HISTOLOGY & EMBRYOLOGY

http://jpkc.fudan.edu.cn/s/426/main.htm

FEMALE REPRODUCTIVE SYSTEM

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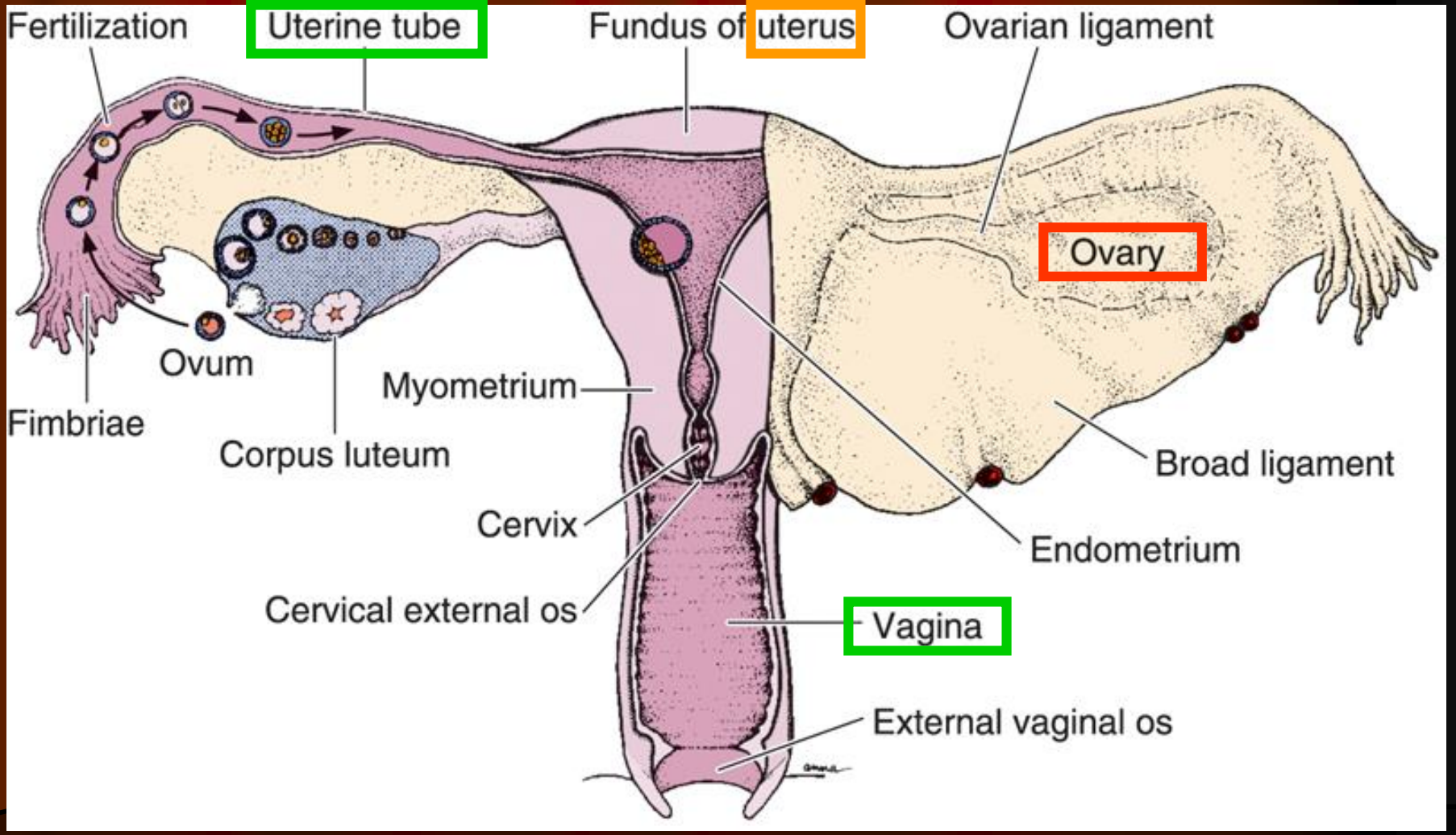
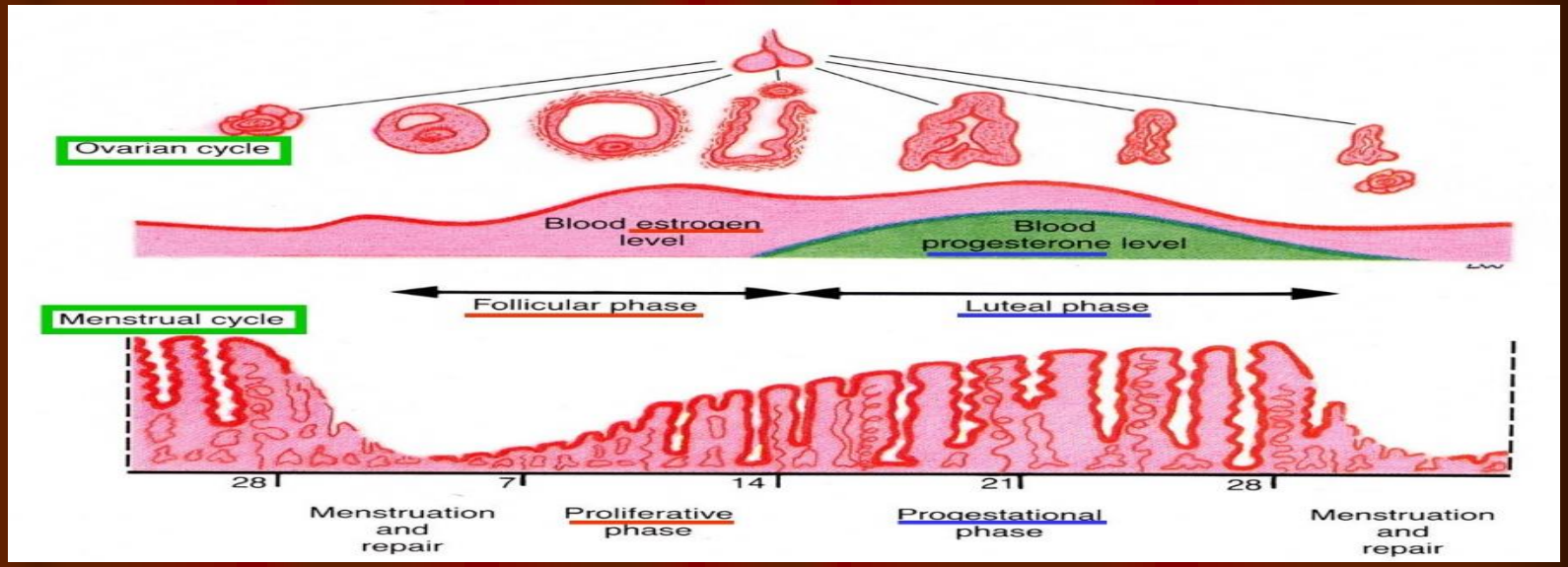
Female Reproductive System



OBJECTIVES

- Structure of ovary and maturation of oocyte
- Structure of uterine tube, uterus and vagina
- Endometrial structure and changes, as well as its regulation during menstrual cycle
- Structure of mammary gland

Questions ?



How are oocytes produced?

- **Key points: refer to the ovarian cycle, follicular and luteal phases.**

What are the reactions of uterus during the oocyte production?

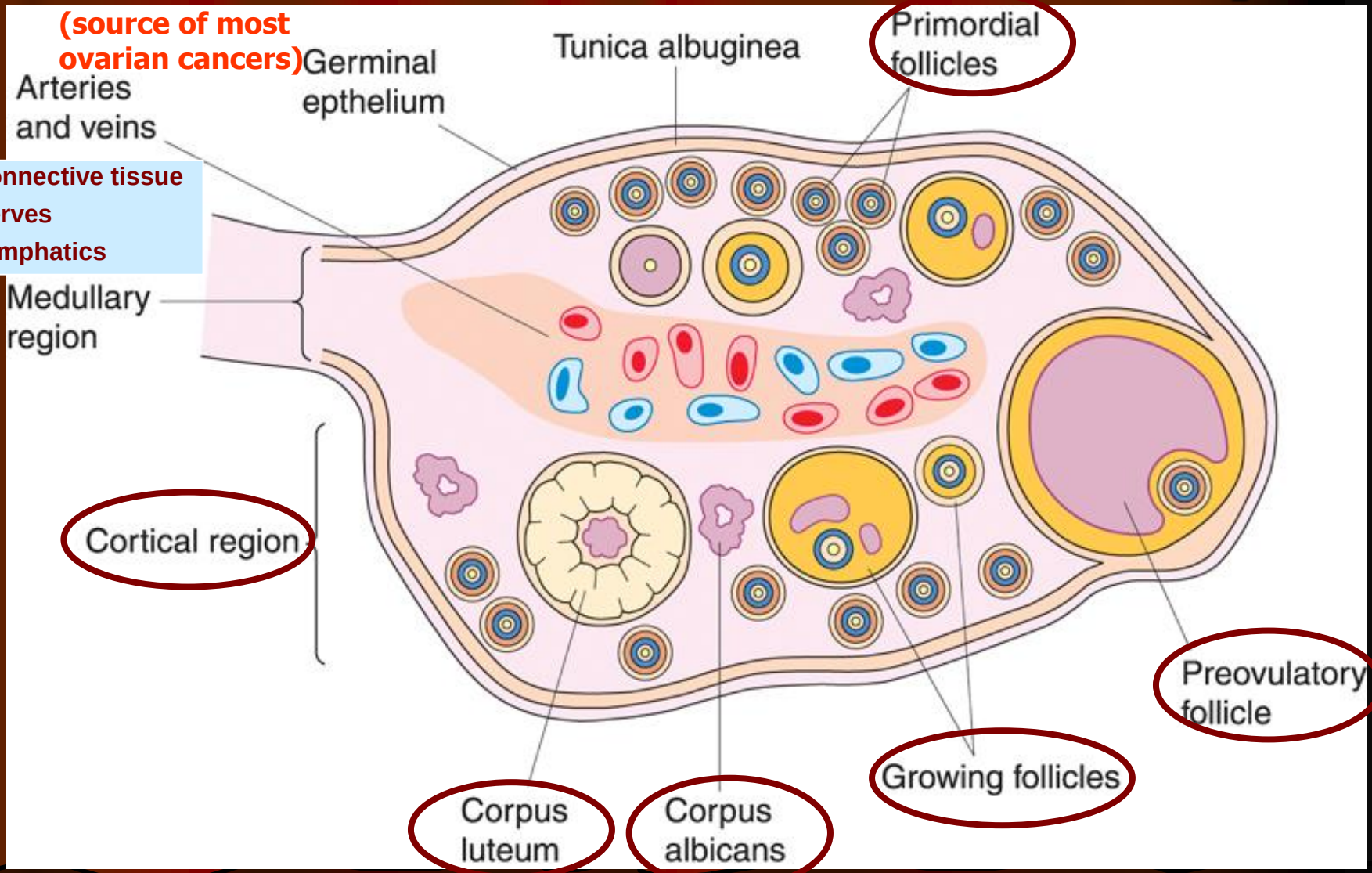
- **Key points: refer to the menstrual cycle, proliferative and progestational phases.**

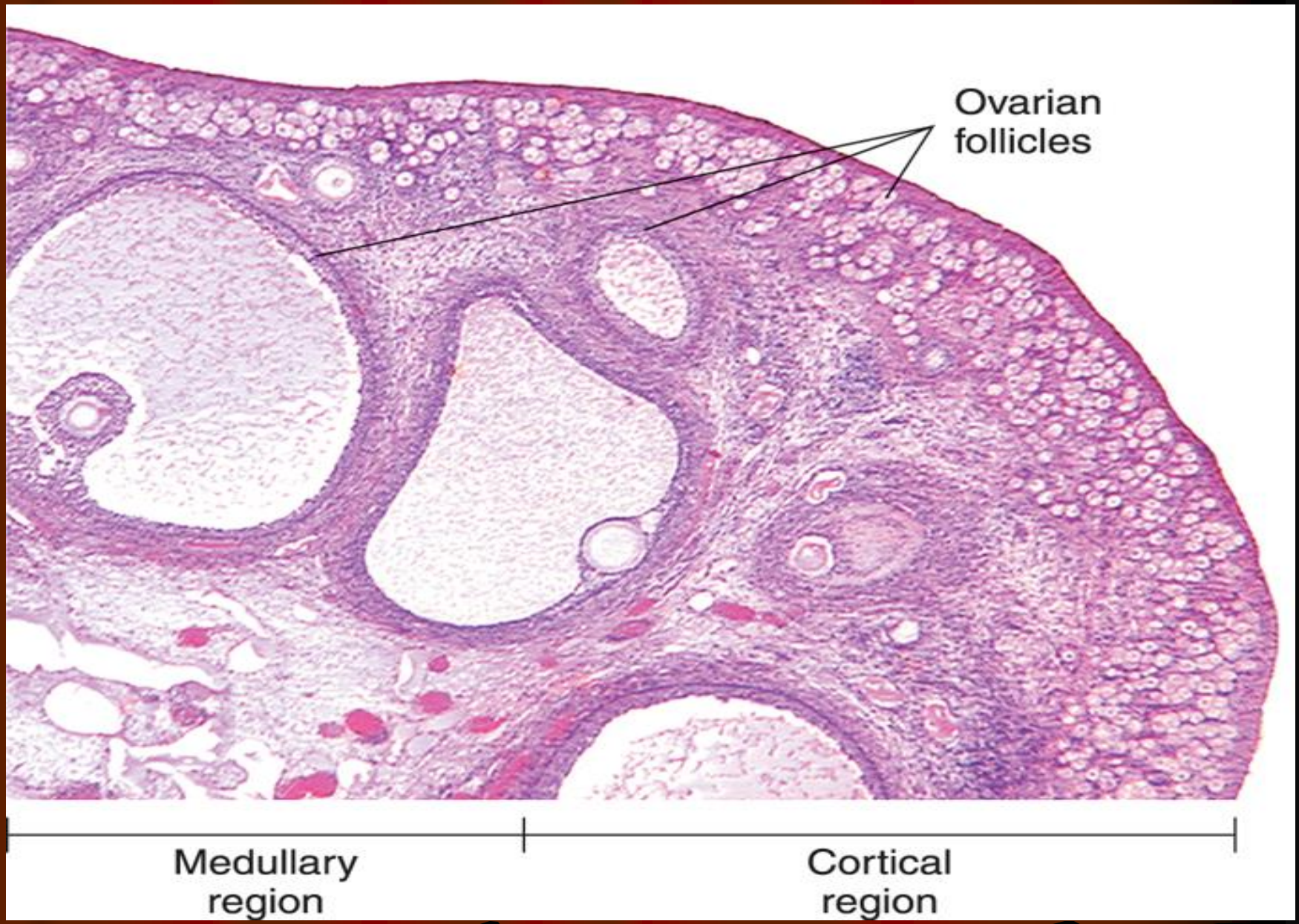
I. Ovary

- The follicular development
- Ovulation & Corpus luteum formation

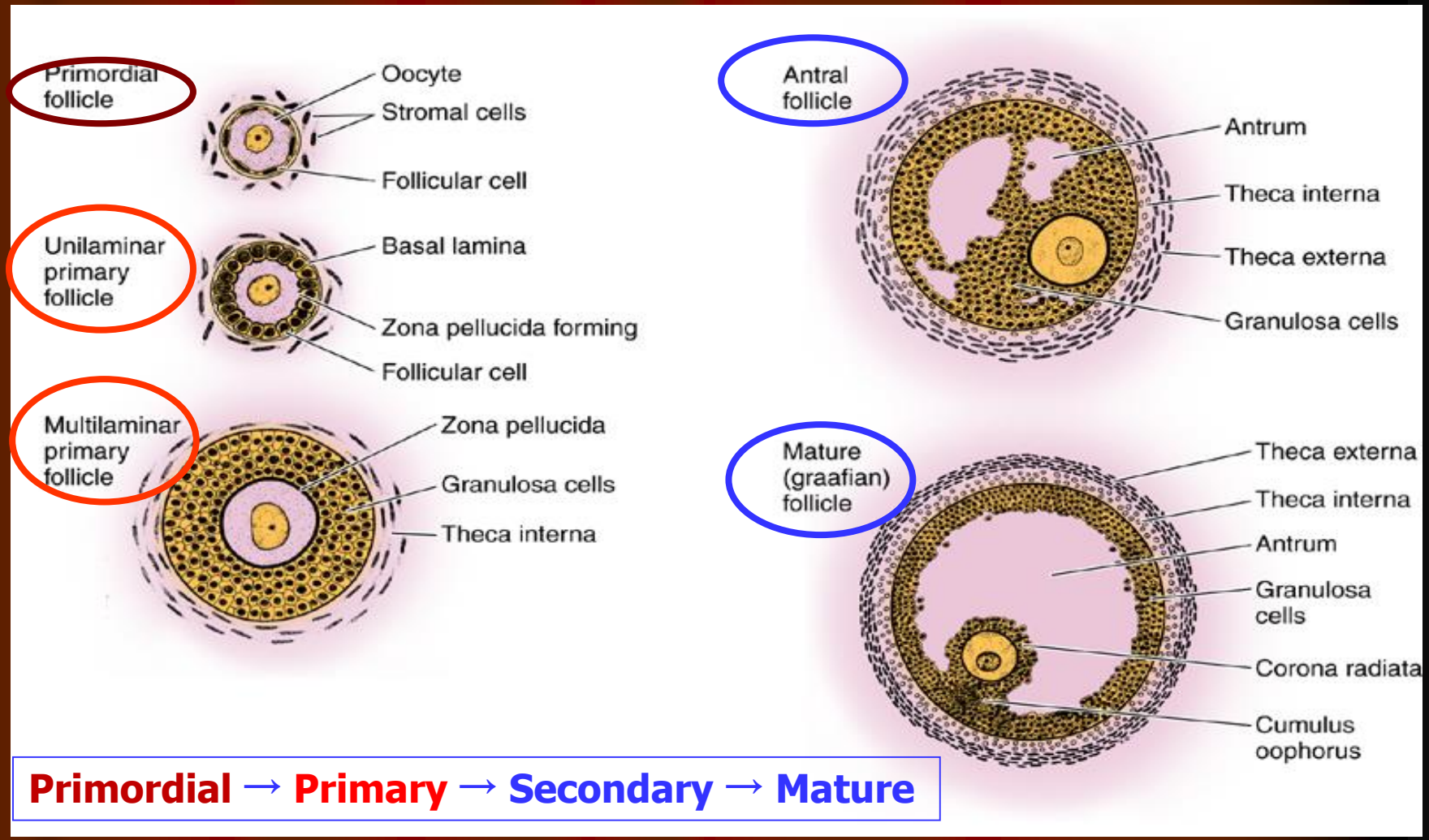
Q1: How are oocytes produced?

The Structure of the Ovary




Ovarian follicles
Medullary region
Cortical region

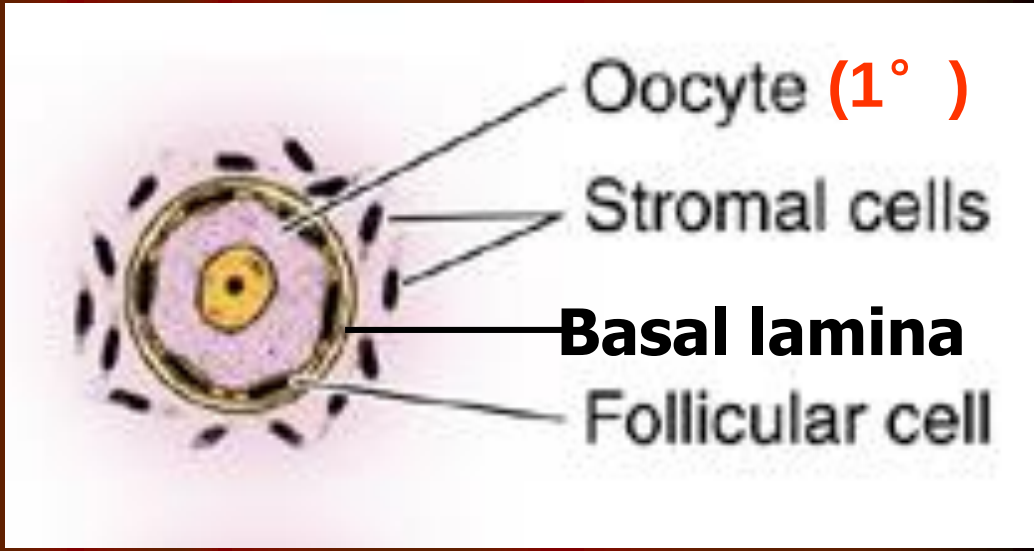
1. The Follicular Development



Primordial → Primary → Secondary → Mature

Primordial Follicle

1. Some 600,000 at birth
2. Many are lost through atresia before birth and before reaching puberty
3. After puberty, several primordial follicles are stimulated to growth at beginning of each cycle
4. Usually only one reaches full maturity and ovulated/cycle
5. Others undergo atretic [degenerative] changes at different stages



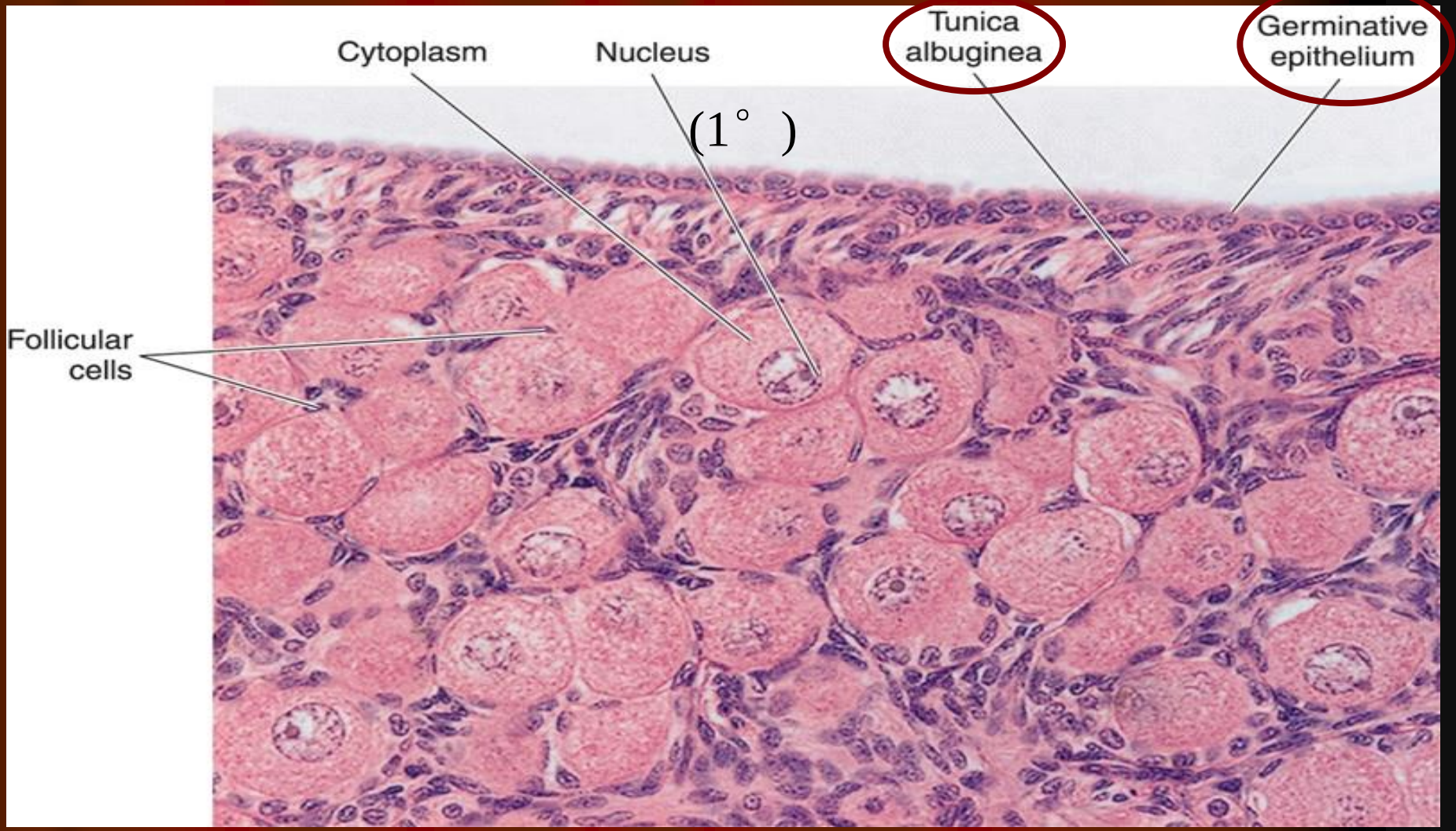
Nucleus of oocyte
(arrested at 1st meiotic prophase, before birth)

No zona pellucida

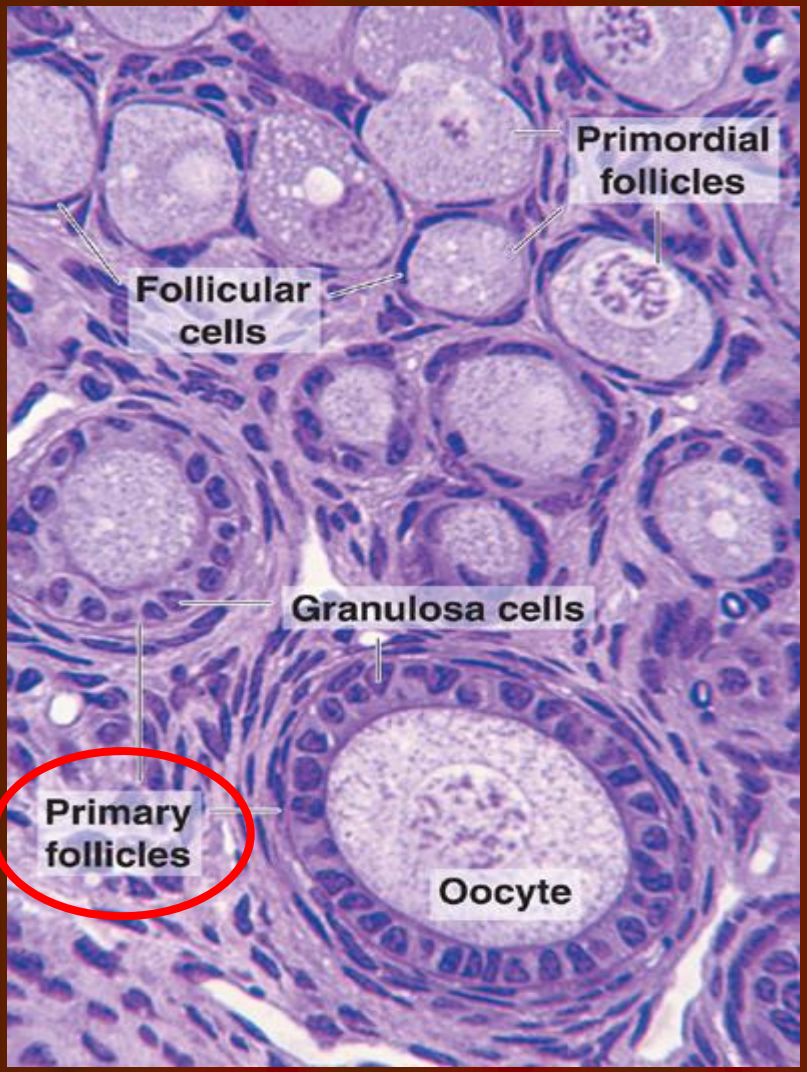
Single layer of squamous follicular cells

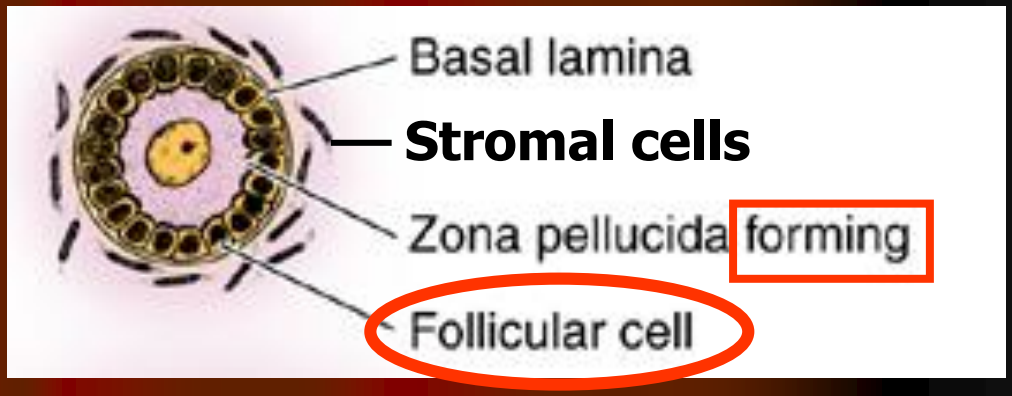
The only type in cortex before puberty; but no follicles in ovary after menopause

Primordial Follicle



Unilaminar Primary Follicle





Zona pellucida forming

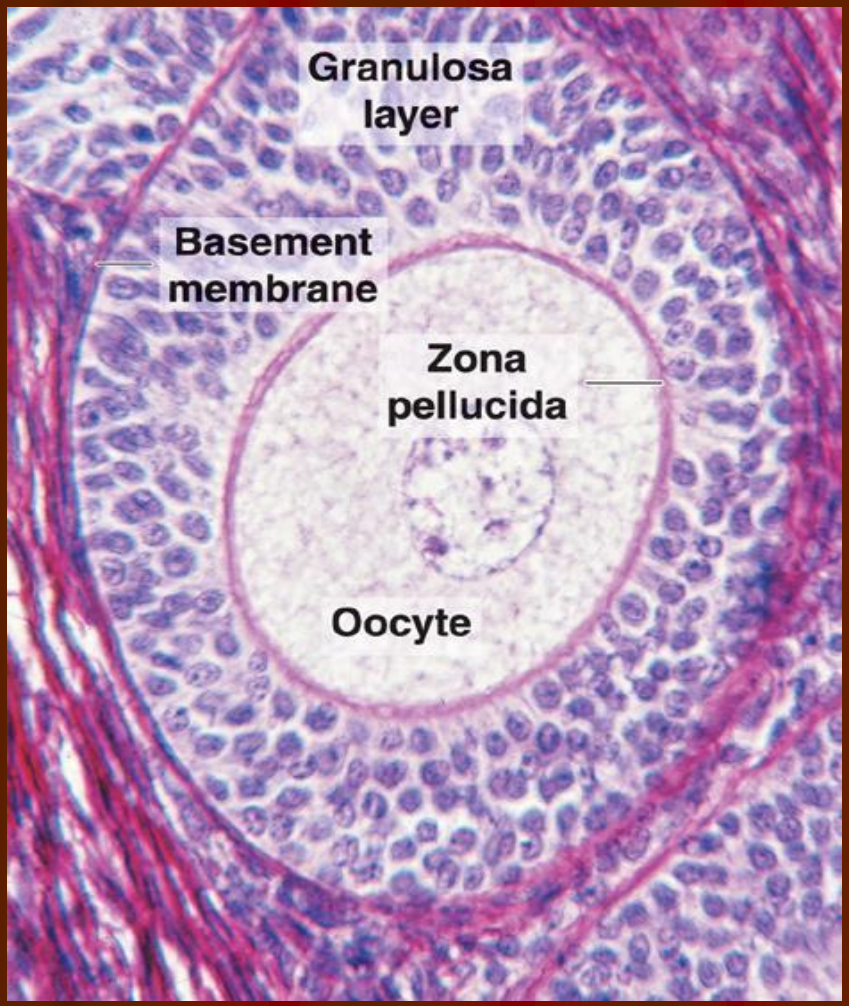
+

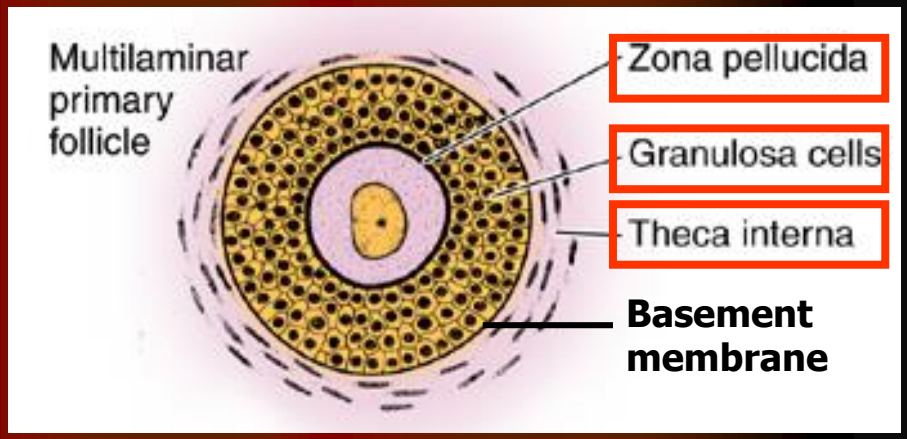
Single layer of cuboidal or columnar follicular cells

+

Basal lamina

Multilaminar Primary or Preantral Follicle





Zona pellucida formed → **Zona pellucida**

+

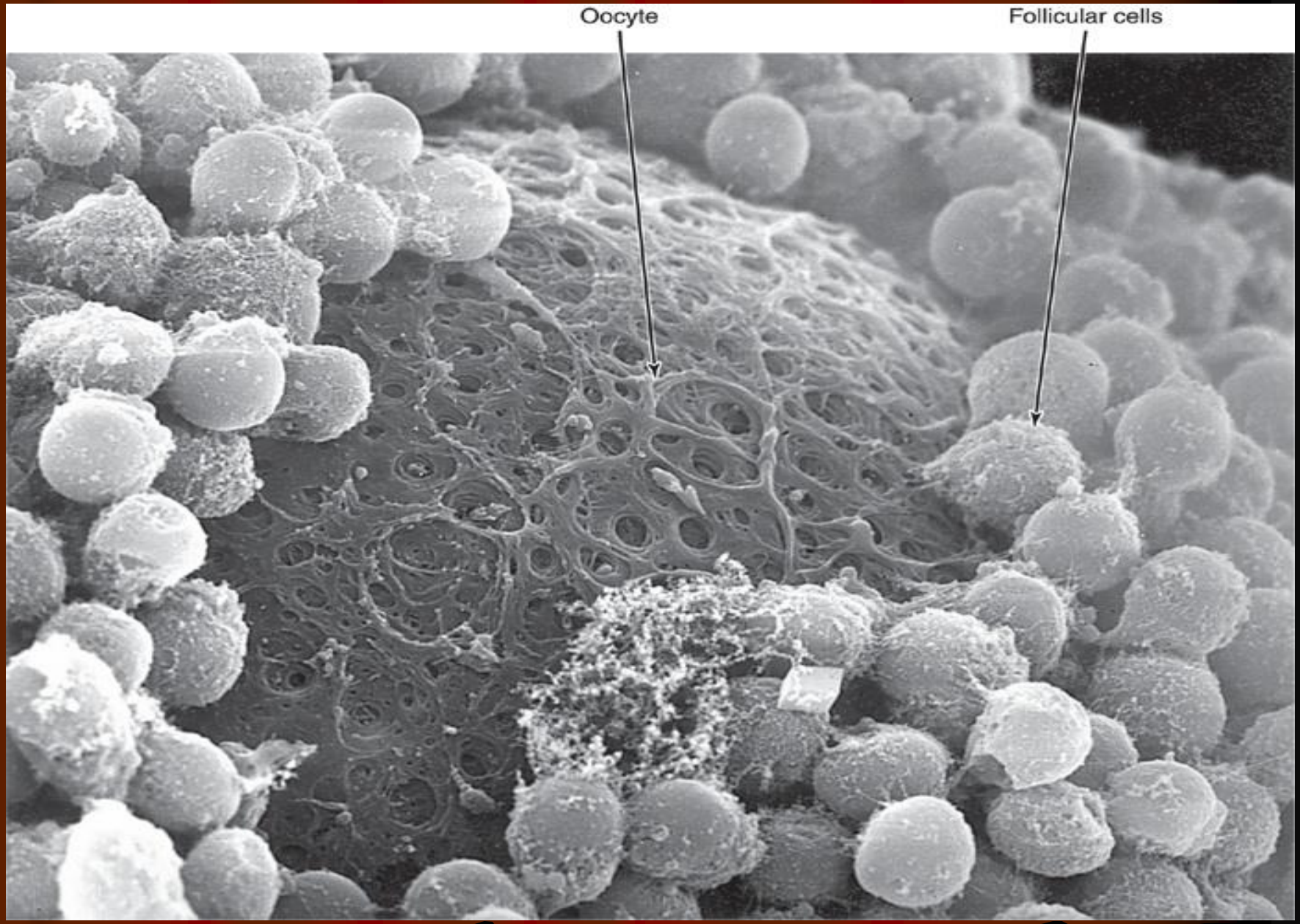
More than one layer of follicular cells → **Granulosa cells or layer**

+

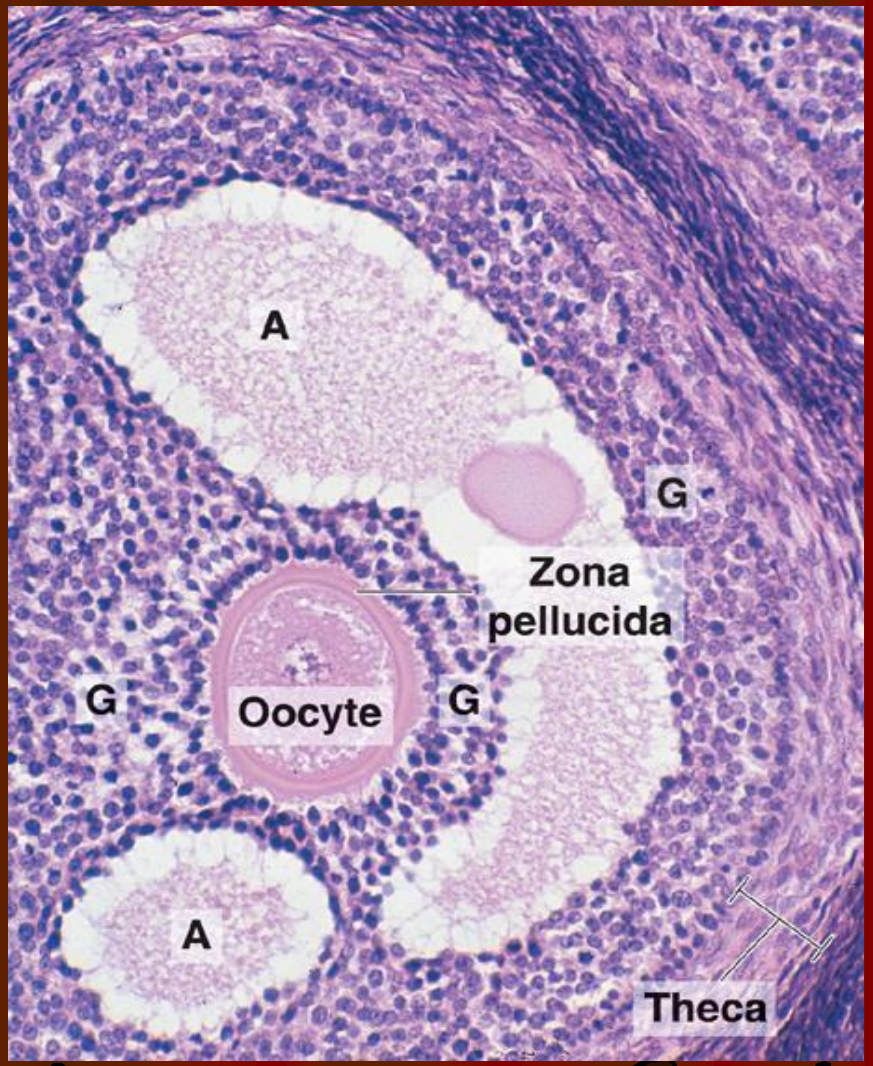
Basement membrane

+

Appearance of theca cells → **Theca layer**


Oocyte
Follicular cells

Antral or Secondary Follicle

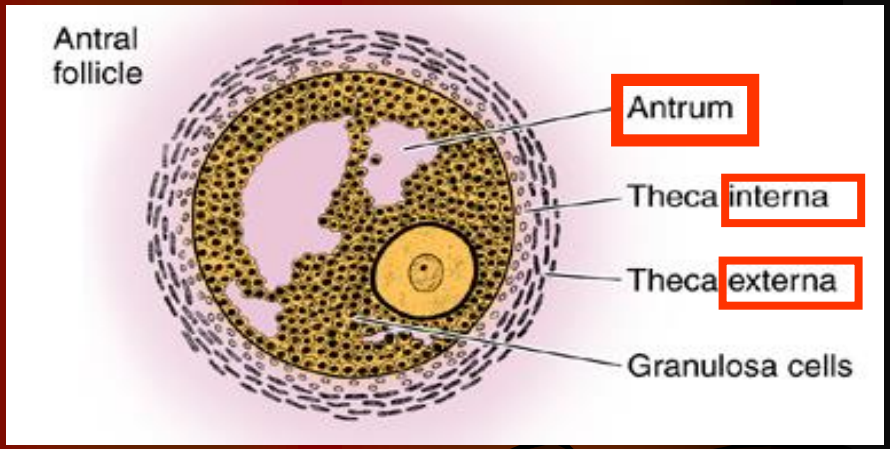


Granulosa cells of primary follicle ⋯▶

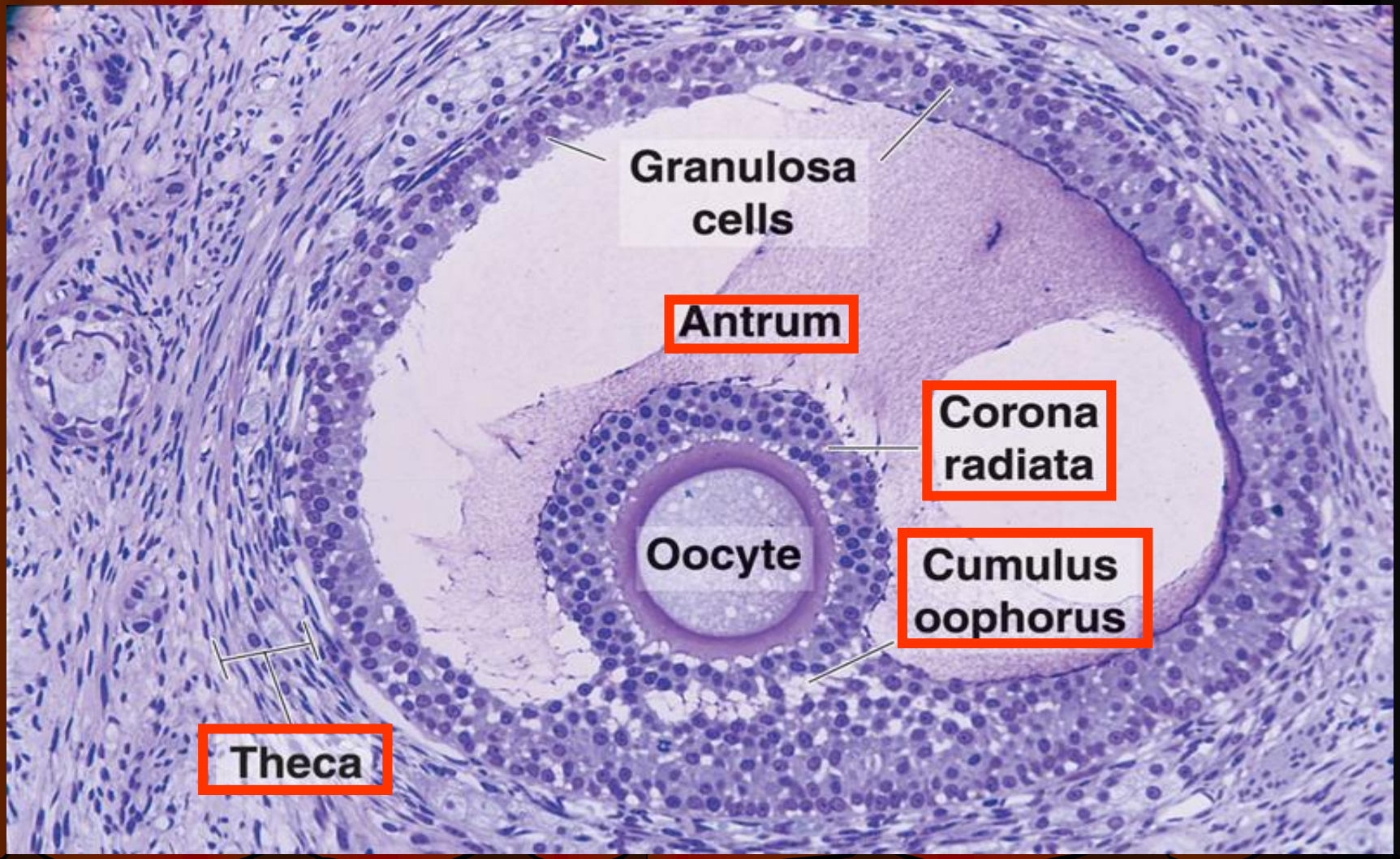
- Liquid-containing Antrum
- Cumulus oophorus
- Corona radiata

Theca layer of primary follicle ⋯▶

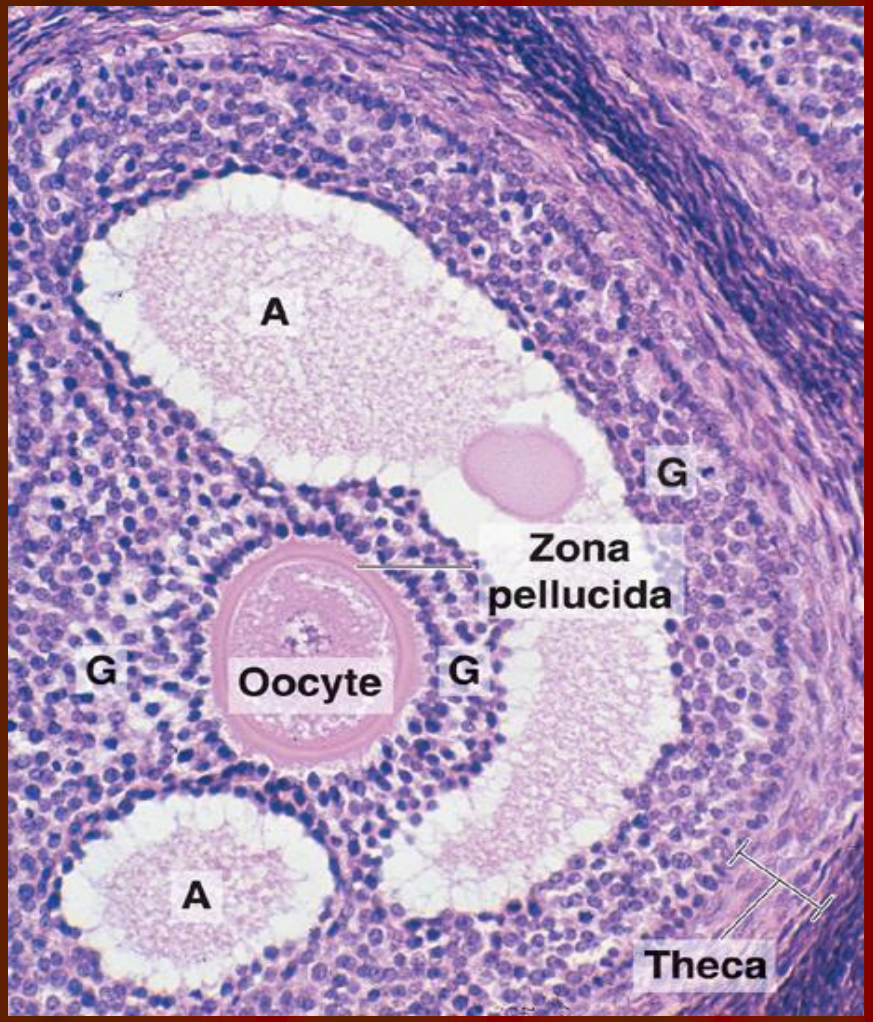
- Theca interna
- Theca externa



Antral or Secondary Follicle



Antral or Secondary Follicle



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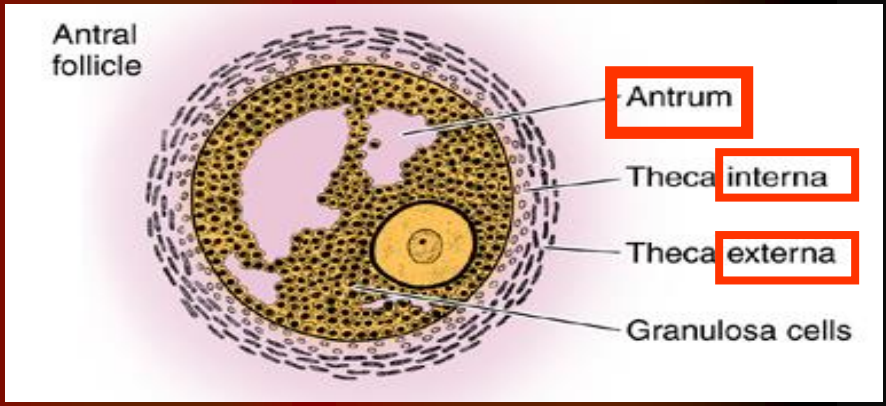
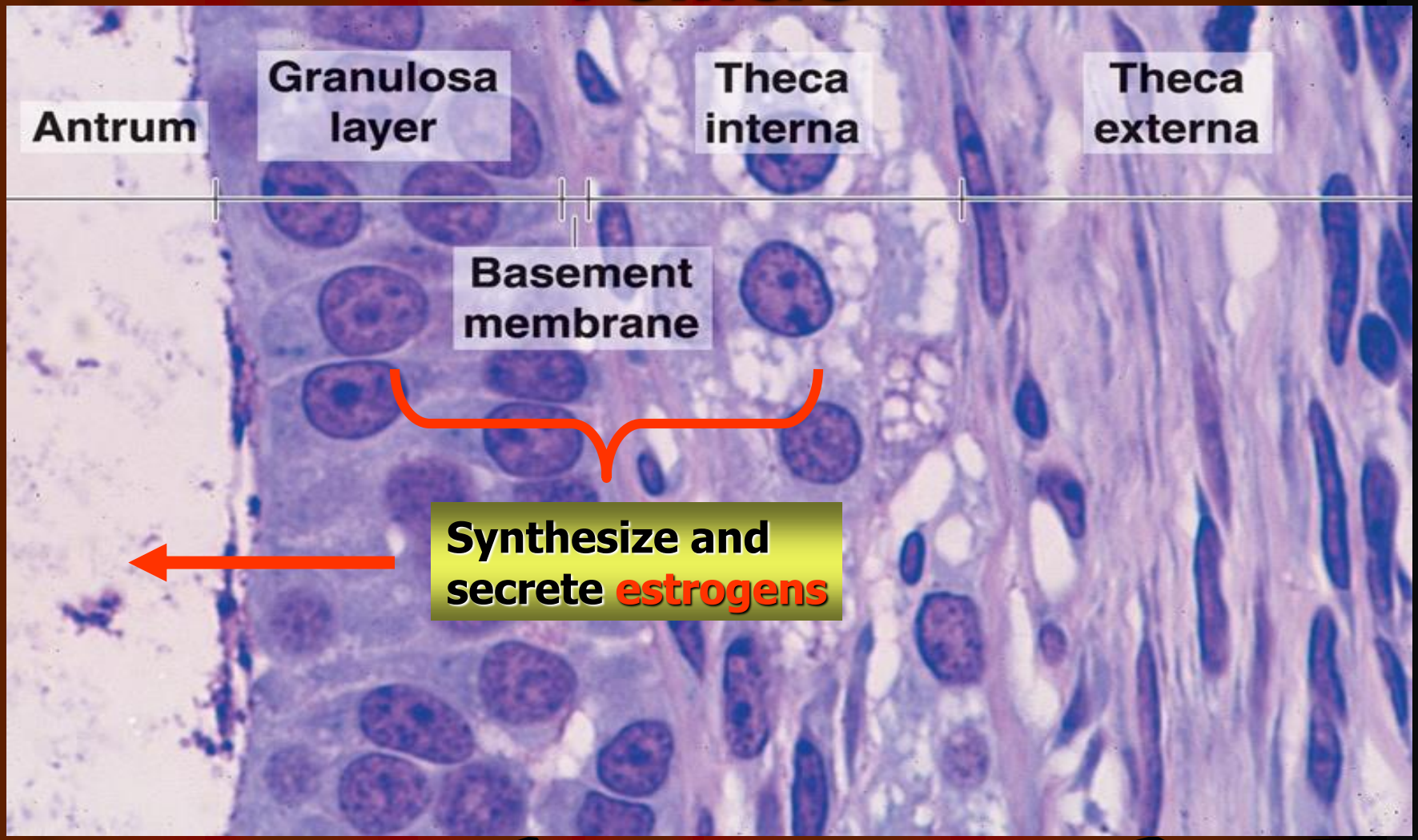
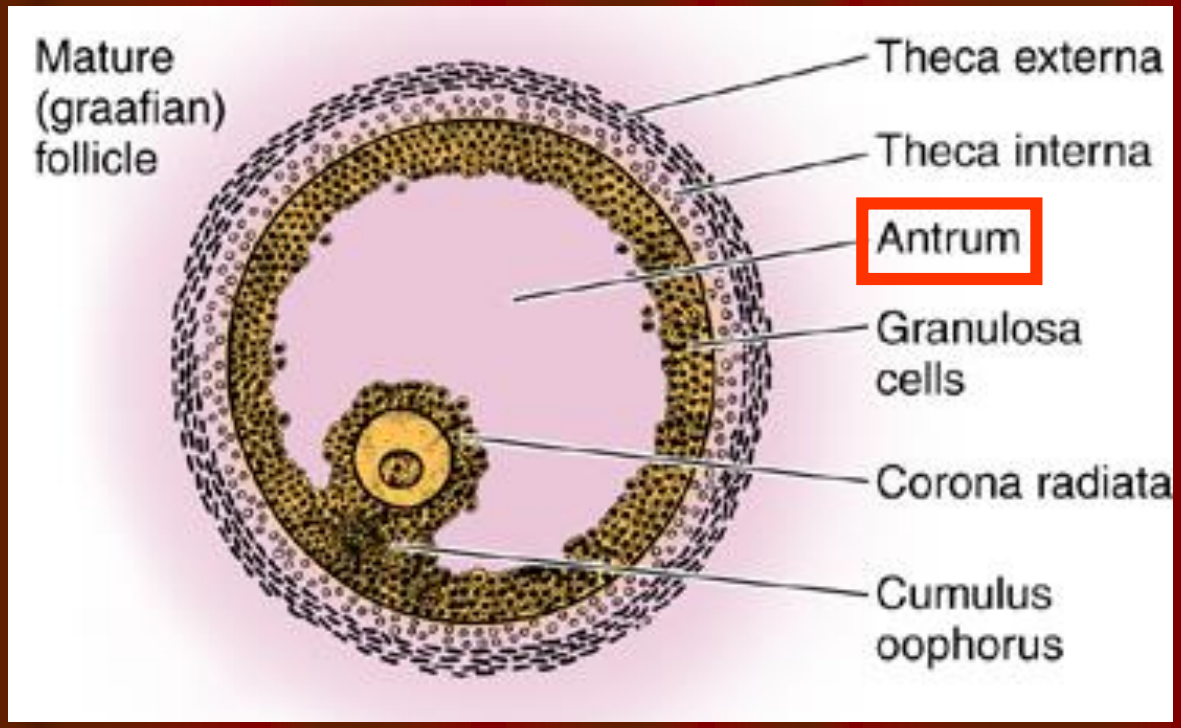


The Part of the Wall of an Antral Follicle



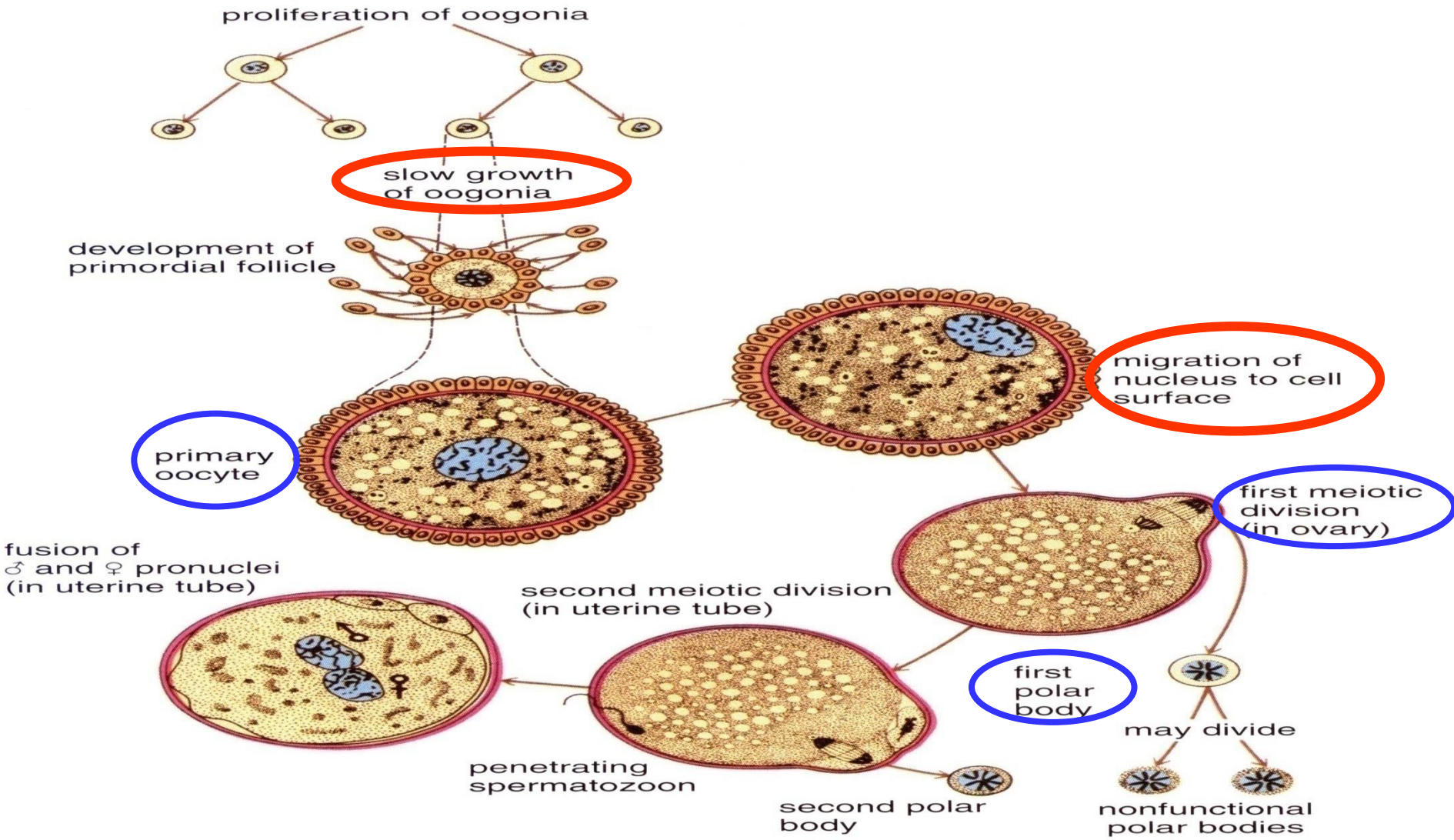
Mature or Graafian Follicle



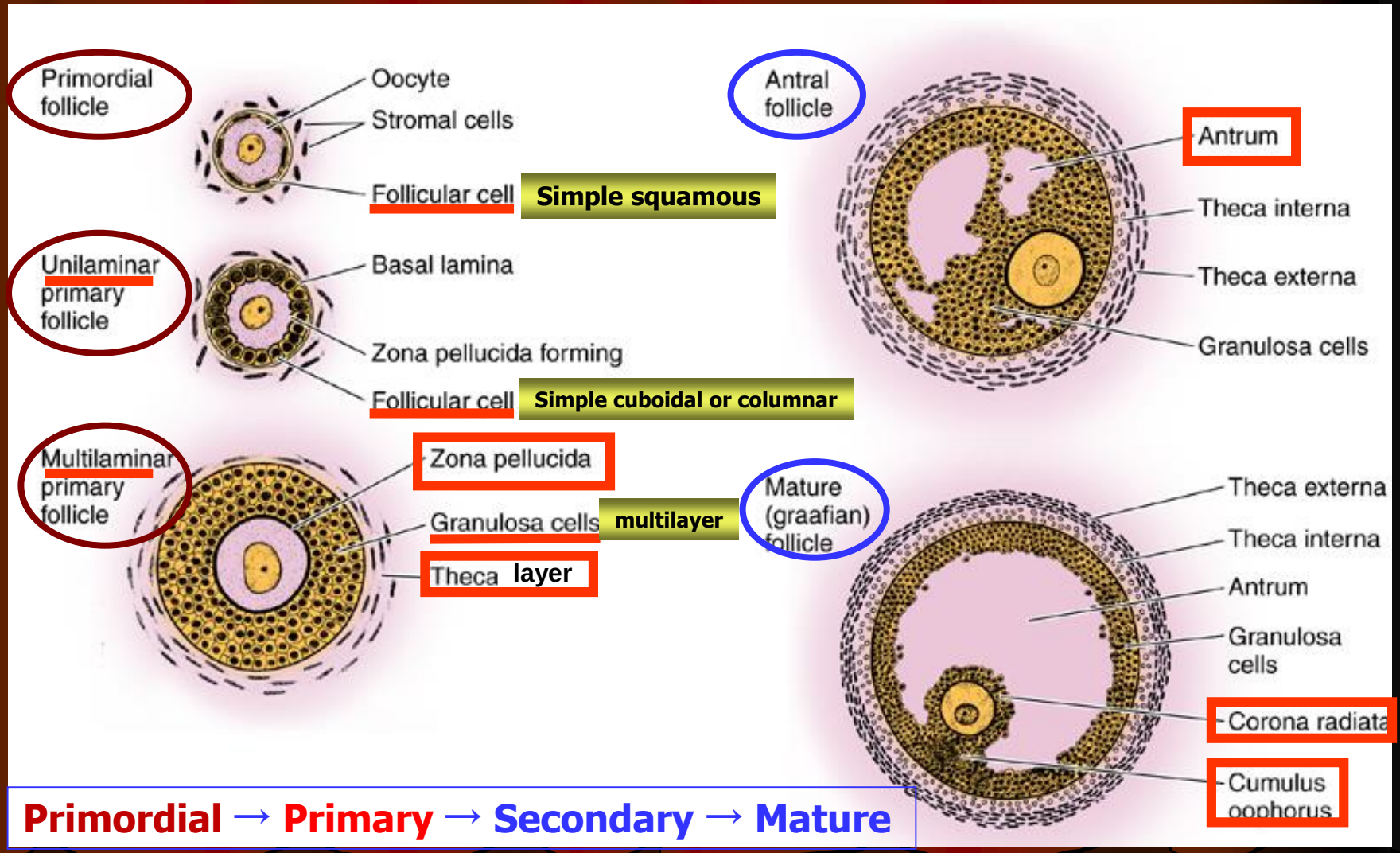
- **10 to 25 mm in diameter**
- **Large antrum**
- **Causing a bulge on the surface of the ovary**

Between 12 and 24 hours after LH surge (before ovulation), the 1st meiotic division of the primary oocyte resumes, and the 2nd oocyte arrested at MII and the 1st polar body were formed.

Diagram illustrating changes that occur during growth, maturation, and fertilization of the oocyte



Summary I.1

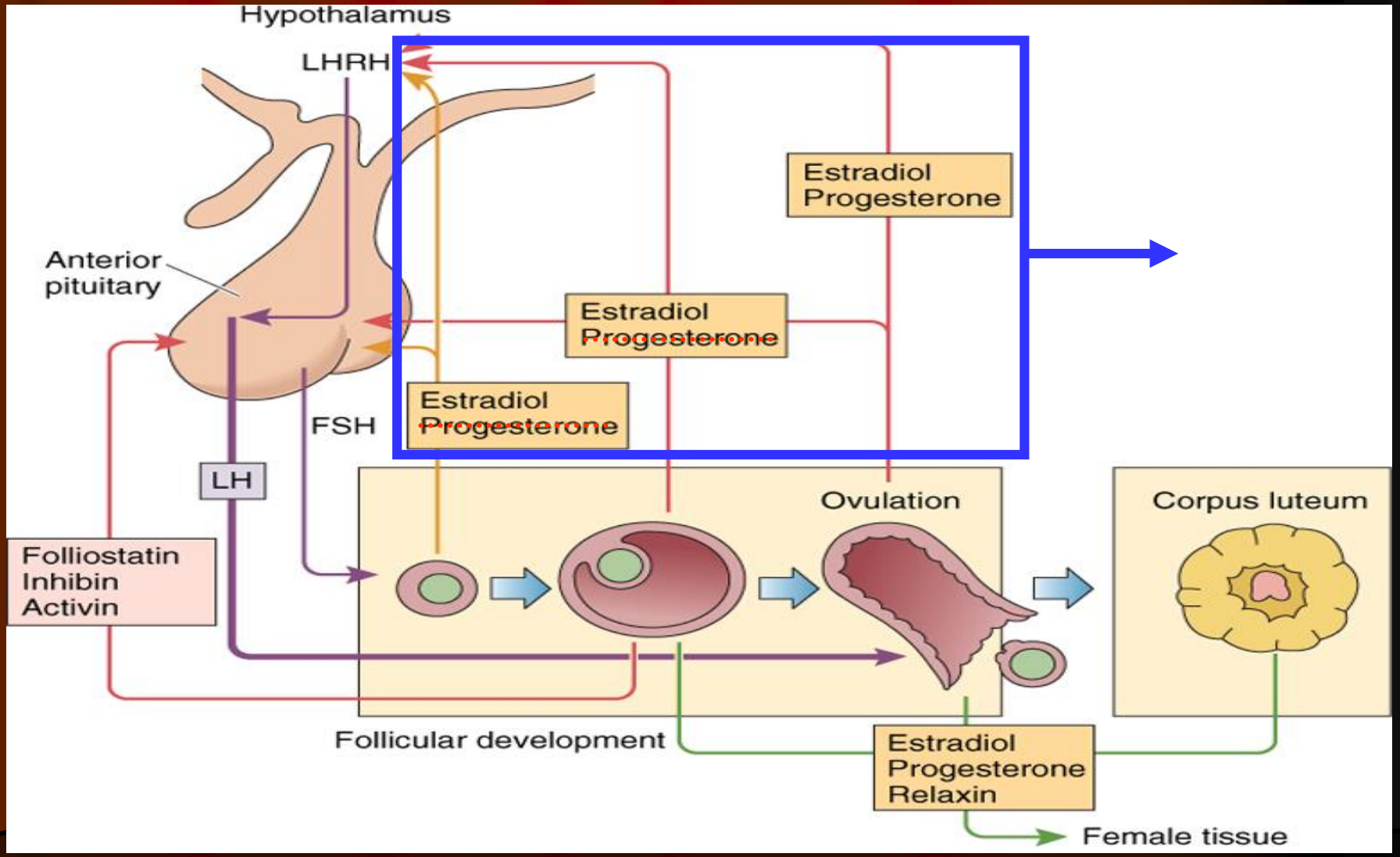


Primordial → Primary → Secondary → Mature

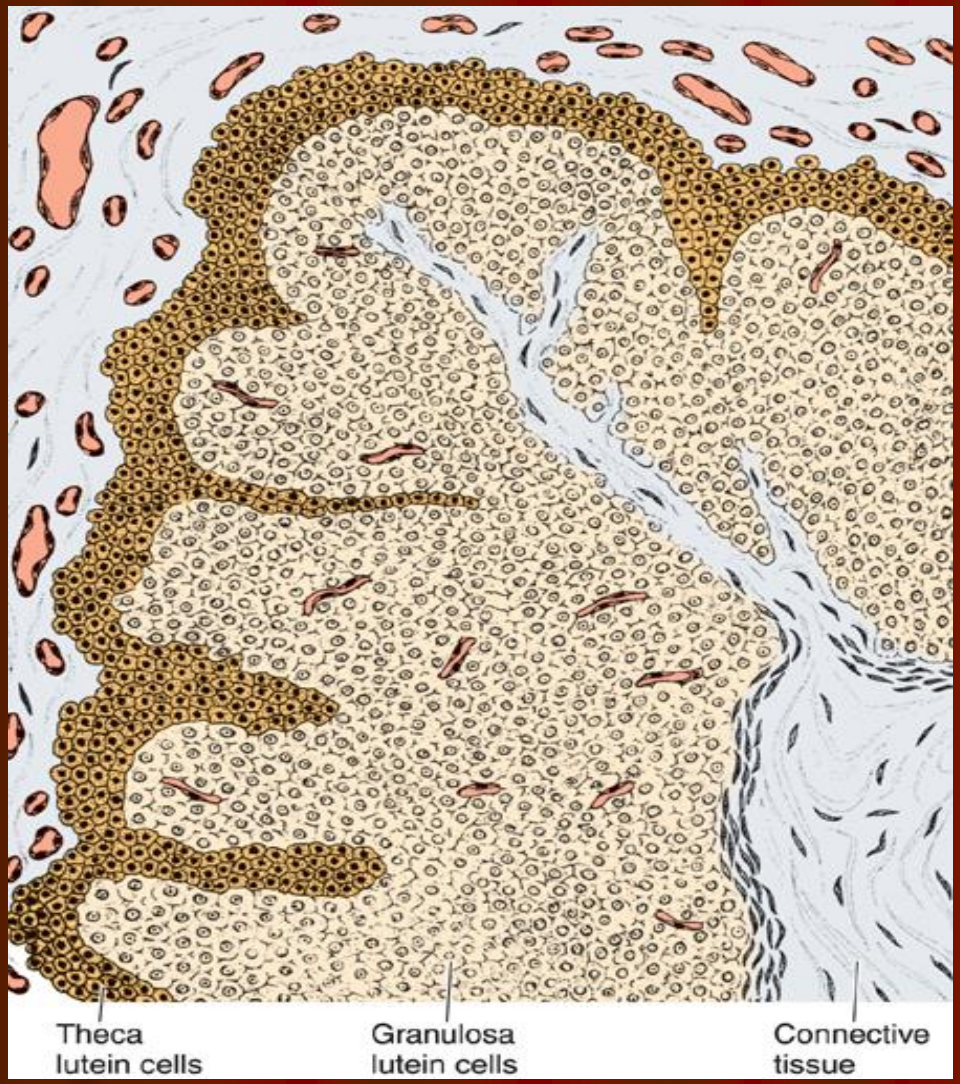
2. Ovulation

- **Characteristics**
  - The rupture of the part of the wall of the mature follicle
  - Liberation of the oocyte with zona pellucida, corona radiata and cumulus oophorus
- **Frequency and amount during each cycle**
  - Once around the 14th day of a 28-day cycle
  - Only one oocyte, alternation of left and right side
  - Sometimes, none; sometimes, two or more
- **Consequence**
  - Between 12 and 24 hours after LH surge (before ovulation)
    - the 1st meiotic division of the primary oocyte resumes
    - the 2nd oocyte arrested at MII
    - the 1st polar body formed.

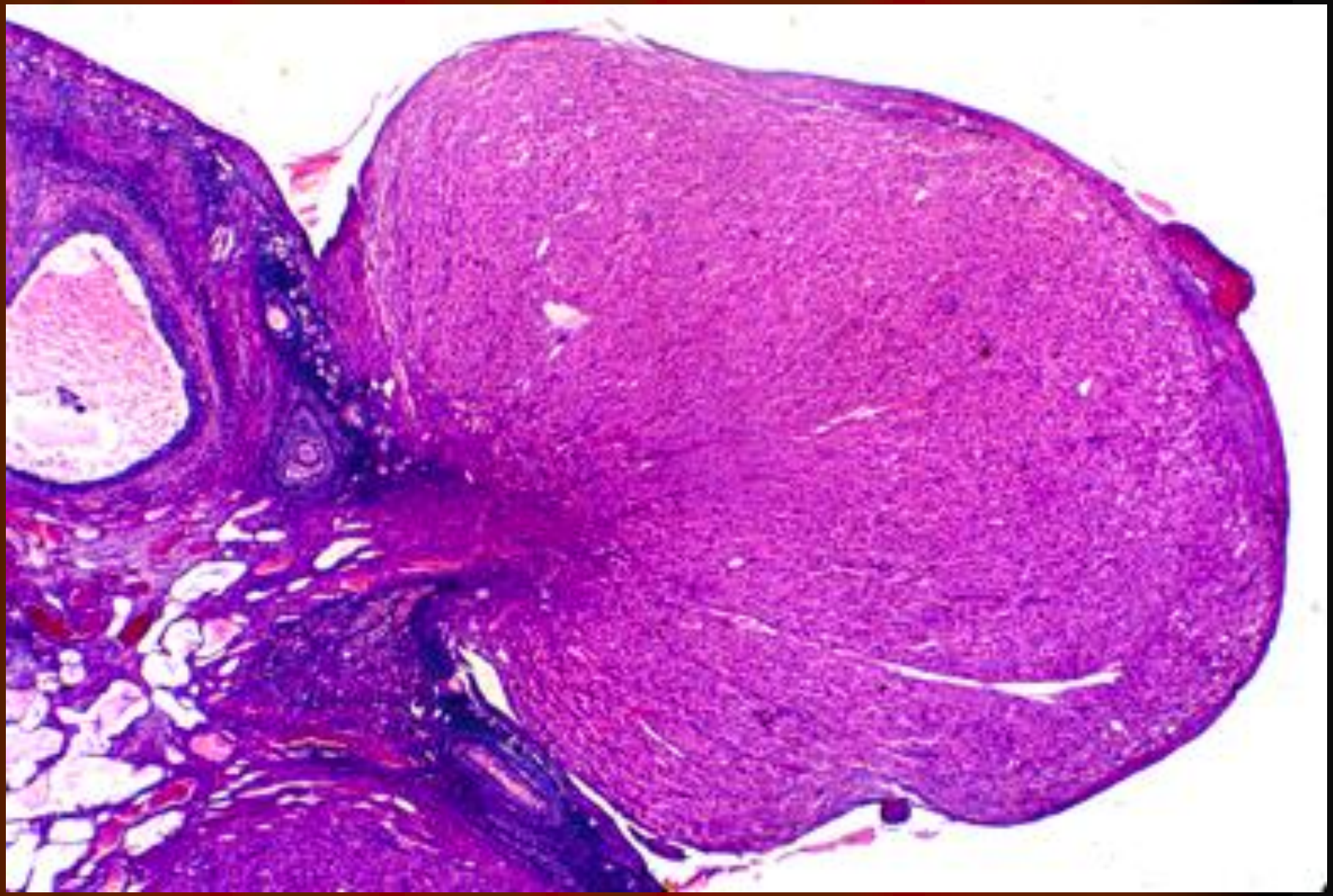
Hormonal Control of Ovarian Functions



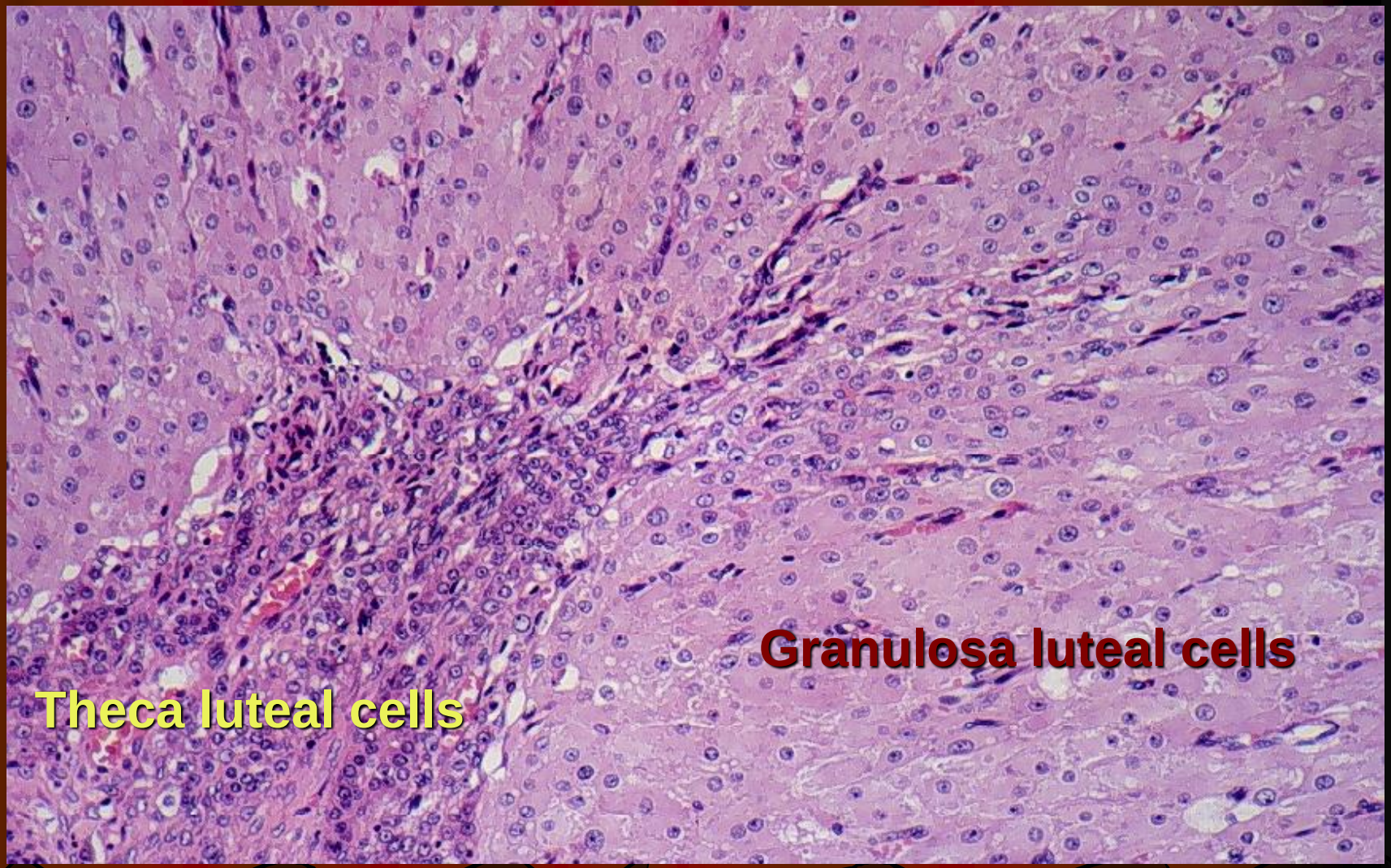
Corpus Luteum



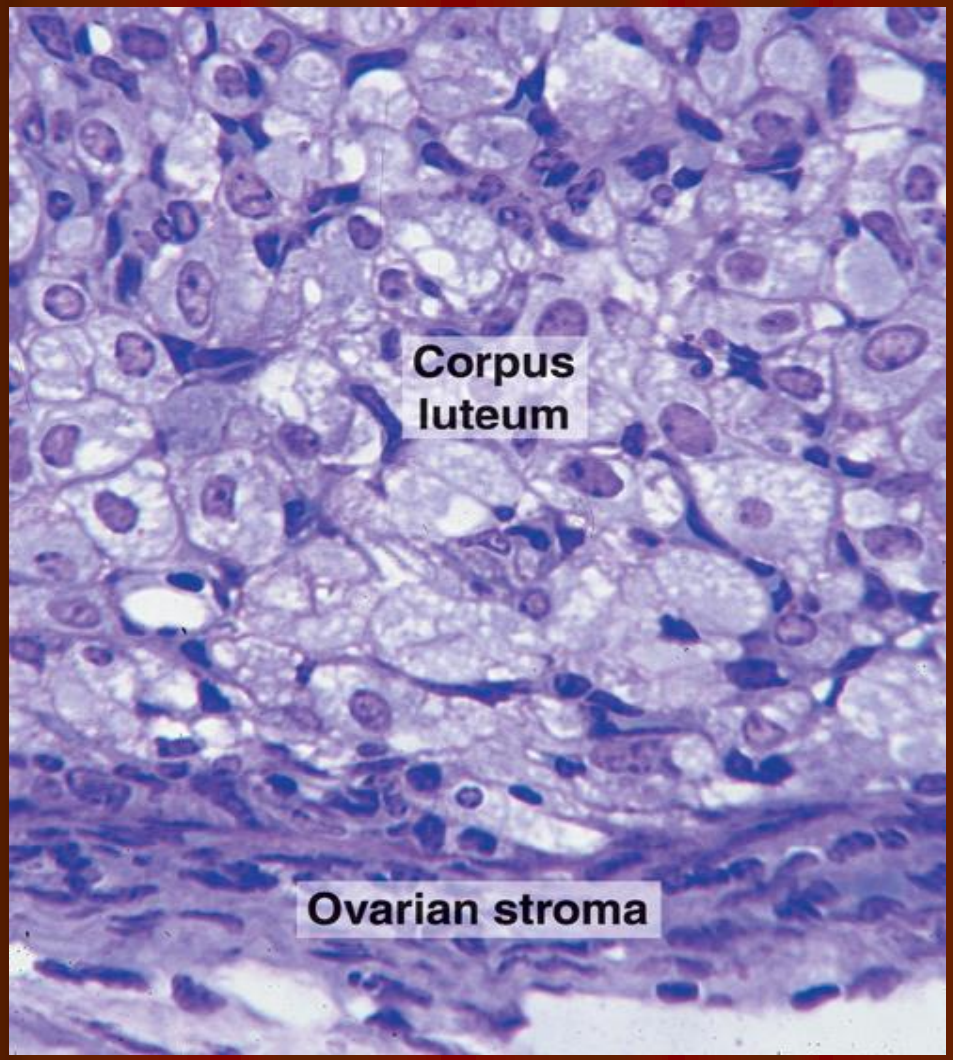
- **Granulosa luteal cells**
  - Larger
  - more centrally located
  - Paler stained
  - Typical steroidogenic cells
- **Theca luteal cells**
  - Smaller
  - Peripherally located
  - More darkly stained
  - Typical steroidogenic cells



Corpus Luteum

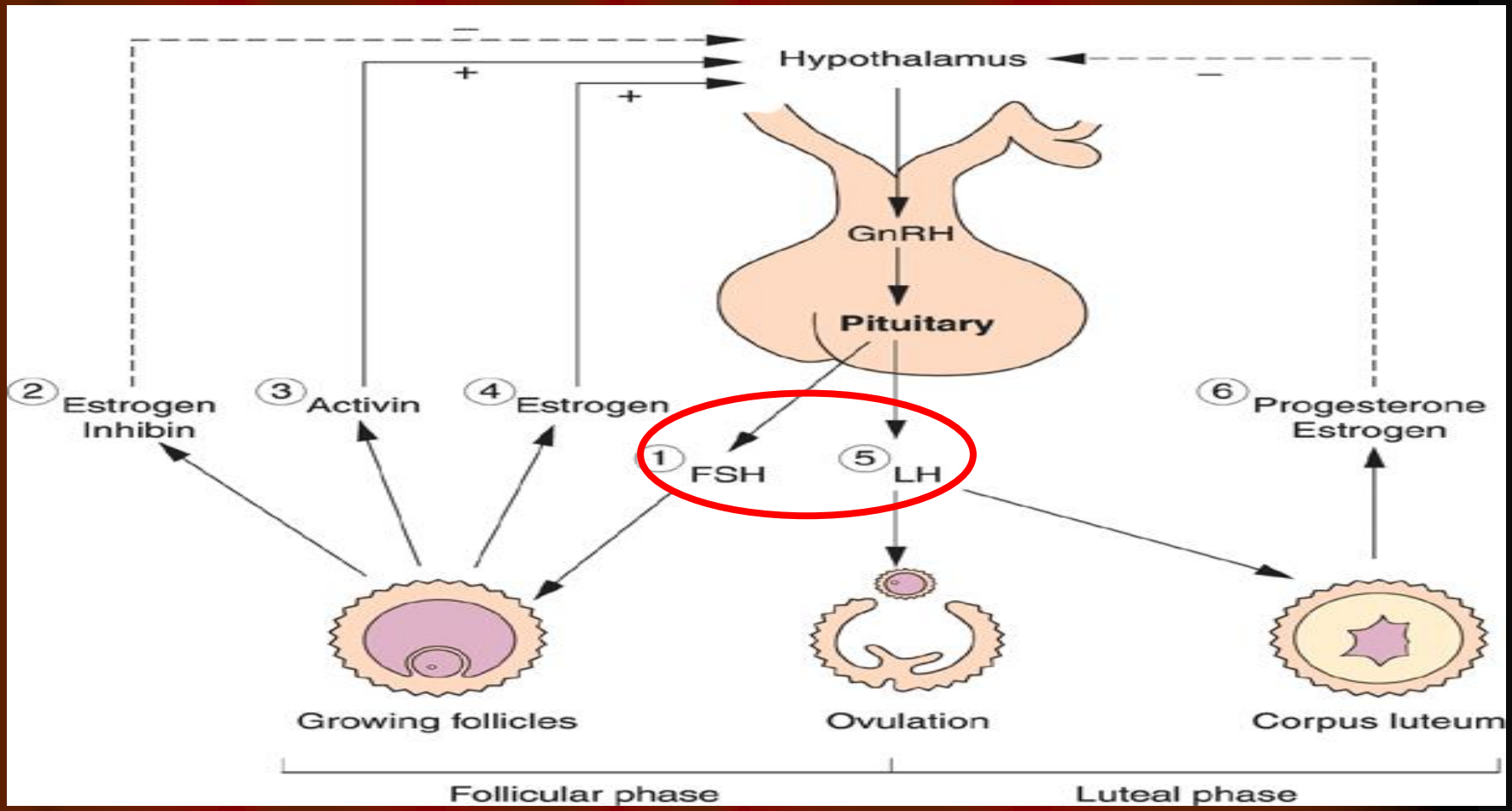


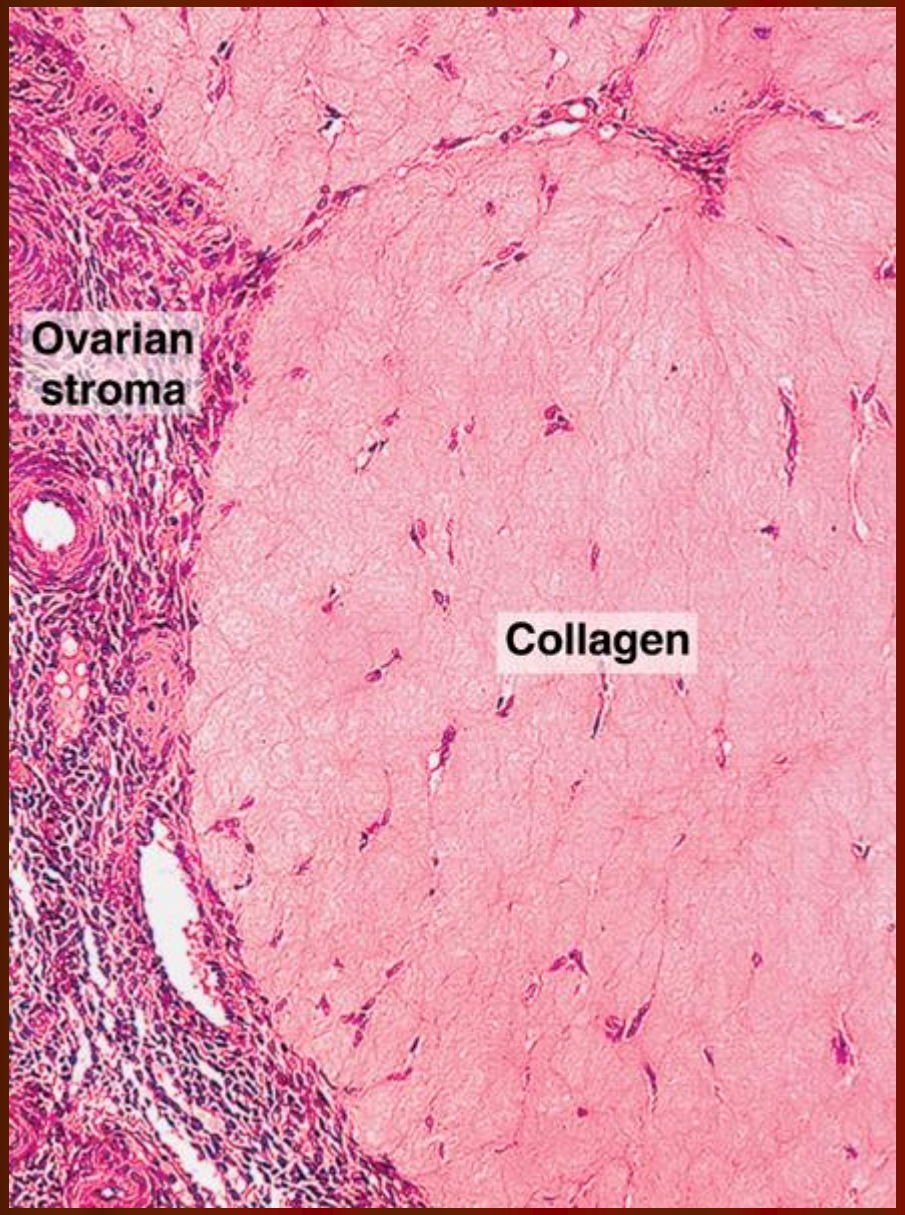
Corpus Luteum



- Granulosa luteal cells
  - Larger
  - more centrally located
  - Paler stained
  - Typical steroidogenic cells
  - Secrete P and relaxin
  - Secrete E collaborating with theca luteal cells

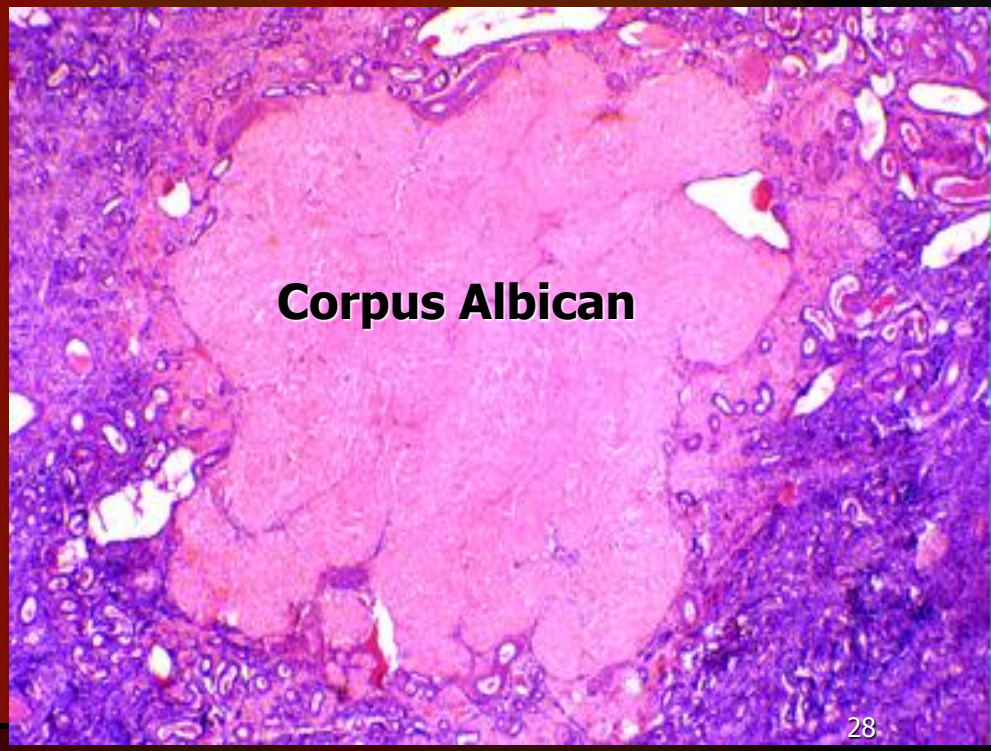
Hormonal Control of Ovarian Functions





Corpus Albican

- If unfertilized
  - Corpus luteum of menstruation-formed will degenerate after 14 days and be replaced by collagen, forming white body
- If fertilized
  - Corpus luteum of pregnancy-formed will degenerate after 6 months and be replaced by collagen, forming white body



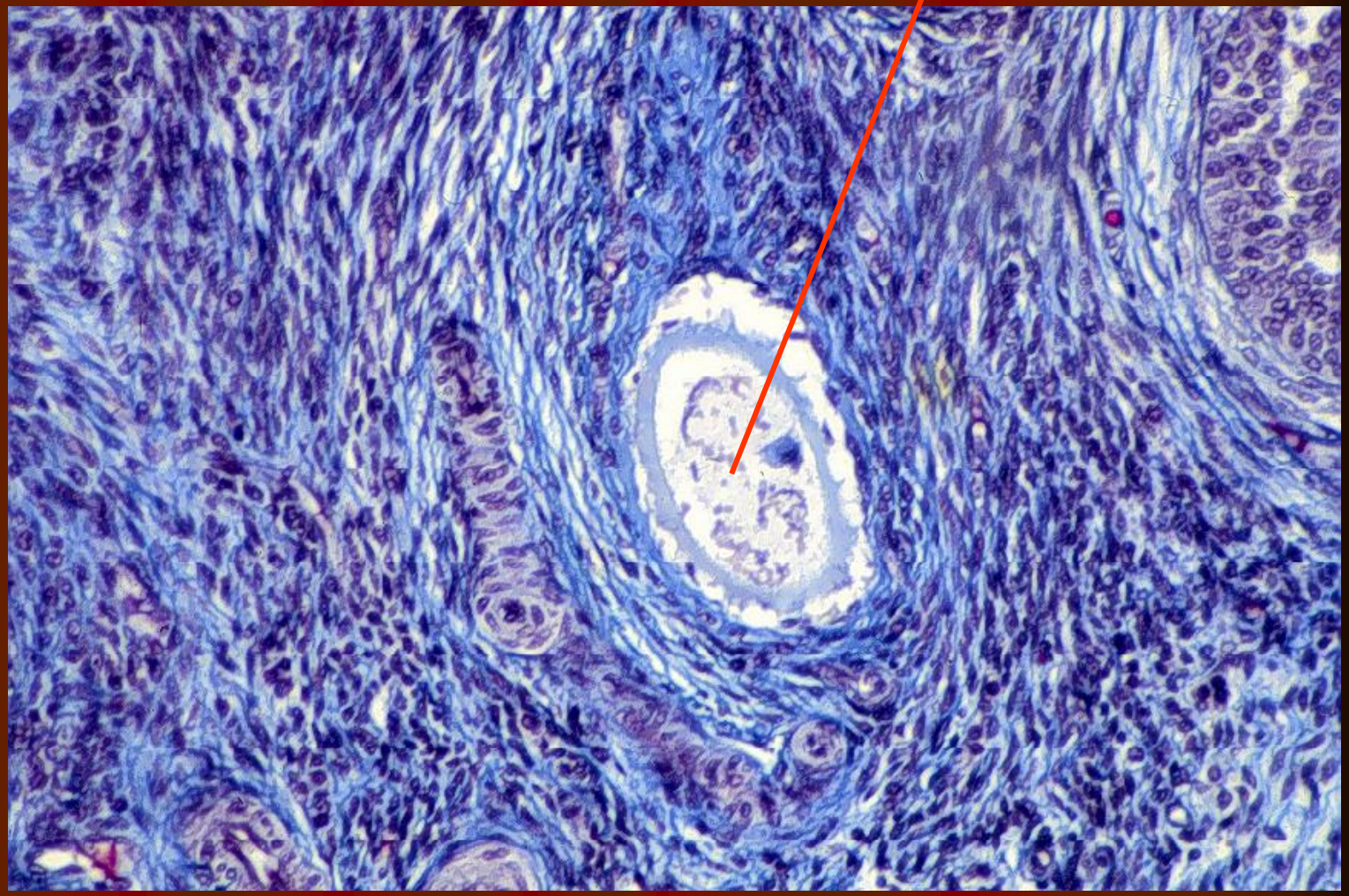
Follicular Atresia

- Most ovarian follicles are lost by atresia mediated by apoptosis of granulosa cells DURING
  - Fetal development
  - Early postnatal life
  - Puberty

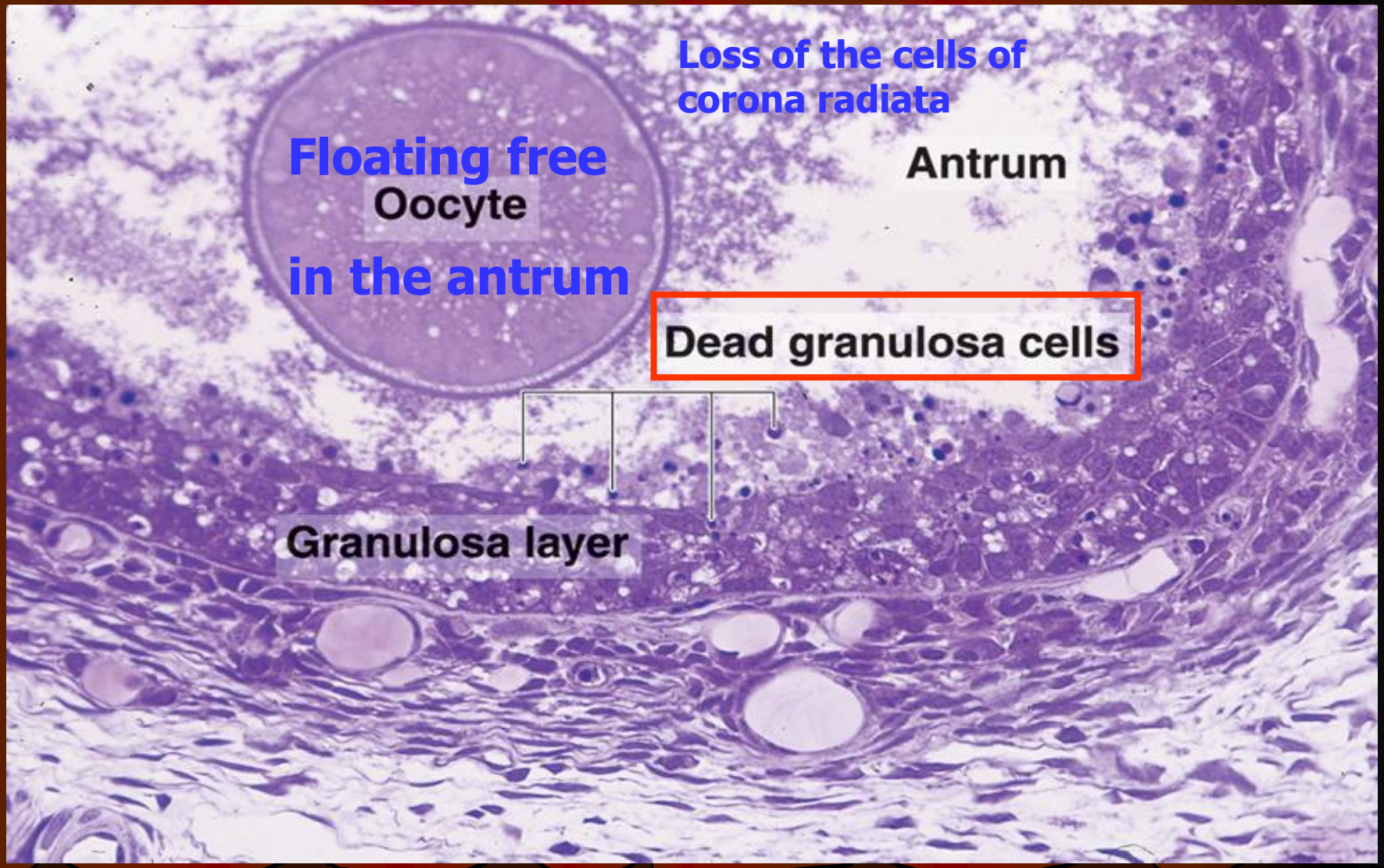
- After puberty,
  - Groups of follicles begin to mature during each menstrual cycle.
  - BUT only one follicle completes its maturation.
  - Thus, at any stage a follicle may undergo atresia

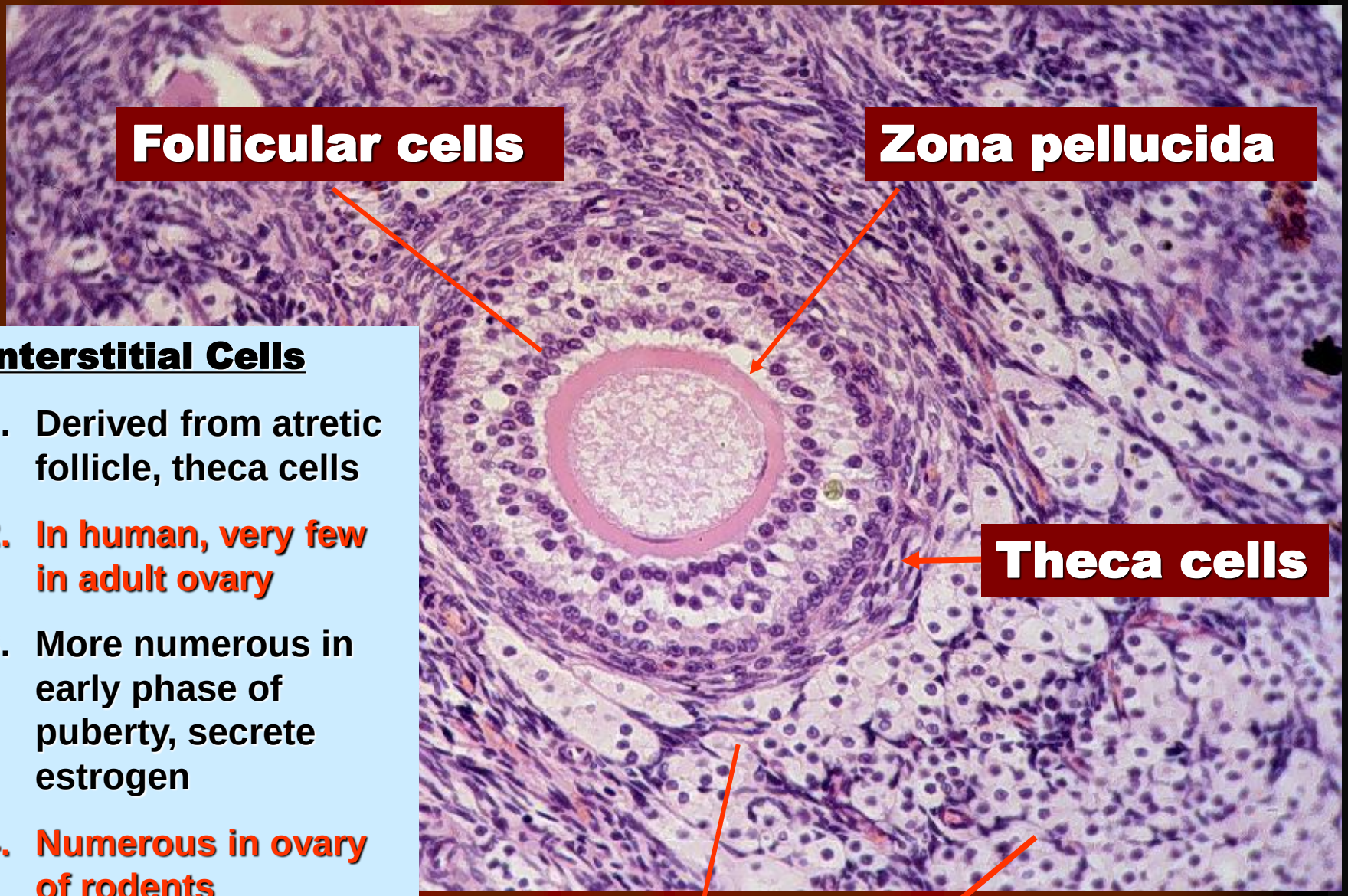
- Features:
  - Cessation of mitosis in the granulosa cells
  - Detachment of granulosa cells from the basal lamina
  - Death of the oocyte and granulosa cells
  - Invasion of macrophages to the follicle
  - Occupation of fibroblast in the follicle

Atretic Follicle



An Atresic Antral Follicle





Interstitial Cells

1. Derived from atretic follicle, theca cells
2. In human, very few in adult ovary
3. More numerous in early phase of puberty, secrete estrogen
4. Numerous in ovary of rodents

Interstitial Cells

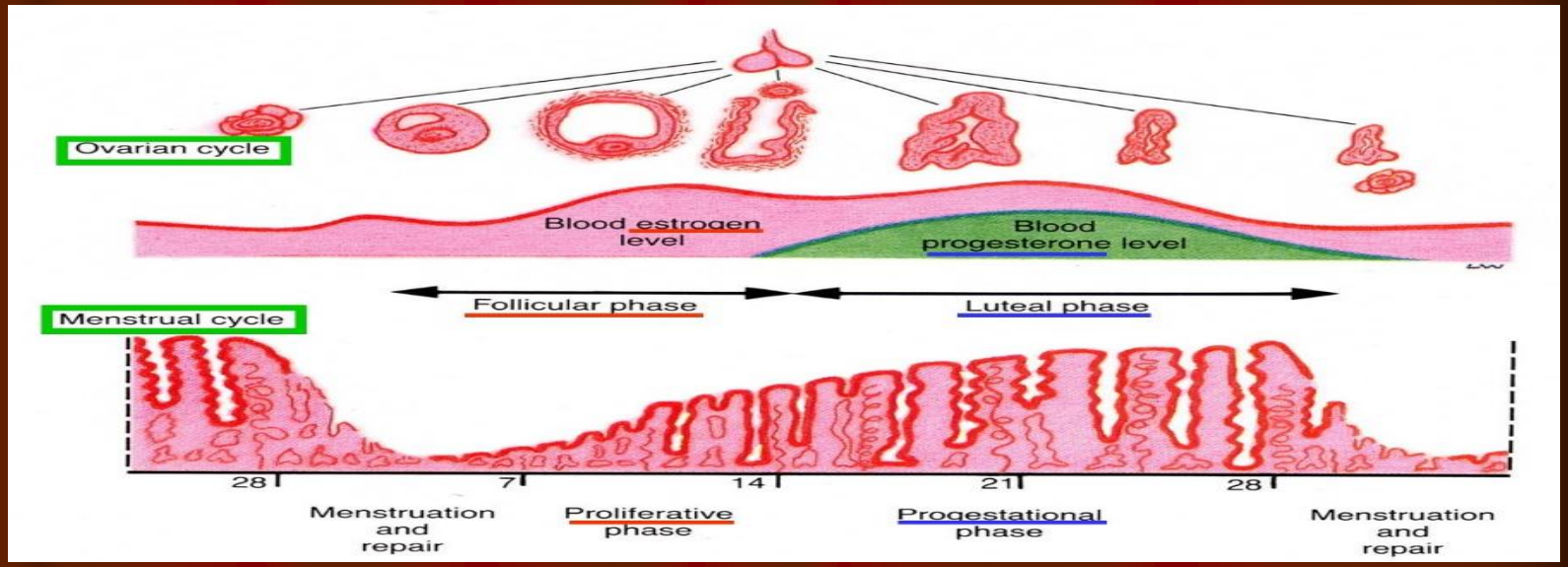
Summary I.2

- Only one follicle completes its maturation and ovulates one oocyte with zona pellucida, corona radiata and cumulus cells during each cycle.
- Most ovarian follicles are lost by atresia mediated by apoptosis of granulosa cells at any stage, forming atresic follicle or interstitial glands.
- Corpus luteum formed from the remained granulosa cells and theca cells after ovulation.
- Corpus albicans formed when corpus luteum degenerate in 14 days if unfertilized or 6 months if fertilized.

Summary I - OVARY

- **Paired** ovary
- **Source** of oocytes
- **Active** at/after puberty
- **Cyclic changes** to produce oocytes
- **Secretion** of estrogen and progesterone
- **Cycle ceases** at menopause, thus no estrogen and progesterone

Questions ?



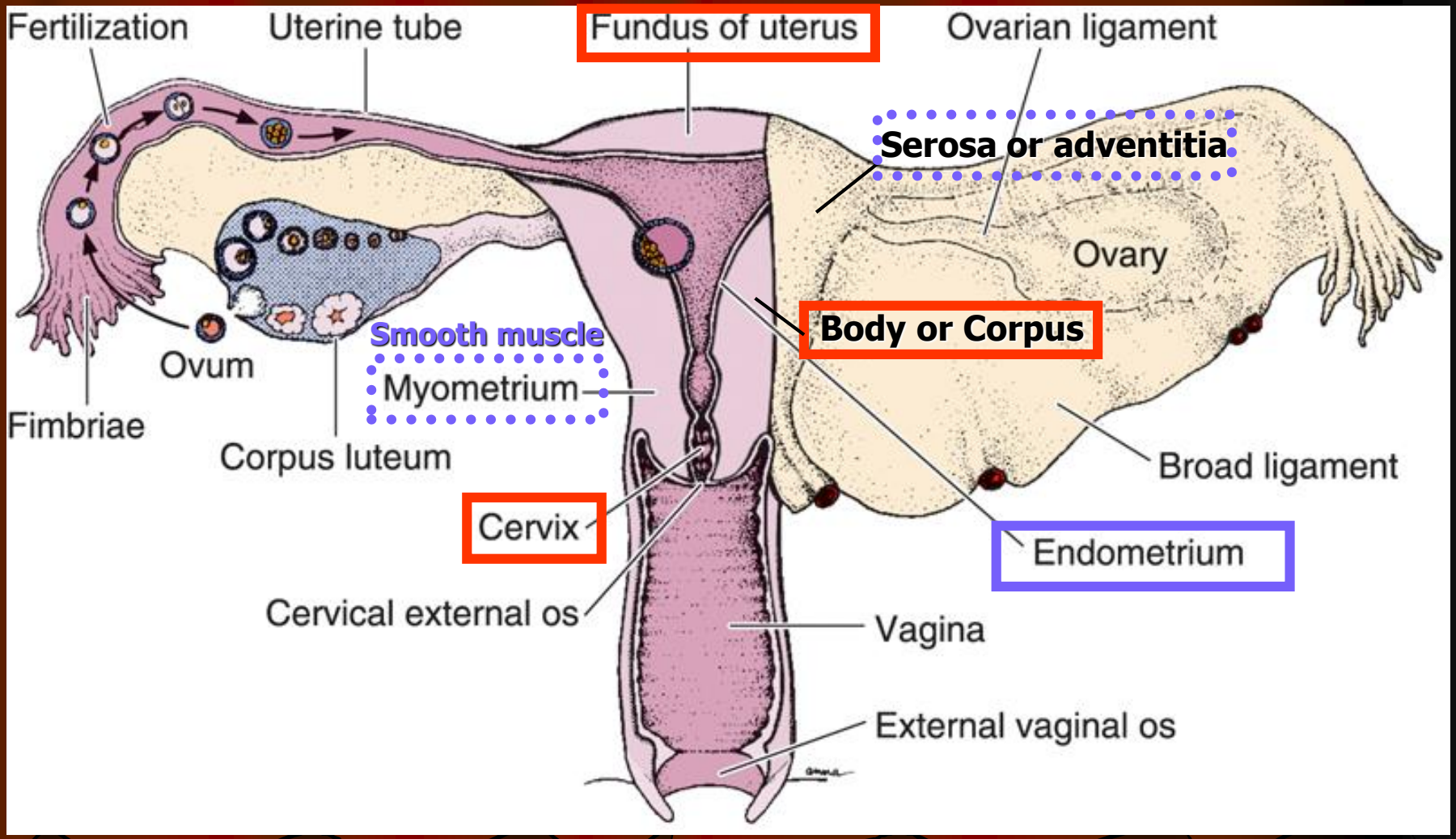
How are oocytes produced?

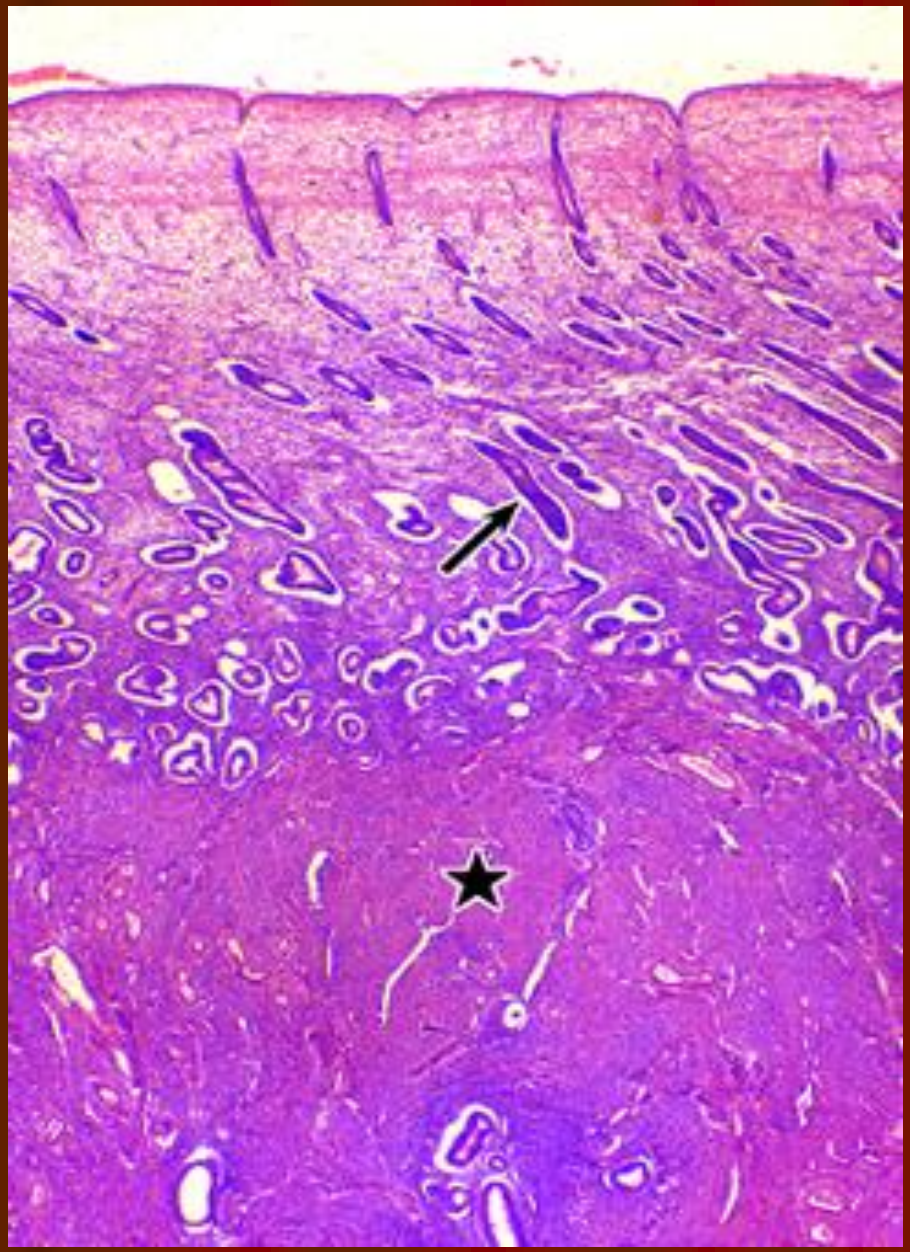
- **Key points: refer to the ovarian cycle, follicular and luteal phases.**

What are the reactions of uterus during the oocyte production?

- **Key points: refer to the menstrual cycle, proliferative and progestational phases.**

Female Reproductive System

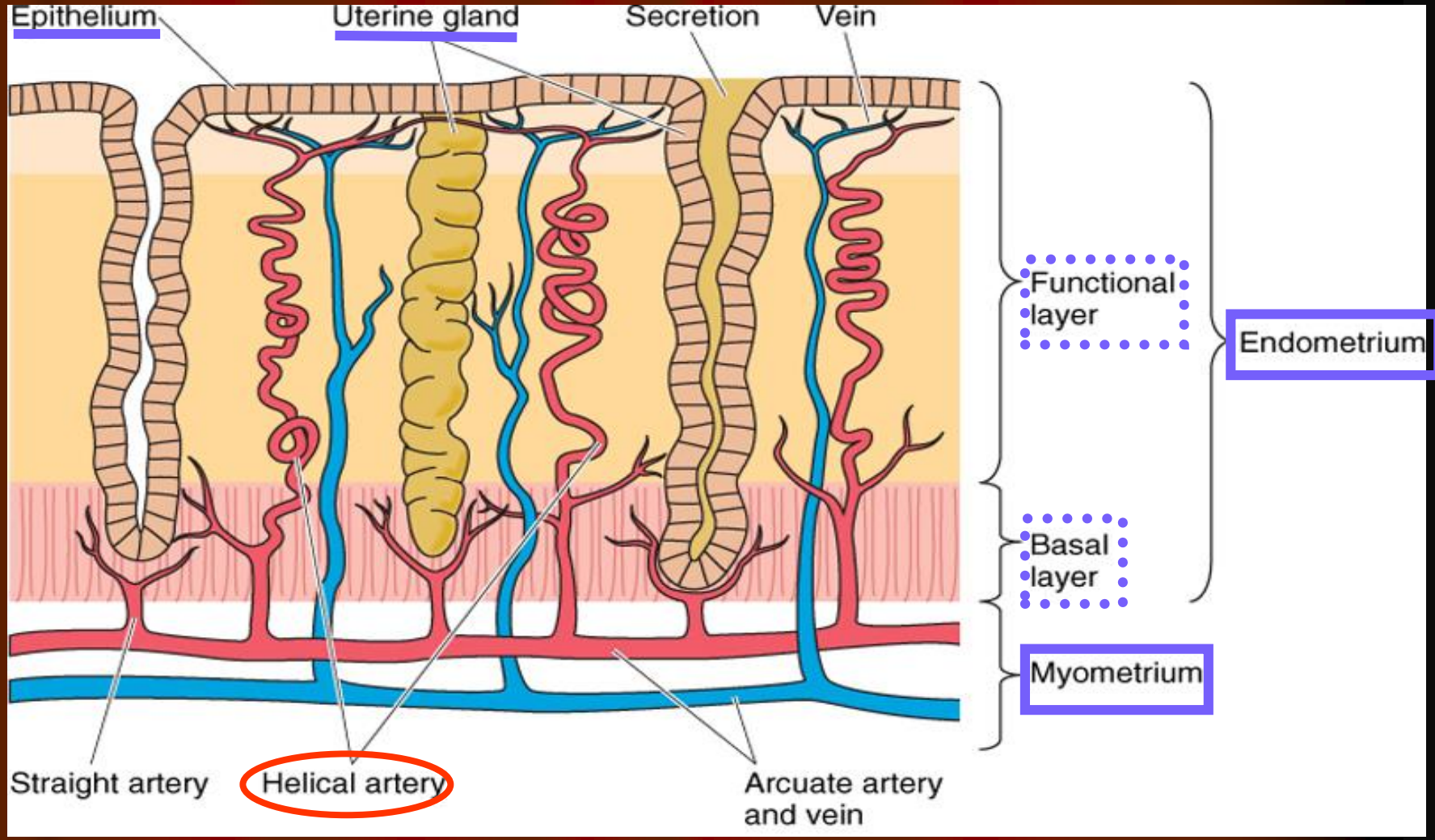


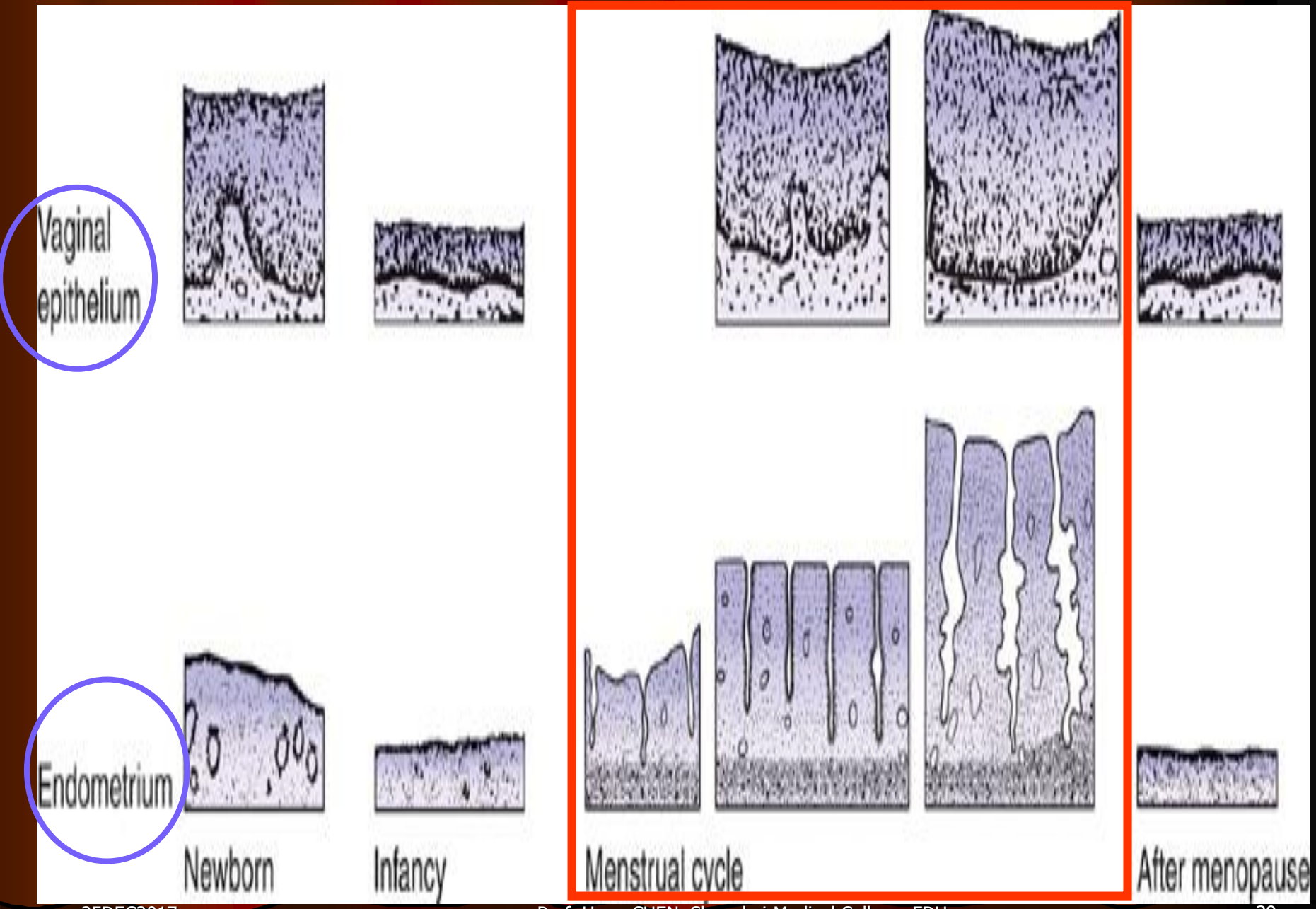


Human Endometrium

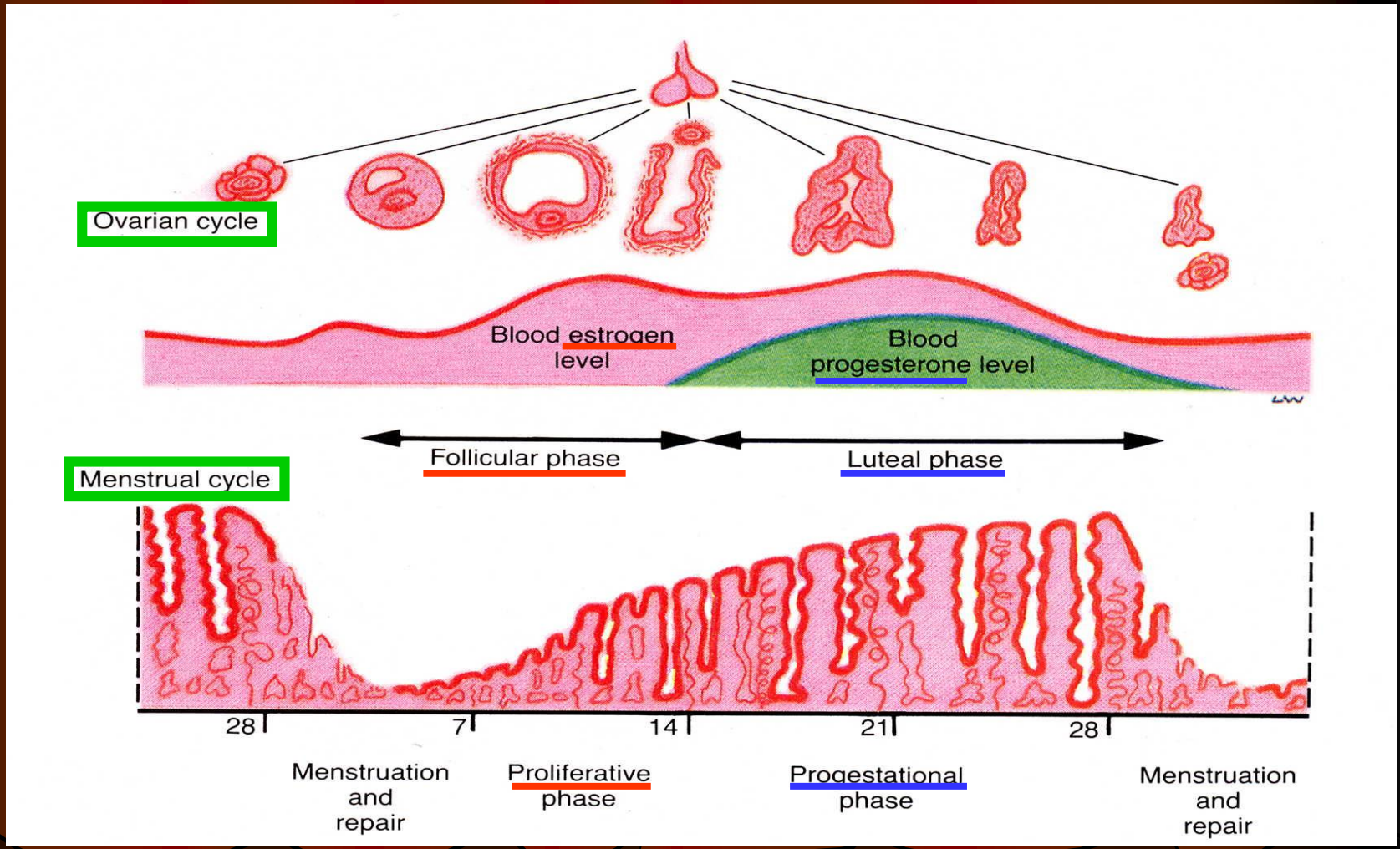
- **Epithelium**
  - A mixture of ciliated and secretory simple columnar cells
- **Lamina propria**
  - simple tubular glands (↗)
    - Similar to the superficial epithelium, but ciliated cells are rare
  - connective tissue
    - rich in fibroblast (stroma cells)
    - Contains abundant ground substance

Human Endometrium




Vaginal epithelium
Endometrium
Newborn
Infancy
Menstrual cycle
After menopause

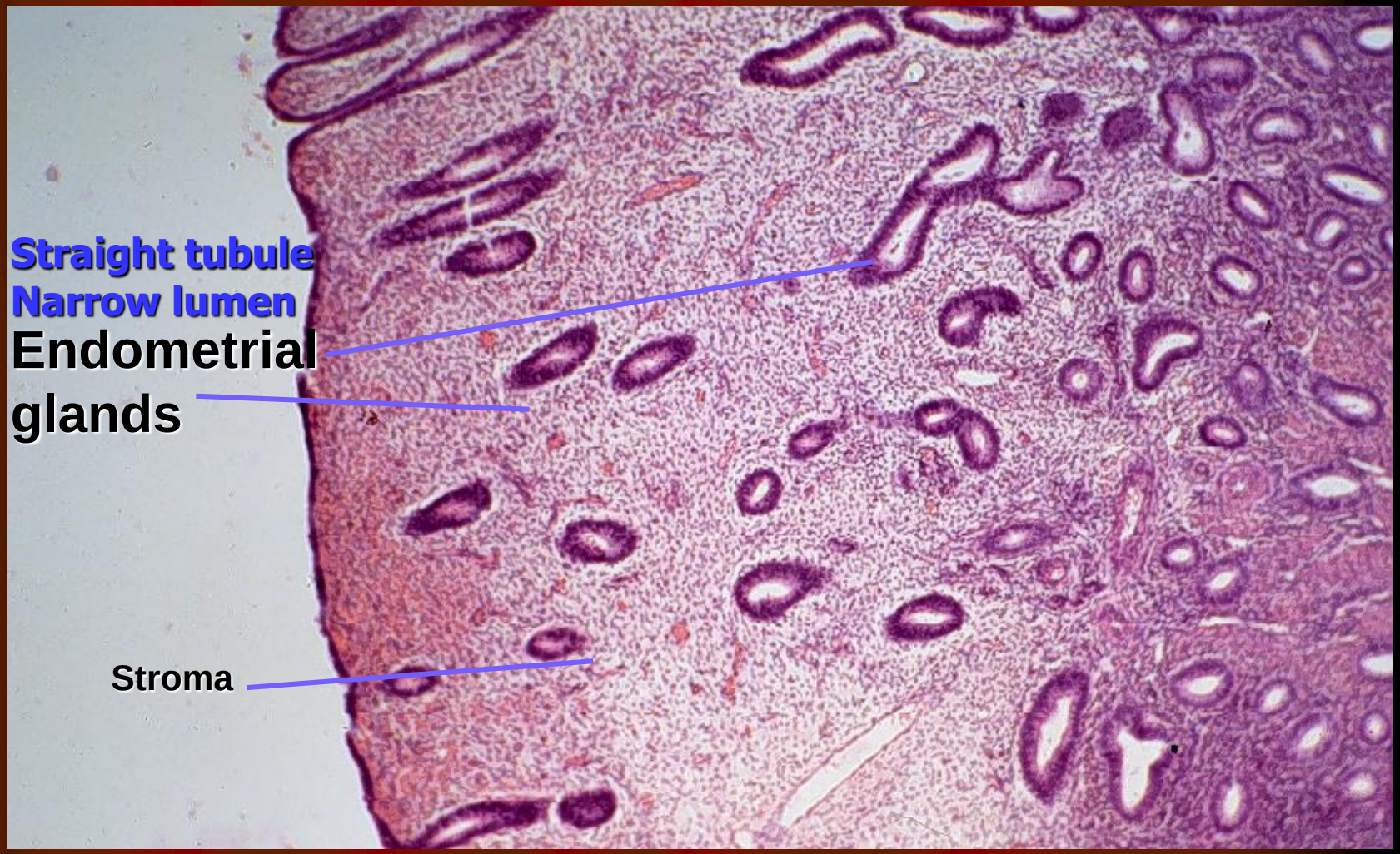
Relationship of Ovarian Cycle and Menstrual Cycle

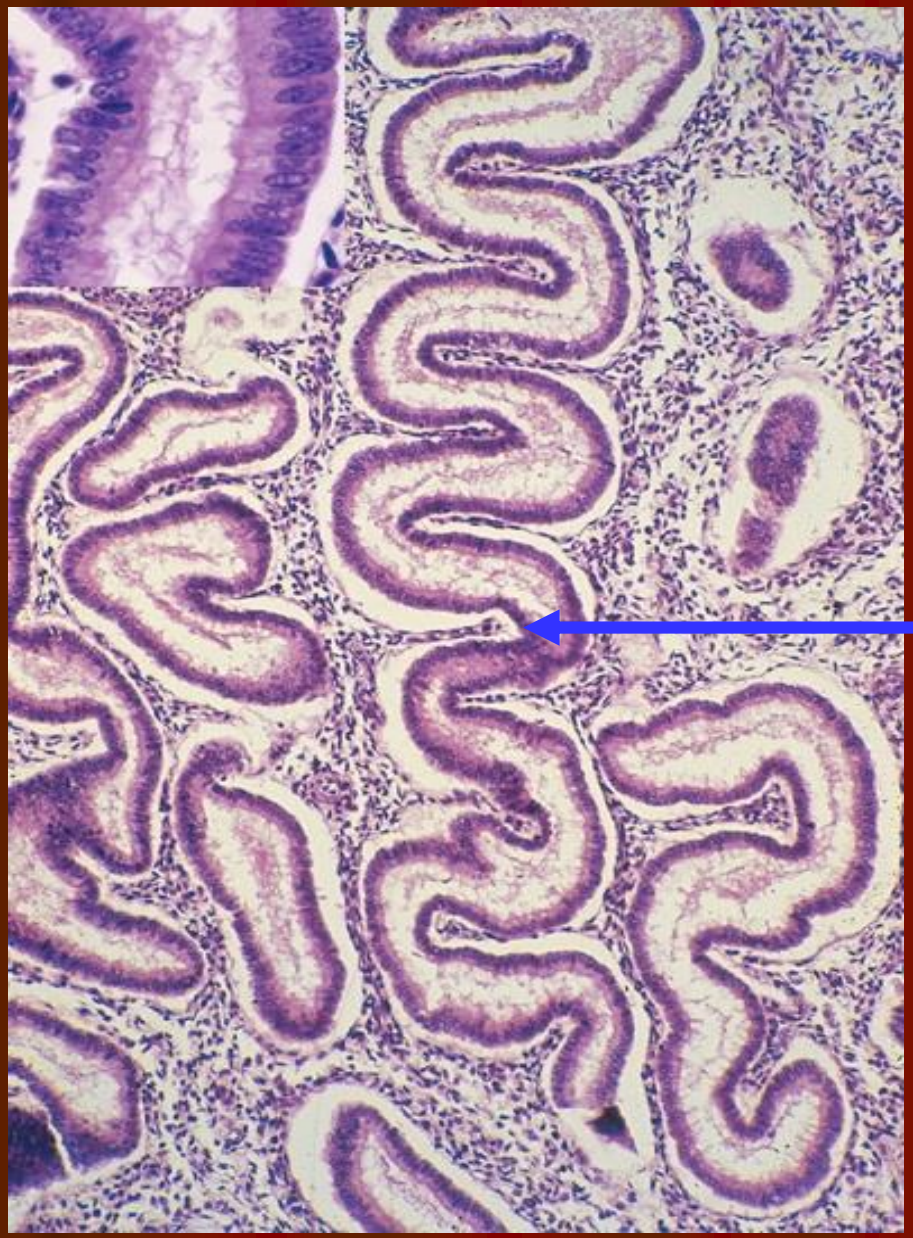


Menstruation

- Result from a rapid decline of ovarian hormones
- Changes in blood supply to functional layer
- Prolonged contraction of spiral arterioles, each lasting several hours, leading to ischemic functional layer
- The process continues for about two days
- Disruption of surface epithelium, glands and arterioles in functional layer
- Sloughing of tissues from functional layer, vaginal discharge
- Only the basal layer of endometrium remains intact

Endometrium - Proliferative

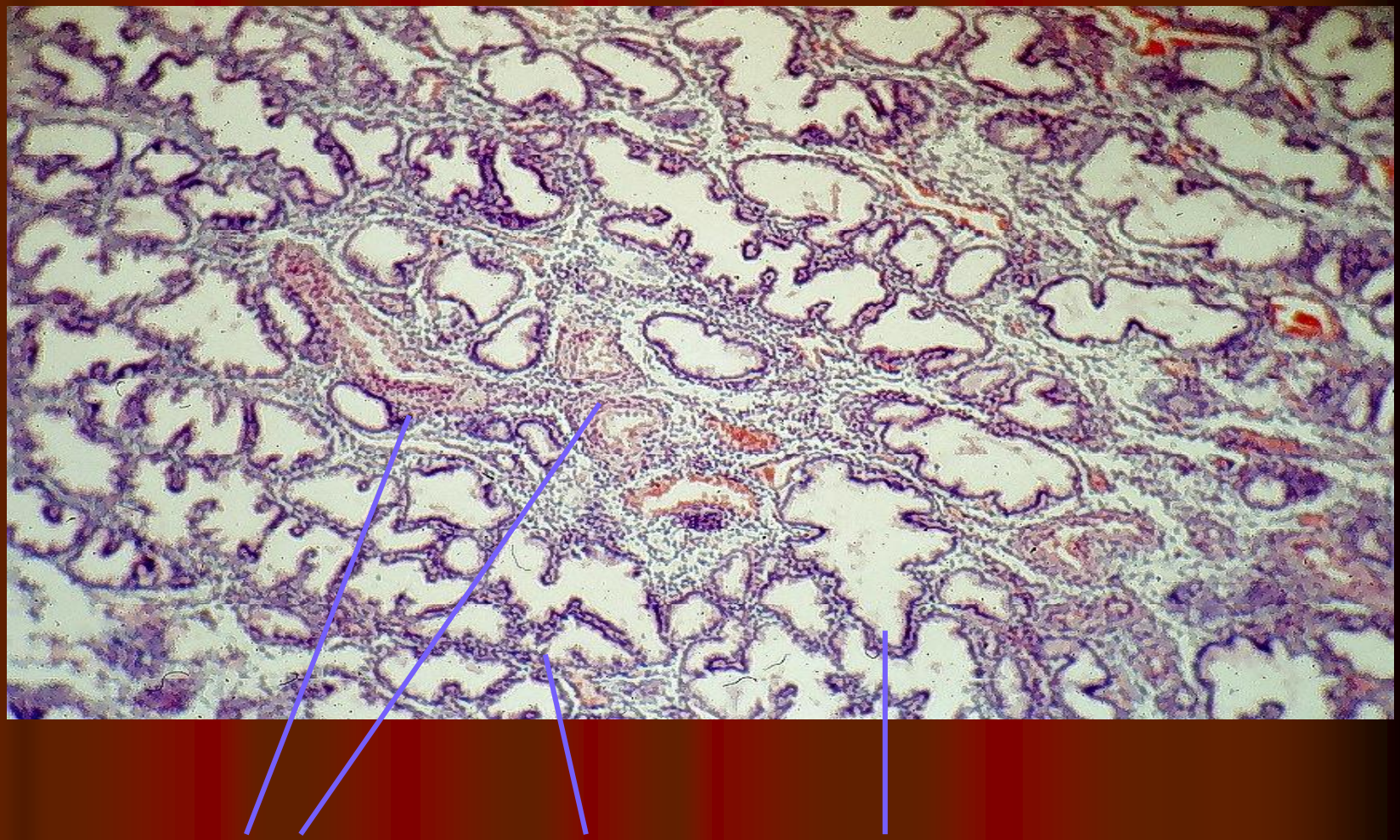




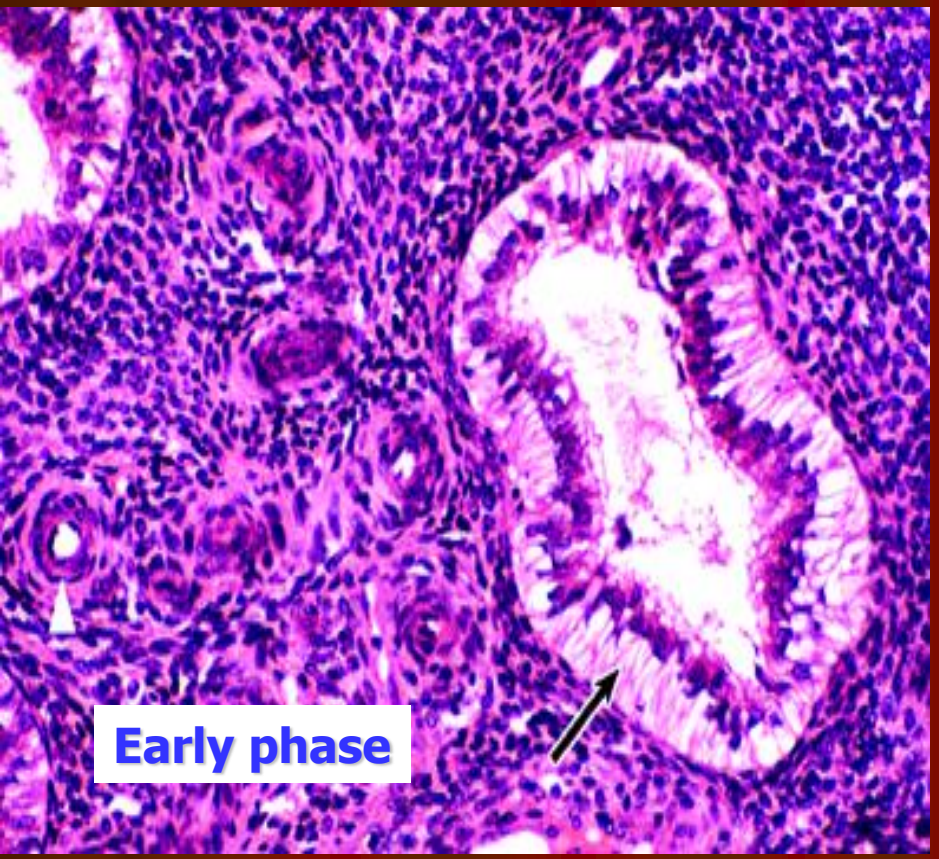
Endometrium (secretory phase)

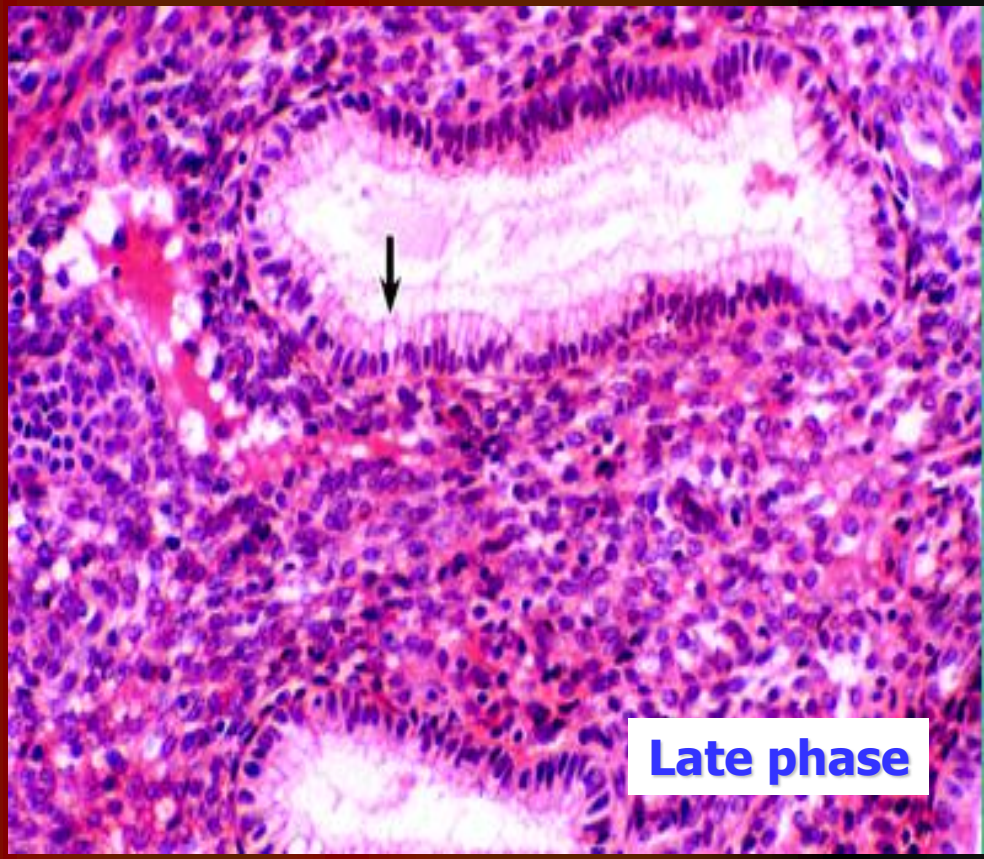
- Extensively coiled arterioles
- Very thick functional layer with highly convoluted glands
- Stroma becomes edematous
- Early secretory phase
  - vacuolar BELOW their nuclei of gland cells
- Late secretory phase
  - vacuolar ABOVE their nuclei of gland cells

Endometrium - Secretory



Human Endometrium (Secretory or Luteal Phase)





Uterine gland with vacuolar BELOW or ABOVE their nuclei of gland cells
Stroma cell → predecidual cell

Changes in the Uterine Glands and in the Gland Cells During Menstrual Cycle

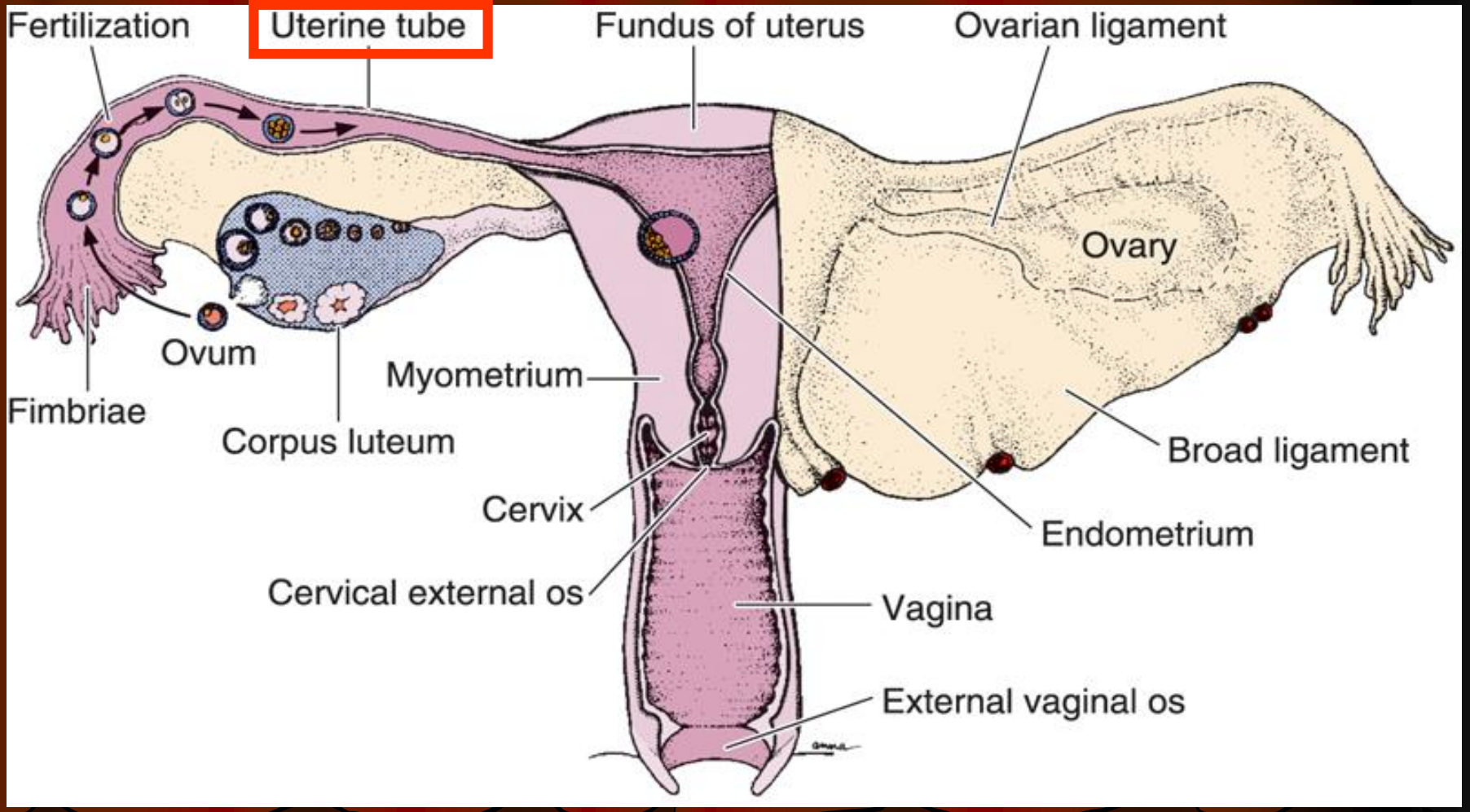
Summary III - UTERUS

- The myometrium forms a structural and functional syncytium
- The endometrium proliferates and degenerates during a menstrual cycle, mainly in
  - The stratum functional or functional layer
  - The vasculature also
- Cyclic changes are presented by
  - The proliferative phase
    - Regulated by Estrogen
  - The secretory phase
    - Regulated by Progesterone
  - The menstrual phase
    - Results from a decline in the ovarian secretion of P and E

Questions ?

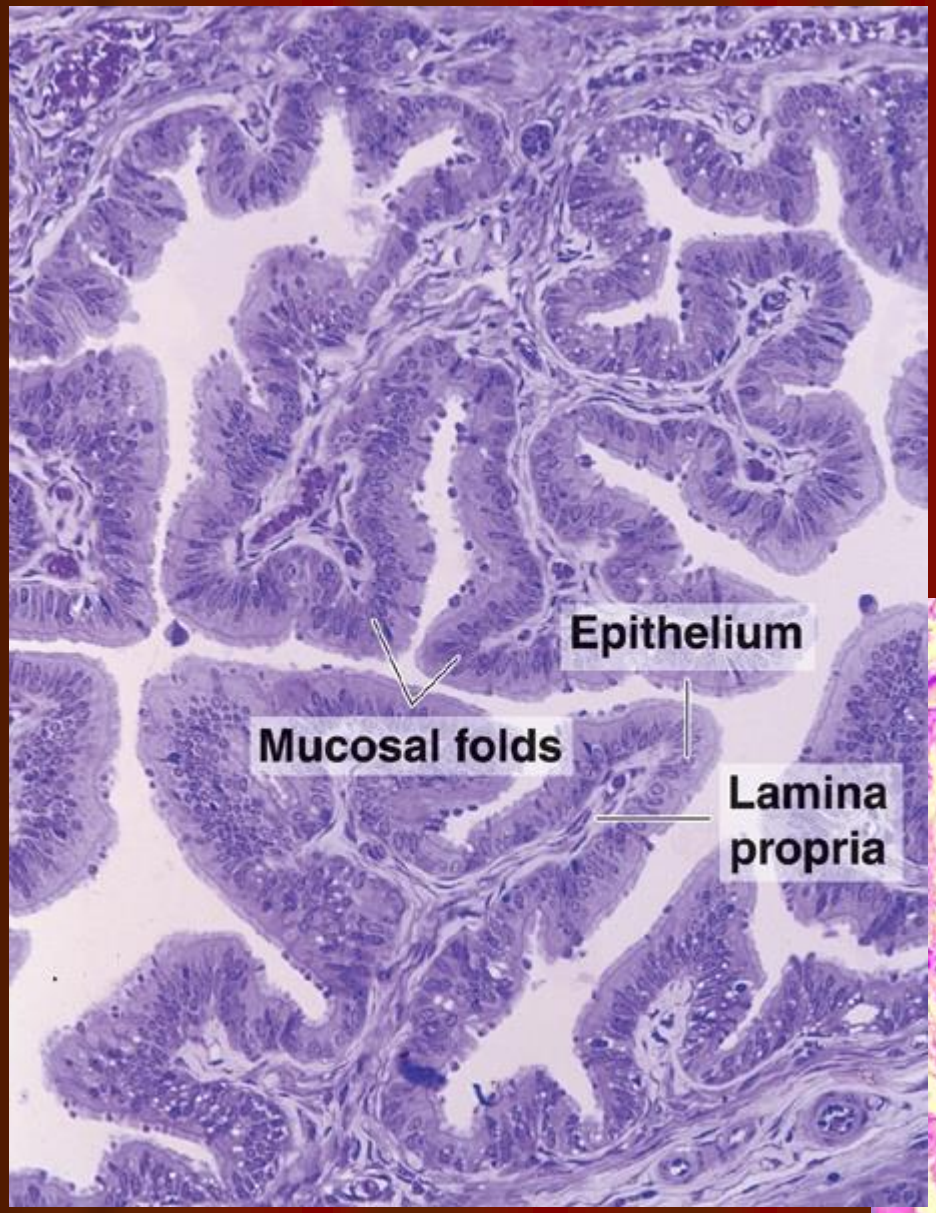
- How are oocytes produced?
- What are their reactions during the oocyte production?
  - Uterus
  - Oviduct
  - Vagina
  - Mammary glands

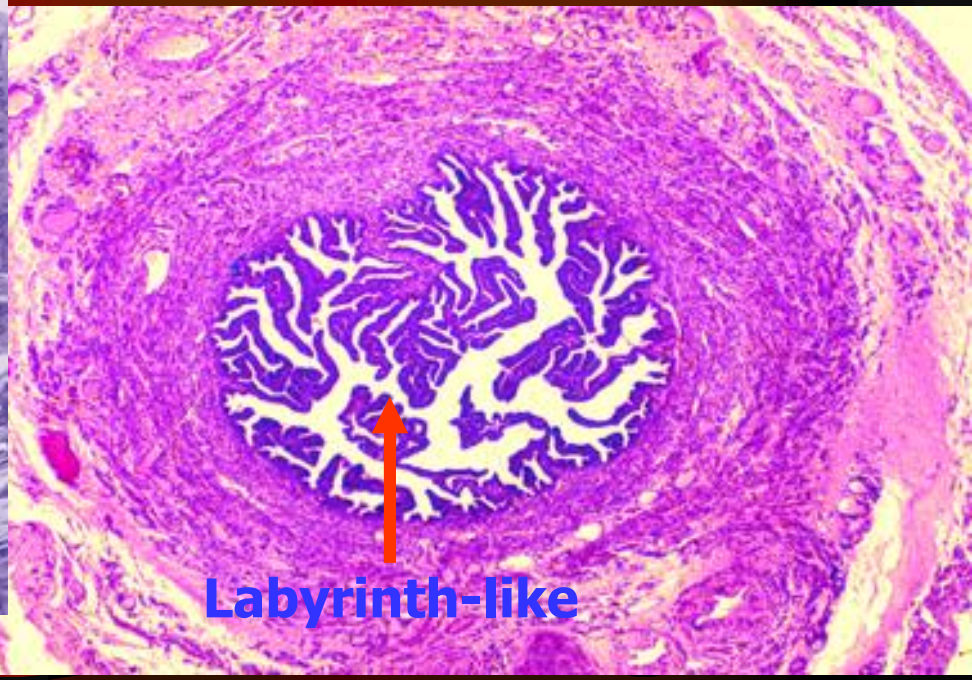
Female Reproductive System

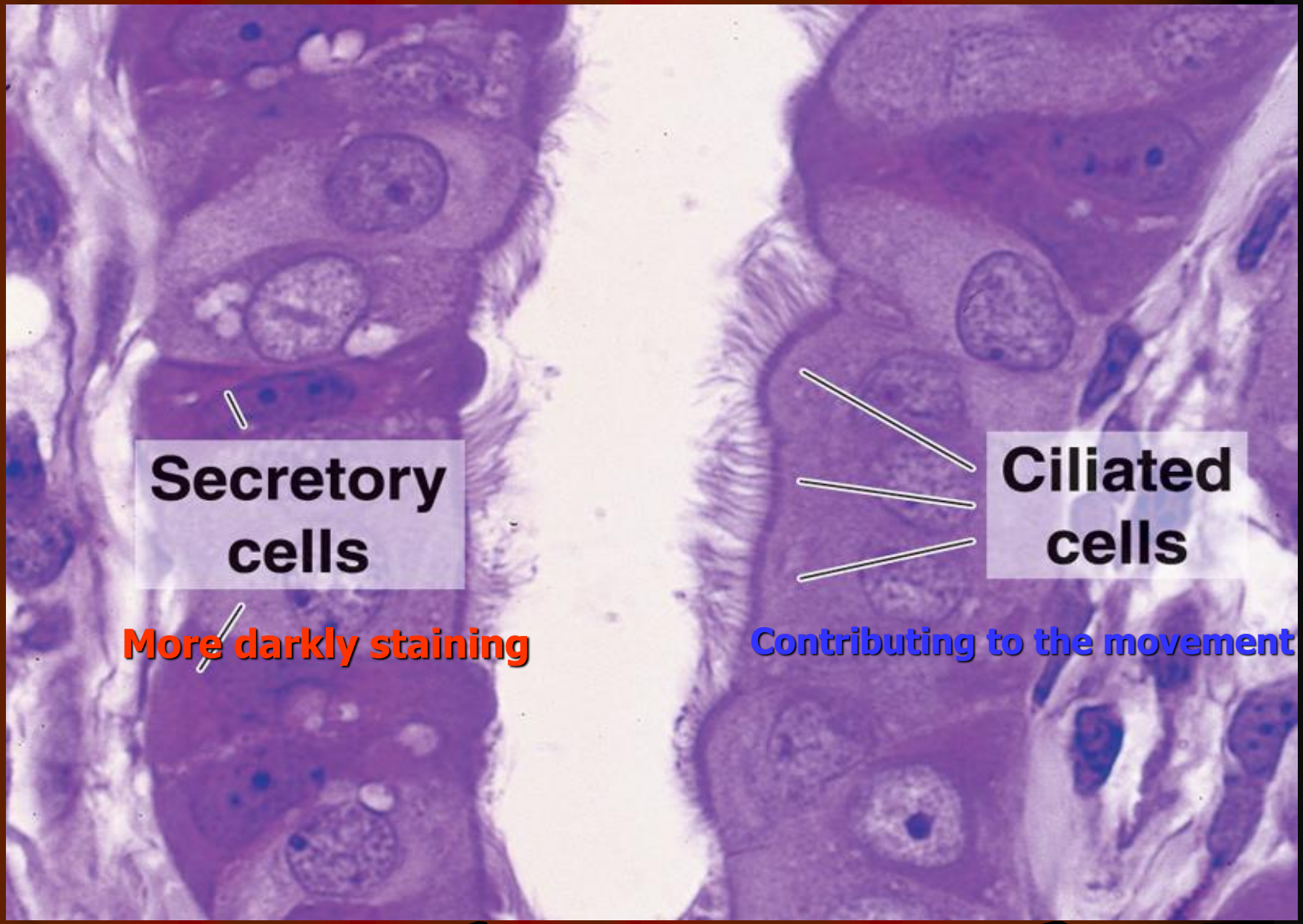


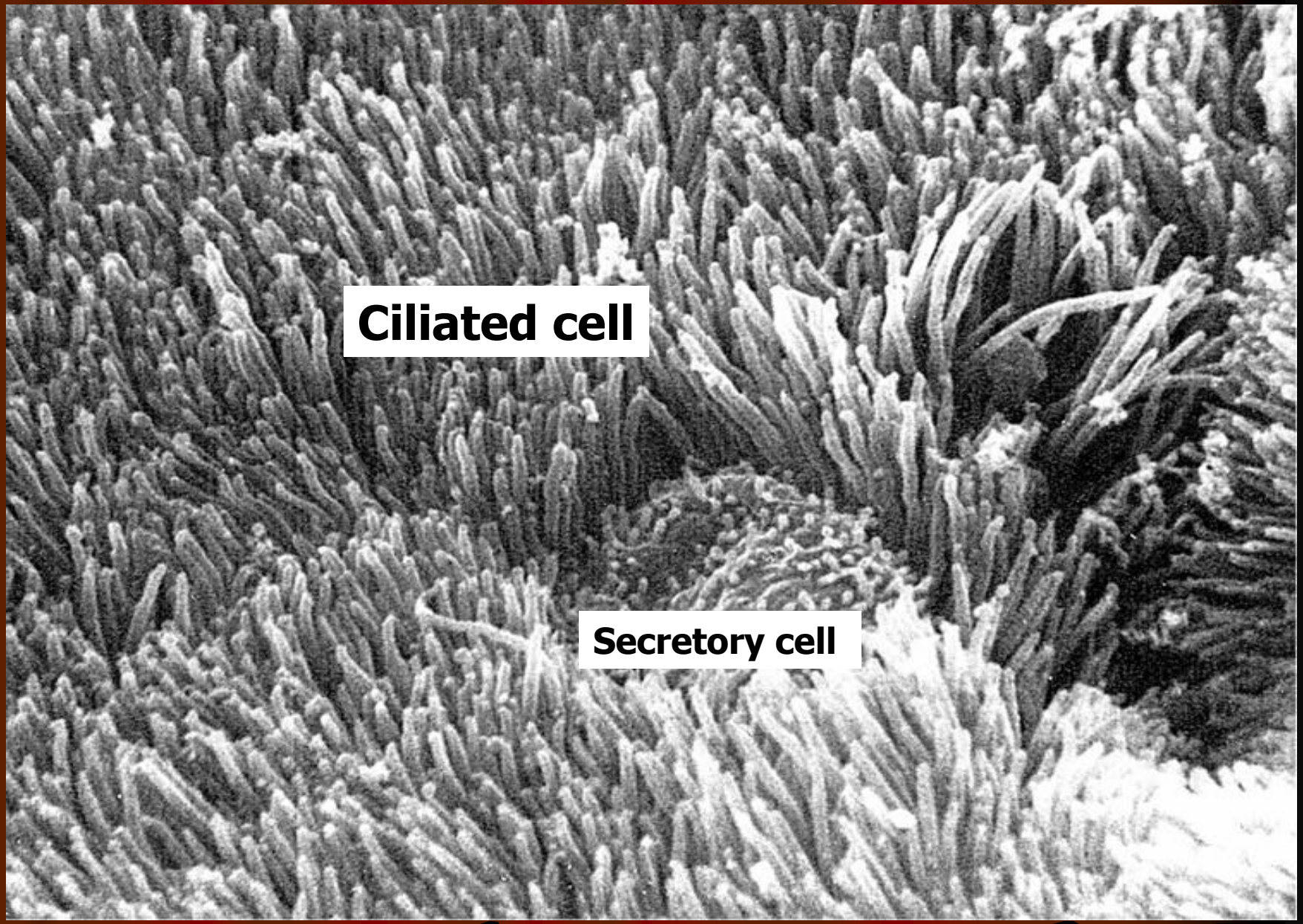
II. Oviduct

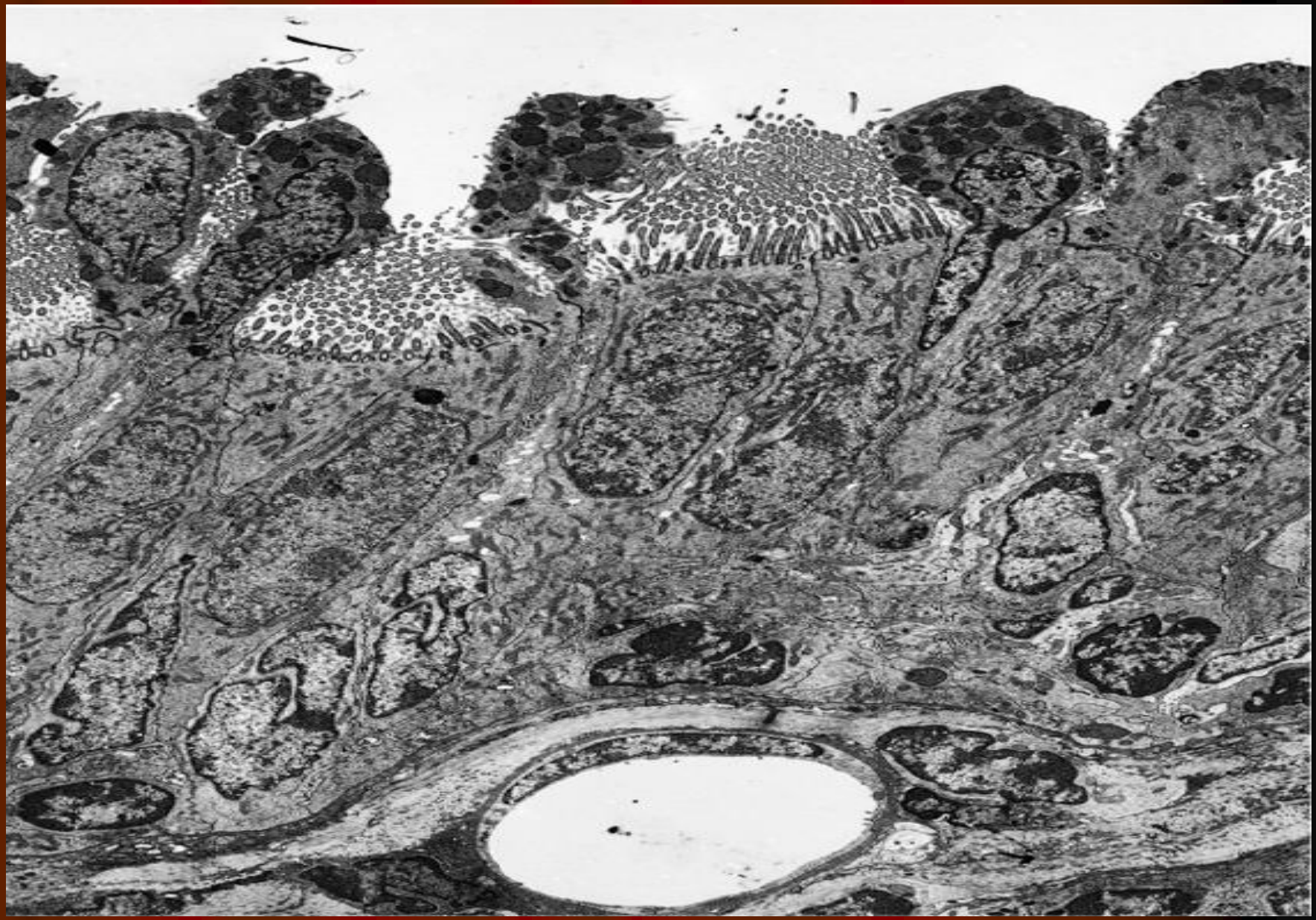
- Highly folded mucosa
  - Simple columnar epithelium
    - Ciliated epithelial cells
    - non-ciliated epithelial cells (secretory cells)
  - Lamina propria
- Muscle layers
- Serosa






Secretory cells
More darkly staining
Ciliated cells
Contributing to the movement

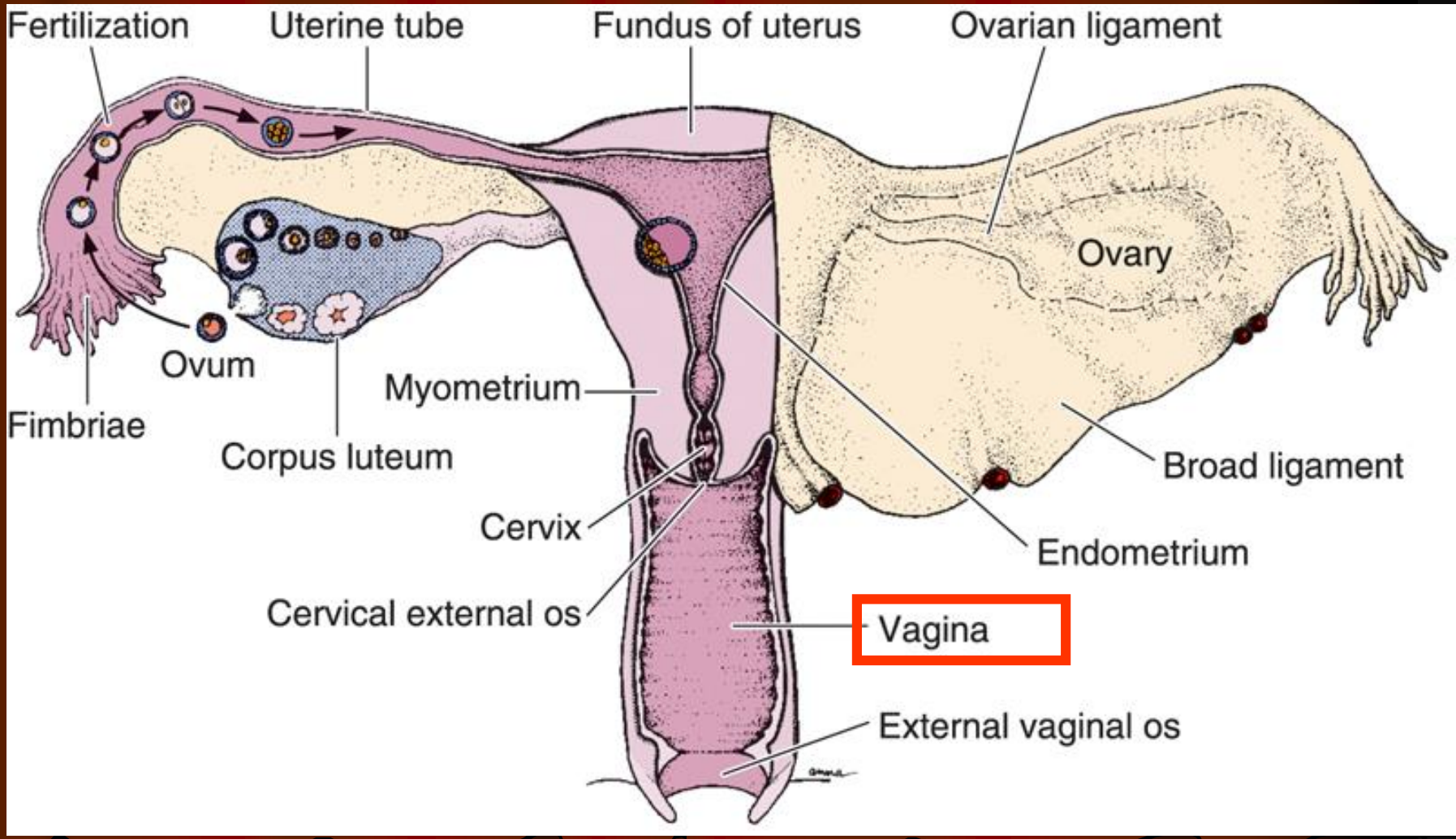

Ciliated cell
Secretory cell



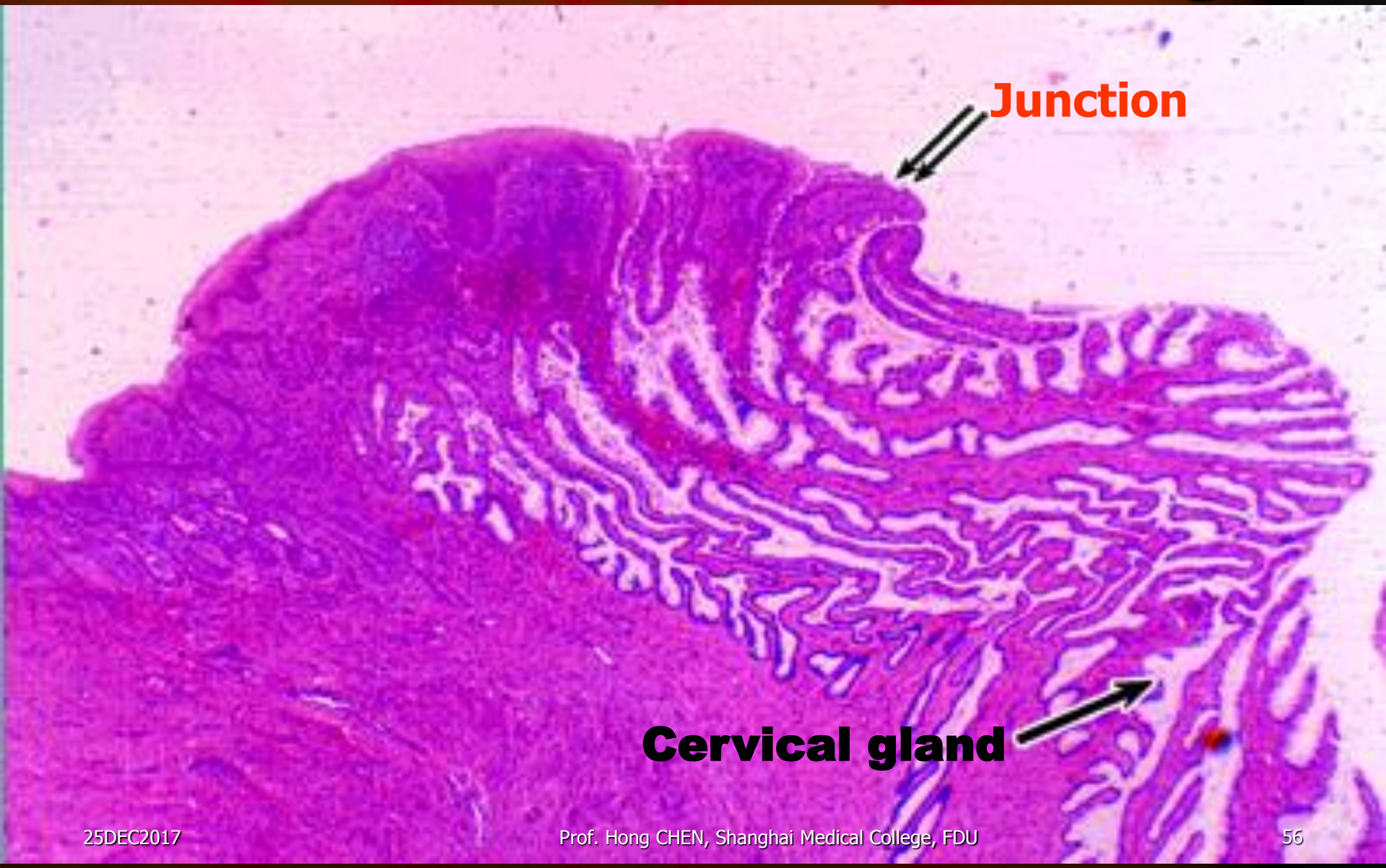
Summary II - OVIDUCT

- **Fertilization occurs in uterine tube, ampulla**
- **Secondary oocyte complete second meiotic division to form mature ovum and second polar body if it is penetrated by a sperm**
- **Second meiotic division is arrested at metaphase if it is not penetrated by a spermatozoon**

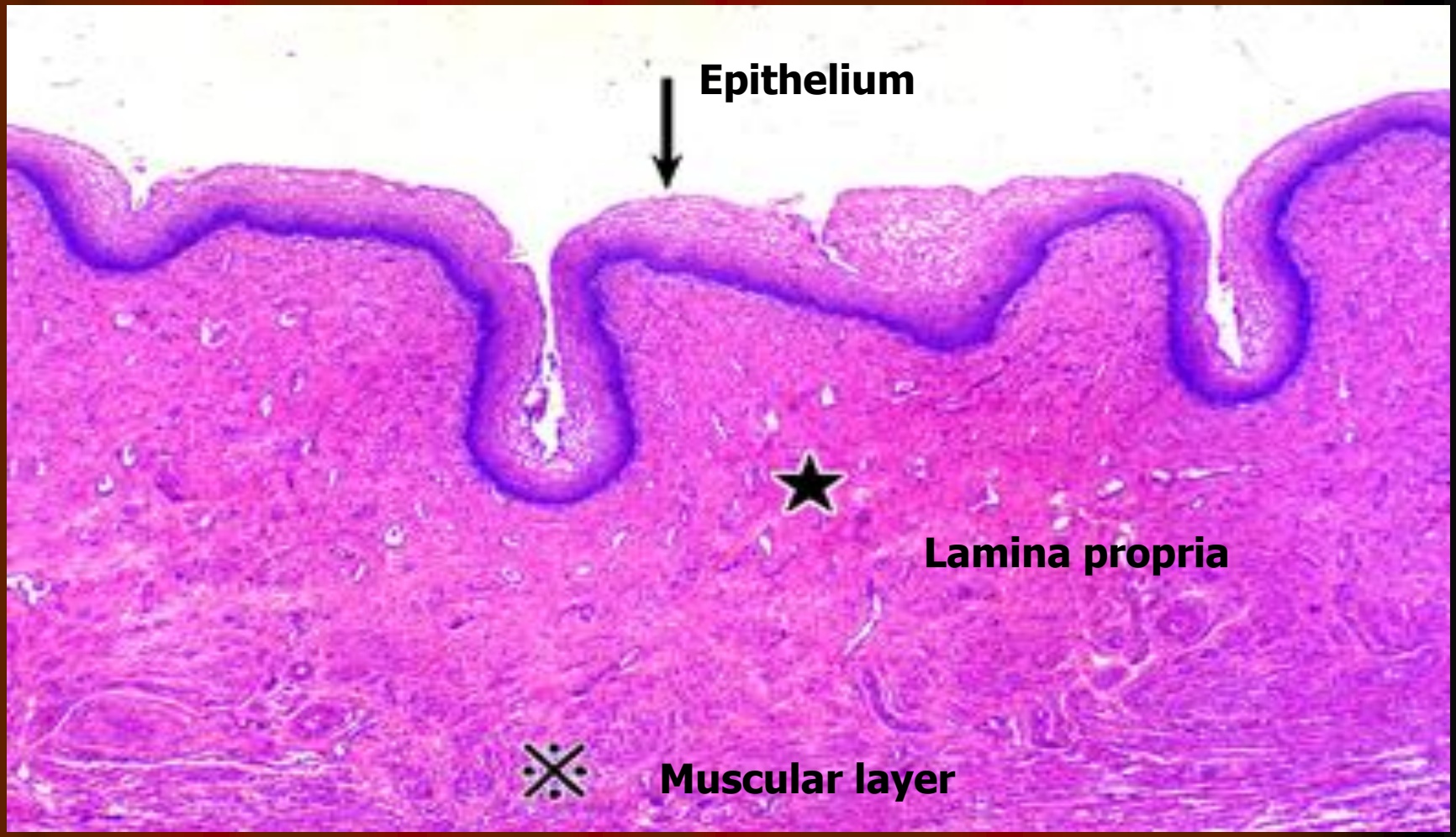
Female Reproductive System



Junction of Human Cervix and Vagina



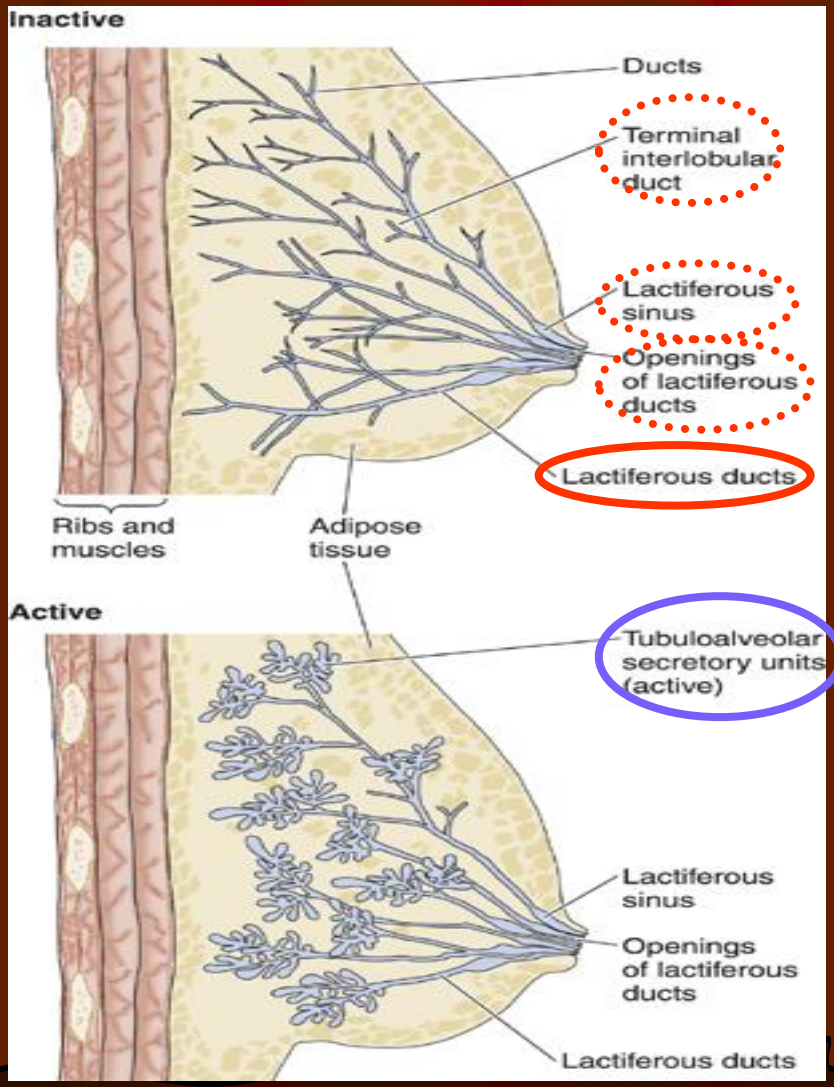
Human Vagina

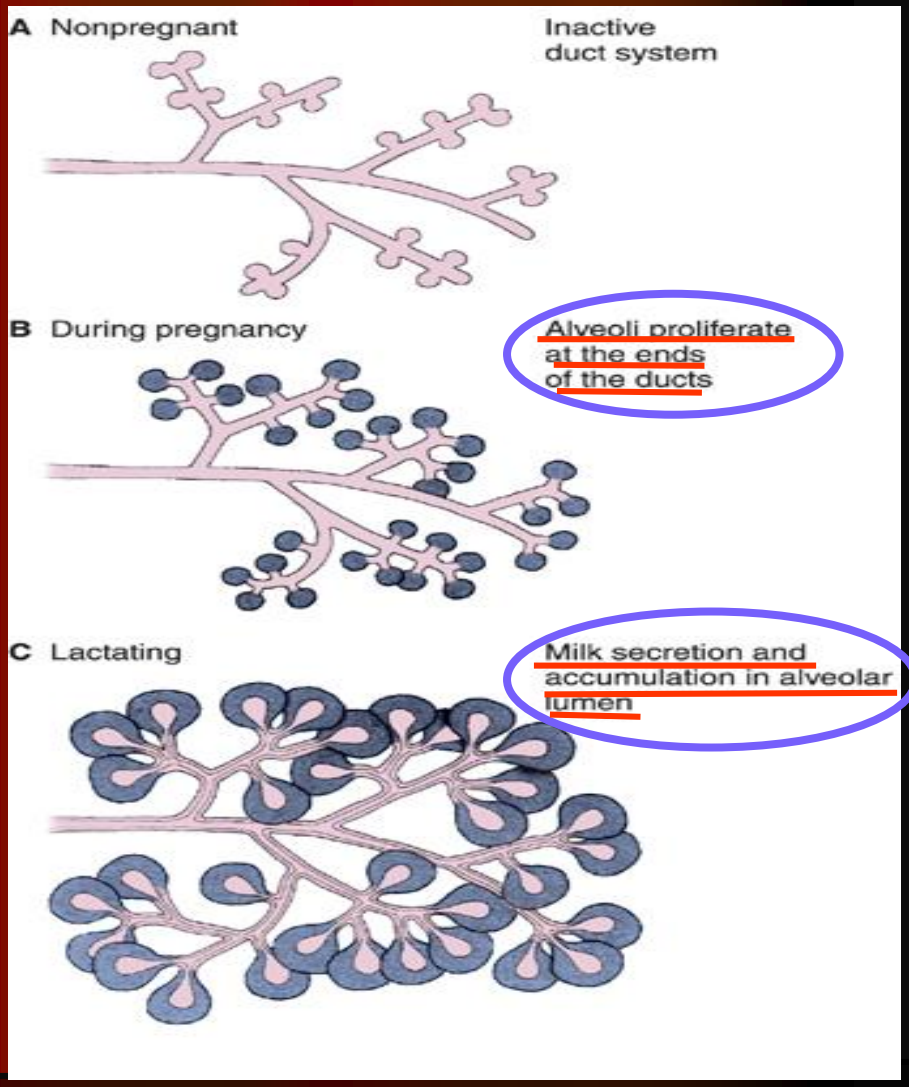


Vagina

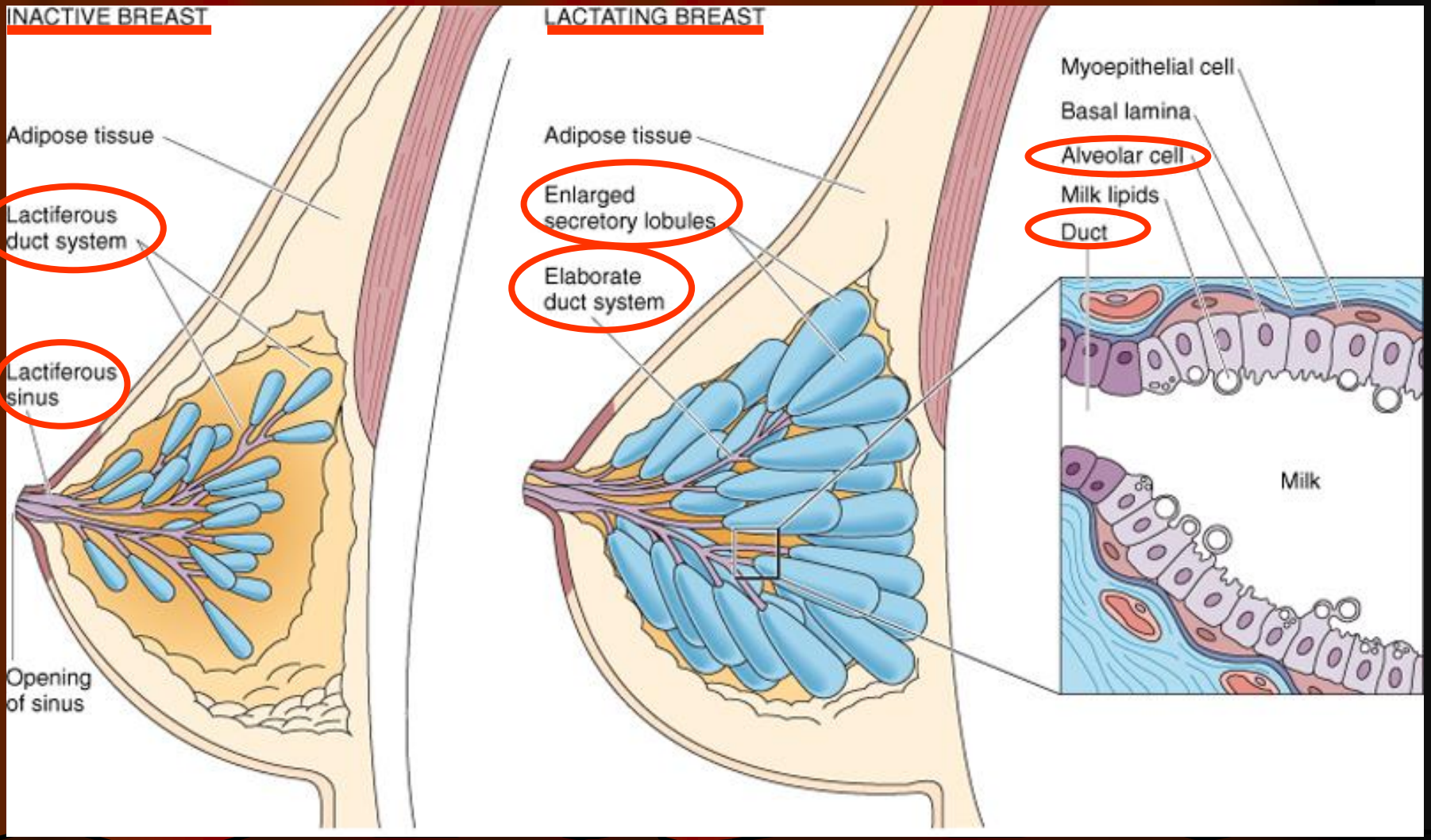
- Mucosa
  - Stratified squamous
    - typical vacuolated epithelial cells
      - Containing glycogen synthesized and accumulated under the stimulus of estrogen
  - Lamina propria
    - Loose connective tissue rich in elastic fibers
- Muscular layer
  - Smooth muscle
  - Innermost: circular
  - The outer: longitudinal mainly
- Adventitia
  - Dense connective tissue rich in thick elastic fibers

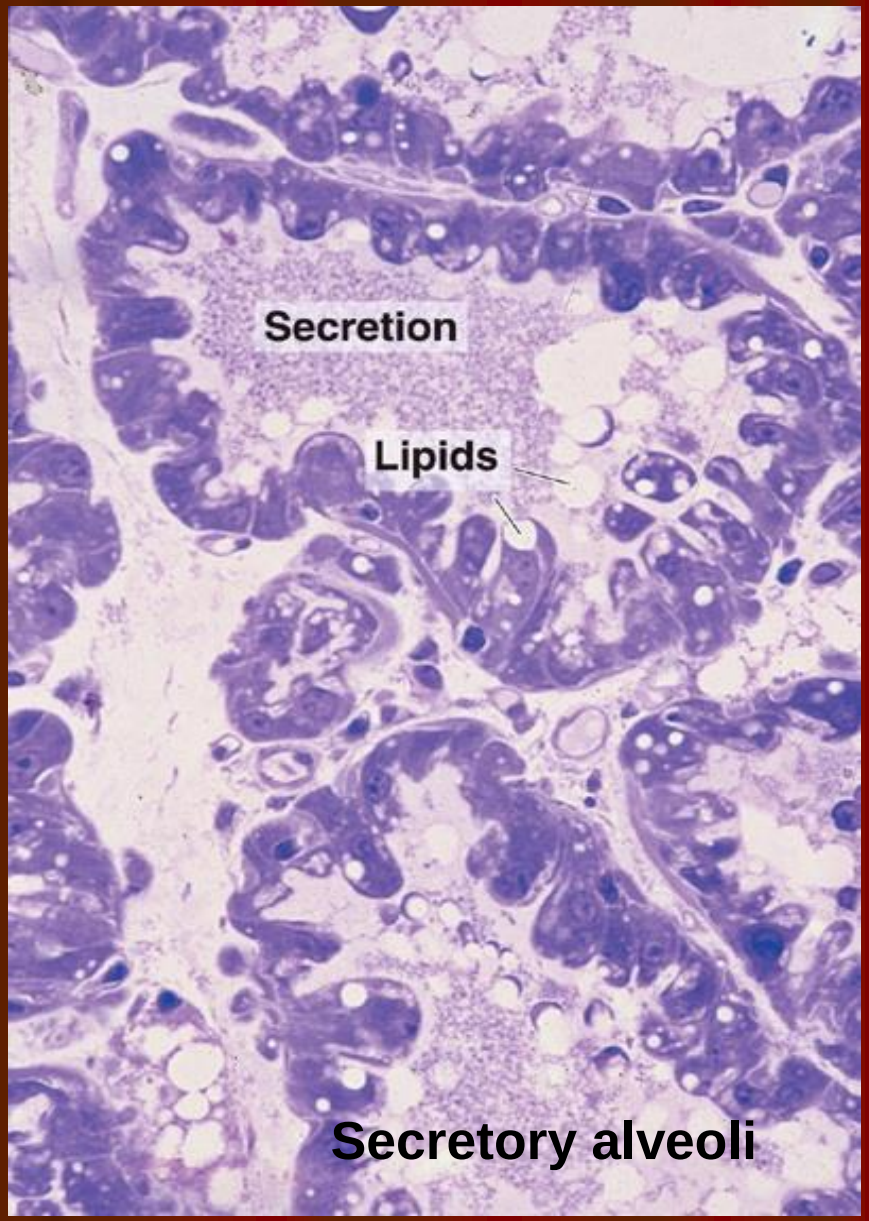
Mammary Glands





Mammary Glands

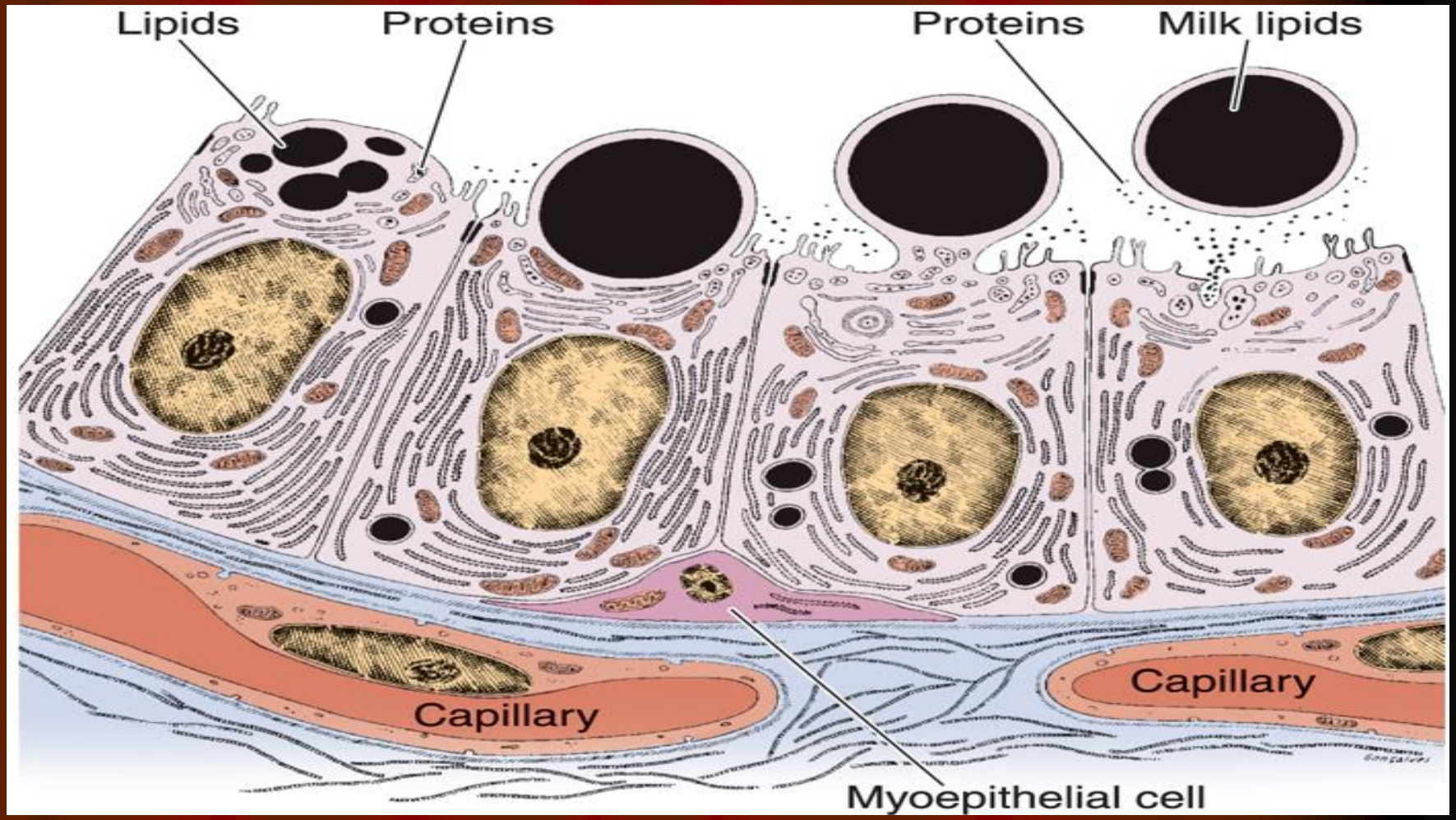




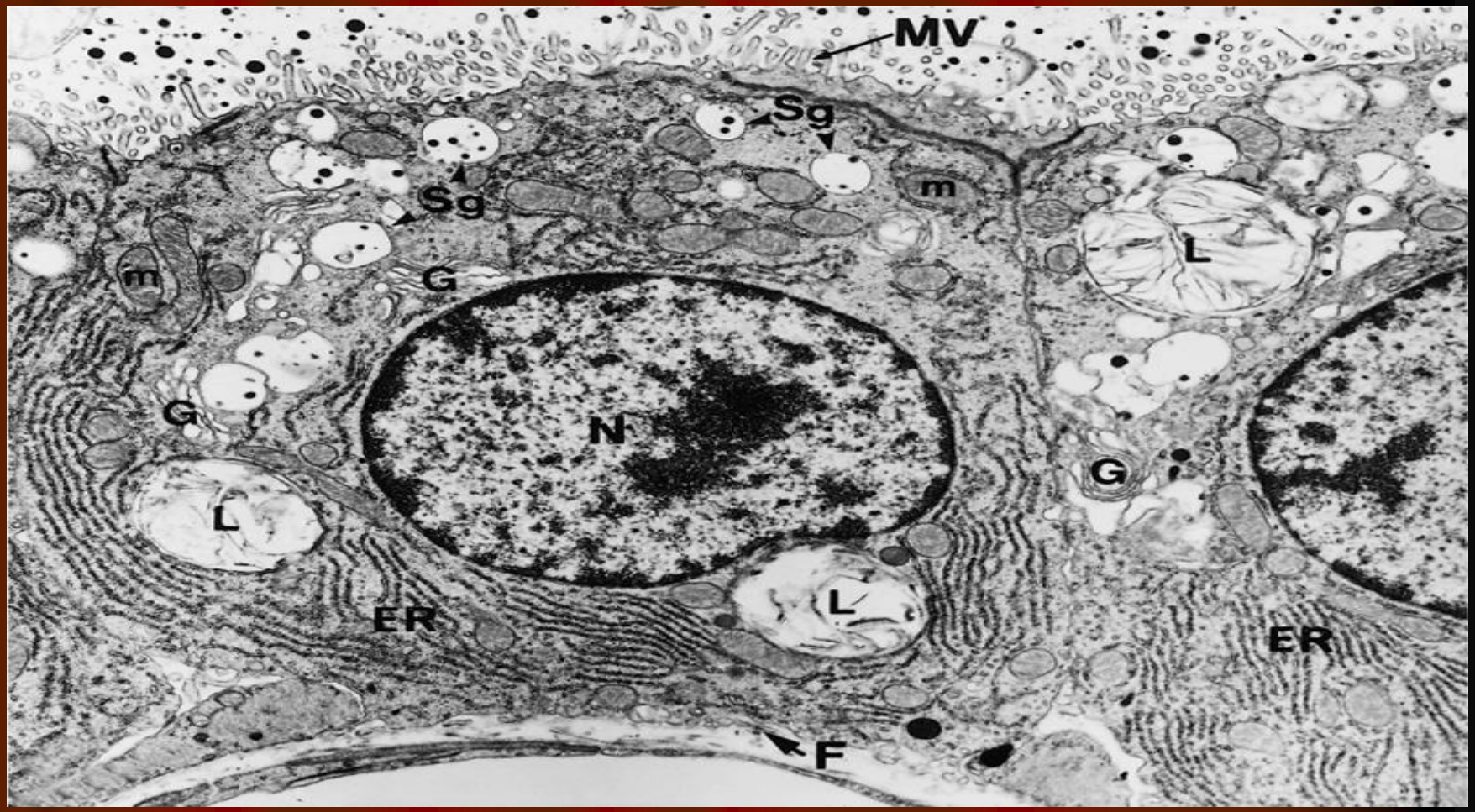
Lactating Mammary Gland

- **Secretory alveoli**
  - **Filled with milk**
    - **Visible as granular material**
    - **Containing**
      - **Protein: merocrine**
      - **Fatty component: apocrine**
        - **Shown as vacuoles in the alveolar cell cytoplasm and in the lumen**

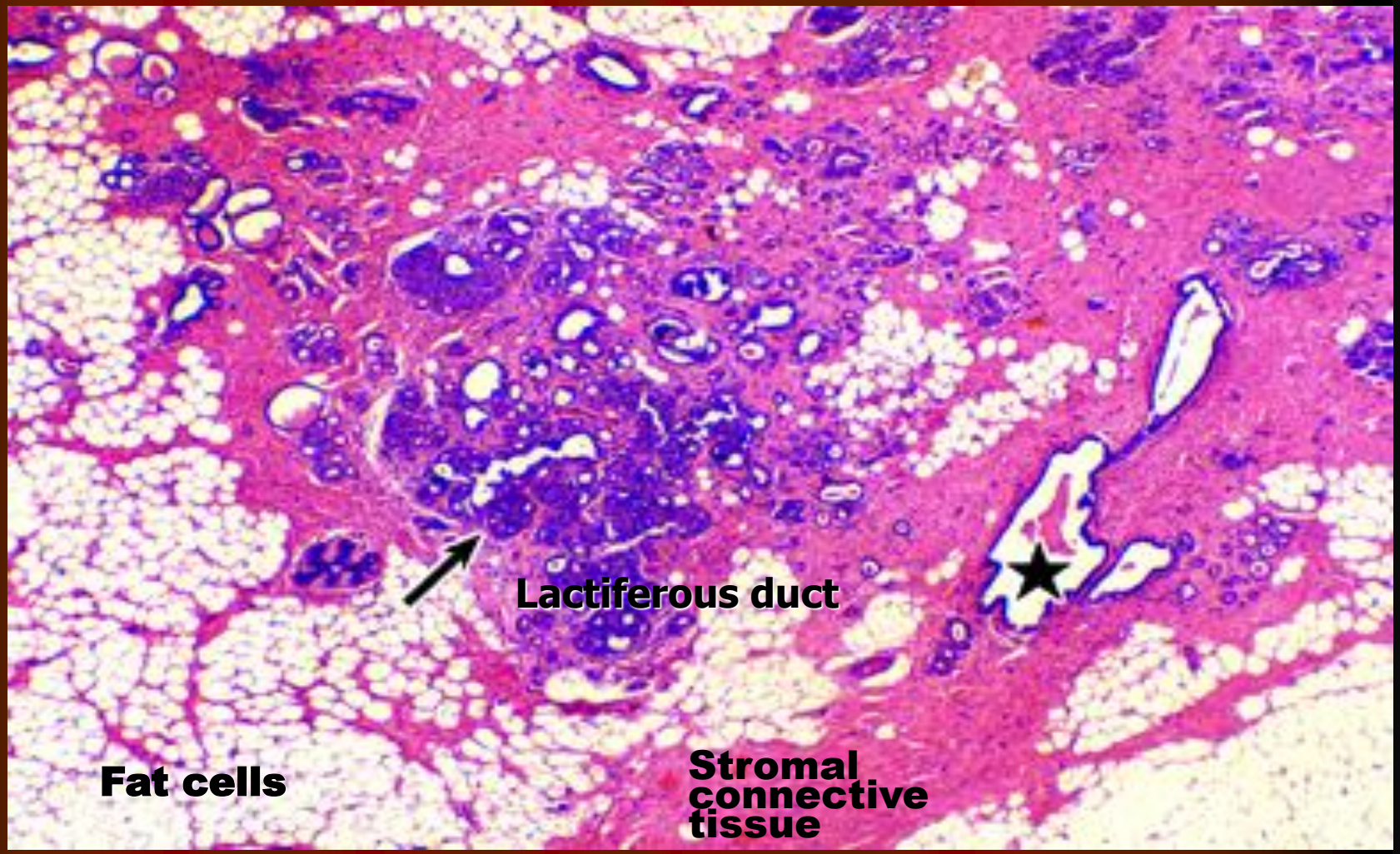
Secreting Cells from the Mammary Gland



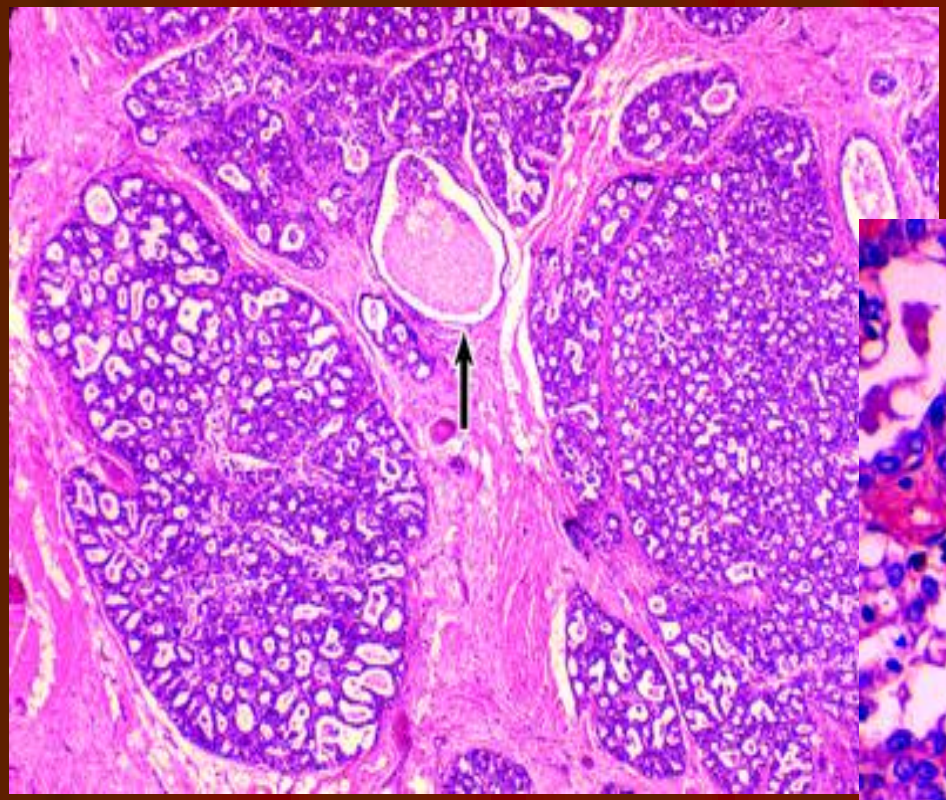
Secreting Cells from the Mammary Gland

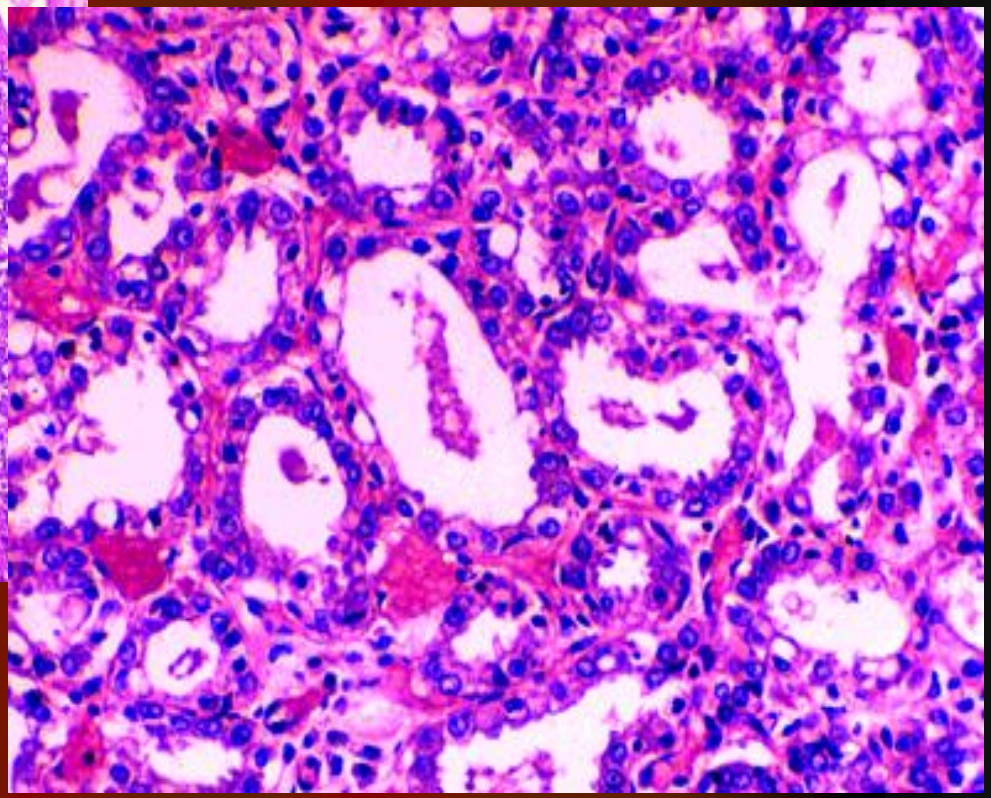


Human Breast - inactive



Human Breast - active





Summary IV

- **The vagina**
  - A fibromuscular tube that joins internal reproductive organs to the external environment
  - Lining a stratified, squamous nonkeratinized epithelium
  - Lacking glands

- **Mammary glands**
  - Are modified apocrine sweat glands that develop under the influence of sex hormones
  - The morphology of the secretory portion varies with the menstrual cycle
  - Undergoing dramatic proliferation and development during pregnancy

Summary

- Ovary
  - Follicle development and maturation for oogenesis (secondary oocyte arrested in the MII before ovulation)
  - Secrete E and P by "two cells" theory in follicle or corpus luteum
- Uterine tube function as fertilization location
  - If fertilized, mature ovum formed and second polar body eluted
- Changes of endometrium during different stages of menstrual cycle
- Structure of mammary gland


Thank You All!