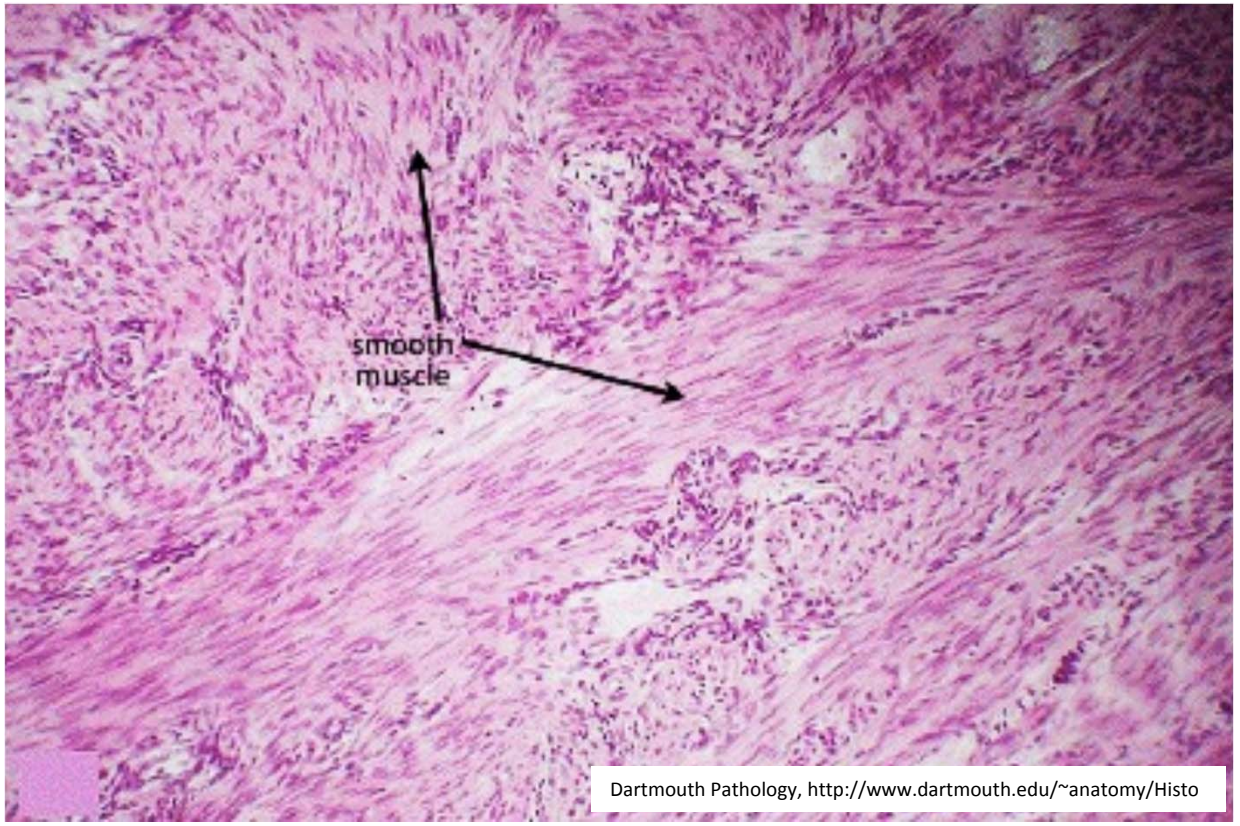
Endometrium – Menstrual phase





- lack of estrogen and progesterone from the dead corpus luteum
- the stratum functionalis dies and loses its anatomical integrity, breaking lose and shedding from the stratum basalis

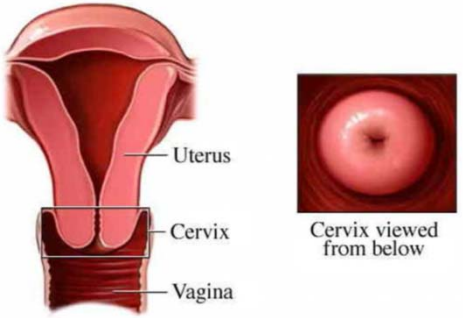
Uterus – Myometrium



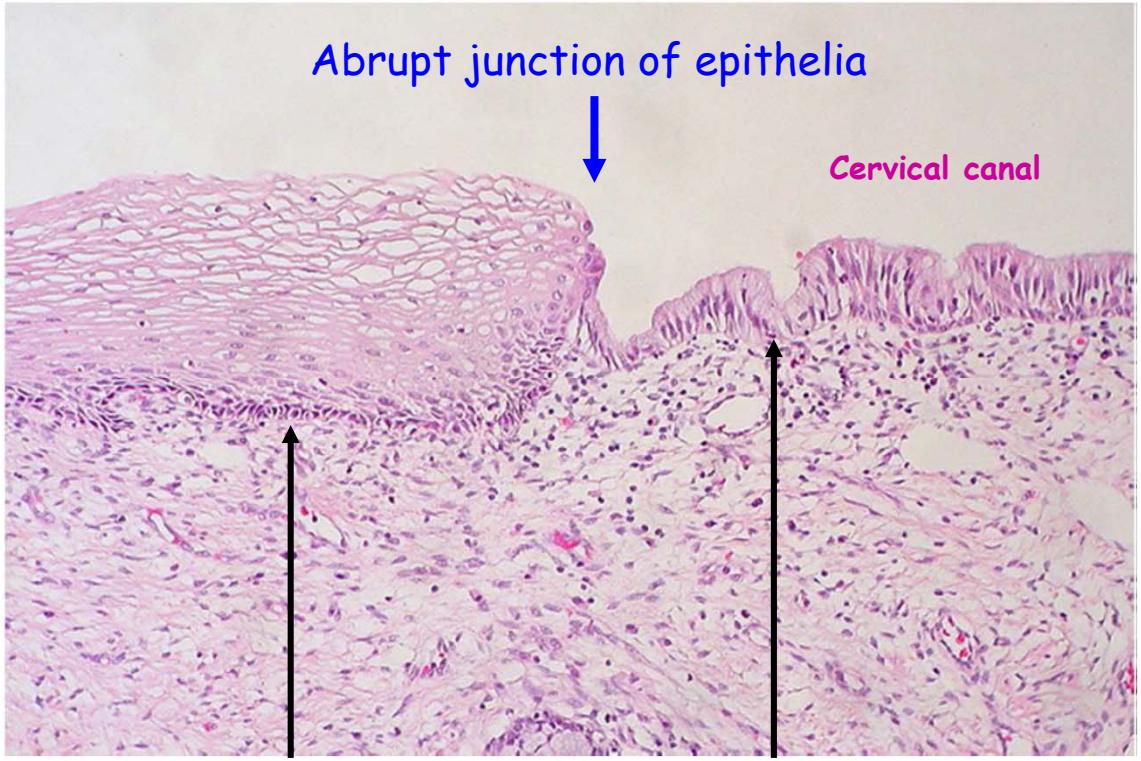
- three intewoven layers of smooth muscle
- during pregnancy – smooth muscle cell hyperplasia + hypotrophy
- contract in response to oxytocin during labor to expel the fetus from the uterus

The Cervix + Orificium externum uteri

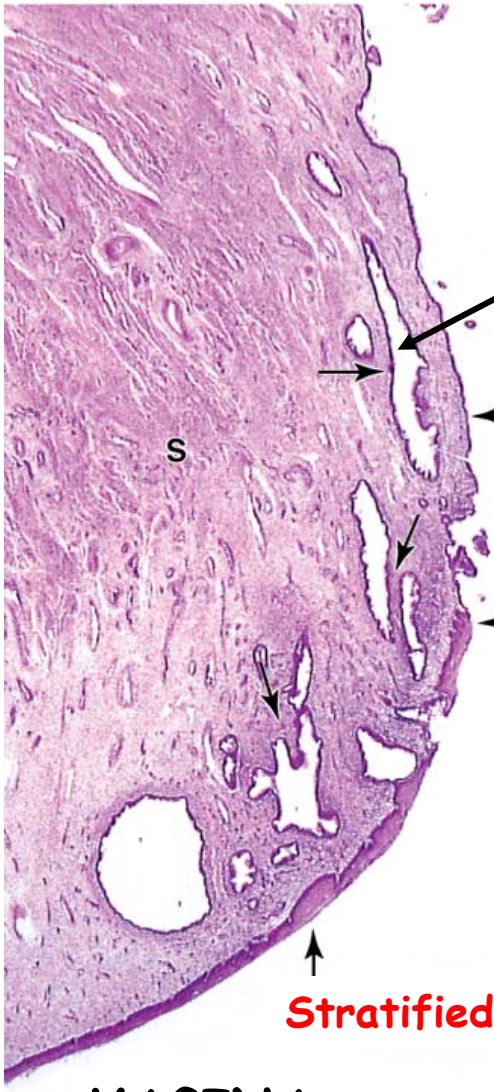
- **2-3 cm** in length
- **cylindrical** shape
- cervical canal connects lumen of uterus to lumen of vagina
- numerous **mucous glands**
- changes thickness throughout ovulation cycle
- important for pregnancy and childbirth
- contributes to **capacitation**



uvahealth.com



The Cervix



Cervical glands
(tubular, branched, mucus secreting)

Simple collumnar ep.

Junction - collumnar to stratified squamous ep.

Stratified squamous ep.

a **VAGINA**

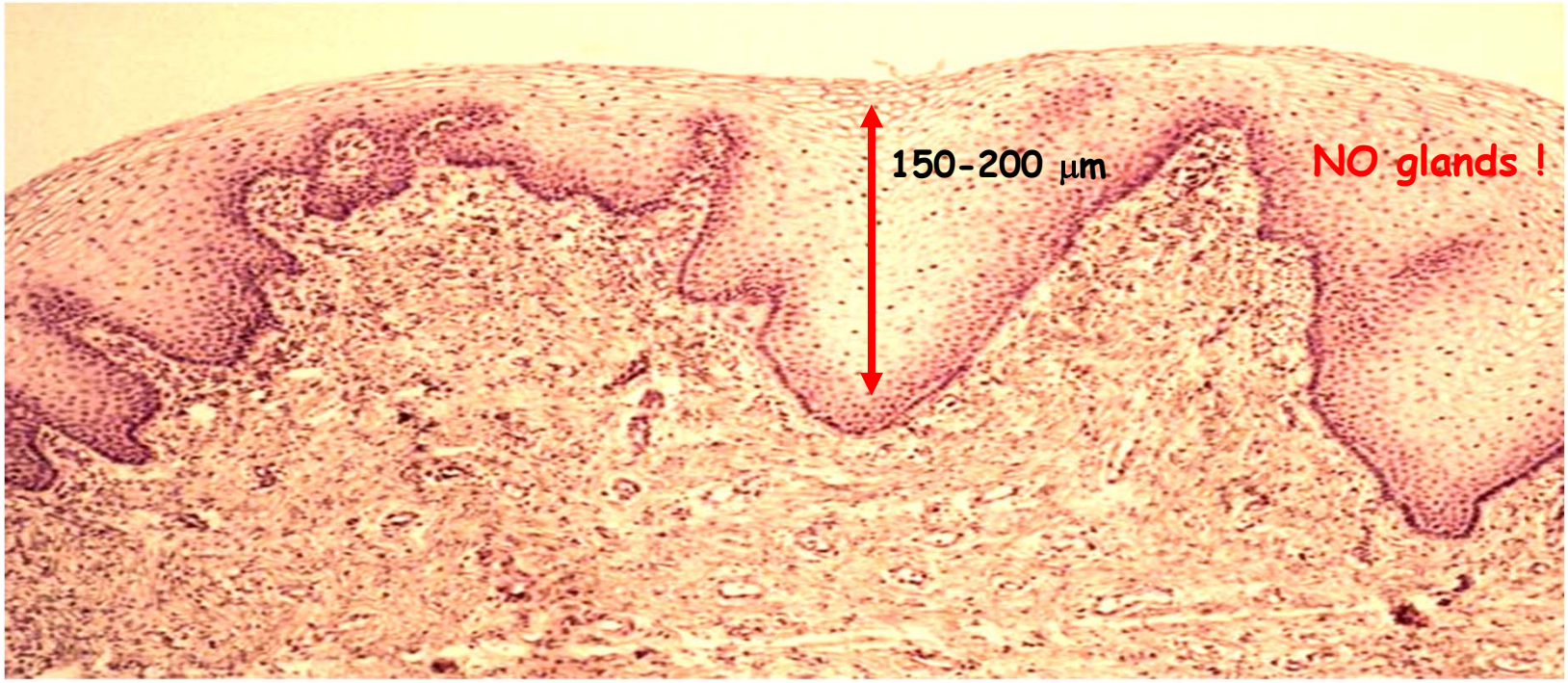
Mescher, 2016

Vagina 1

- receives sperm during copulation
- serves as birth canal

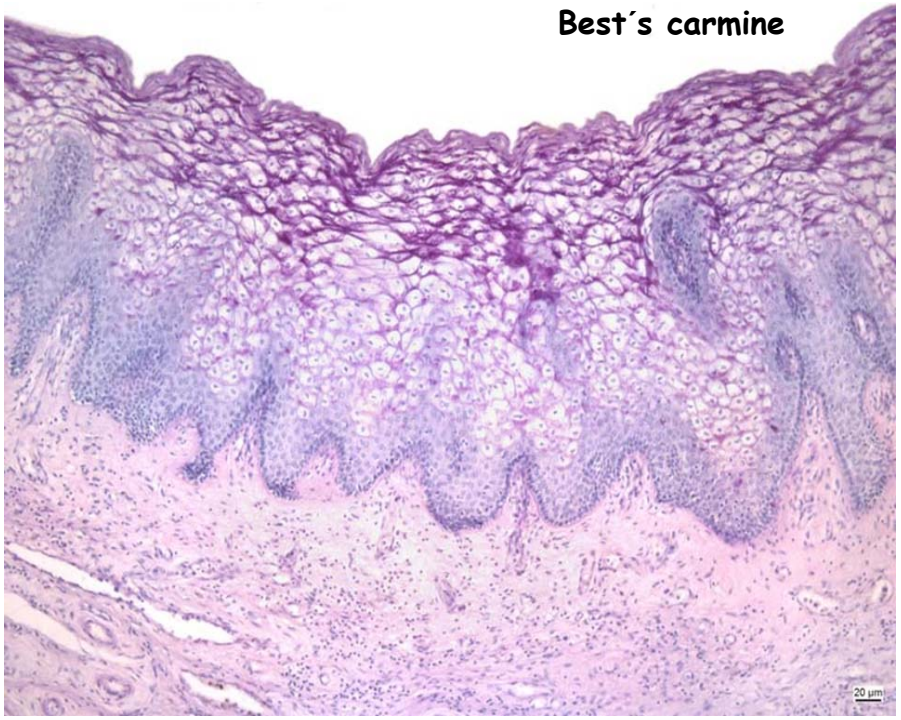
3 tissue layers

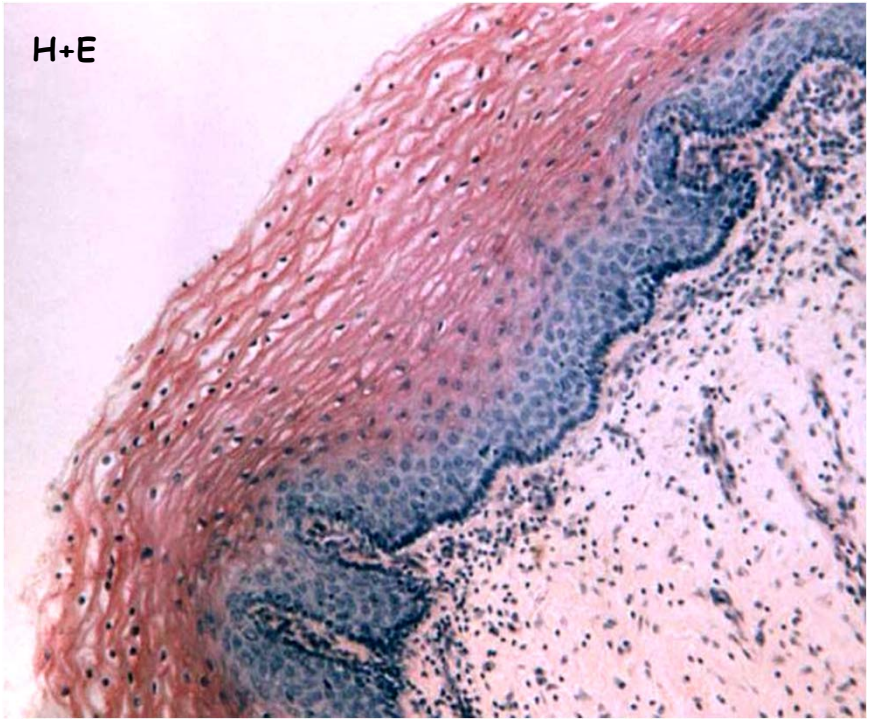
a) mucosal layer – inner layer; non-keratinizing stratified squamous
b) muscular layer – middle layer; smooth muscle in two layers
c) advetitia – outer layer; areolar connective tissue



Vagina 2

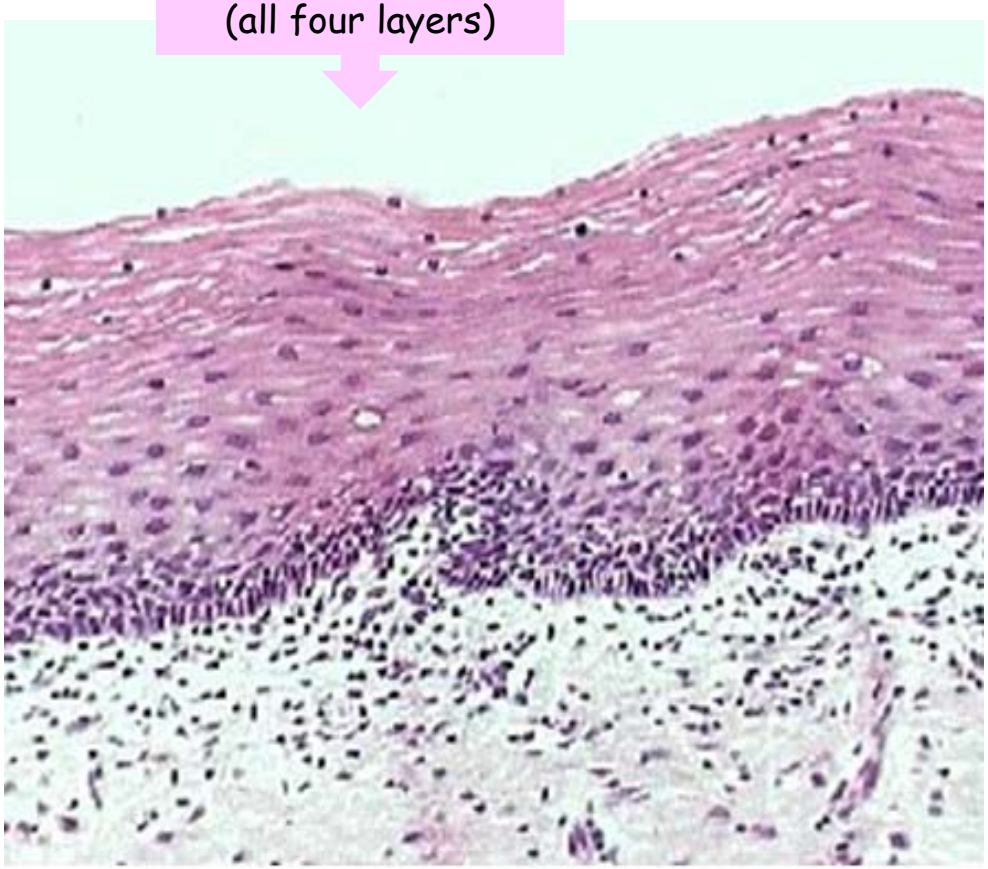
Epithelial cells sythesize and accumulate **glycogen** (upon stimulation by estrogens)

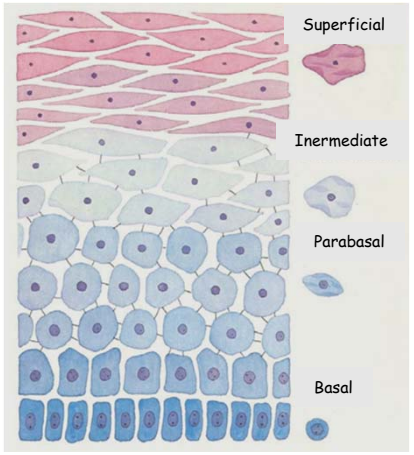




Vagina 3

Preovulatory state
(all four layers)

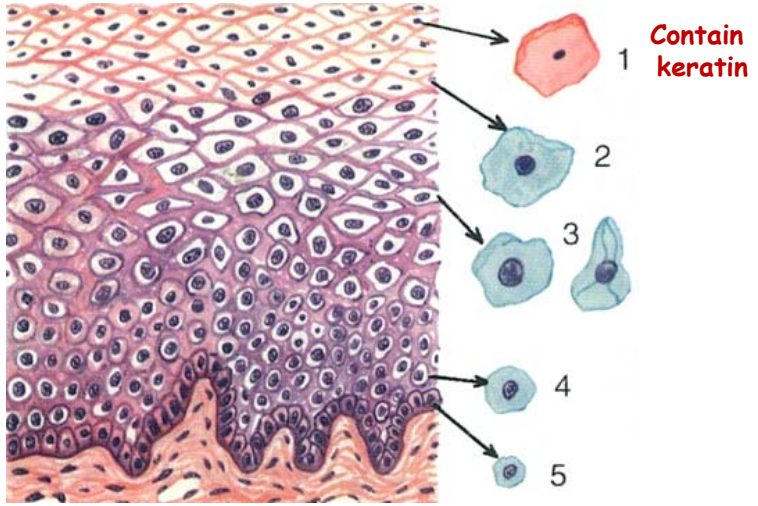




Released after ovulation

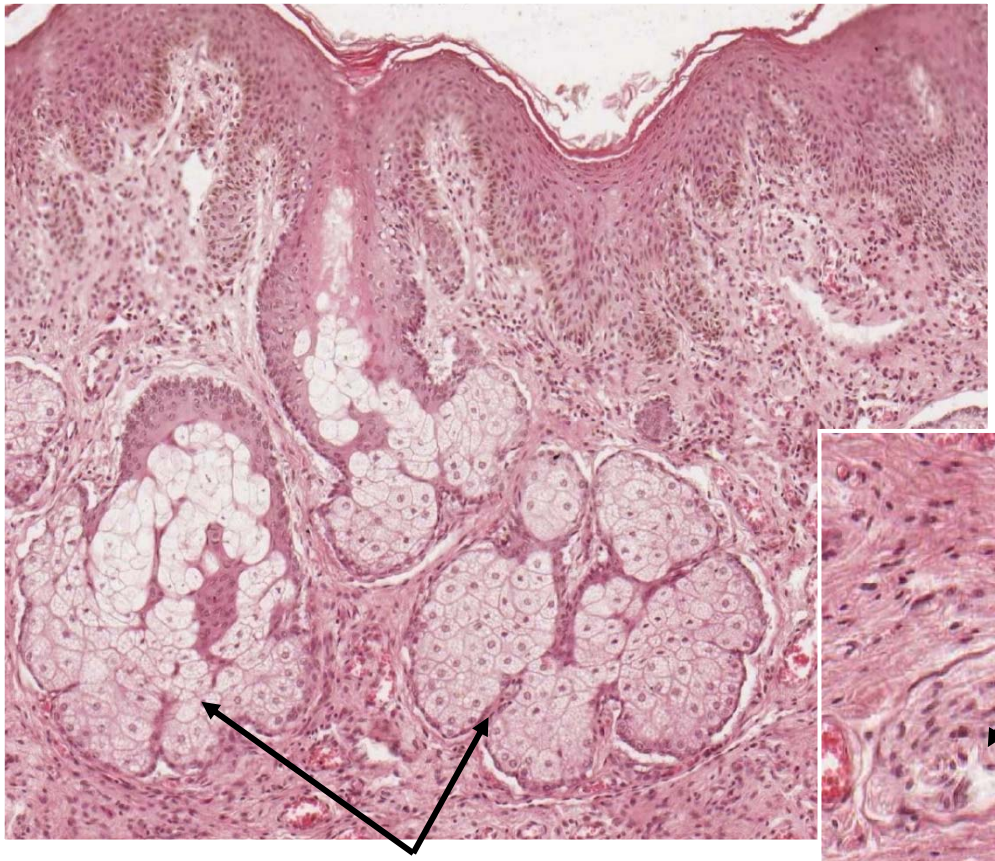
- glycogen
- Lactobacillus
- acidification

Cervical smear – Giemsa staining



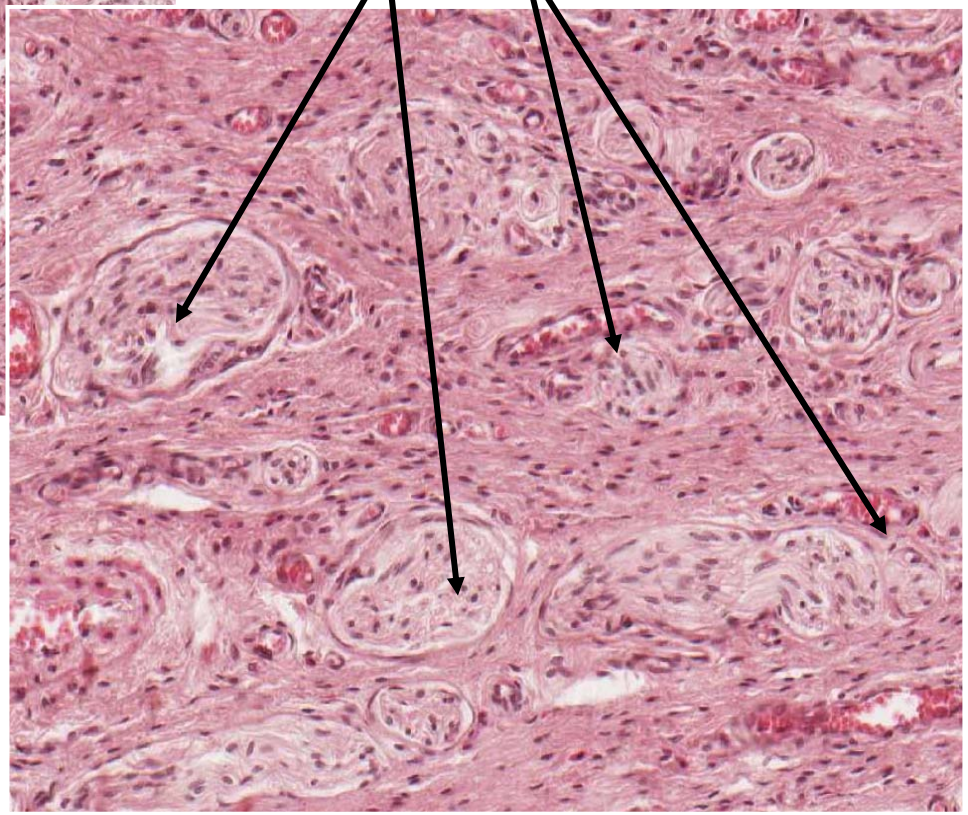
Labia minora

Covered by hairless skin



Sebaceous glands

Nerves Veins



Placenta 1

Temporary organ

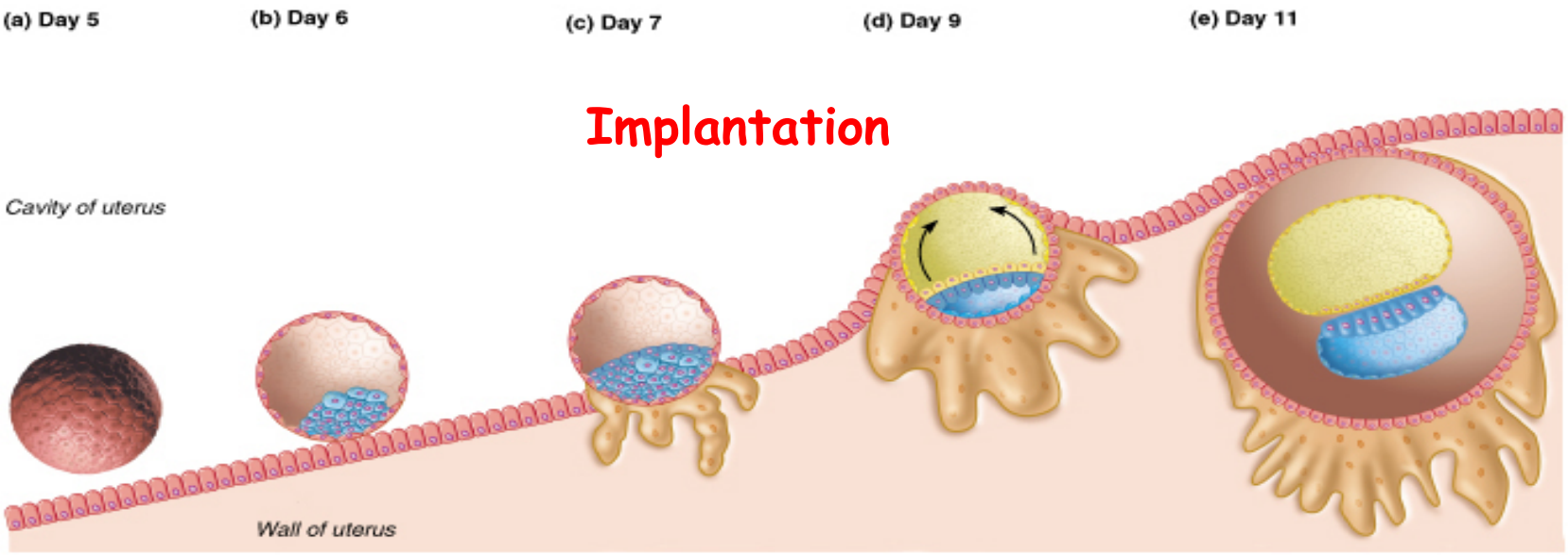
Functions

1) **transport** (water, oxygen, carbon dioxide, nutrients, antibodies, drugs, waste, …)
2) **metabolism** (synthesis of glycogen, cholesterol, fatty acids)
3) **hormonal production**

steroids: progesteron, estrogen – maintenance of pregnancy

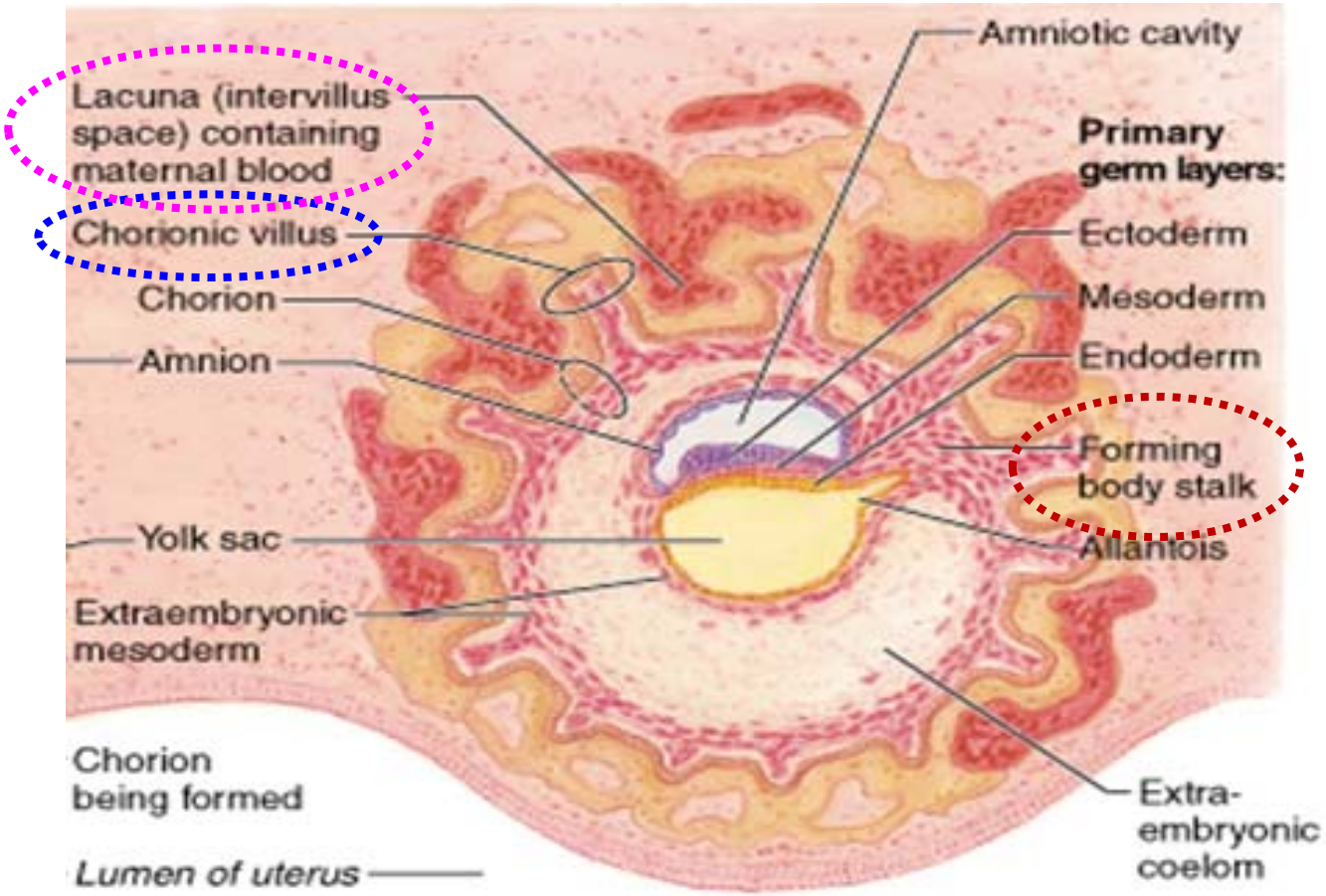
peptides: human chorionic gonadotropin, human placentar lactogen, relaxin, leptin, growth factors)

Implantation



Syncytiotrophoblast invades the sorrounding stroma

Placenta 2



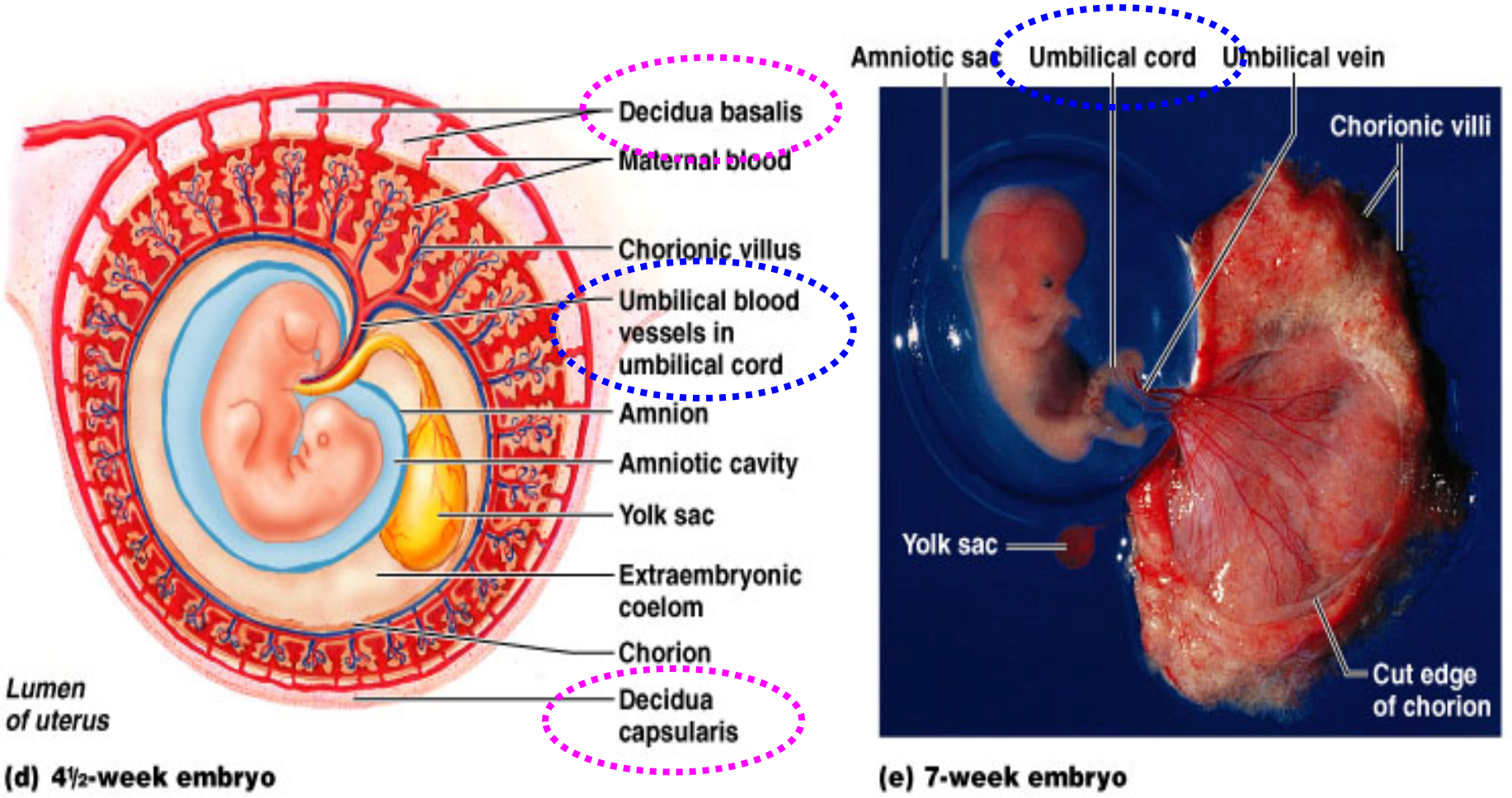
(c) 16-day embryo

Chorionic villi - finger like projection of embryonic tissue that come in contact with bleeding endometrium

Decidual cells – fibroblast of endometrium (large, cuboidal, very active proteosynthesis)

Placenta – thick disk made by decidua and chorionic villi (formed at the start of month 4)

Placenta 3



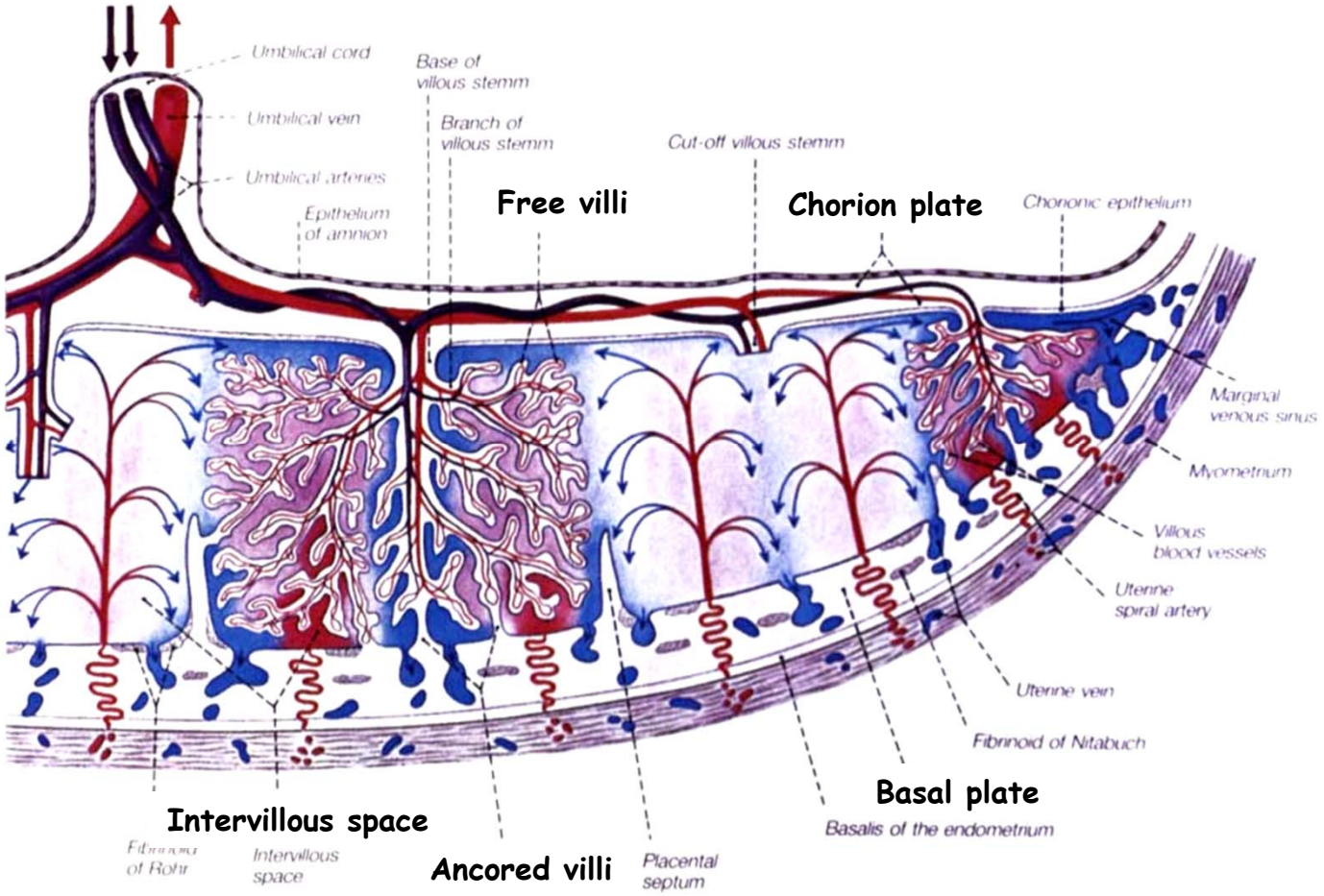
Decidua basalis – between embryo and myometrium
Decidua capsularis – between embryo and the uterine lumen (thins as the embryo grow)

discoid
15 – 20 cm
400 – 600 g

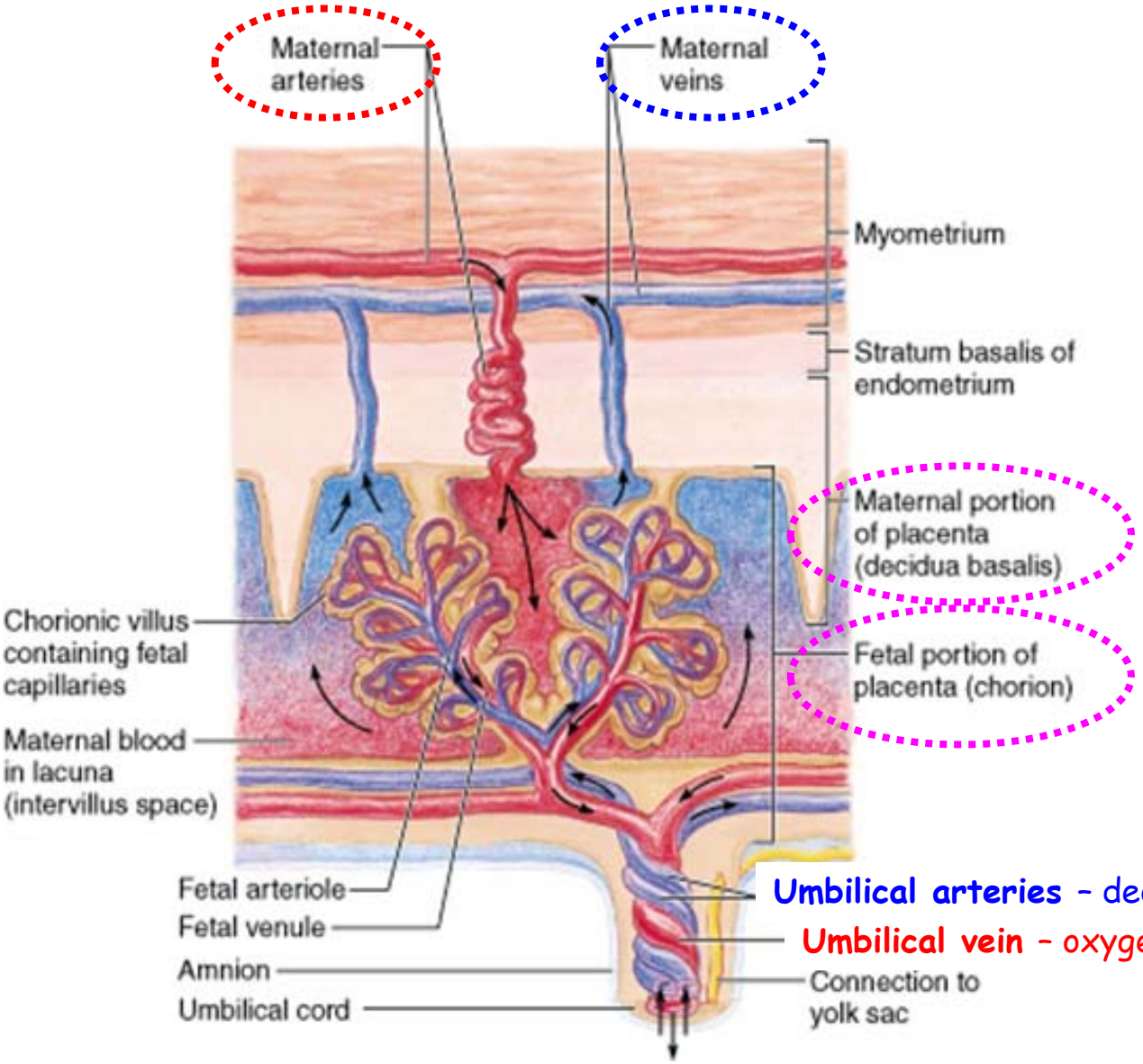
Placenta 4

Discoidalis + Hemochorialis

- **pars fetalis** – chorion plate, chorion villi (anchored, free = terminal)
- **pars materna** – decidua basalis
- **intervilous spaces** – develop from lacunes



Placenta 5



Umbilical arteries – deoxygenated blood

Umbilical vein – oxygenated blood

Placenta 6

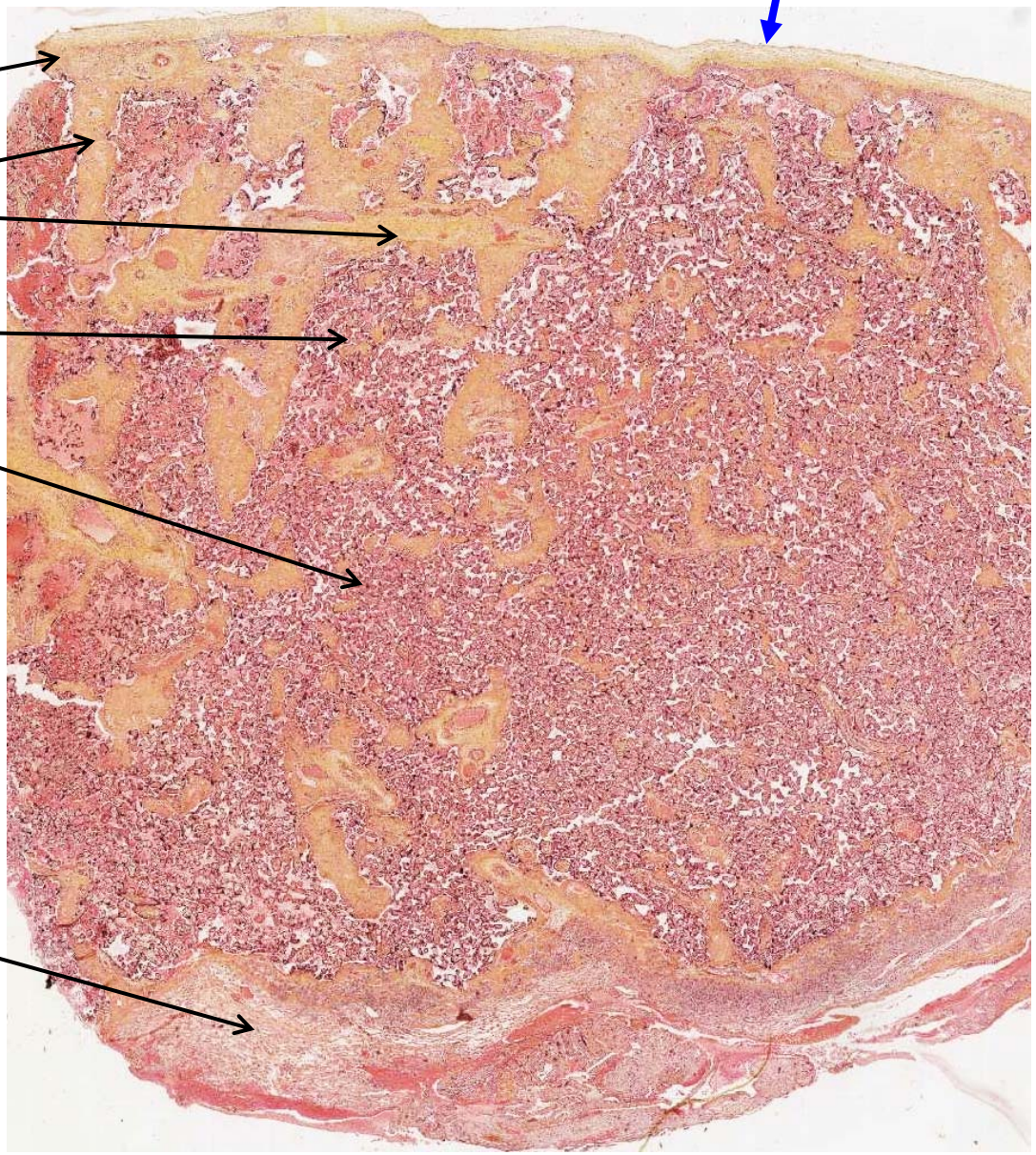
Ambiotic epithelium
(ectoderm)

Pars fetalis

Chorion plate

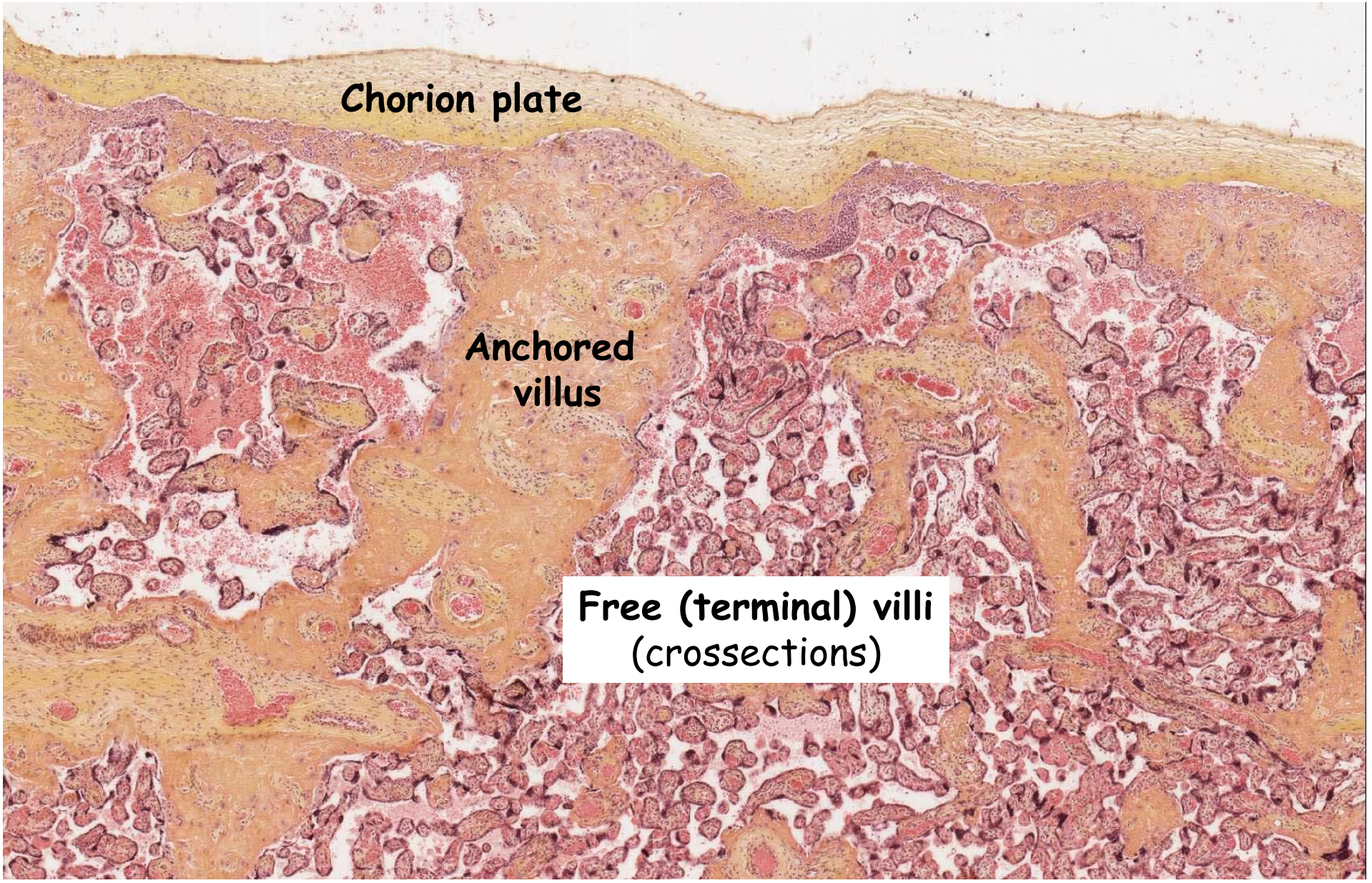
Anchored villi

Free villi

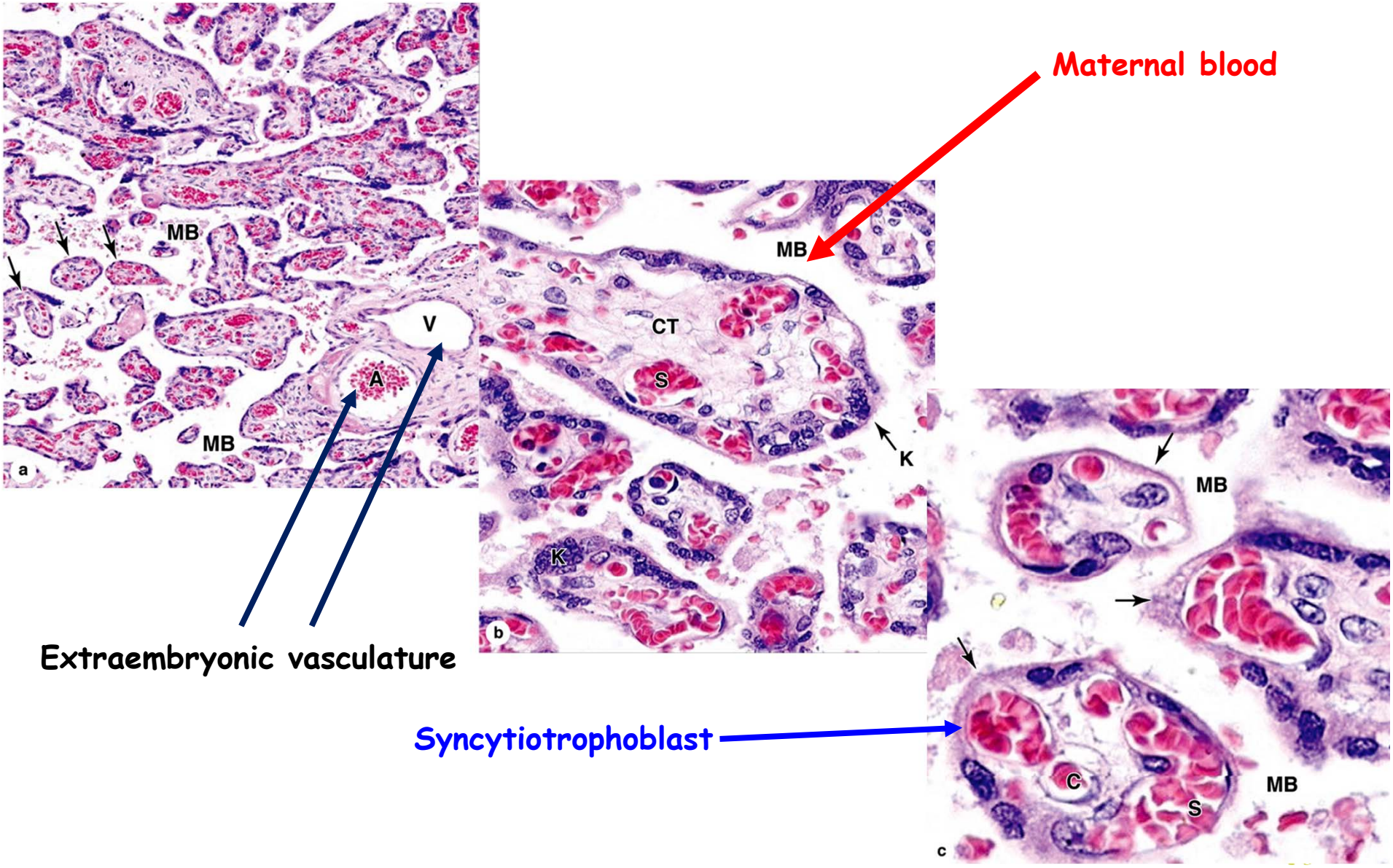


Pars materna

Placenta 7


Chorion plate
Anchored villus
Free (terminal) villi
(crossections)

Placenta 8 – Free villi



Mescher, 2010

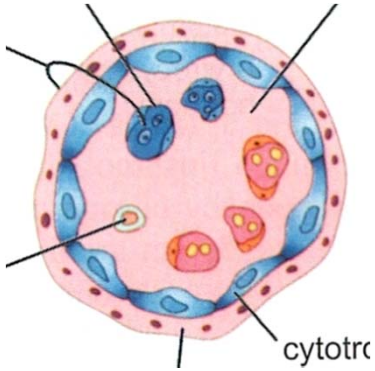
Placental barrier

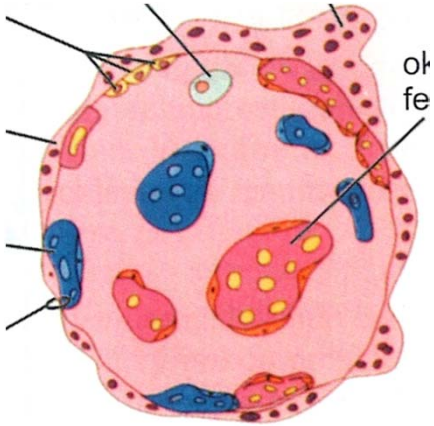
Until mid pregnancy

- capillary endothelium
- basal lamina of endothelium
- mucous connective tissue
- cytotrophoblast
- basal lamina of syncytiotrophoblast
- syncytiotrophoblast

Since month 5

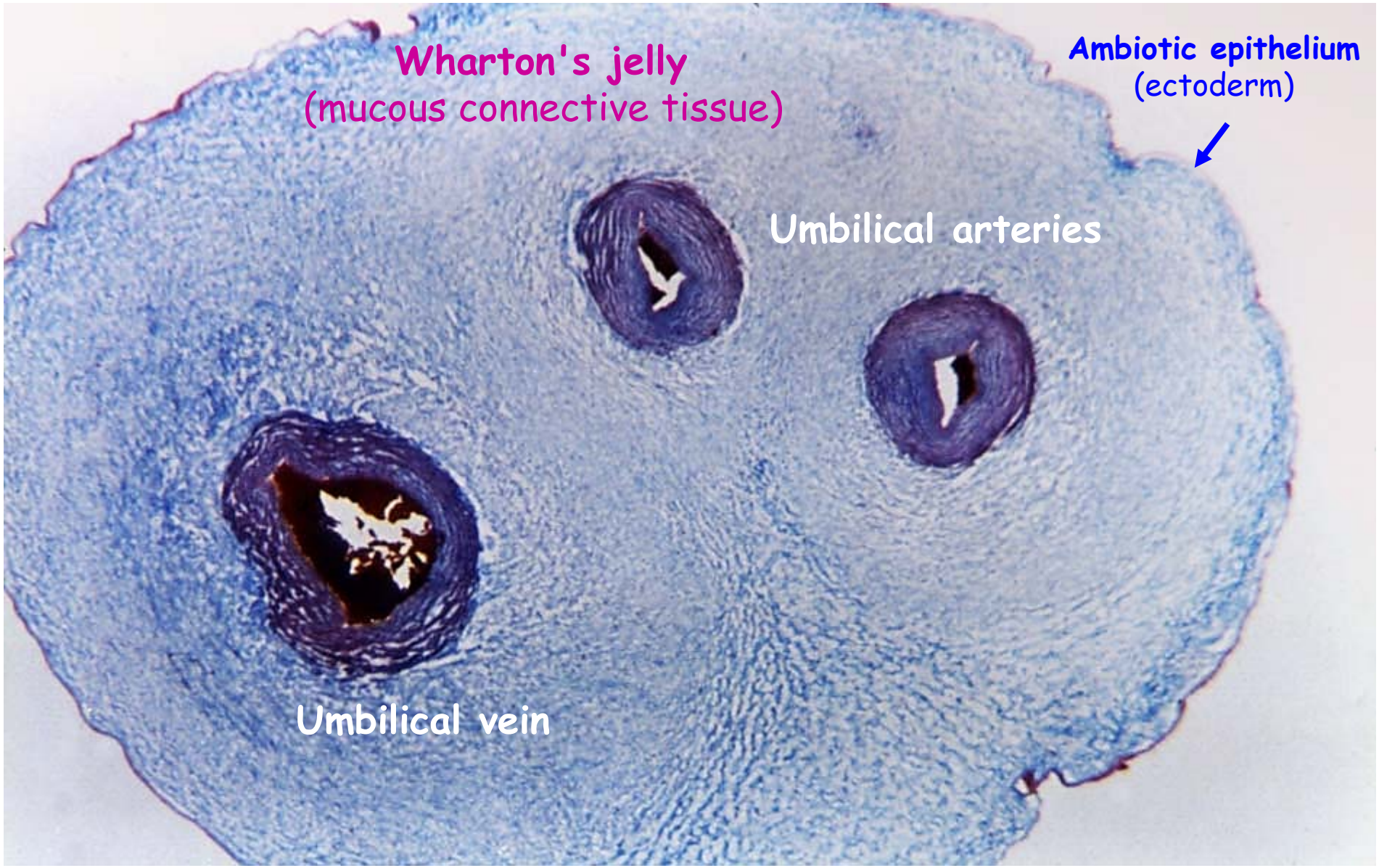
- capillary endothelium
- basal lamina of endothelium
- basal lamina of syncytiotrophoblast
- syncytiotrophoblast



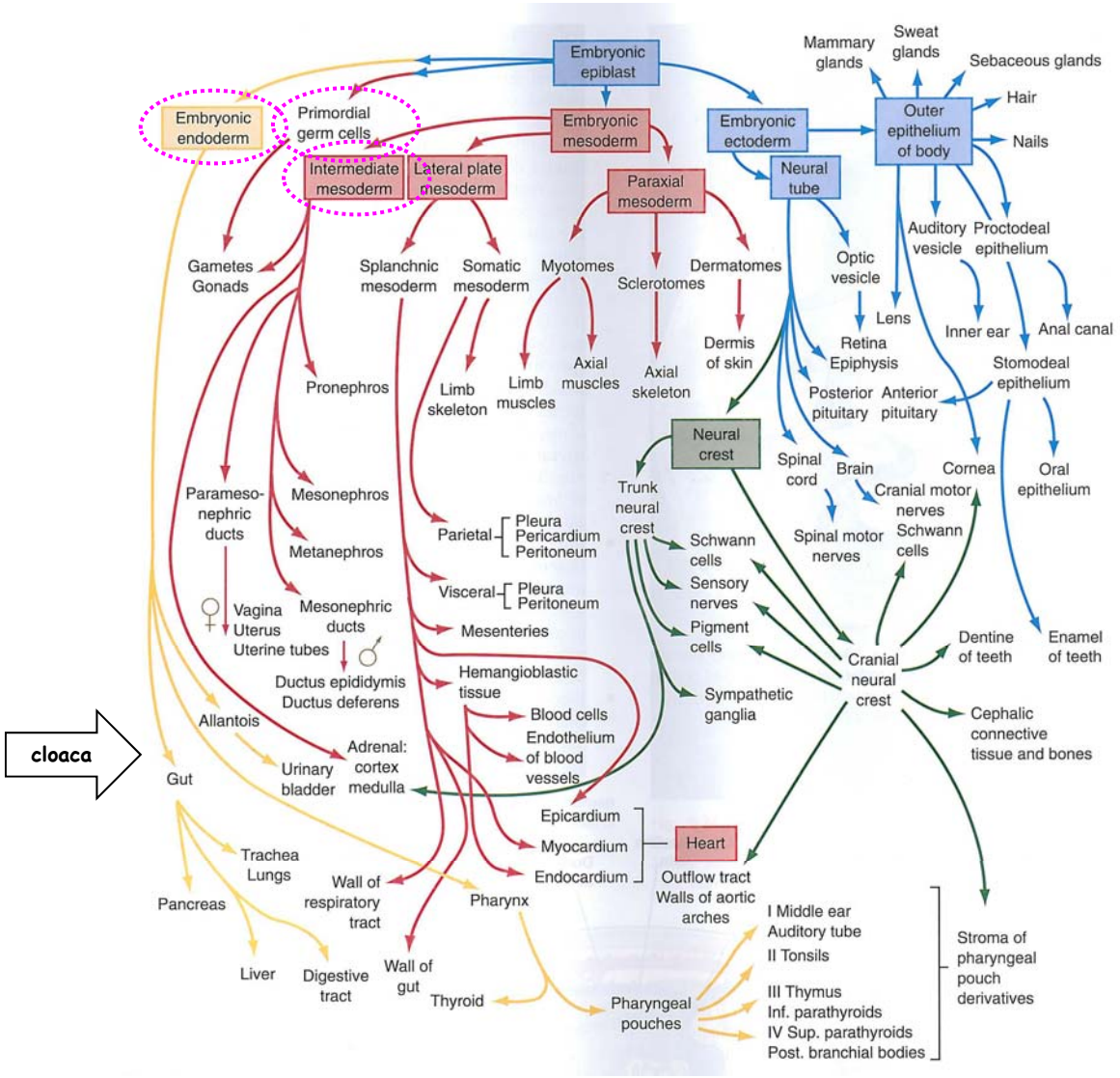


Umbilical cord

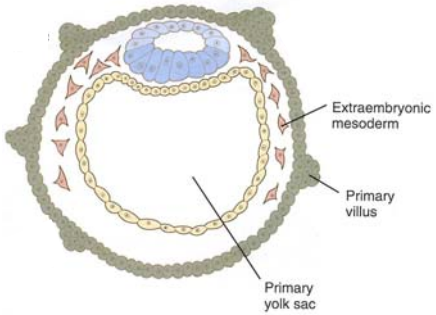
- links foetus to placenta
- about 55 cm in legth

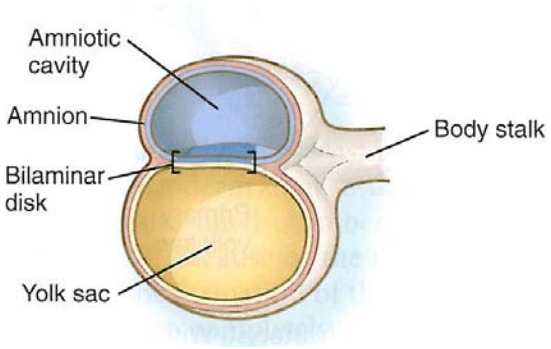


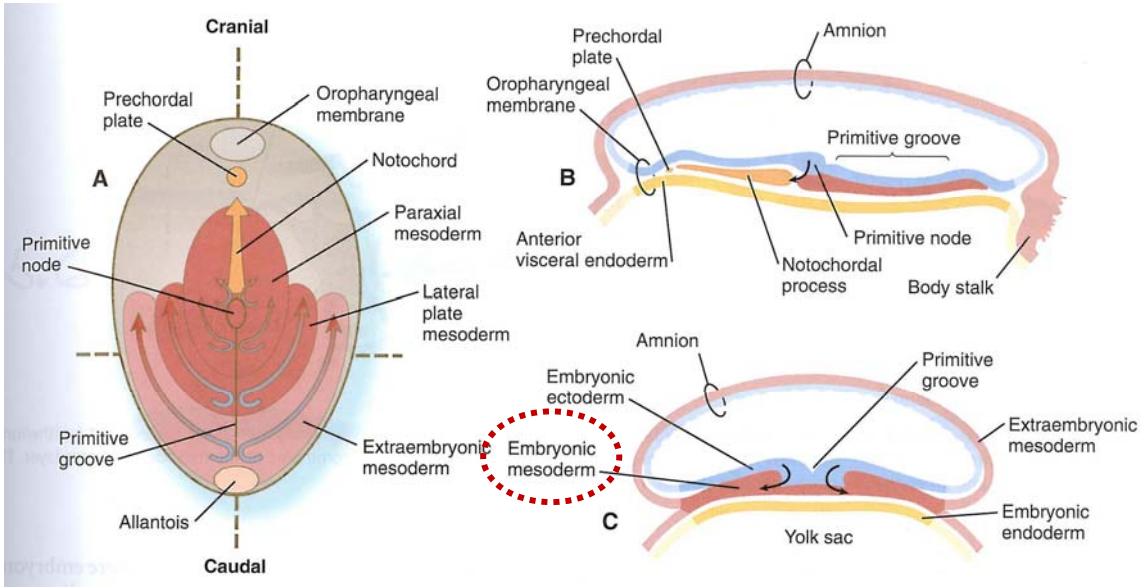
Urogenital system – Overall picture



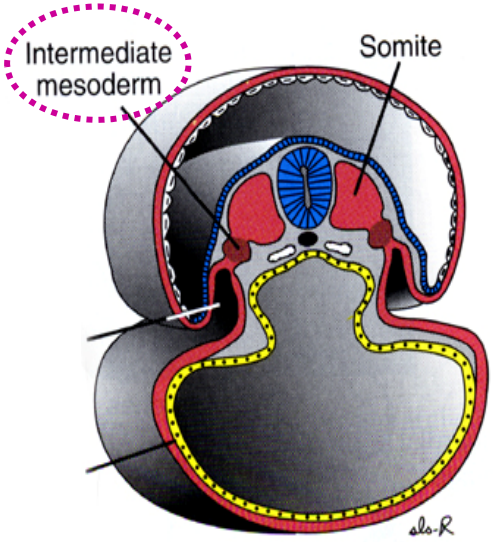
Urogenital system – Reminder

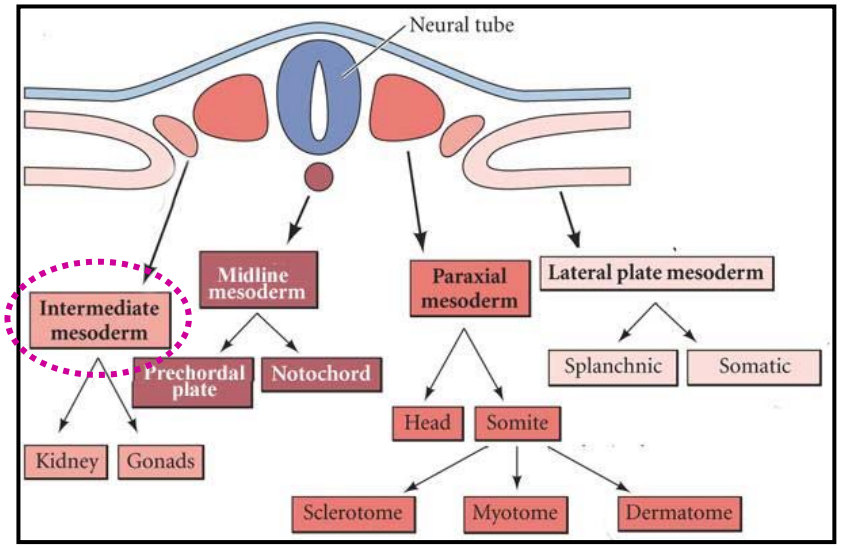


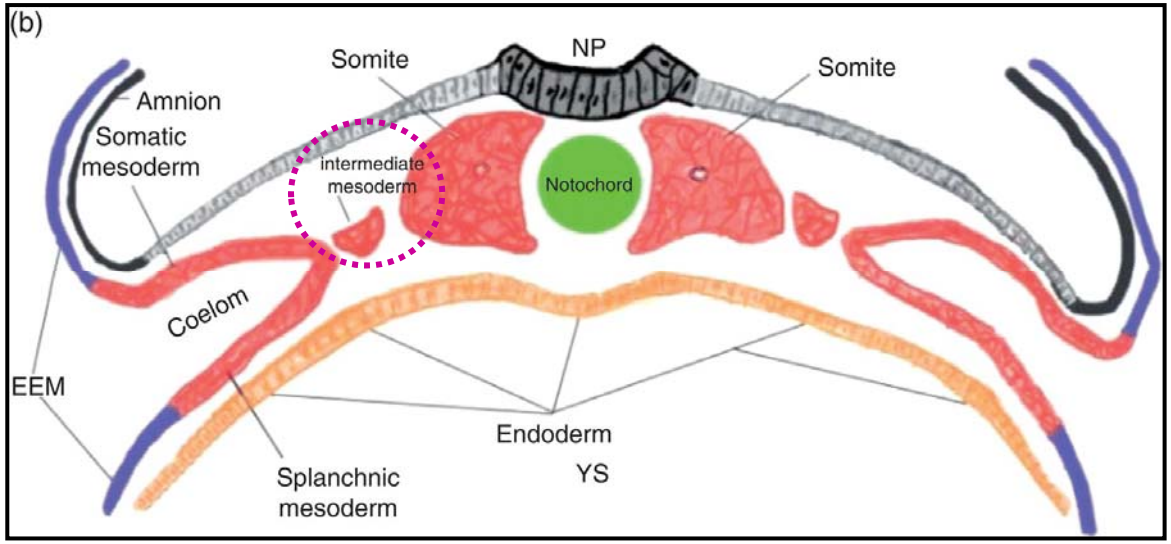




Urogenital system – Intermediate mesoderm





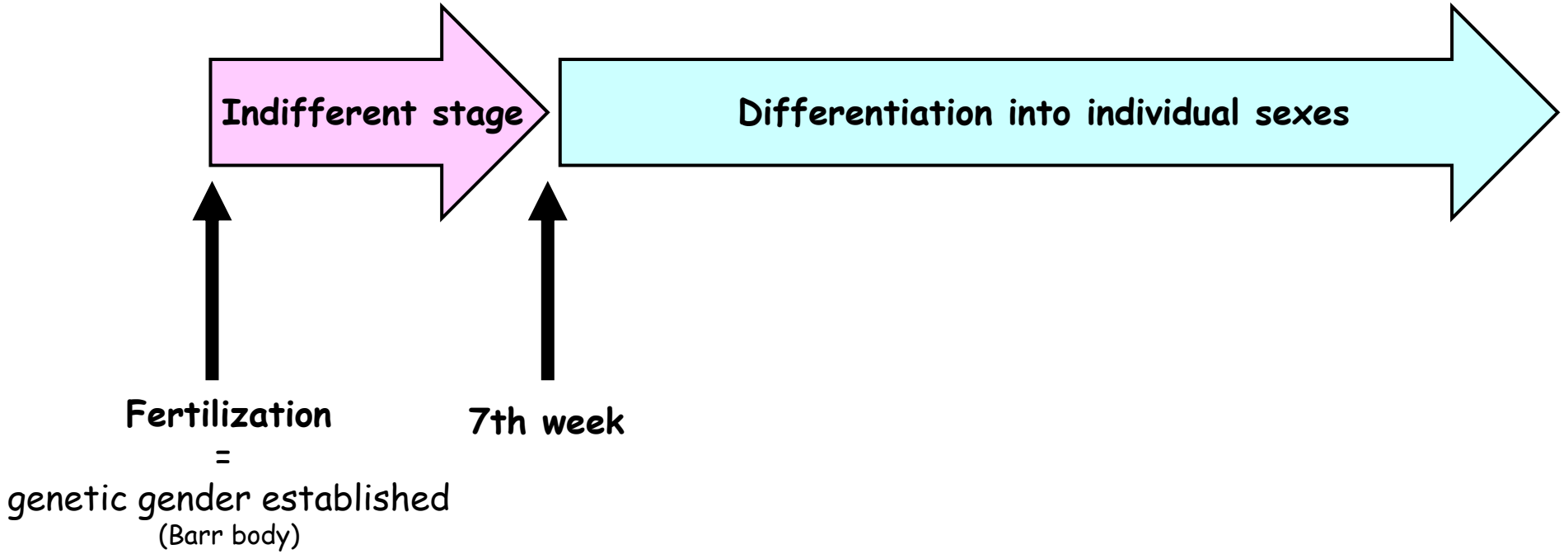


Genital system

Sexual dimorfism – individual can only have one type of genital organs

Genetic determination:

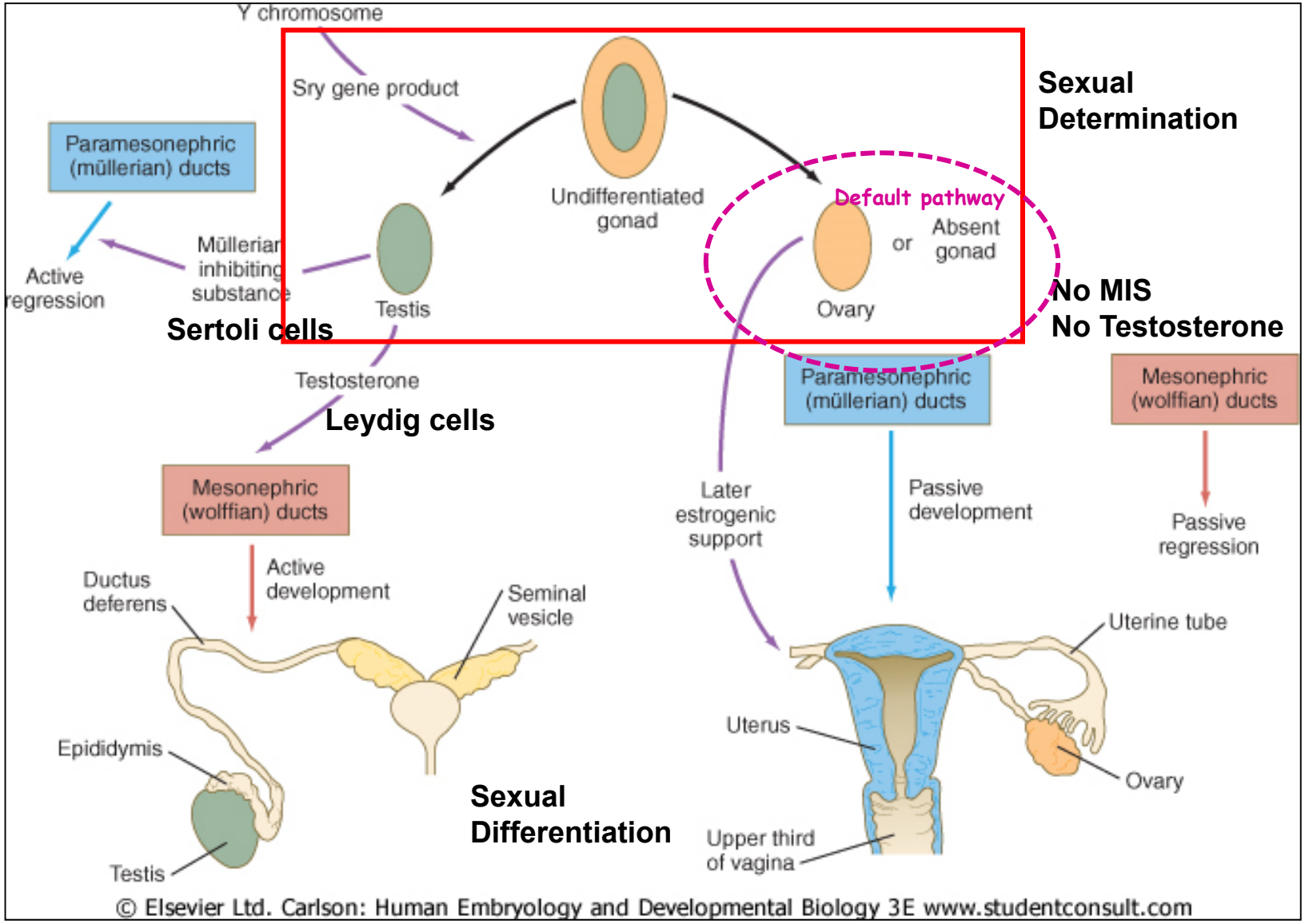
- Heterogametic (XY) – male
- Homogametic (XX) - female



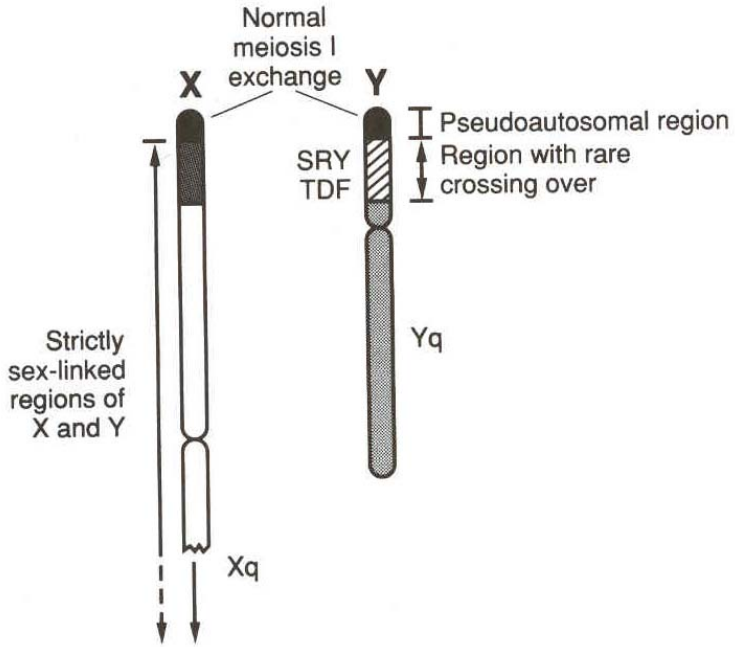
Genital system – Sry gene

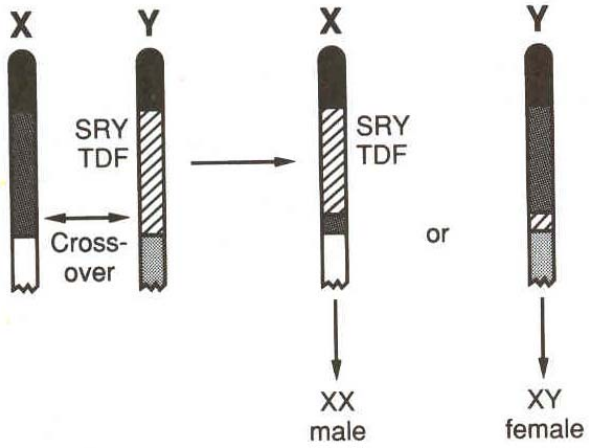
Sry gene – Sox family TF – on short arm of Y chromosome

Y chromosome decides
XXY – male
XO – female



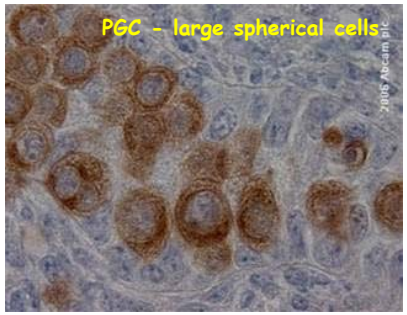
Genital system – Sry gene



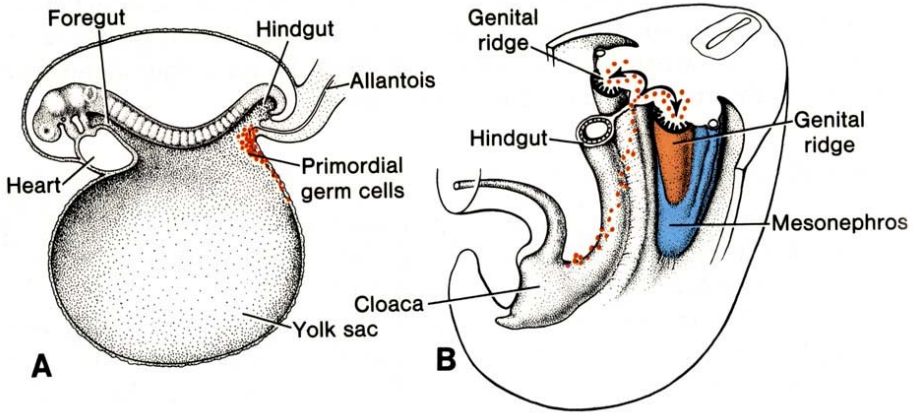


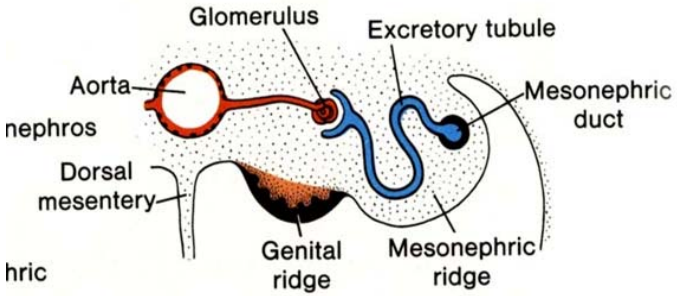
Pairing of X and Y chromosomes in pseudoautosomal region during meiosis

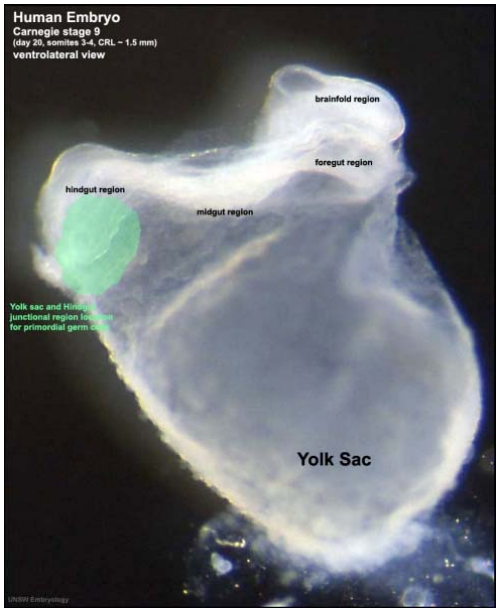
Rare crossing-over causes translocation of SRY to X chromosome:
XY females or XX males



Genital system – Primordial germ cells







Primordial germ cells (PGC)

- first recognizable at day 24
- from epiblast-derived extraembryonic msoderm
- few cells among endodermal cells of the yolk sac
- they migrate through the dorsal mesentery of the hindgut
- migrate towards genital rigdes (plicae genitales)
- proliferate during migration
- reach (1-2 thousands) genital ridges on week 6 of gestation

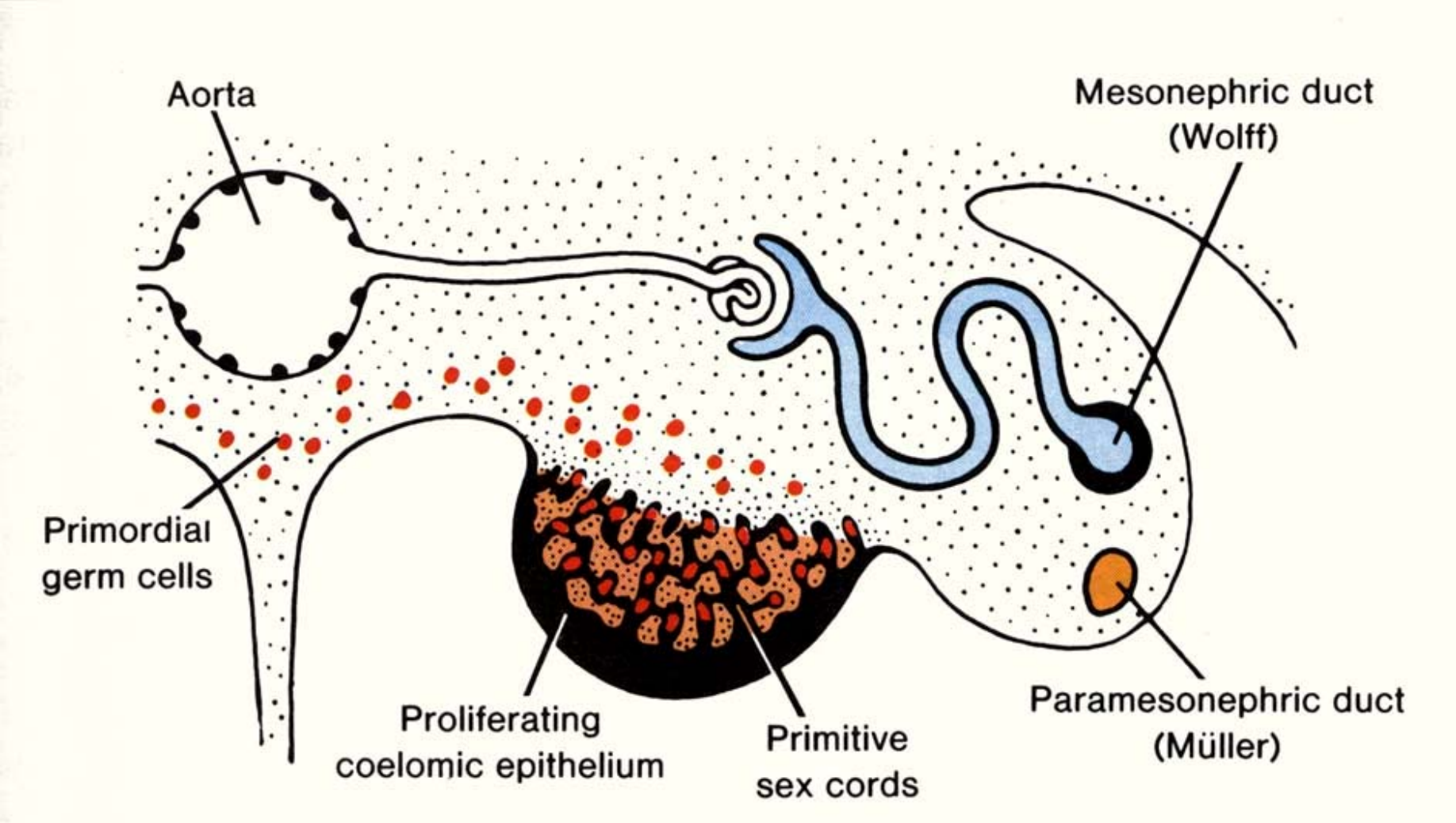
Males
PGC stop dividing

X

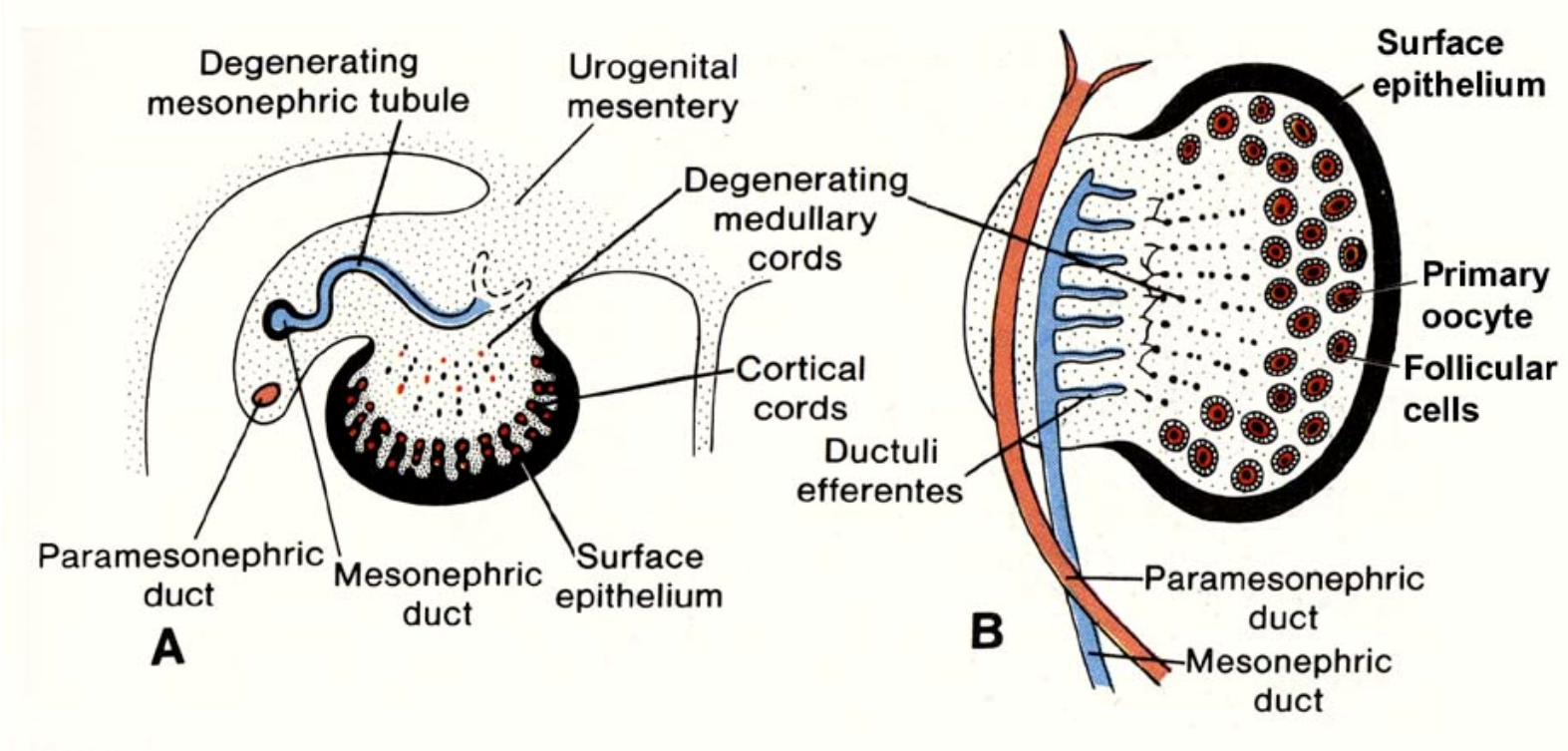
Females
PGC enter meiosis

decided by somatic cells in the genital ridges

Genital system – indifferent gonade (week 6)



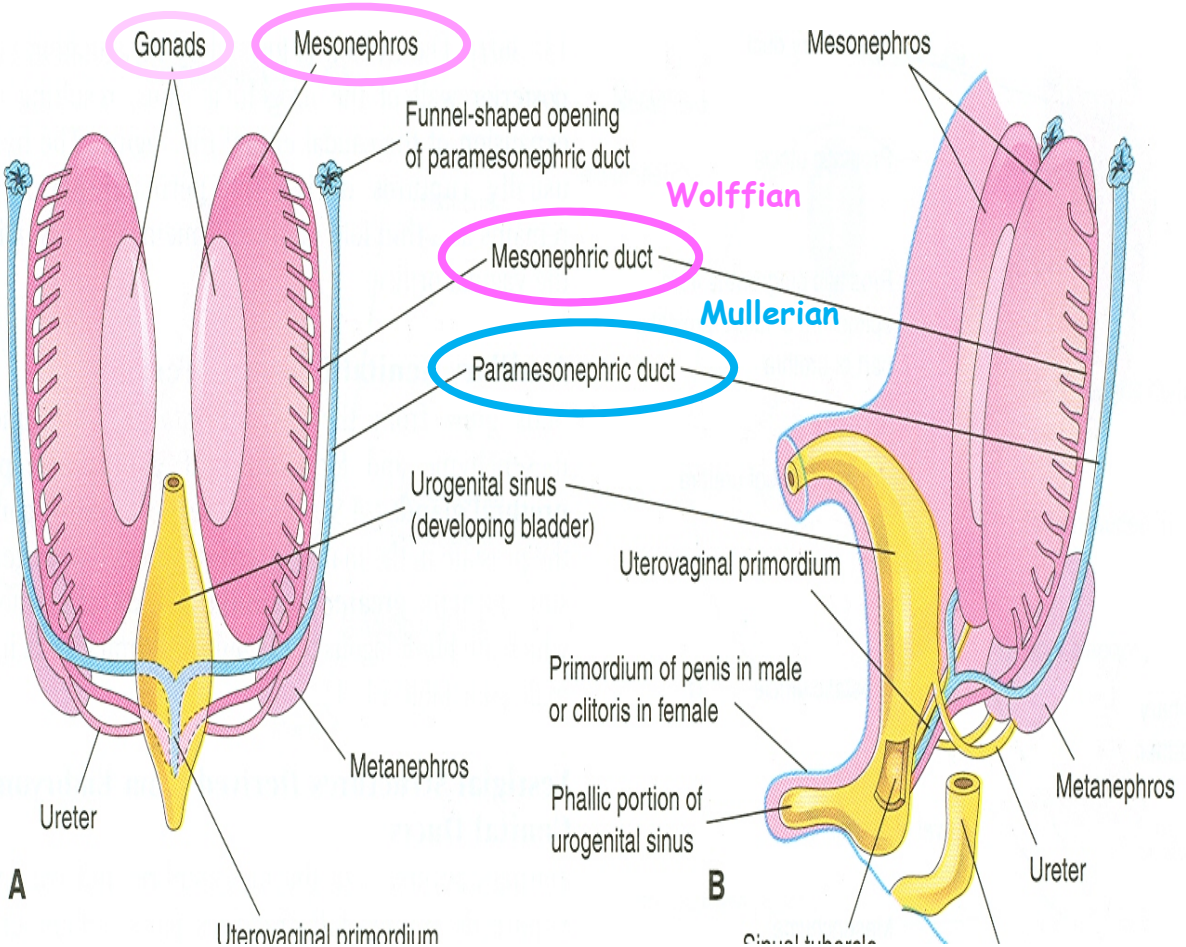
Genital system – Differentiation of the ovaries



- PGC concentrate in the cortical region
- PGC proliferate (max until week 22) and then enter meiosis – arrest in prophase
- Ovarian follicles develop
  (somatic cell contribution is not understood)
- Transient rete ovarii develops in medullary region
- Medulla contains connetive tissue and vasculature derived from mesonephros

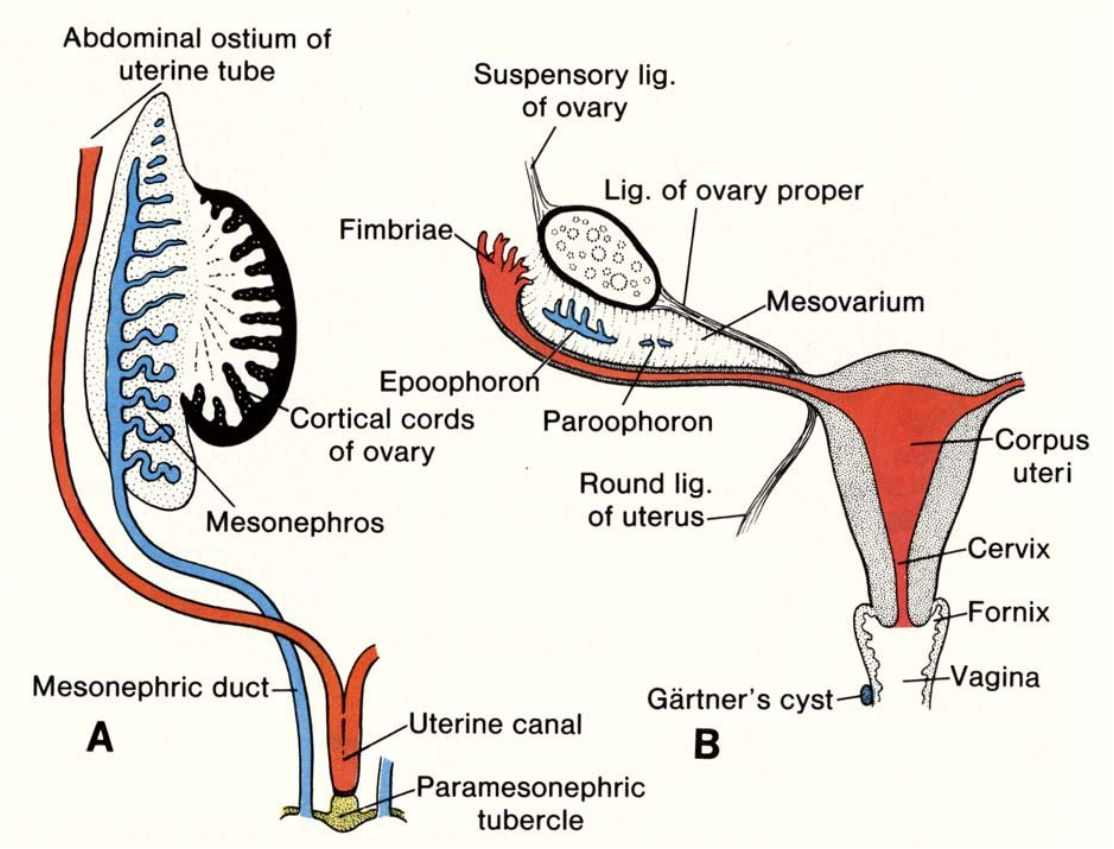
Genital system – Sexual duct system – Indifferent stage

Week 7



Paramesonephric duct
Develops at days 44 to 48
Cranially opens to coelomic cavity

Genital system – Sexual duct system – Female



Mesonephric ducts (Wolffian)
regresses (absence of testosterone)
- **Gartners cyst** (caudal part)

Paramesonephric ducts (Mullerian)
- **Uterine tubes (oviducts, falopian t.)**
- **Uterus**
- **Vagina**

Mesonephros (+Mesonephric duct)
- **Epoophoron** (appendix of ovary)
- **Paraophaoron**

Genital system – Sexual duct system – Uterus

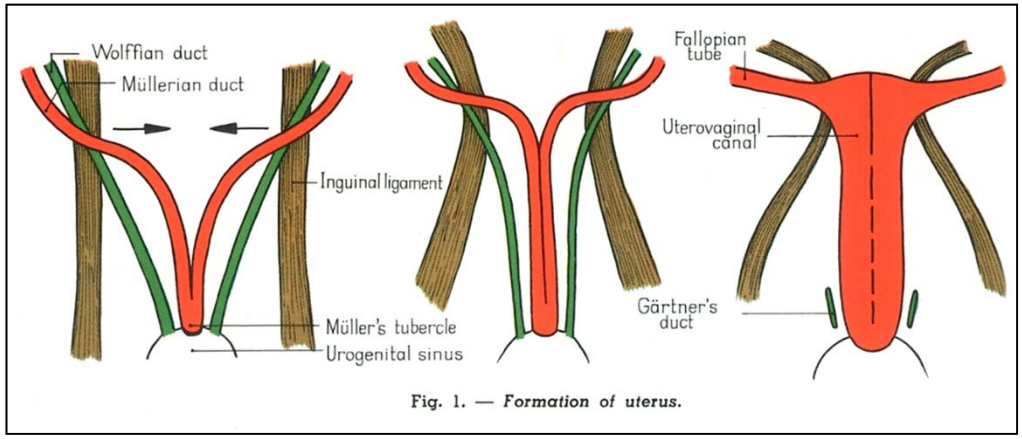
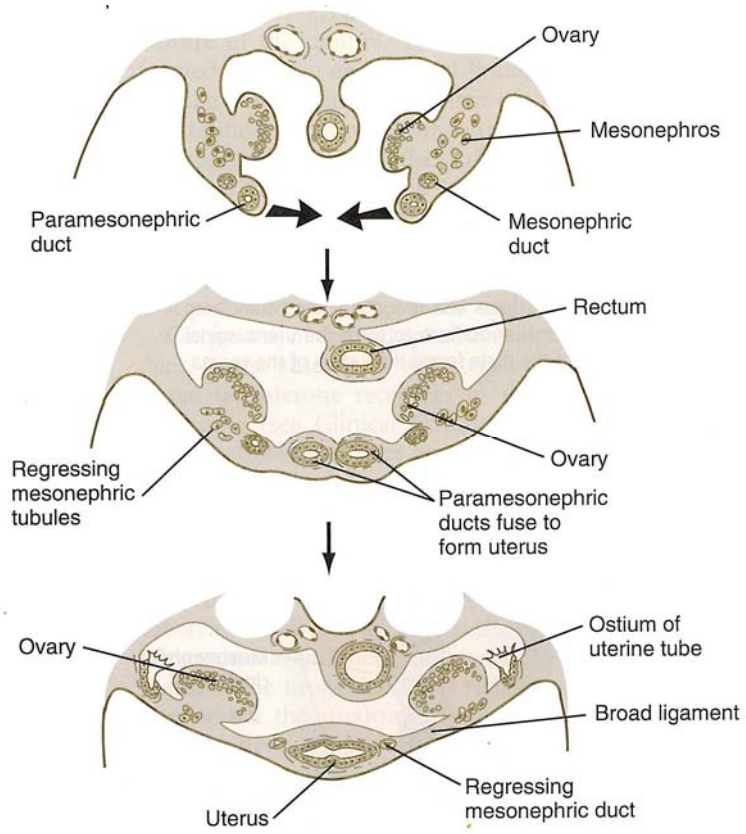
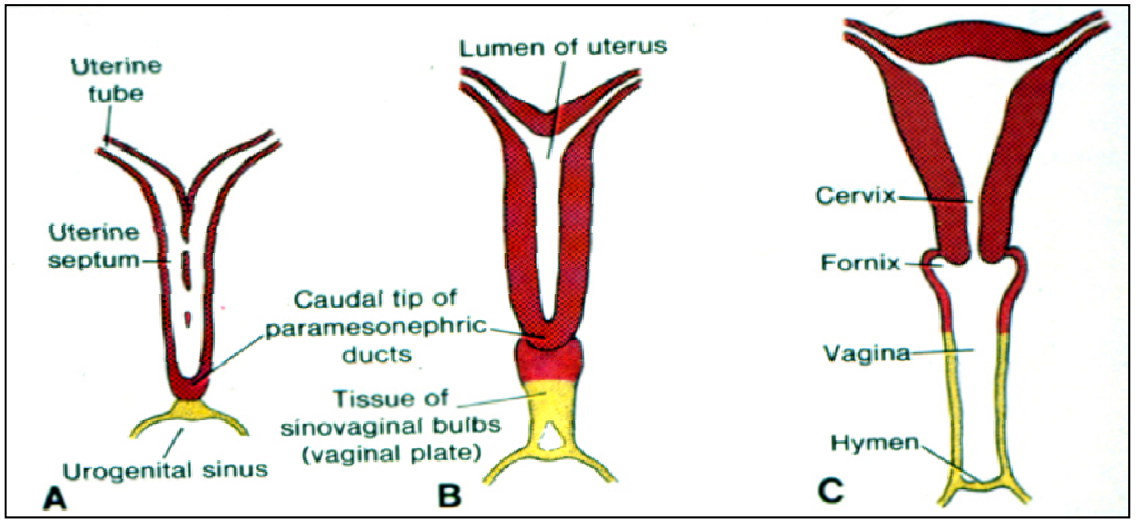


Fig. 1. — *Formation of uterus.*

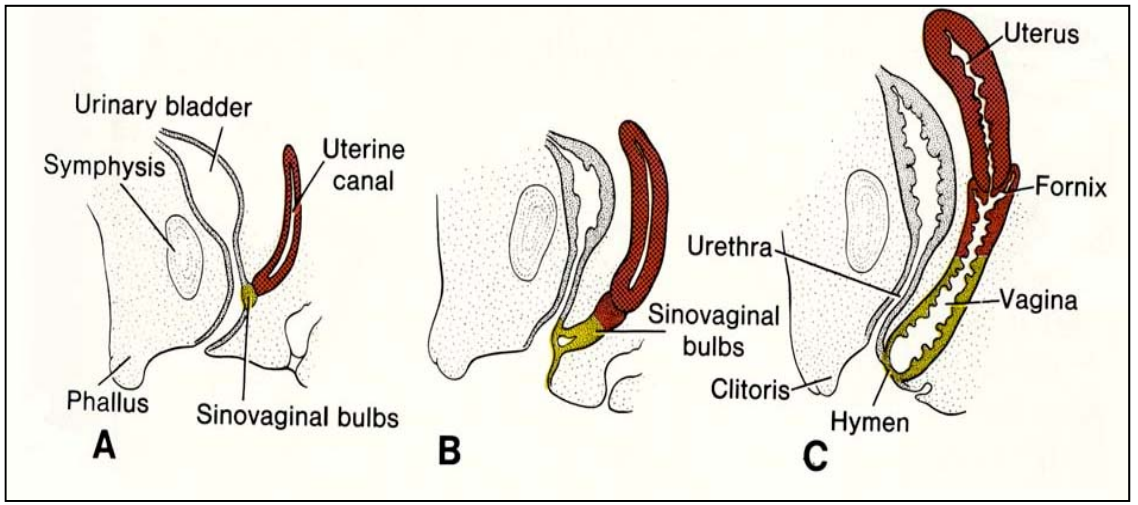


Genital system – Duct system – Uterovaginal channel

Dorsal view

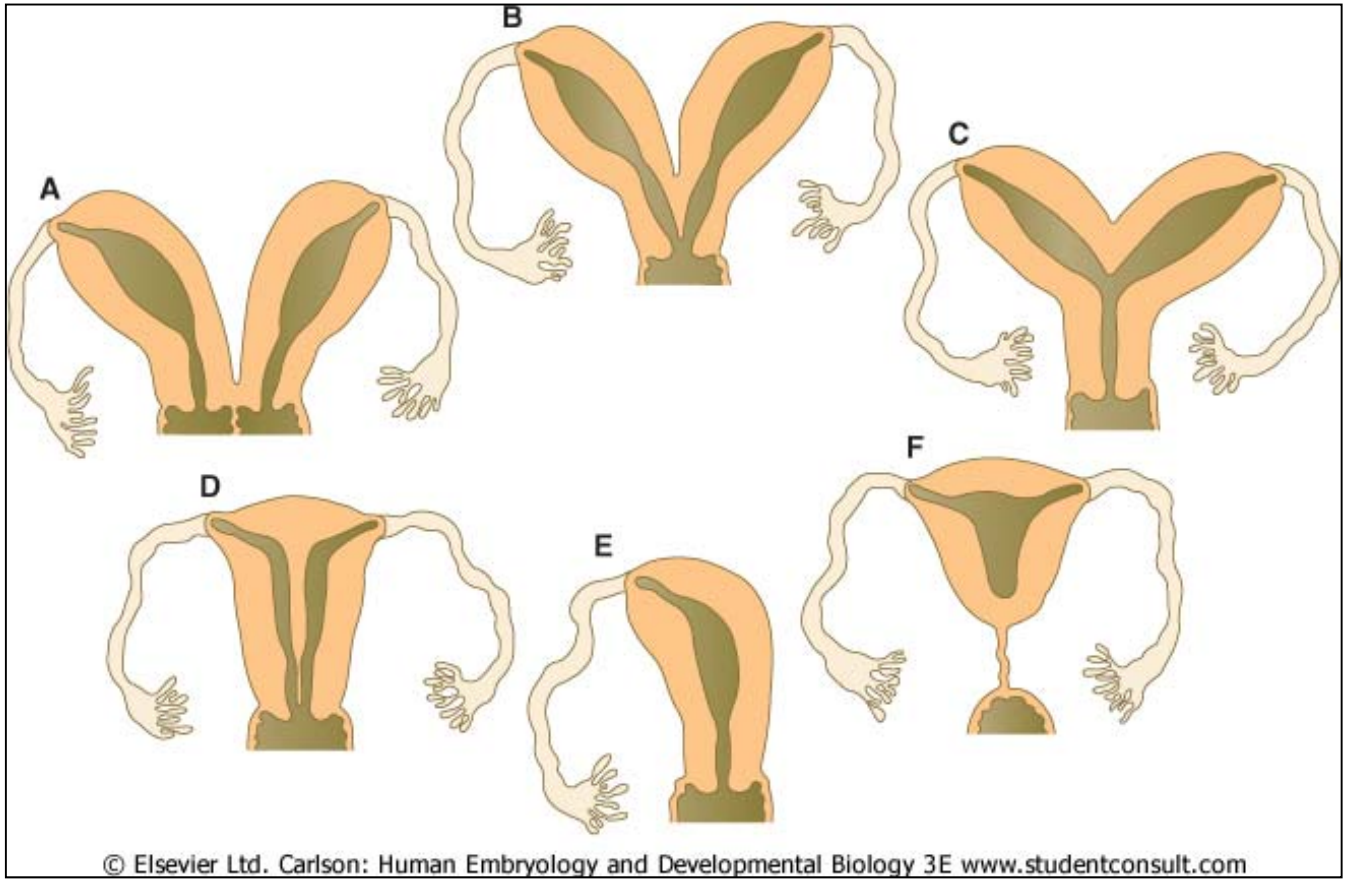


Lateral view



Paramesonephric (Mullerian) ducts fuse to form uterus and upper 1/3 of vagina

Genital system – Uterovaginal channel - Anomalies

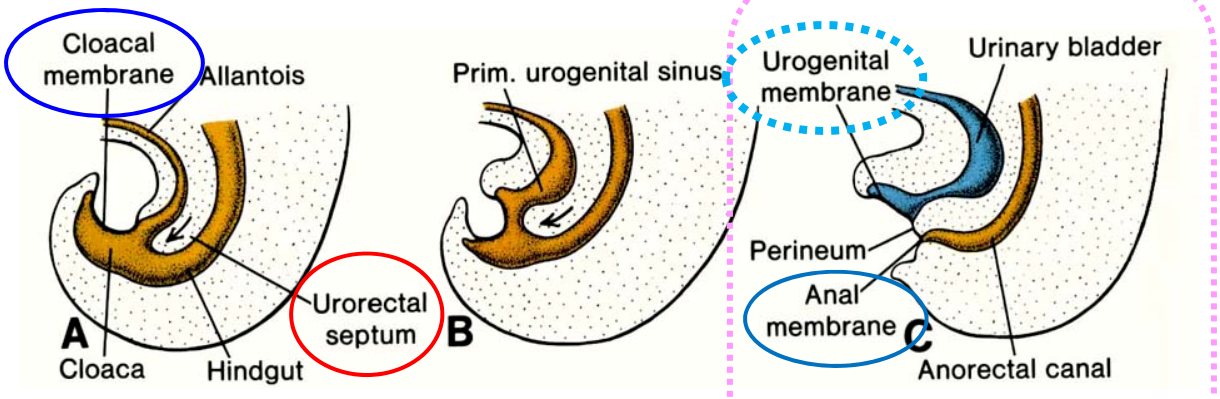


Genital system – External genitalia - Indifferent stage

They are derived from a complex mesodermal tissue located around cloaca.

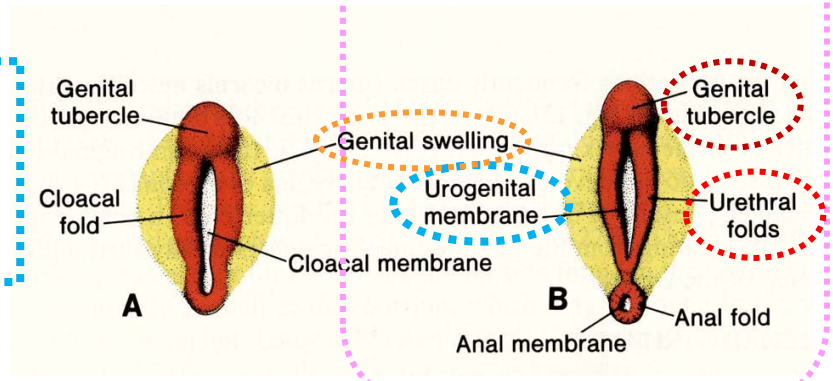
HORMONE-INDEPENDENT

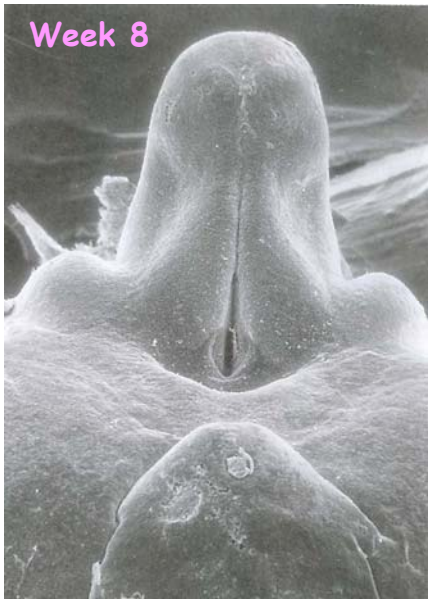
Week 6 to 8



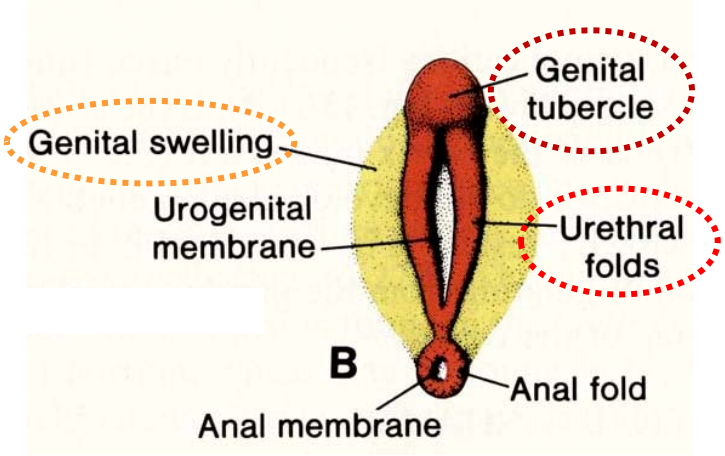
Orificium urogenitale primitivum demarcated by:

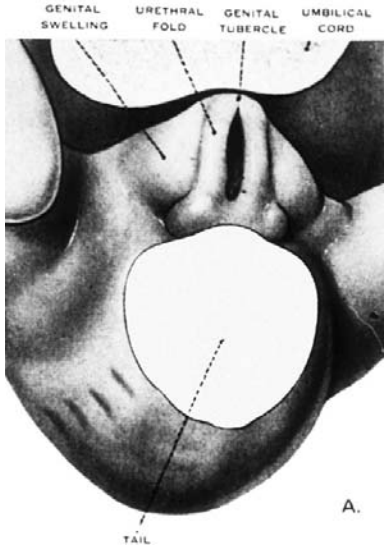
- Genital tubercle – Phallus
- Urethral (genital) folds – Plicae urogenitales
- Genital swellings – Tori genitales





Genital system – External genitalia - Dimorphism



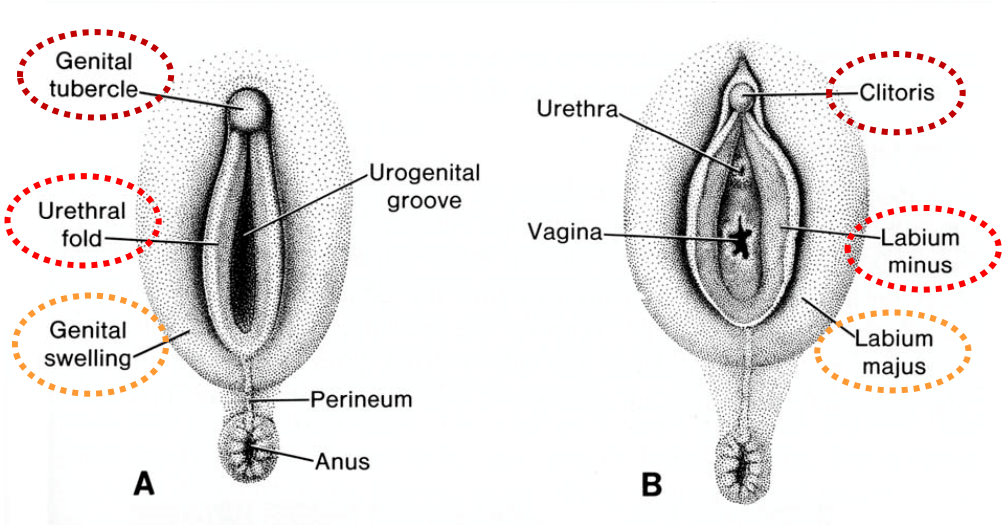


Week 9 to 13

Weeks 12 + 13 are particularly critical
=
fusing of urethral folds

MALE		FEMALE
Penis	Genital tubercle	Clitoris
Urethra	Genital (urethral) folds	Labia minora
Scrotum	Genital swellings	Labia majora

Genital system – External genitalia - Female



urethra and vagina open into
vestibule = from urogenital sinus

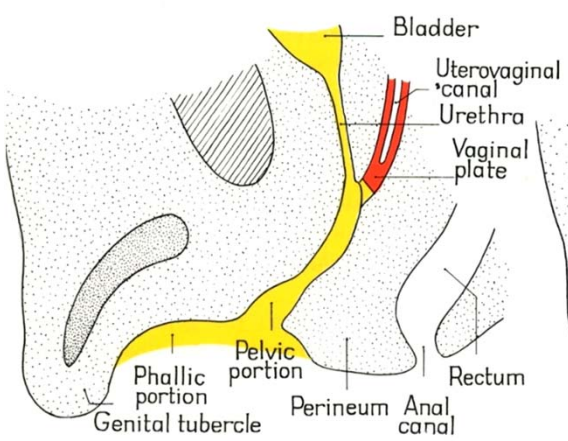


Fig. 2. — *Opening of urogenital membrane.*

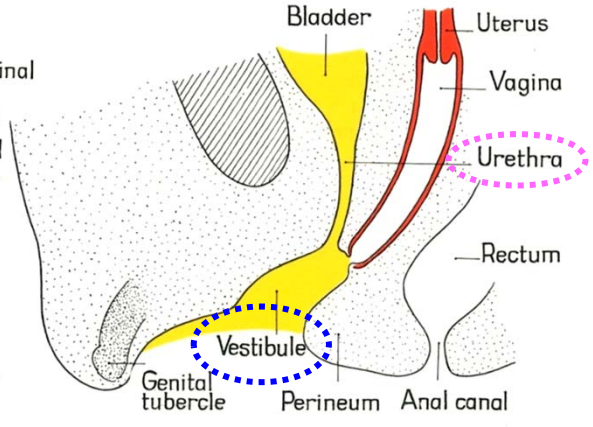


Fig. 3. — *The definitive vestibule.*

urethra develops from
the more cranial part
of urogenital sinus – equivalent
to prostatic urethra

Thank you for your attention !

Questions and comments at:
ahampl@med.muni.cz