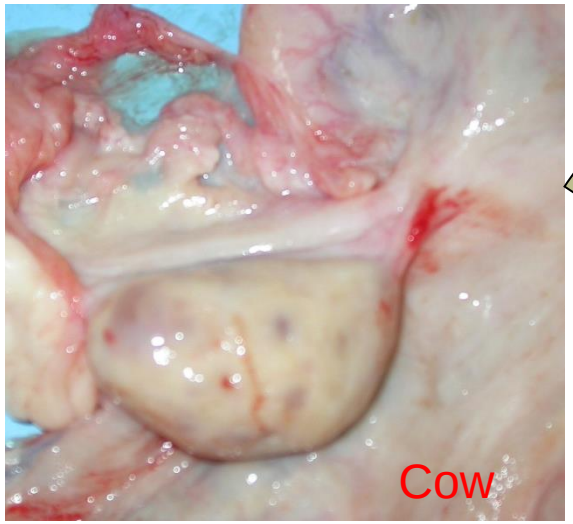
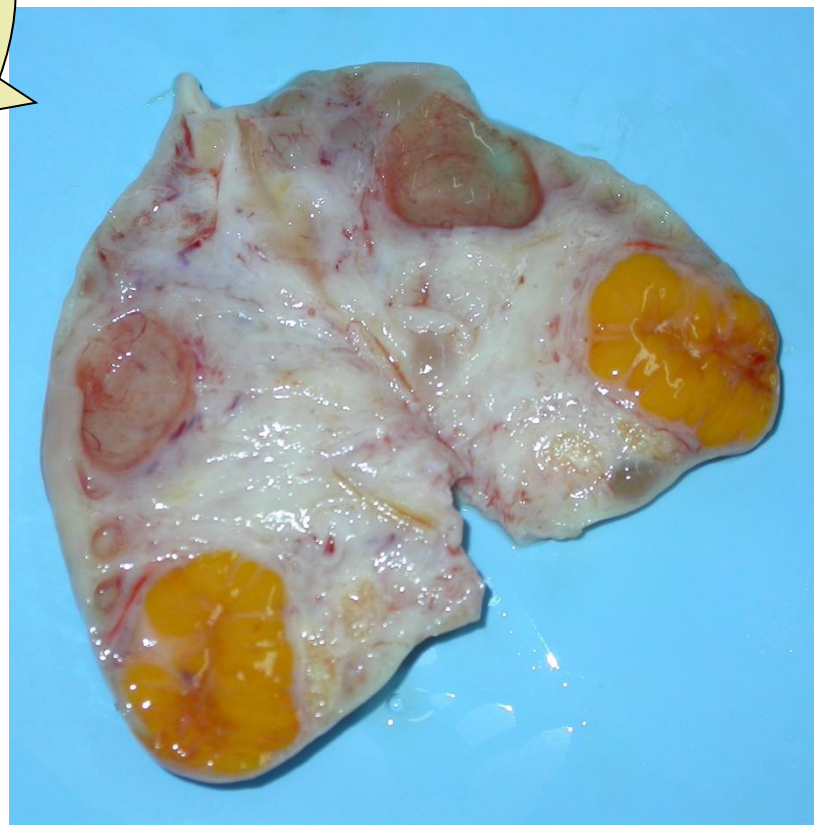
OVARY

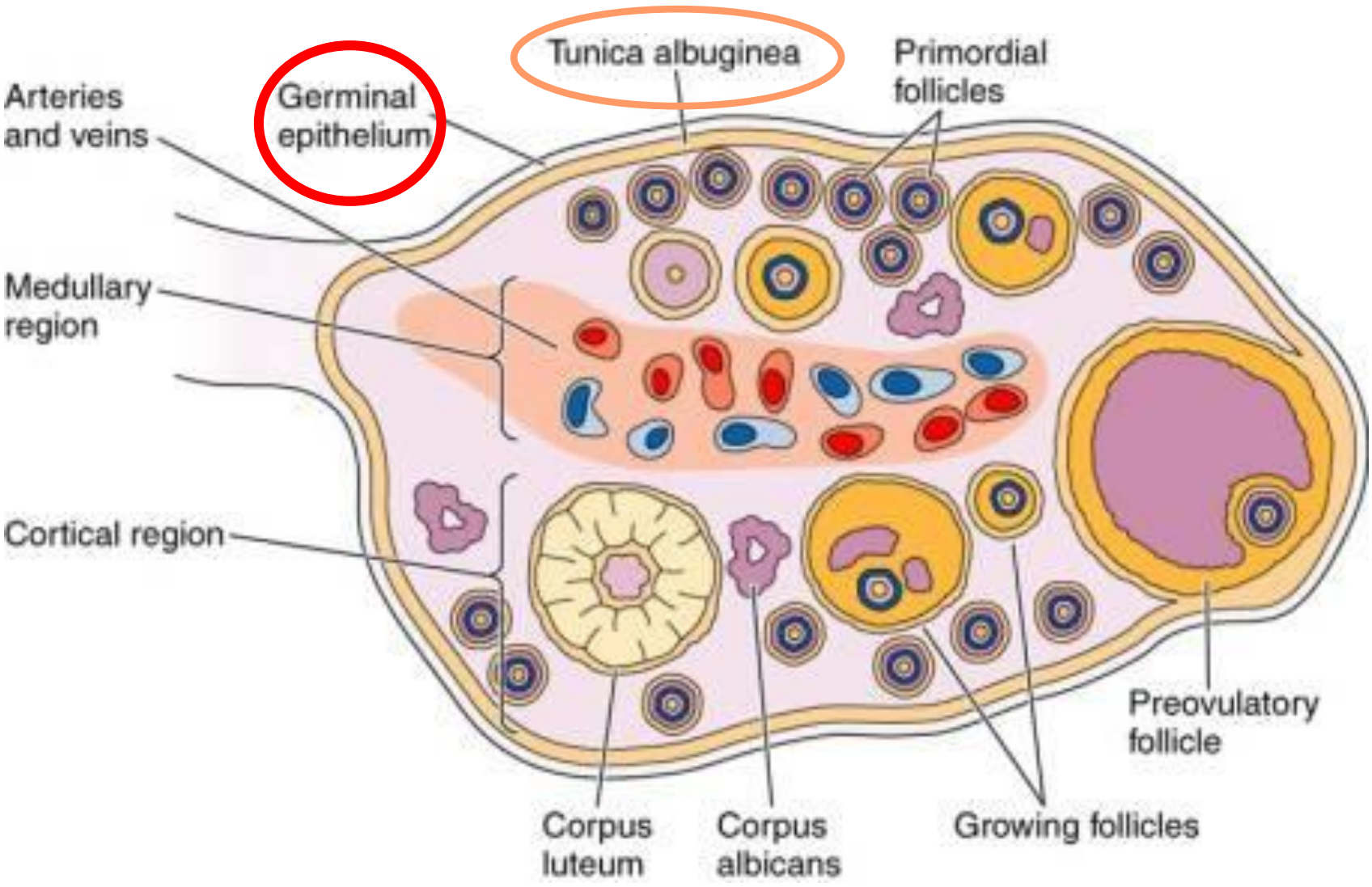




The ovary, or female gonad, is:

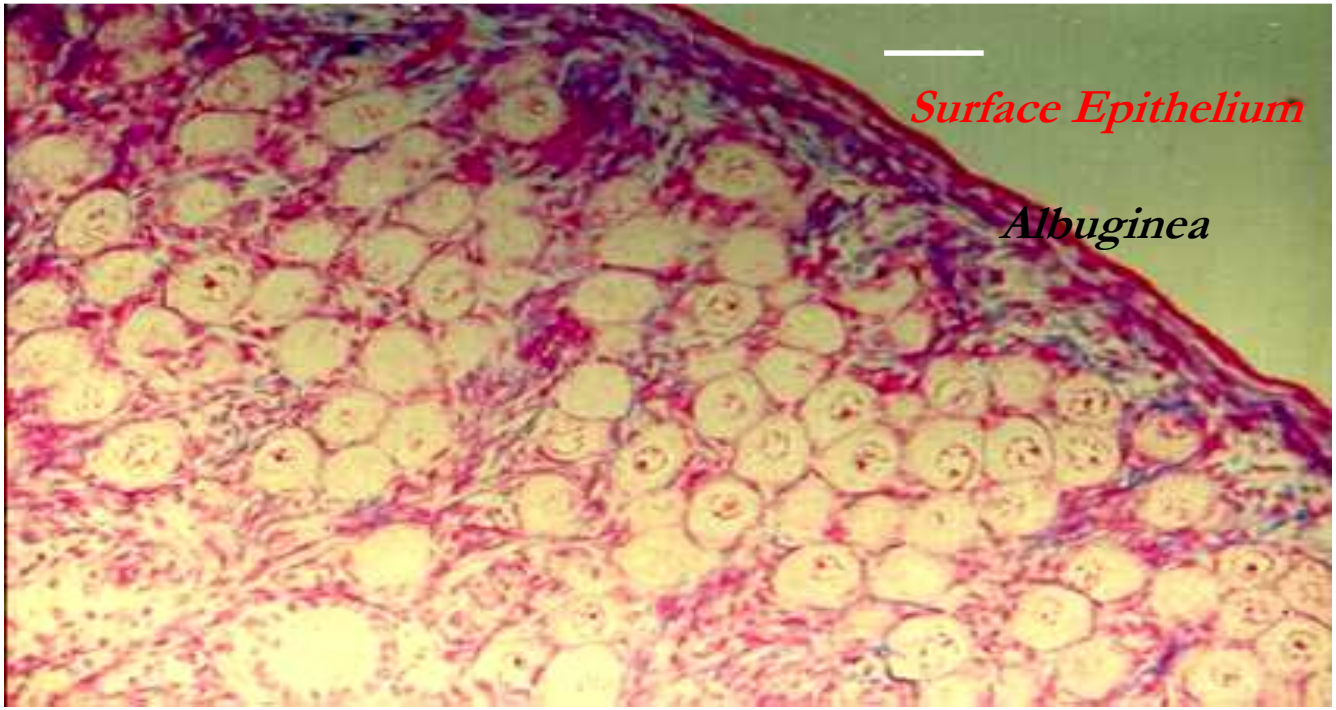
1. an exocrine gland, producing oocytes
2. an endocrine gland, secreting hormones, i.e., estrogen and progesterone

OVARY


Tunica albuginea
Primordial follicles
Arteries and veins
Germinal epithelium
Medullary region
Cortical region
Preovulatory follicle
Corpus luteum
Corpus albicans
Growing follicles

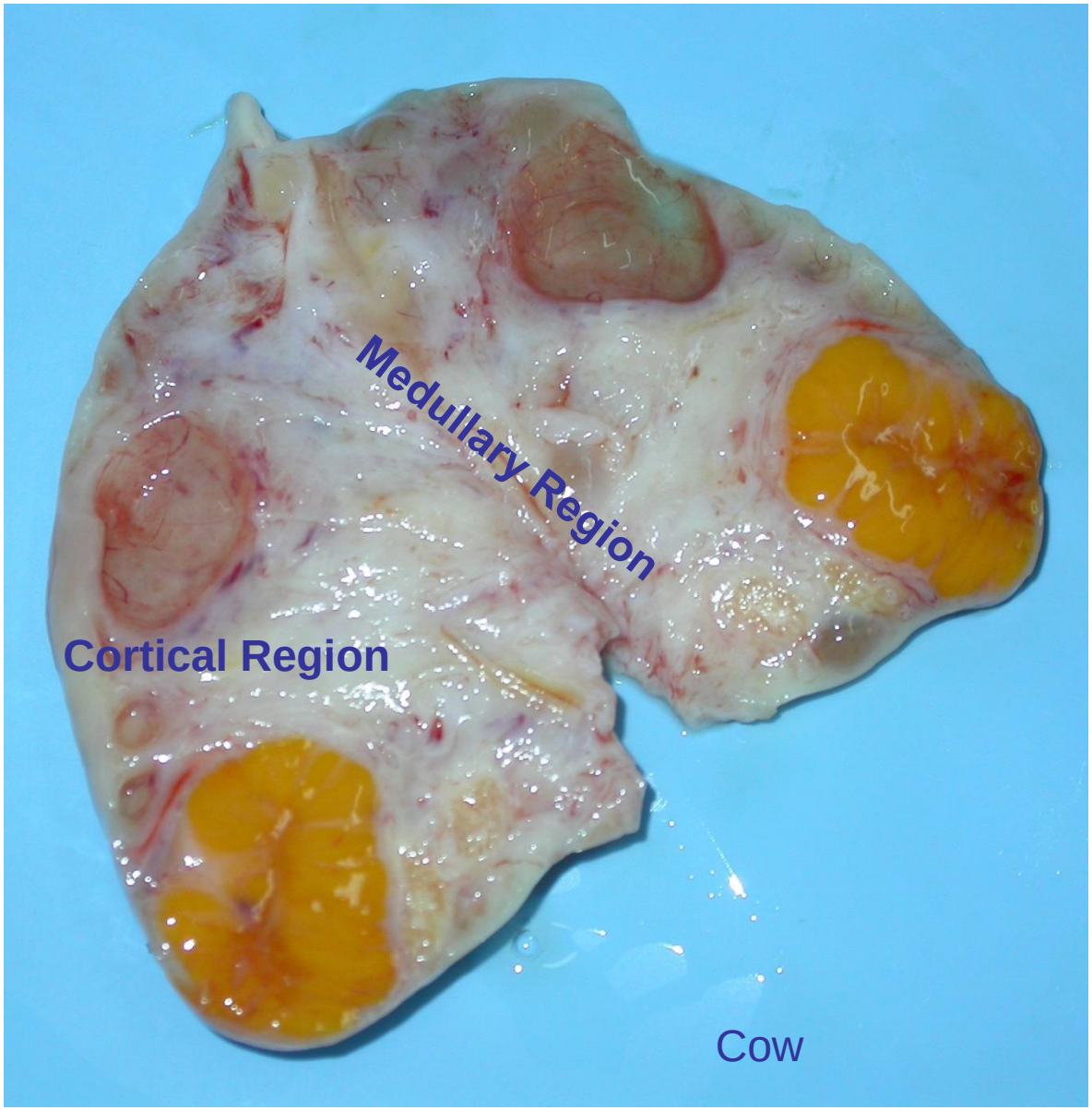
OVARY

The surface of the ovary is covered with *surface epithelium*, a simple epithelium which changes from squamous to cuboidal with age.



Immediately beneath this surface epithelium there is a dense connective tissue sheath, the *tunica albuginea ovarii*

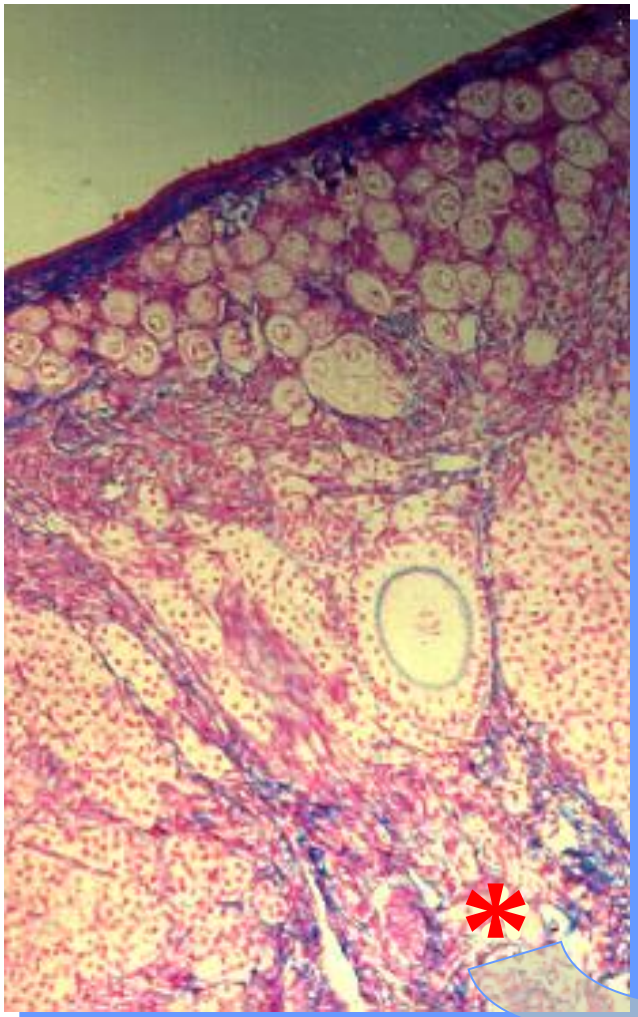
OVARY



Except in the mare where the cortical region is interior to the medulla

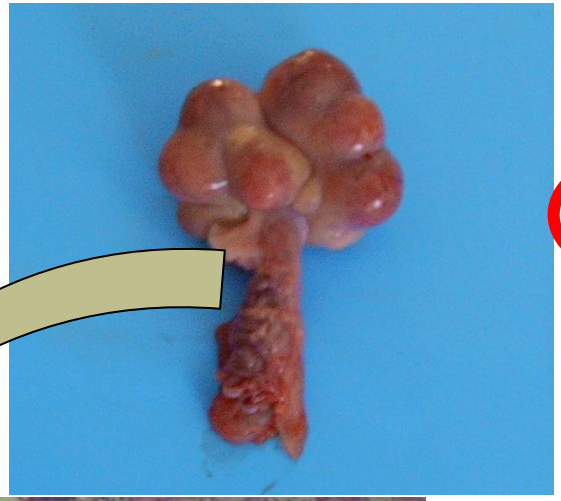
OVARY:

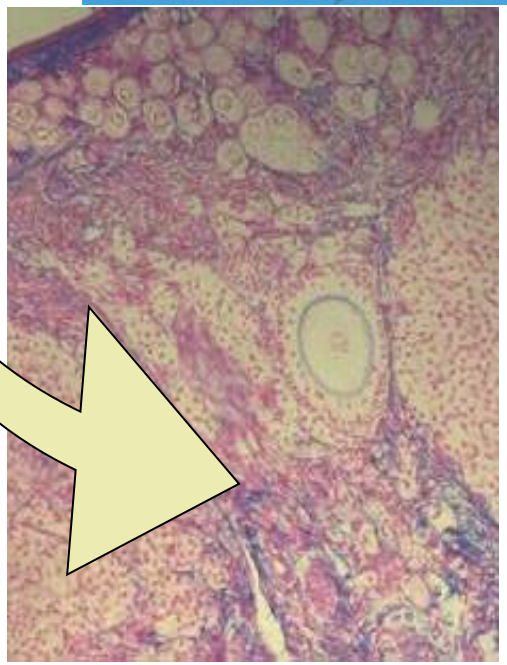
*MEDULLA

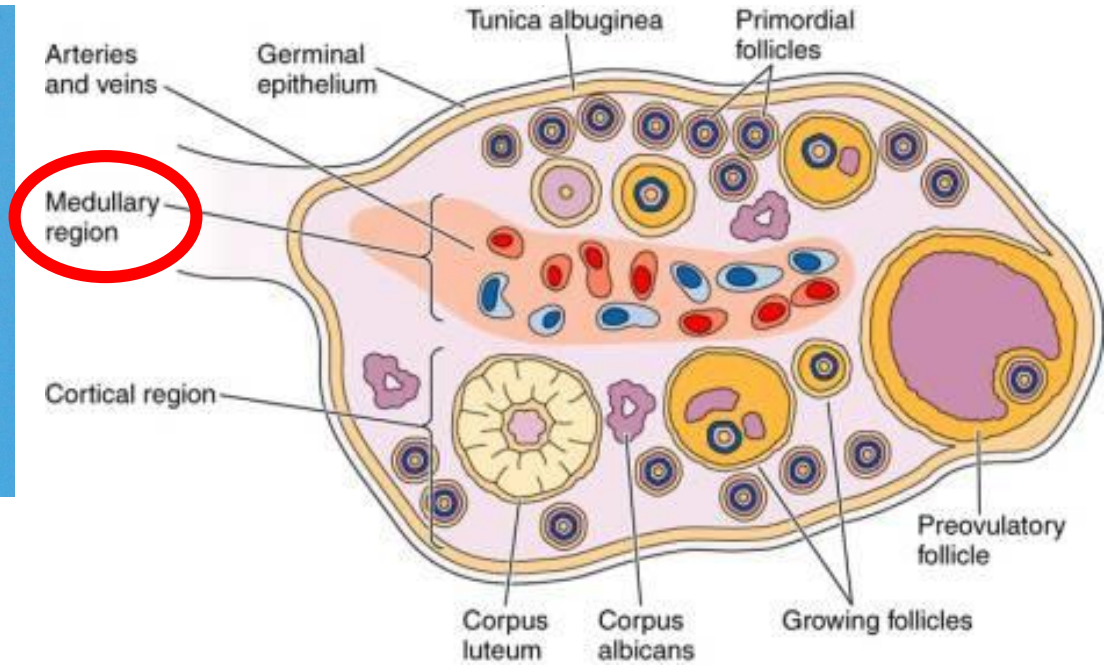


The **medulla** is composed of loose areolar connective tissue containing numerous elastic and reticular fibers, large blood vessels, nerves and lymphatics.

OVARY: HILUS

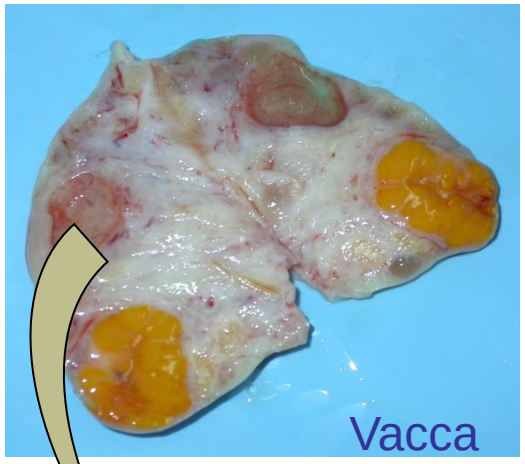




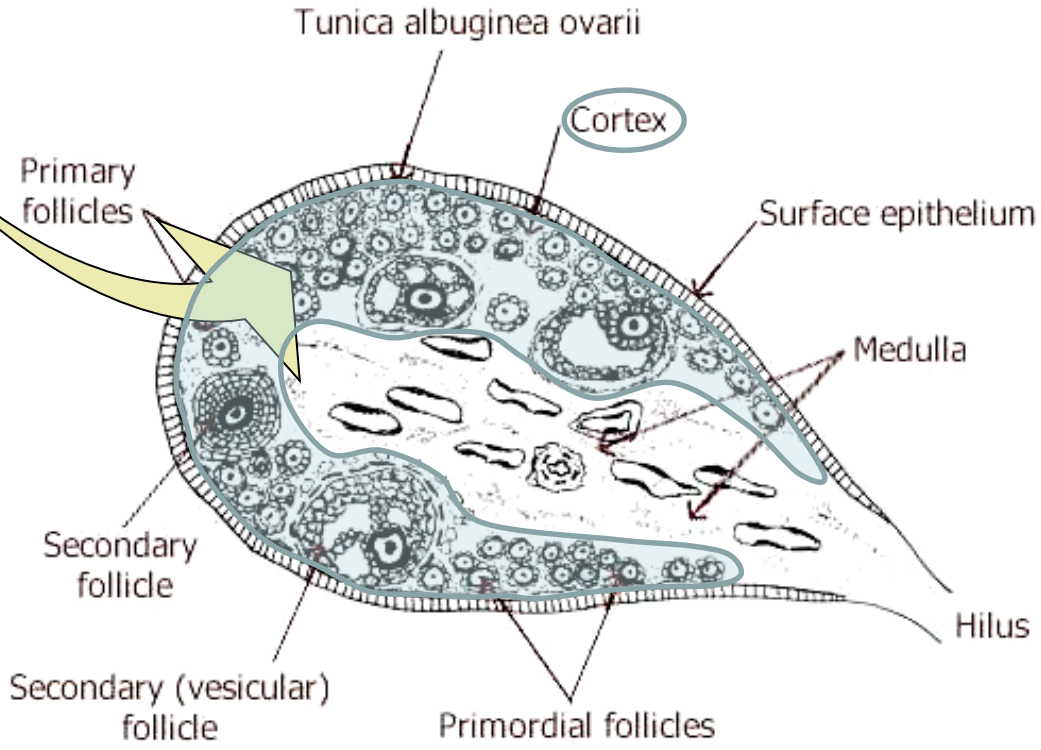


The **hilus** is the region through which blood vessels, lymphatics and nerves enter and leave the ovary. It is contiguous with and histologically similar to the medulla.

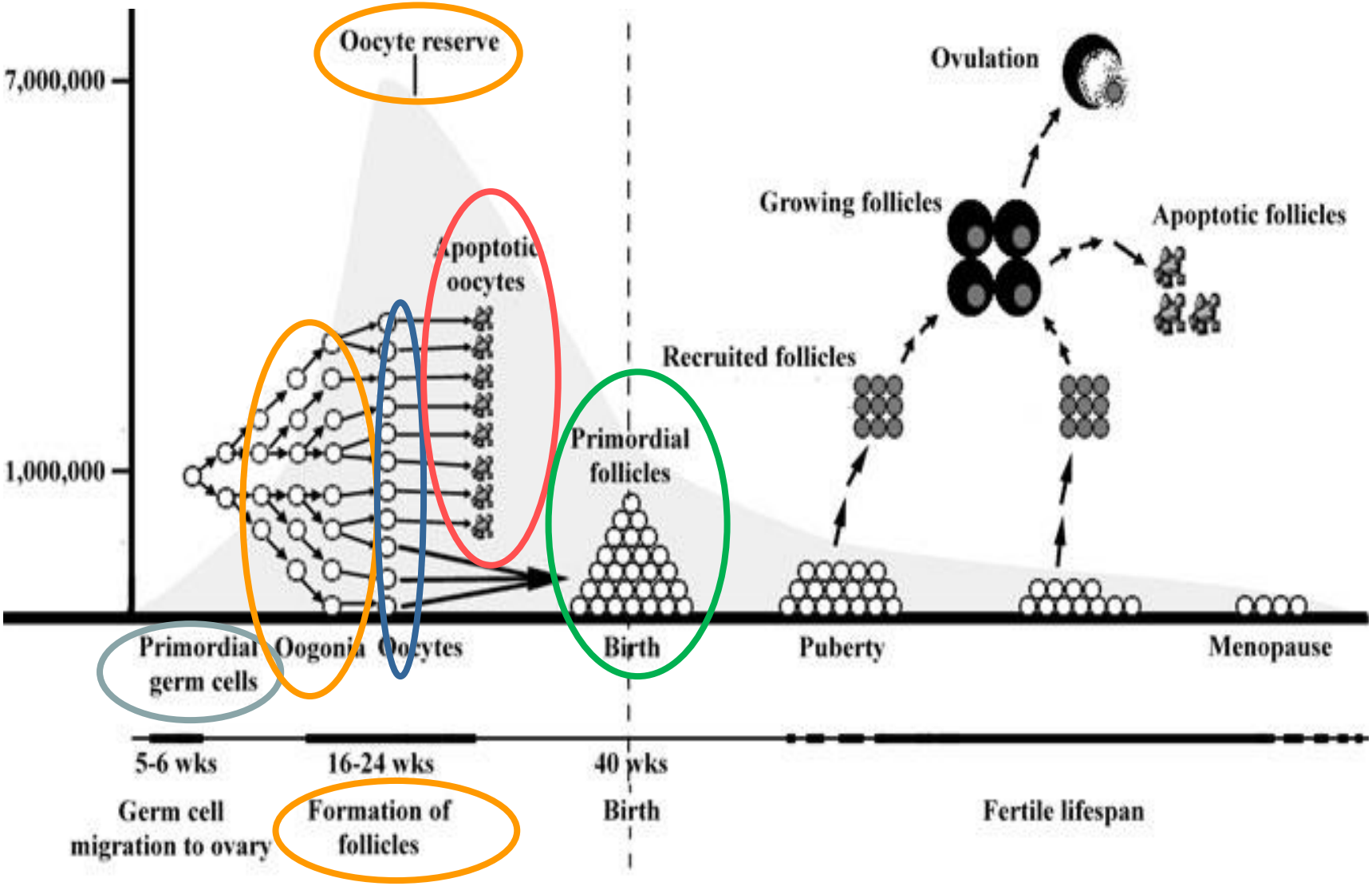
OVARY: CORTEX



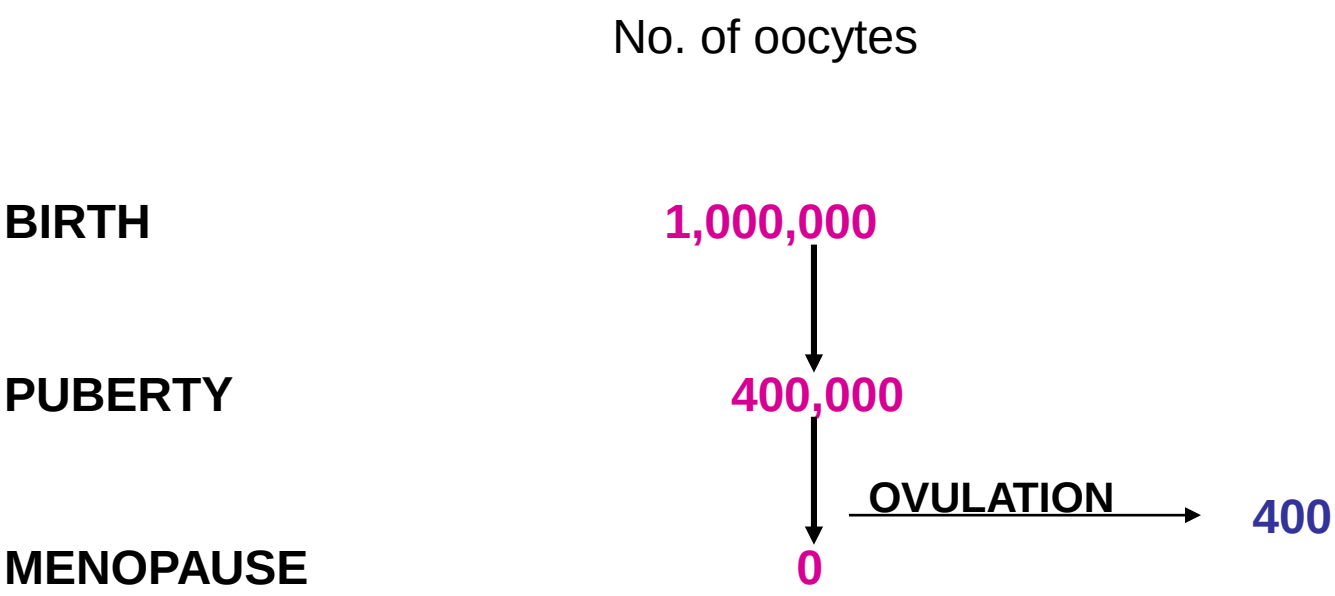
The cortex is composed of ovarian follicles, and stromal elements.
The cortex also contains atretic follicles



OVARY: OOGENESIS



ATRESIA IN HUMAN OVARY



OVARIAN FOLLICLES

PRIMORDIAL FOLLICLES

PRIMARY FOLLICLES

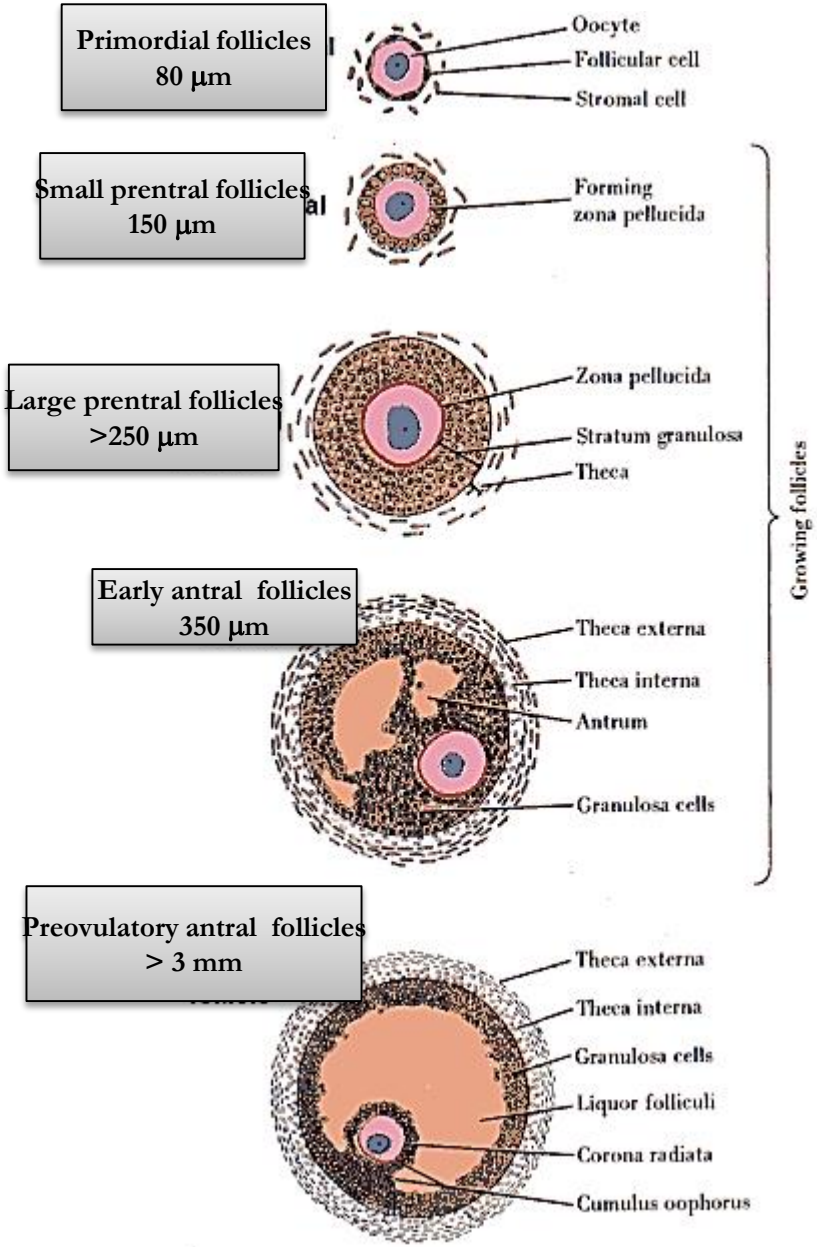
SECONDARY or PREANTRAL FOLLICLES

TERTIARY - EARLY ANTRAL

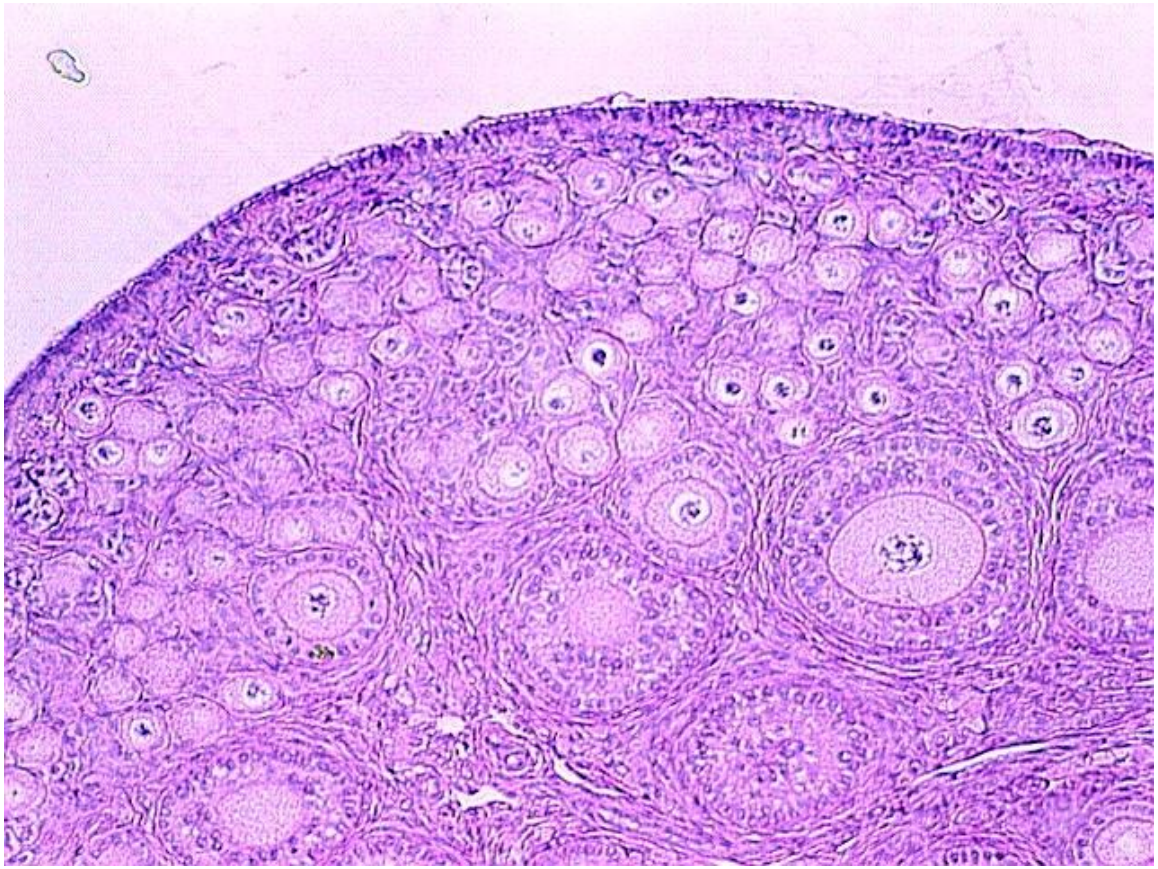
- ANTRAL FOLLICLES

(pre-ovulatory and peri-ovulatory antral follicles)

OVARIAN FOLLICLES

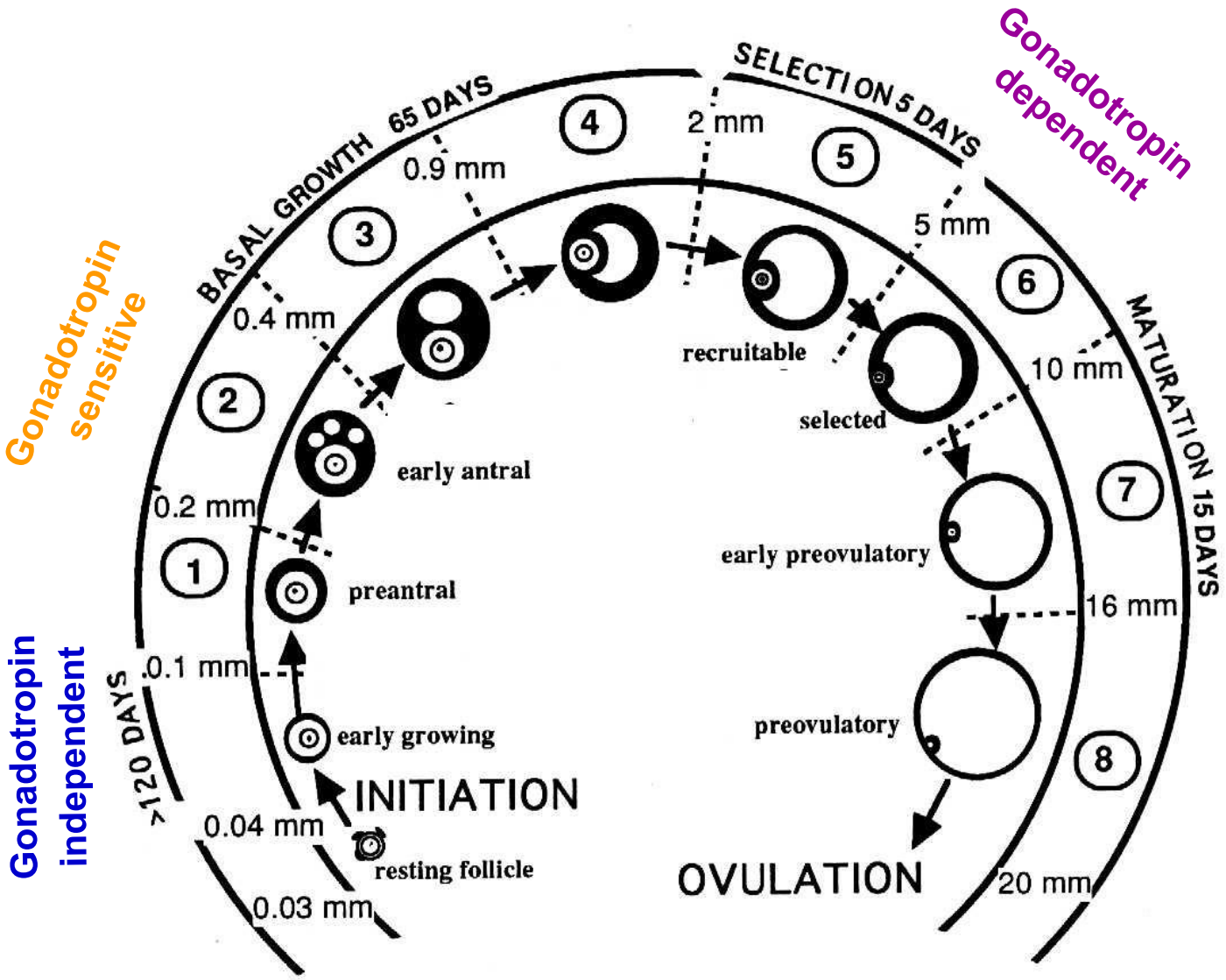


OVARIAN FOLLICLES



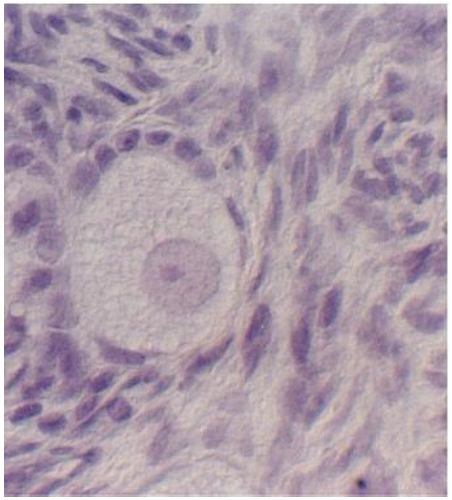
In ovarian follicles there are primary oocytes arrested in prophase of Meiosis I

FOLLICULOGENESIS

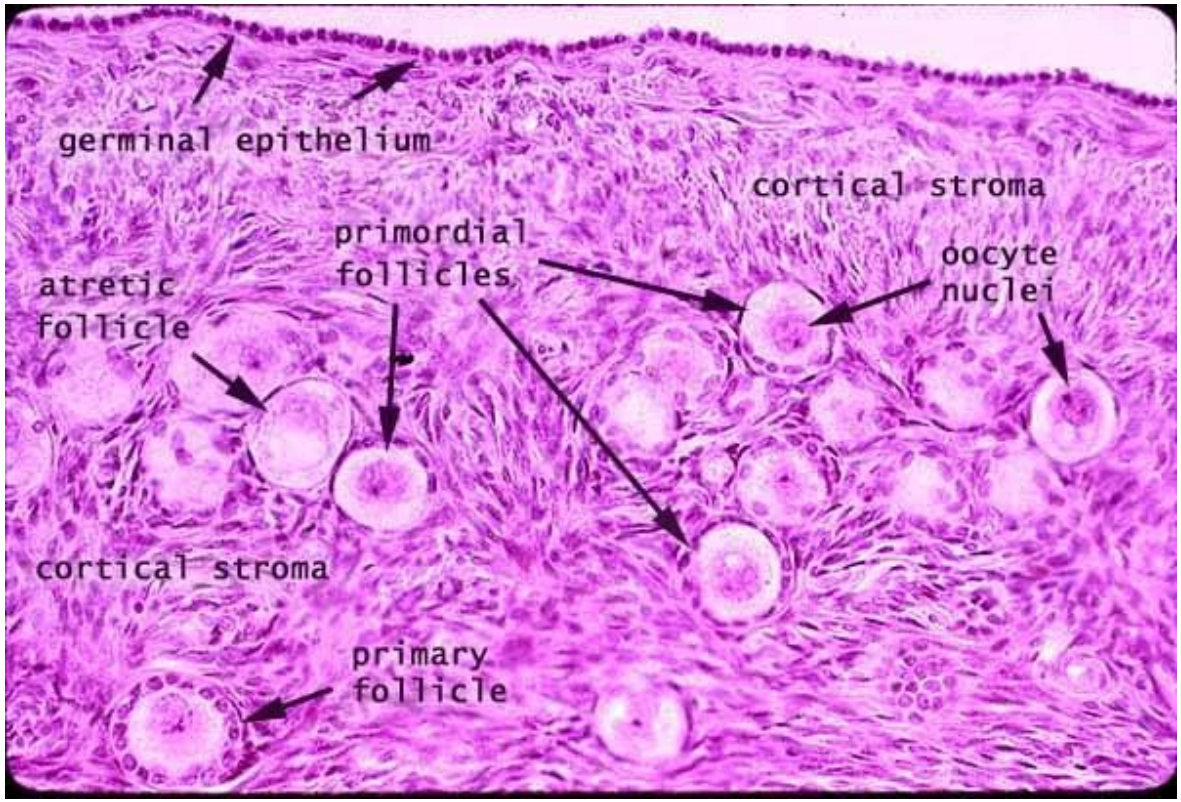


Follicular Growth

PRIMORDIAL FOLLICLES

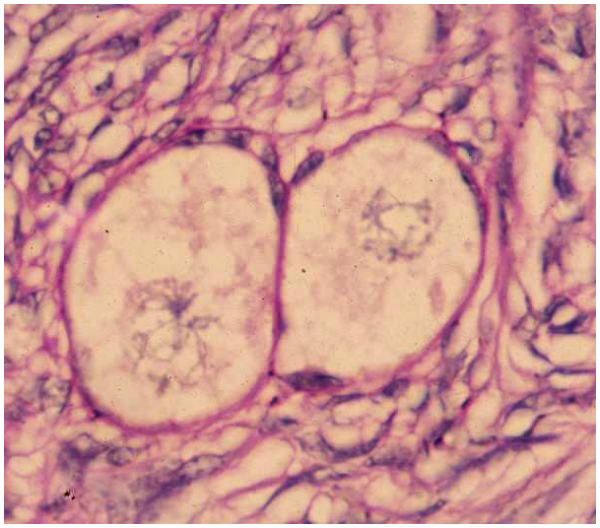


The primary oocyte is surrounded by a single layer of flattened cells called follicular cells.



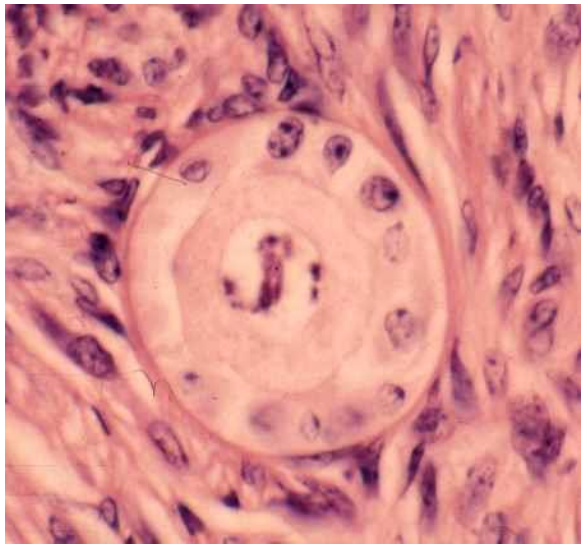
FOLLICLE GROWTH INITIATION

PRIMORDIAL FOLLICLE



quiescent
resting
non-growing

PRIMARY FOLLICLE



growing

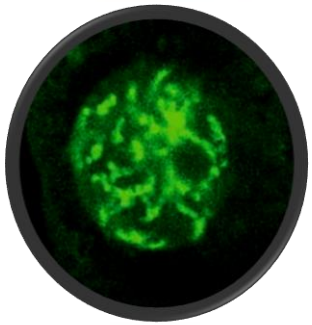
FOLLICLE GROWTH INITIATION

1. CHANGE IN SHAPE OF THE FOLLICULAR CELLS FROM SQUAMOUS TO CUBOIDAL (GRANULOSA CELLS)

2. PROLIFERATION OF GRANULOSA CELLS

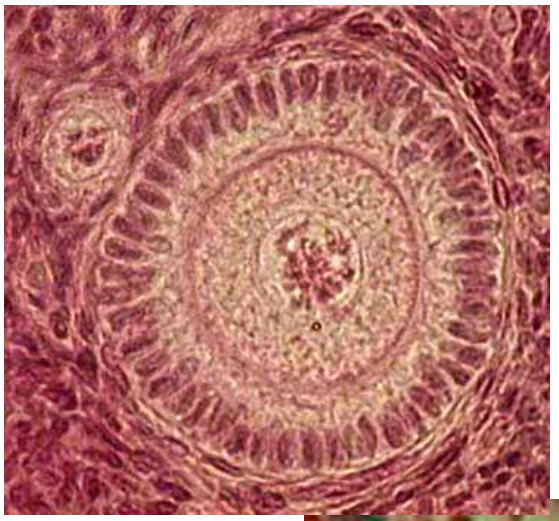
3. ENLARGEMENT OF THE OOCYTE

PRIMARY FOLLICLES

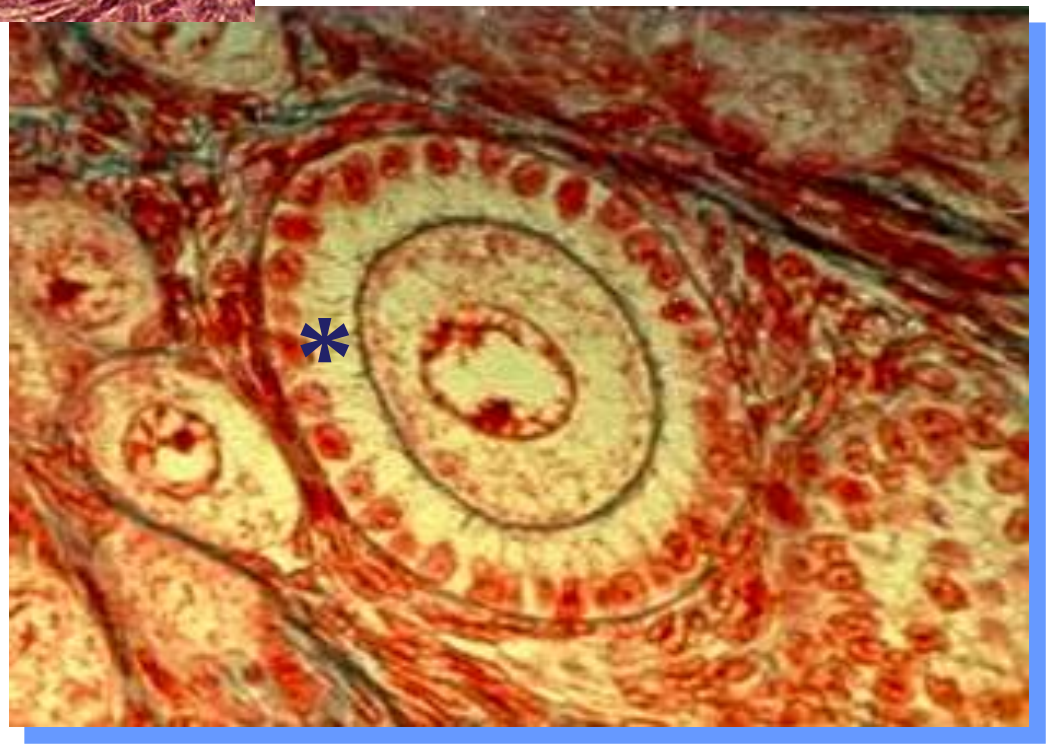


GV

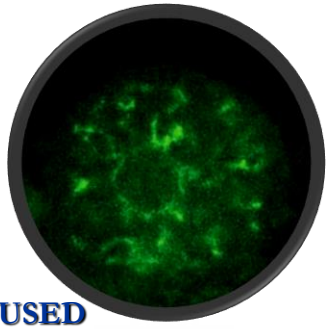
DIFFUSED CHROMATIN



The primary oocyte and its nucleus grow in diameter. The nucleus of the oocyte can now be called germinal vesclicle (GV). The follicular cells are now cuboidal and are referred to as *granulosa cells.



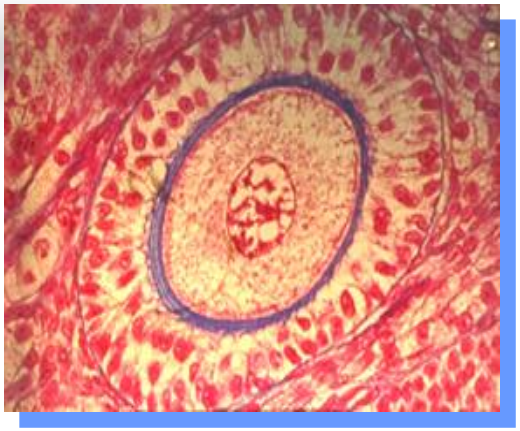
SECONDARY or PREANTRAL FOLLICLES



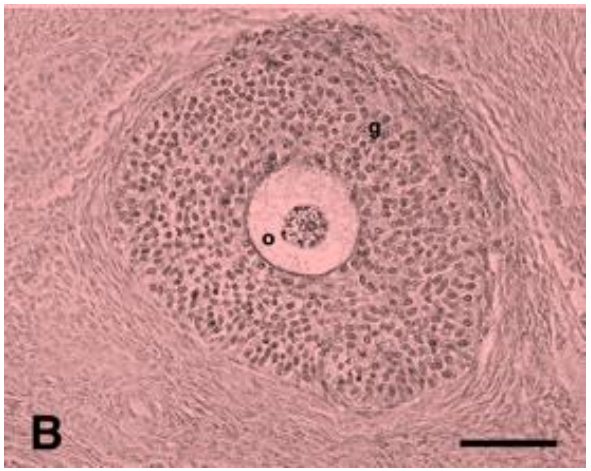
GV

DIFFUSED CHROMATIN

Granulosa cells proliferate.
The *zona pellucida* forms between the primary oocyte and the membrana granulosa. It is a glycoprotein layer secreted by both the oocyte and the granulosa cells. This latter ones send cytoplasmic projections within the oocyte and comunicate through *gap junctions*.



Small preantral



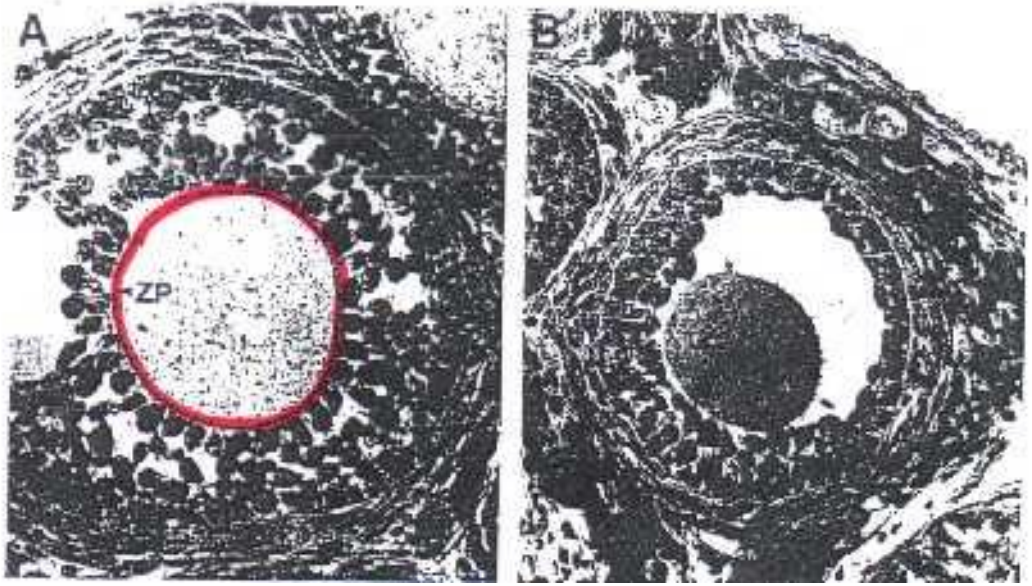
Large preantral

Zona pellucida formation in bovine ovary

Small preantral | Large preantral | Antral follicle

Effect of ZP3 knockout in mice kn

control



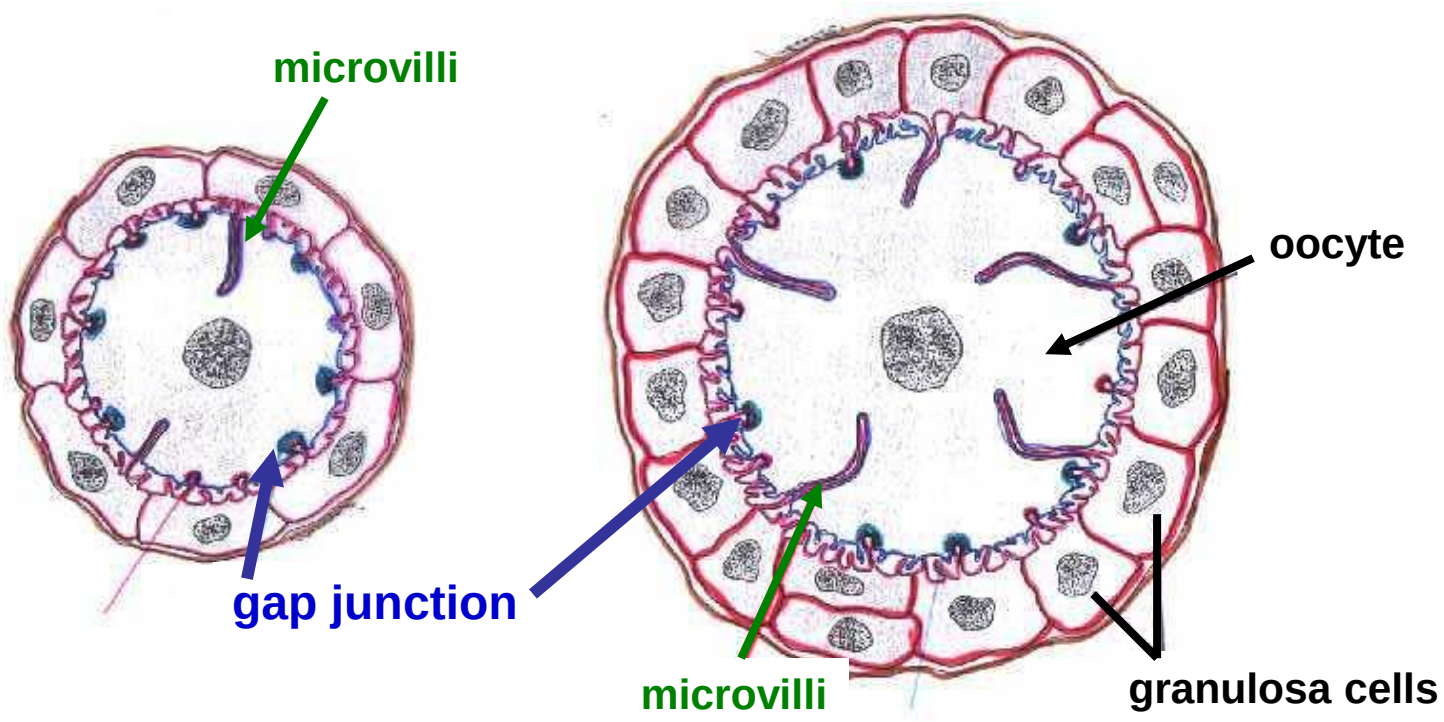
$ZP3^{-/-}$

infertile mice

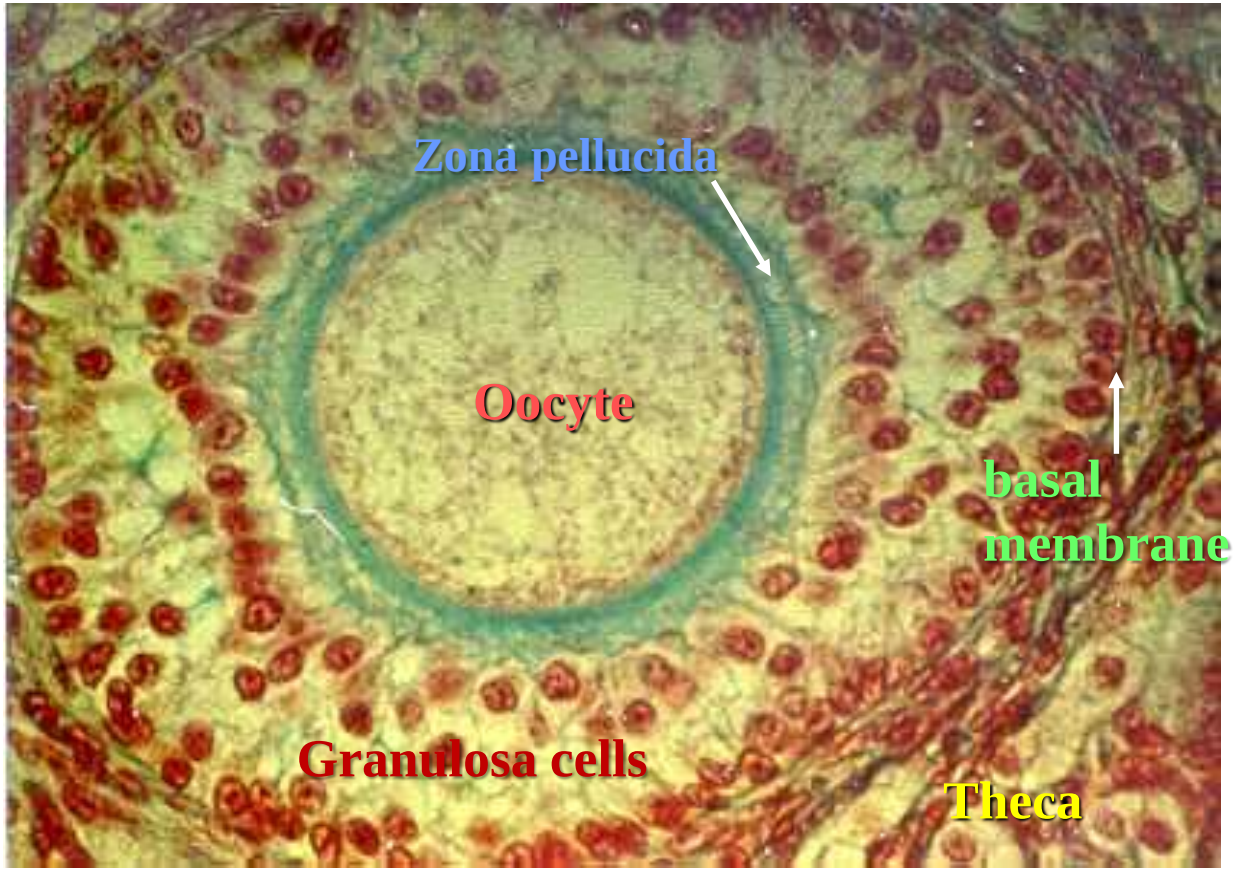
ZP proteins are needed to provide extracellular matrix for gc attachment

OOCYTE-GRANULOSA CELLS COMMUNICATION

(Motta, 1994)

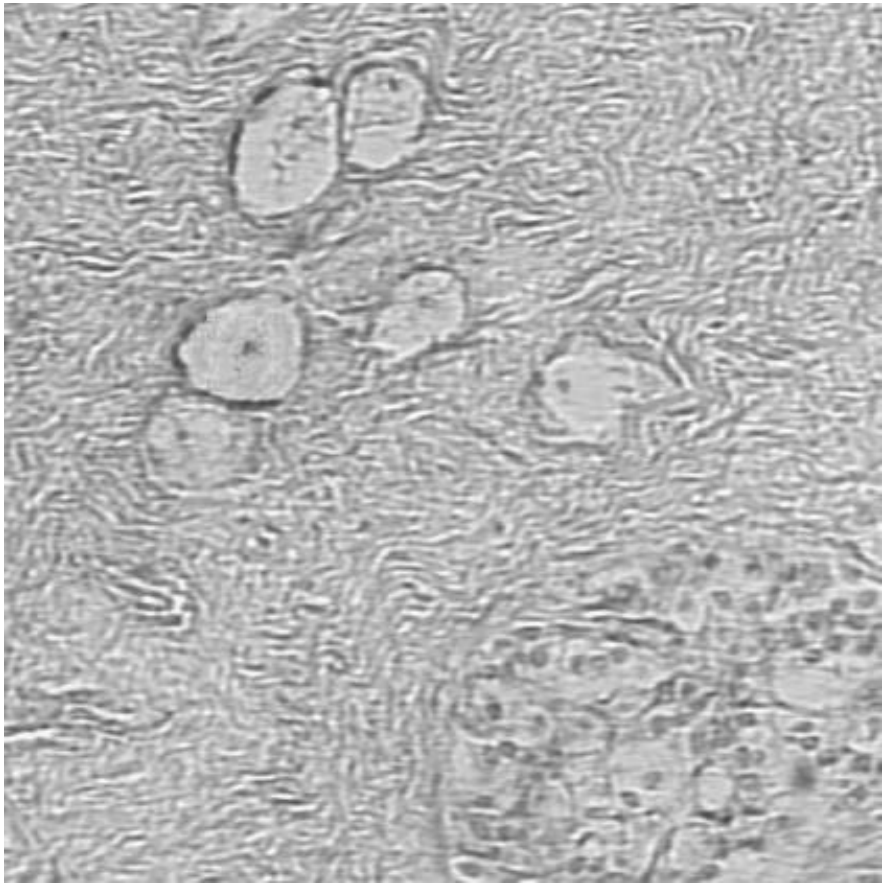


SECONDARY or PREANTRAL FOLLICLES

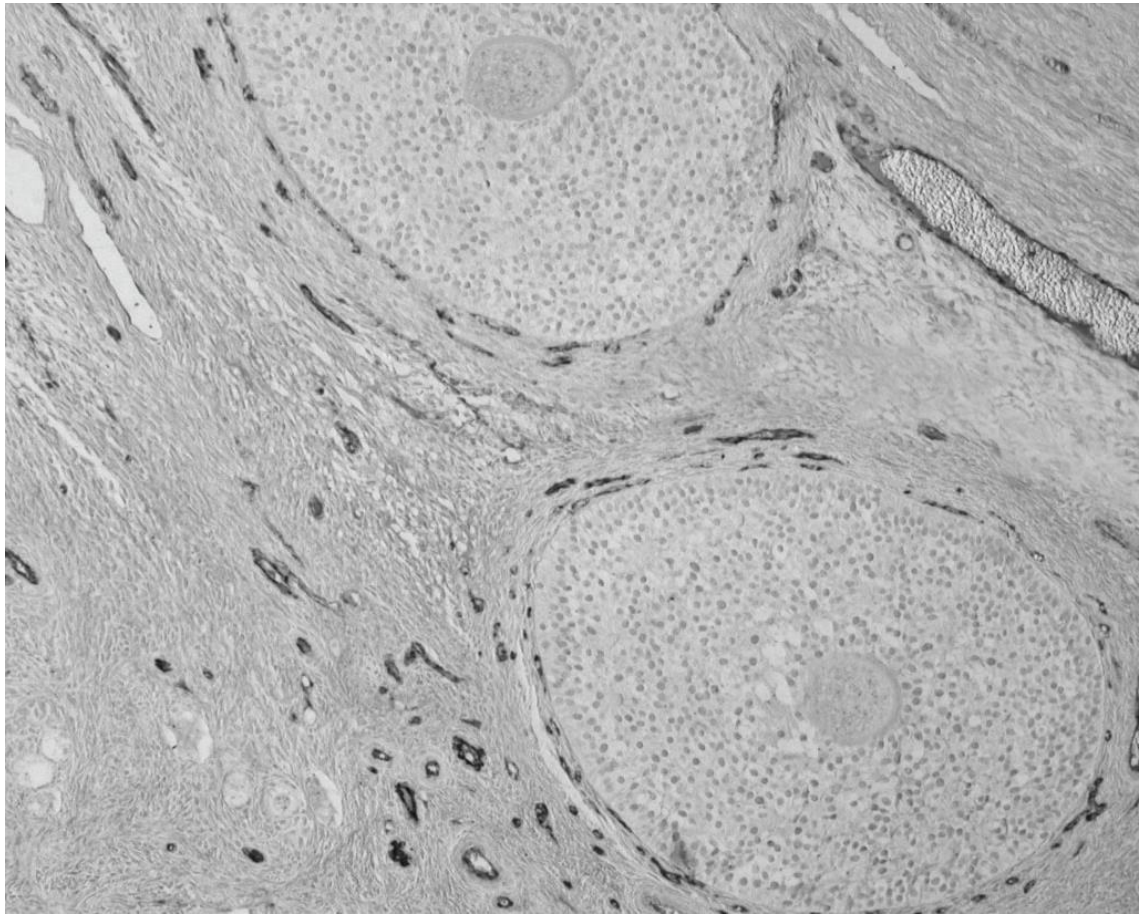


Stromal cells develop around the follicle forming the theca layer.
The theca layer is divided in: the *theca interna* and the *theca externa*.
Theca cells are separated from the membrana granulosa cells of the follicle by a *basement membrane*.

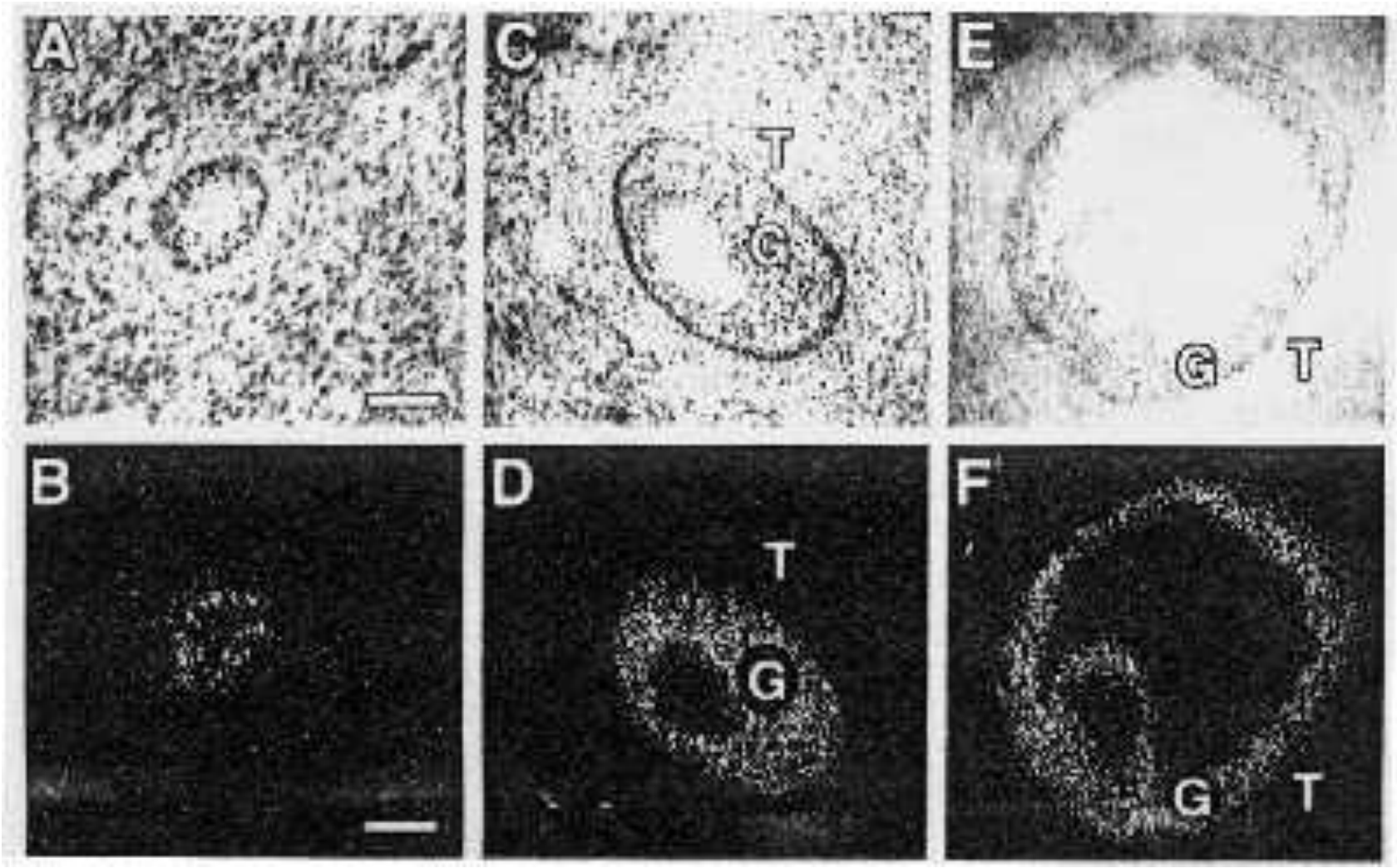
VASCULARIZATION IN
PRIMORDIAL, PRIMARY, AND SMALL PREANTRAL FOLLICLES



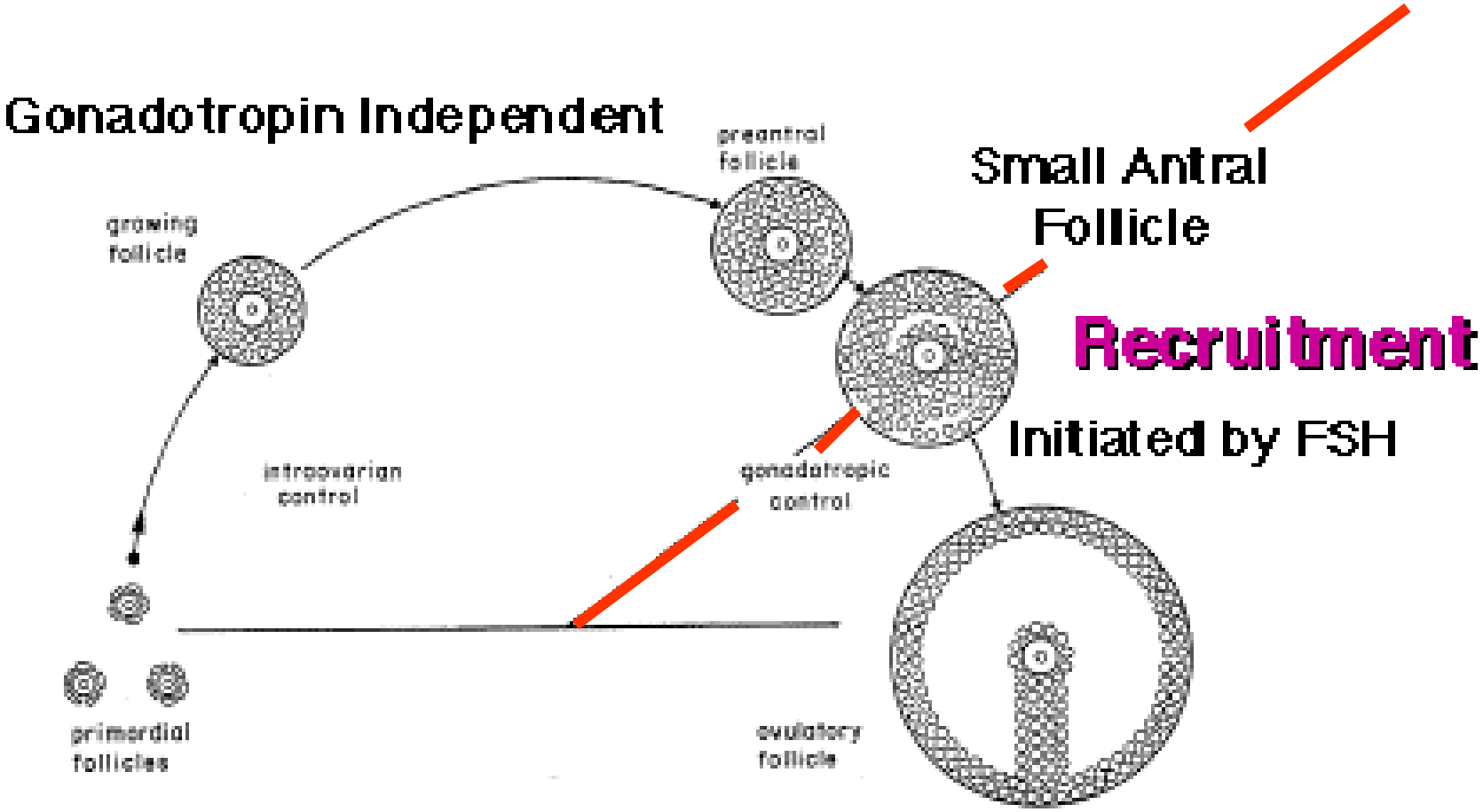
VASCULARIZATION IN
LARGE PREANTRAL FOLLICLES



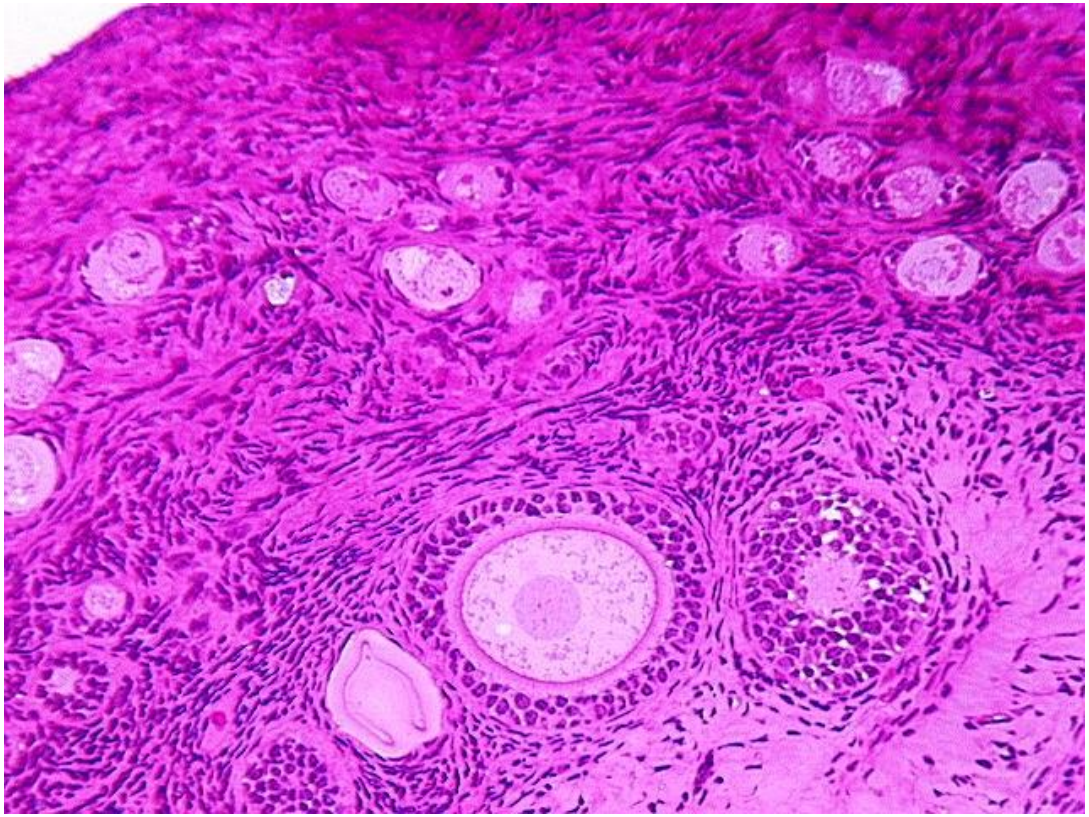
FSH receptors in the granulosa cells



Follicular Growth



SECONDARY or PREANTRAL FOLLICLE

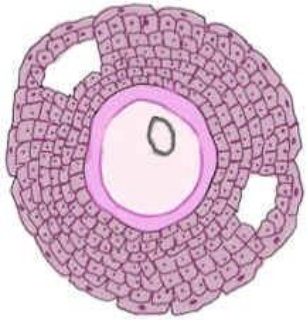


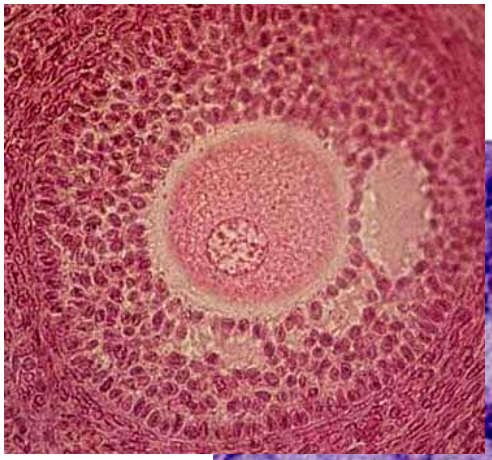
Follicular growth (granulosa cells proliferation) depends on FSH secretion

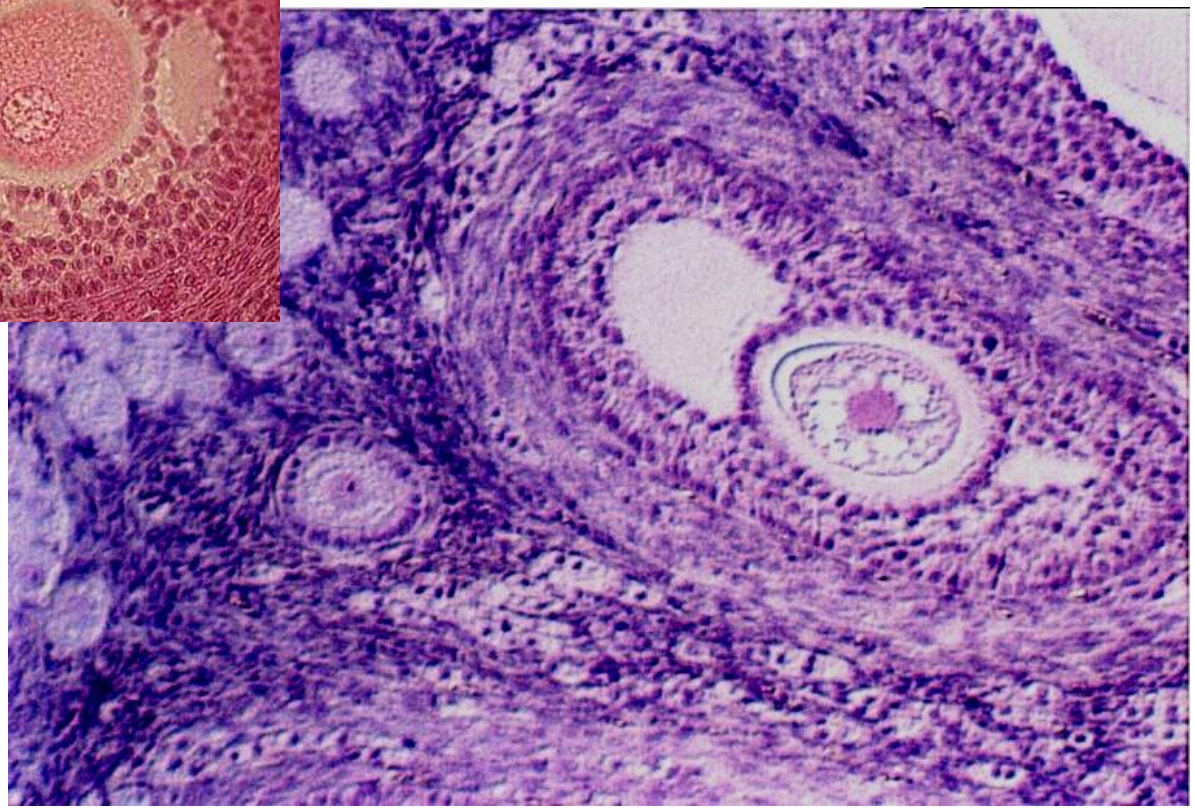
(follicle-stimulating hormone secreted by the pituitary gland).

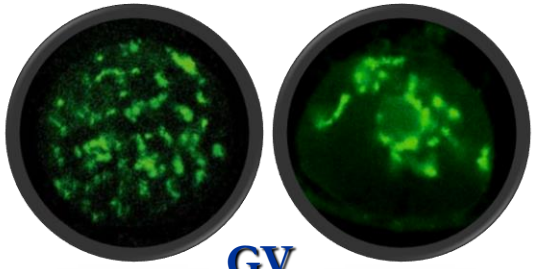
In preantral follicles several granulosa layers form around the oocyte.

TERTIARY EARLY ANTRAL FOLLICLES



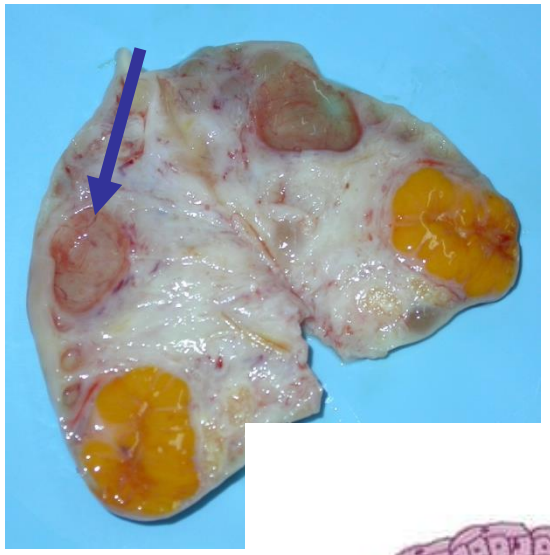


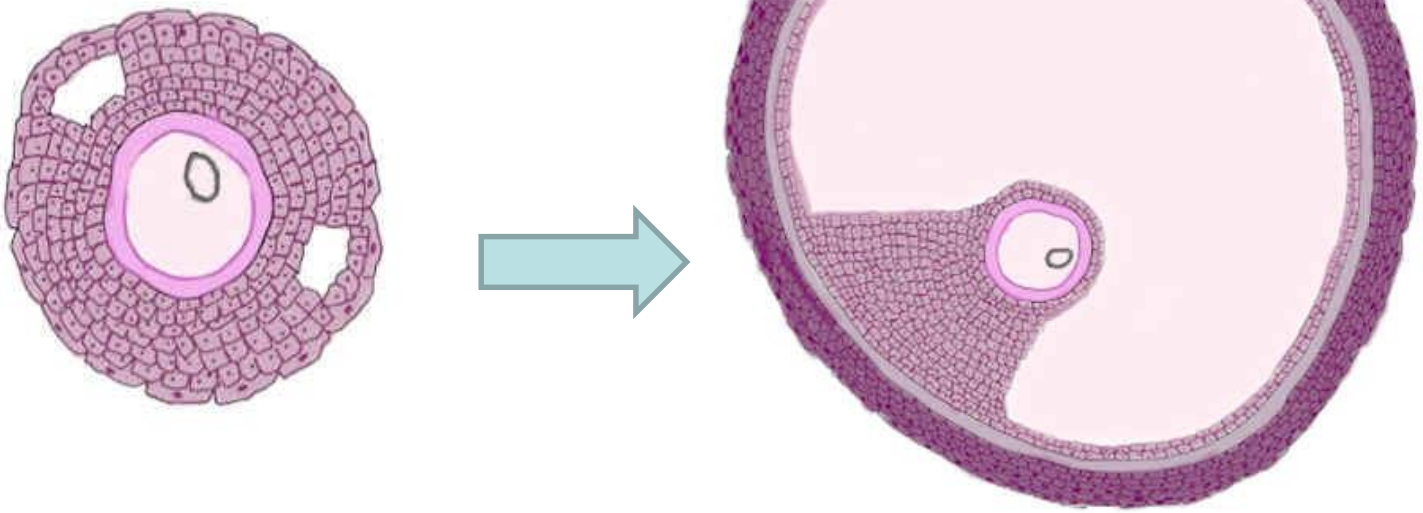




As the follicle grows pockets of follicular fluid within the membrana granulosa. The follicular fluid is a plasma exudate containg glycosaminoglycans and steroid binding proteins as well as hormones and molecules produced by granulosa cells and the oocyte.

TERTIARY or PREOVOLUTARY ANTRAL FOLLICLES

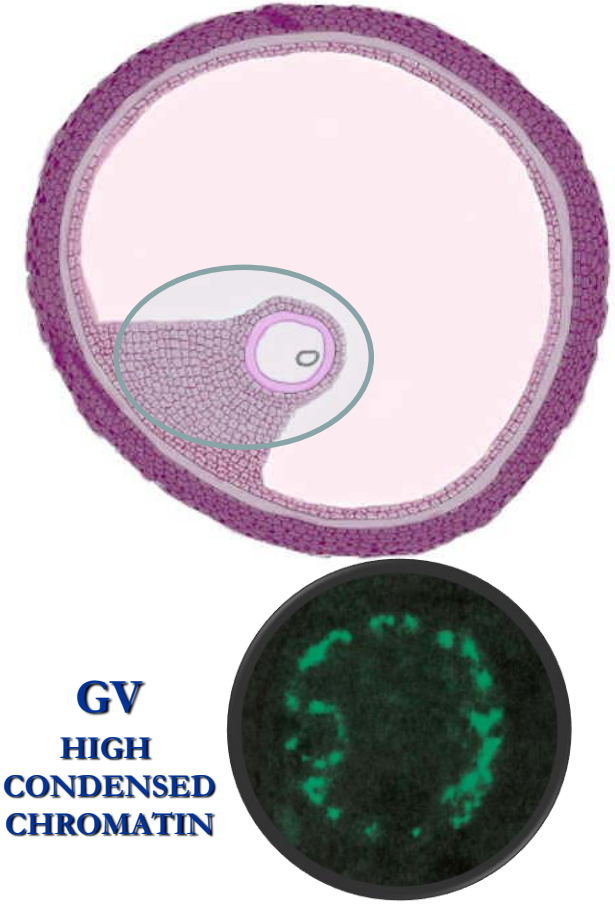




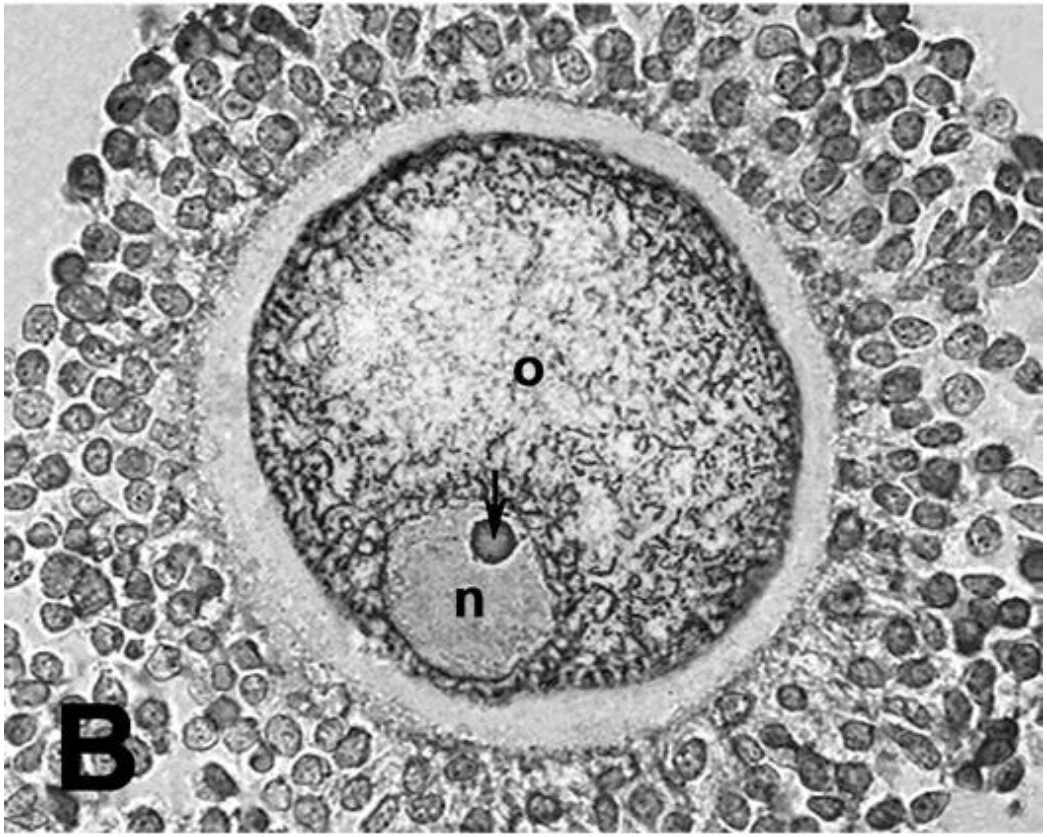
As the follicle continues to develop, the separated pockets fuse to form one large pocket of fluid called the *follicular antrum*.

TERTIARY or ANTRAL FOLLICLES

CUMULUS OOPHORUS



GV
HIGH CONDENSED CHROMATIN

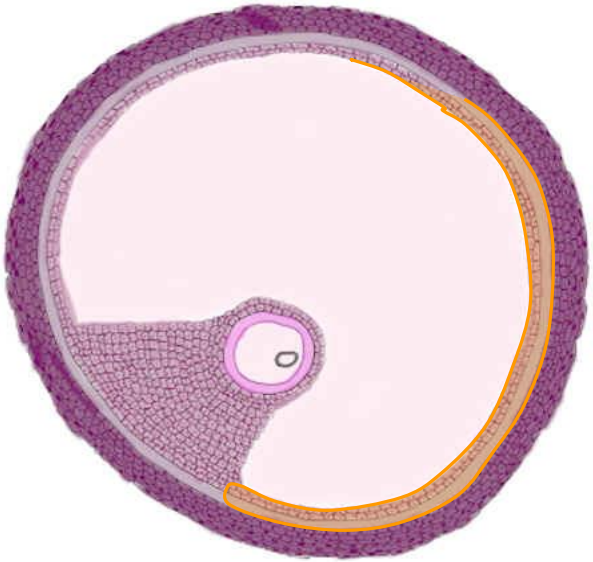


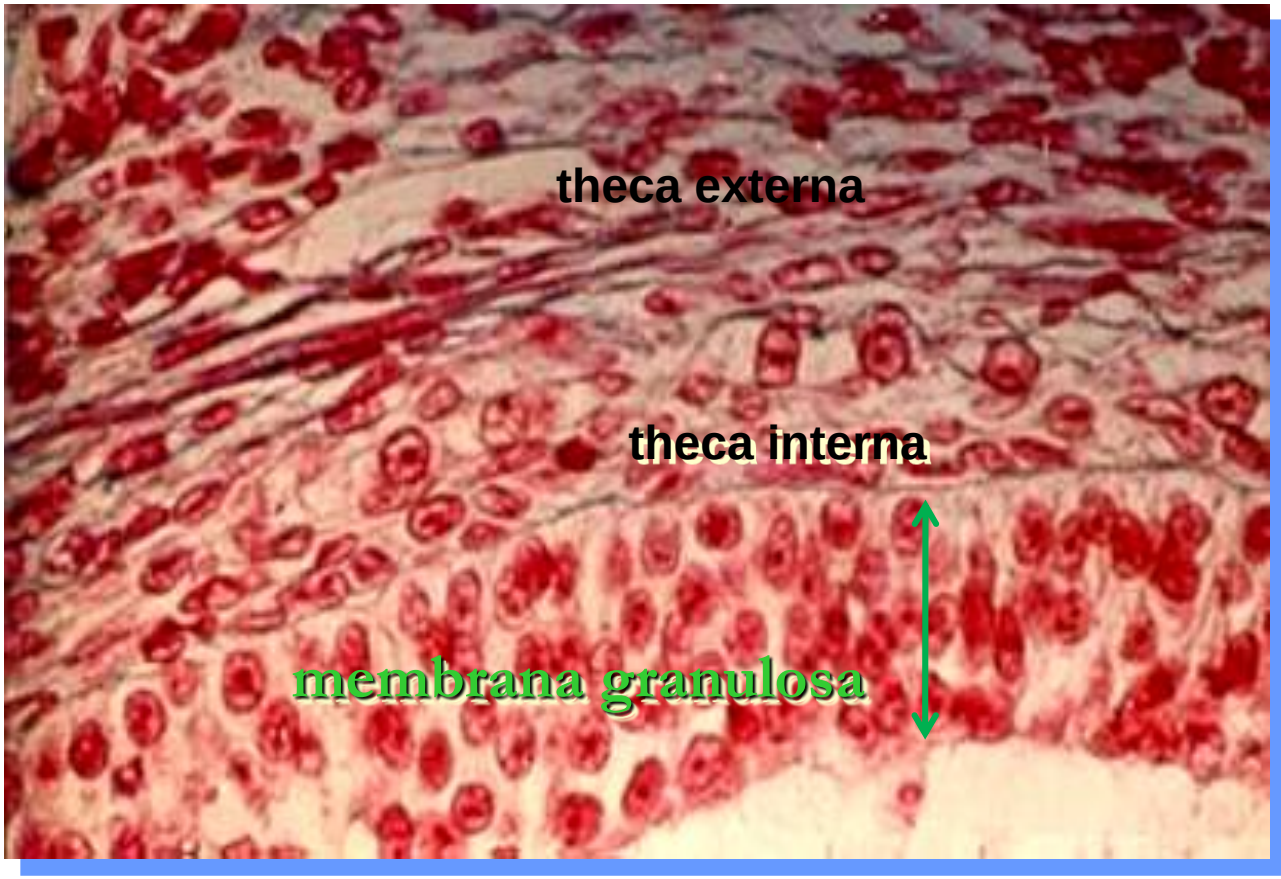
Granulosa cells that surround the oocyte form *the cumulus oophorus* which projects towards the antrum.

Cumulus oophorus cells which remain attached to the oocyte form the *corona radiata*

TERTIARY or ANTRAL FOLLICLES

MEMBRANA GRANULOSA

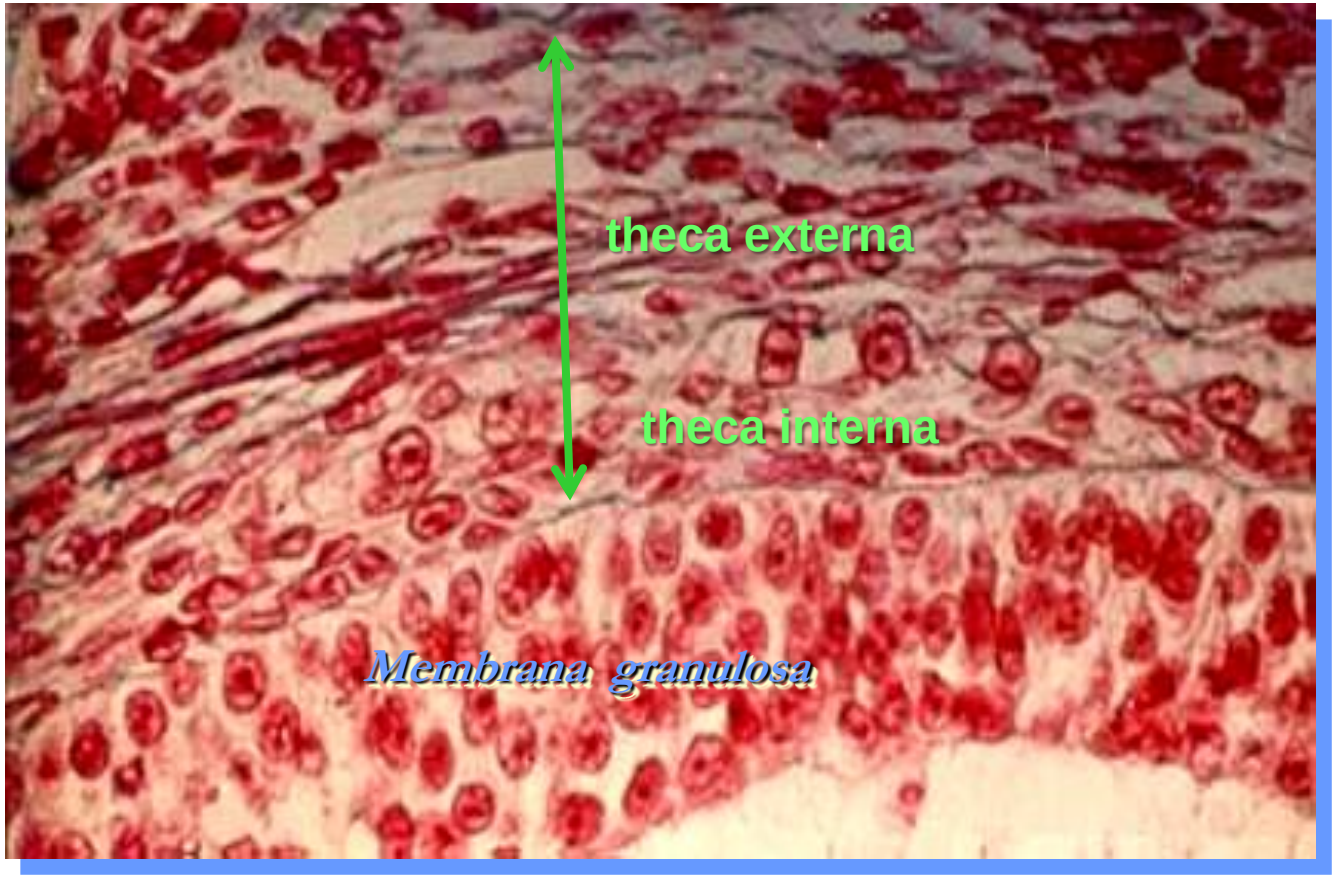




Granulosa cells that form a layer around the periphery of the follicle are the **membrana granulosa**

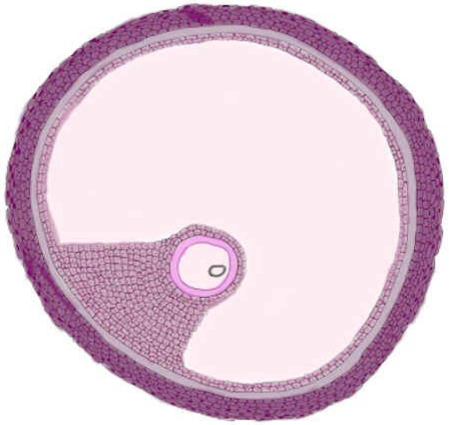
TERTIARY or ANTRAL FOLLICLES

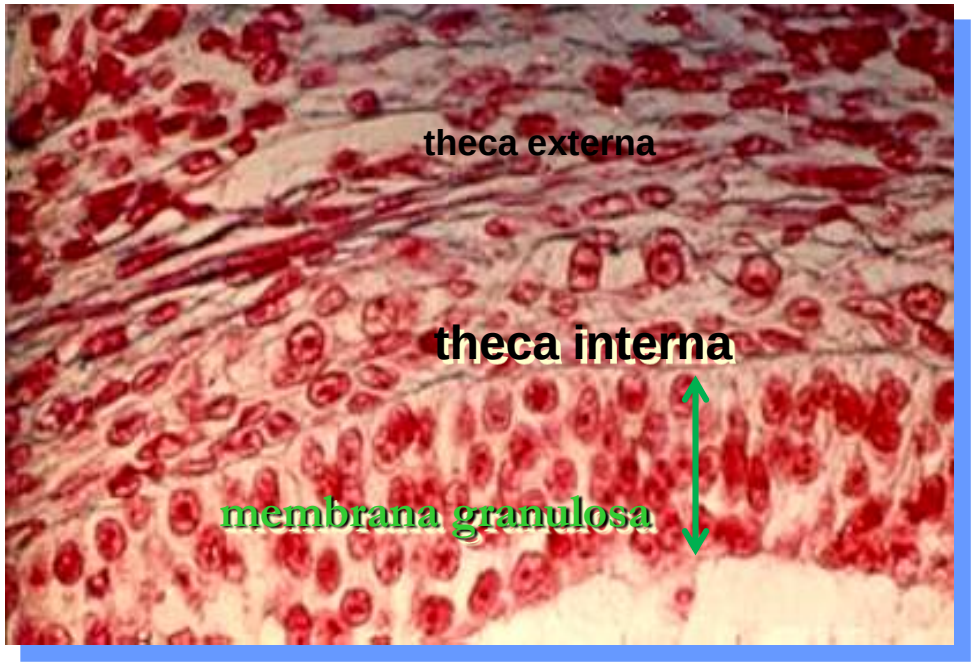
THECA



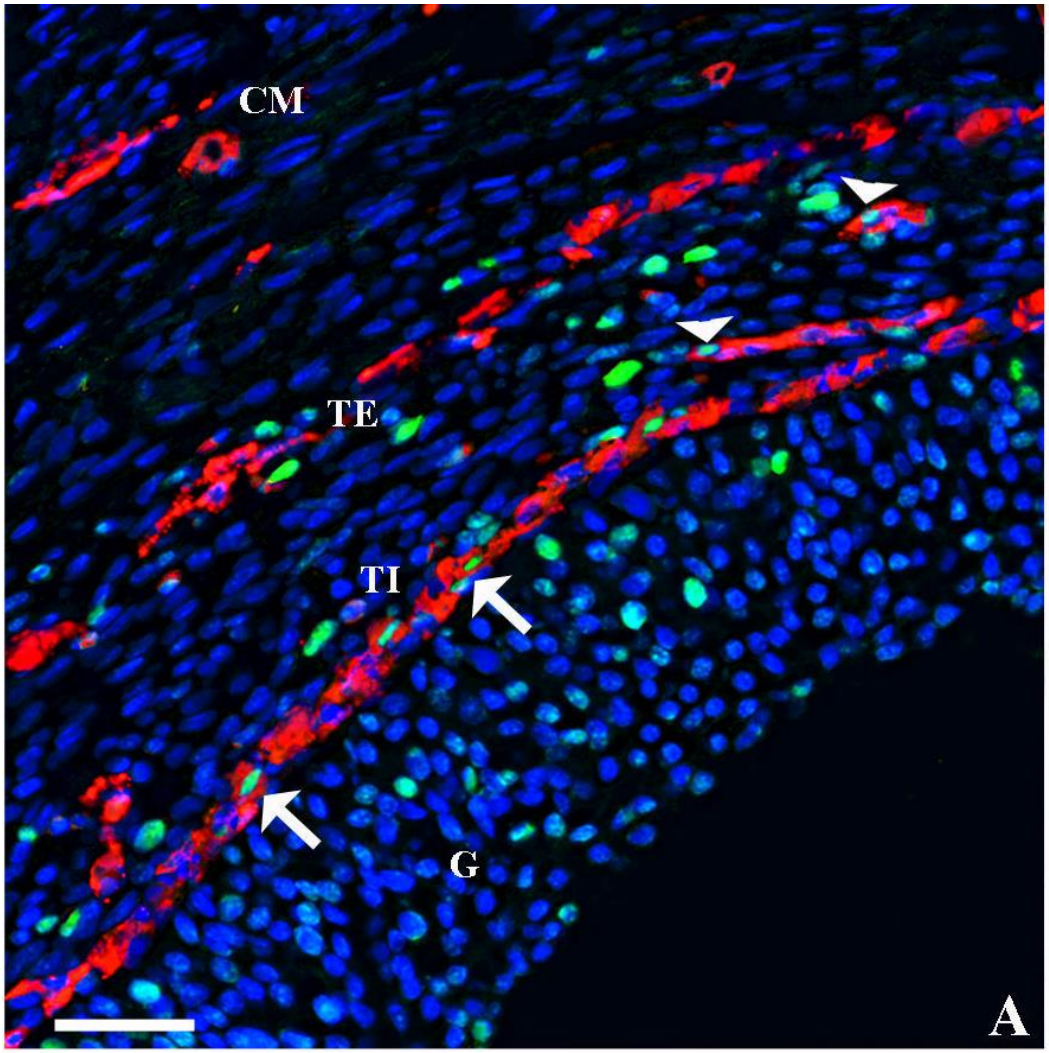
Also the theca interna and externa continue to grow.
Within the theca are present the blood vessels that will nourish the granulosa which is avascular.

TERTIARY or ANTRAL FOLLICLES

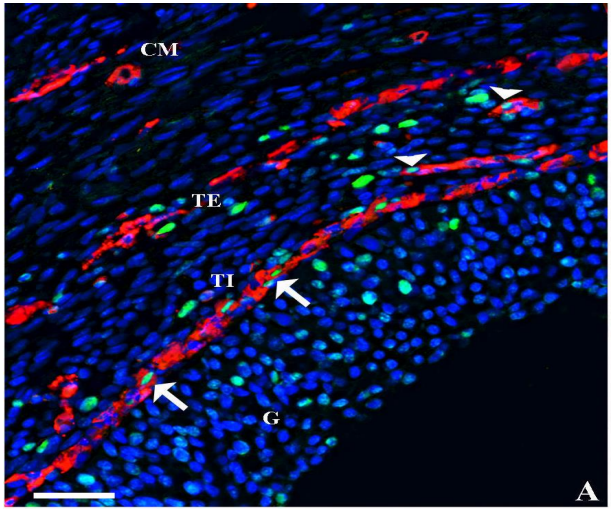


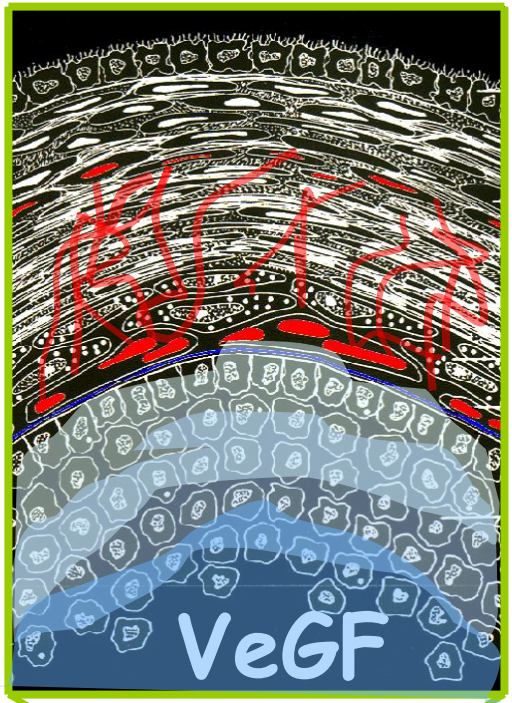


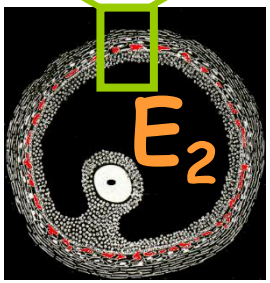
VASCULARIZATION IN
PREOVULATORY ANTRAL FOLLICLES



VASCULARIZATION IN
PREOVULATORY ANTRAL FOLLICLES



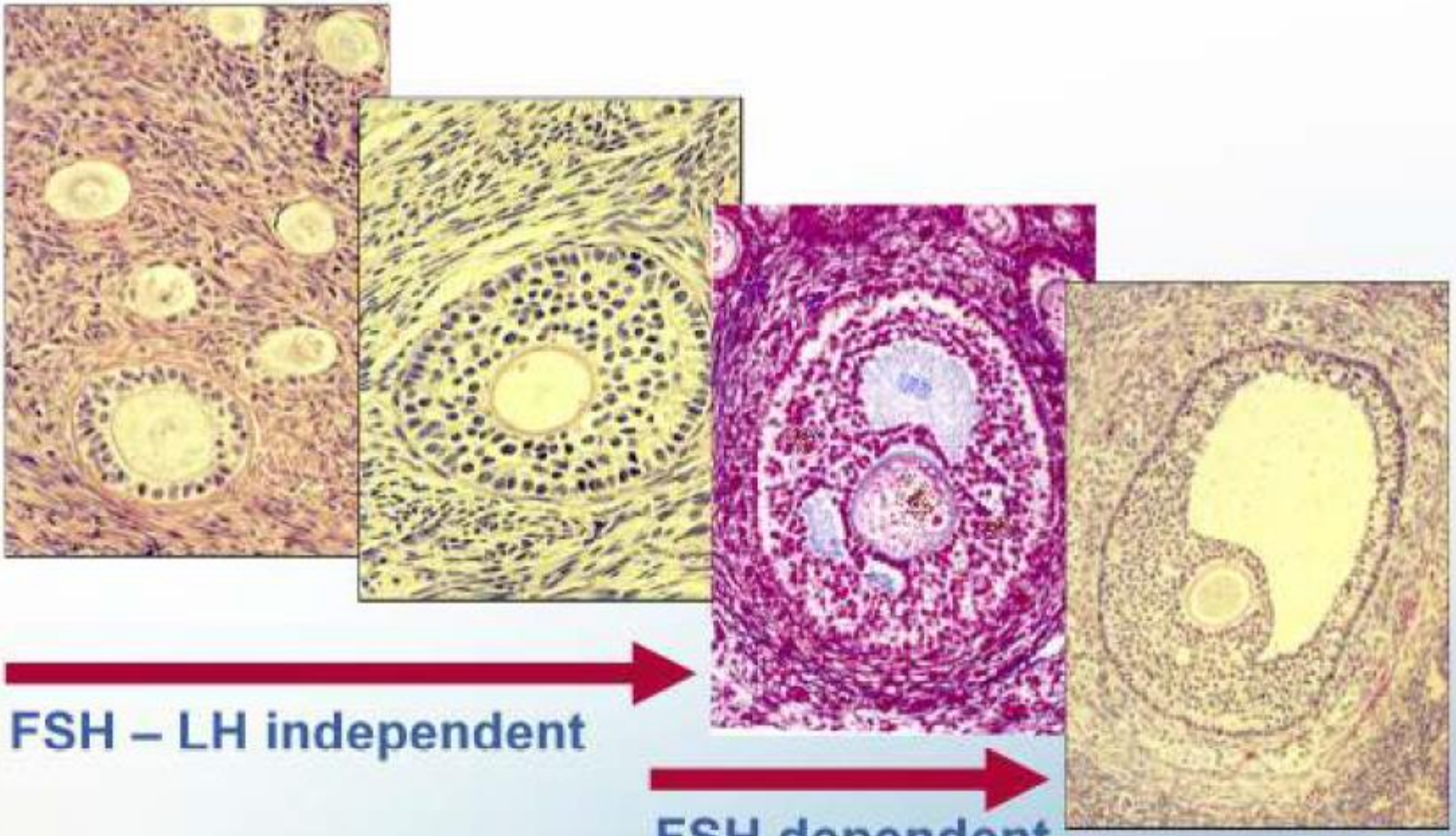




TERTIARY or ANTRAL FOLLICLES: transition from antral to dominant follicle

FSH receptors are expressed exclusively in granulosa cells

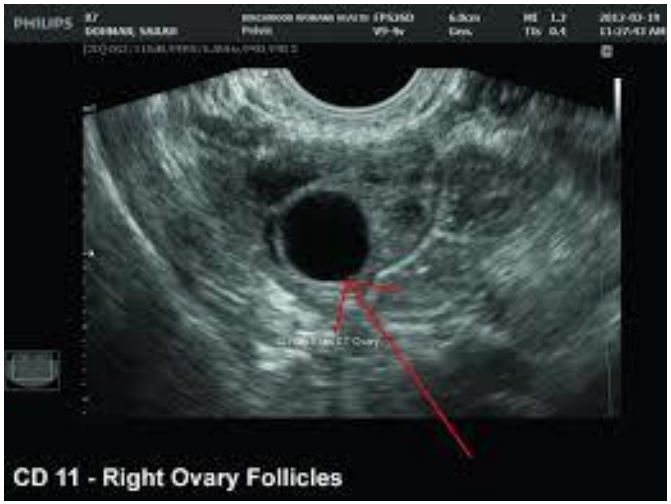
LH receptors are expressed exclusively in theca cells up to the stage of follicular dominance (Periovolutaory follicles), when they start to be expressed also in granulosa cells (initiated by FSH and estrogens).


FSH – LH independent
FSH dependent
LH dependent

TERTIARY or ANTRAL FOLLICLES

PERIOVULATORY ANTRAL FOLLICLES

DOMINANT FOLLICLE

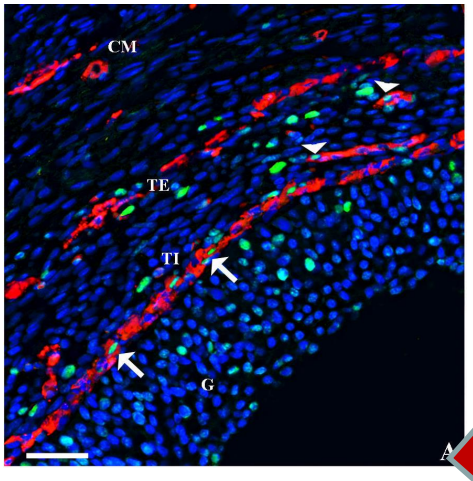


Species	Time of ovulation
Cattle	12 (10–15) hours after end of oestrus
Horse	24–48 hours before end of oestrus
Swine	38–48 hours after onset of oestrus
Sheep	18–20 hours after onset of oestrus
Goat	Near the end of oestrus
Dog	1–2 days after onset of oestrus
Cat	Induced ovulation

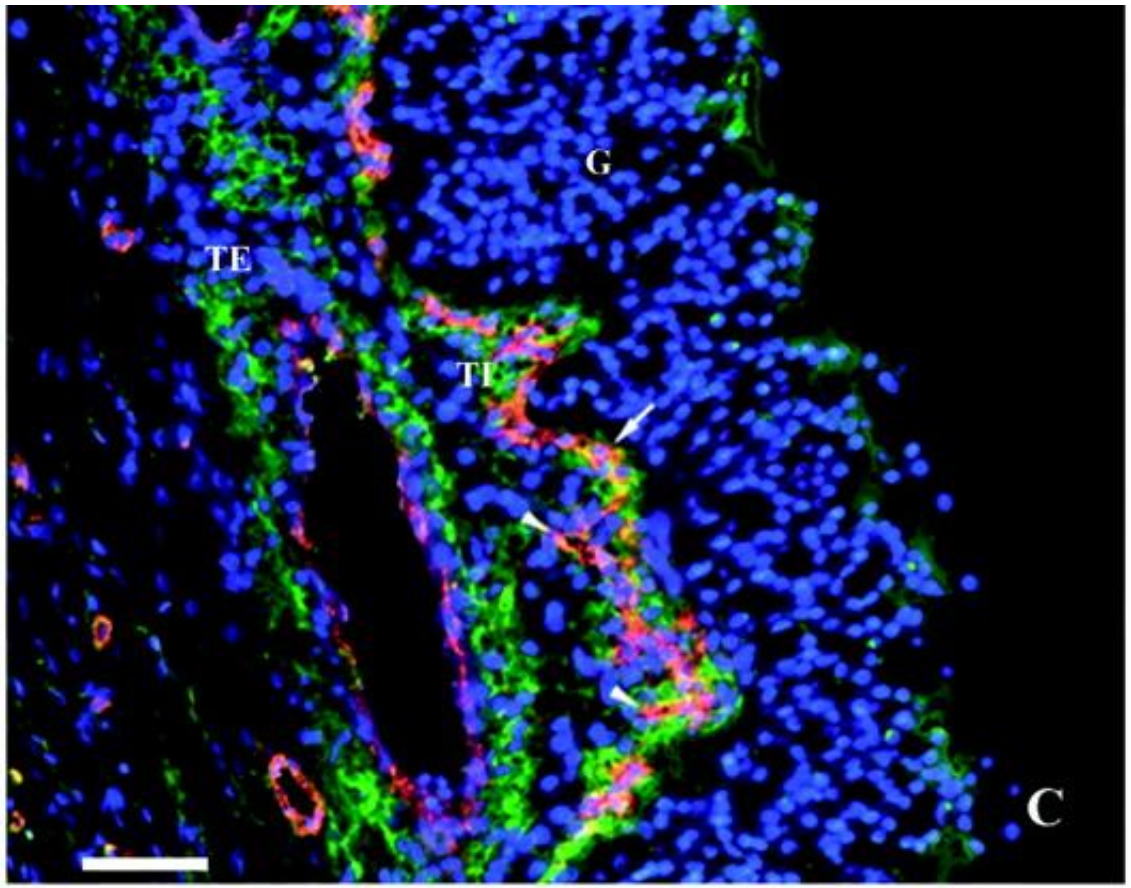
TERTIARY or ANTRAL FOLLICLES

PERIOVULATORY ANTRAL FOLLICLES

DOMINANT FOLLICLE



Follicular maturation

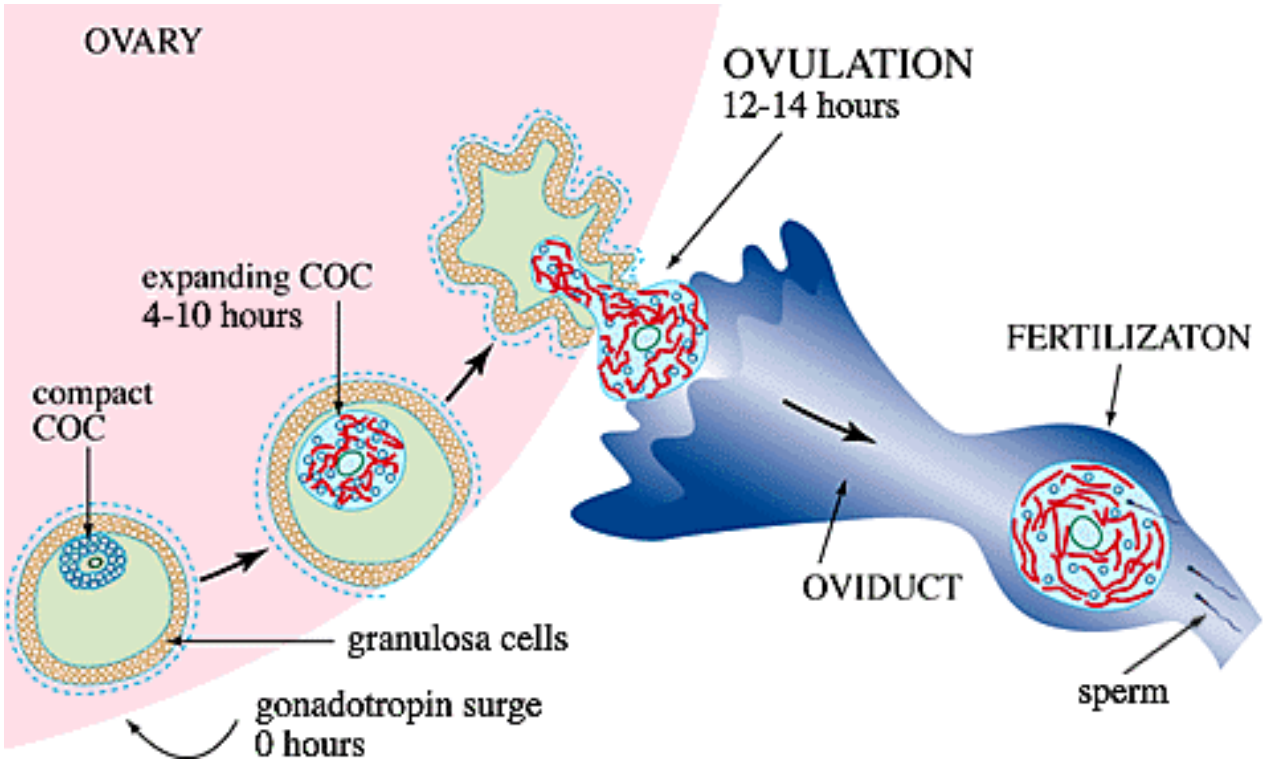


TERTIARY or ANTRAL FOLLICLES

PERIOVULATORY ANTRAL FOLLICLES

DOMINANT FOLLICLE

Cytoplamic oocyte maturation

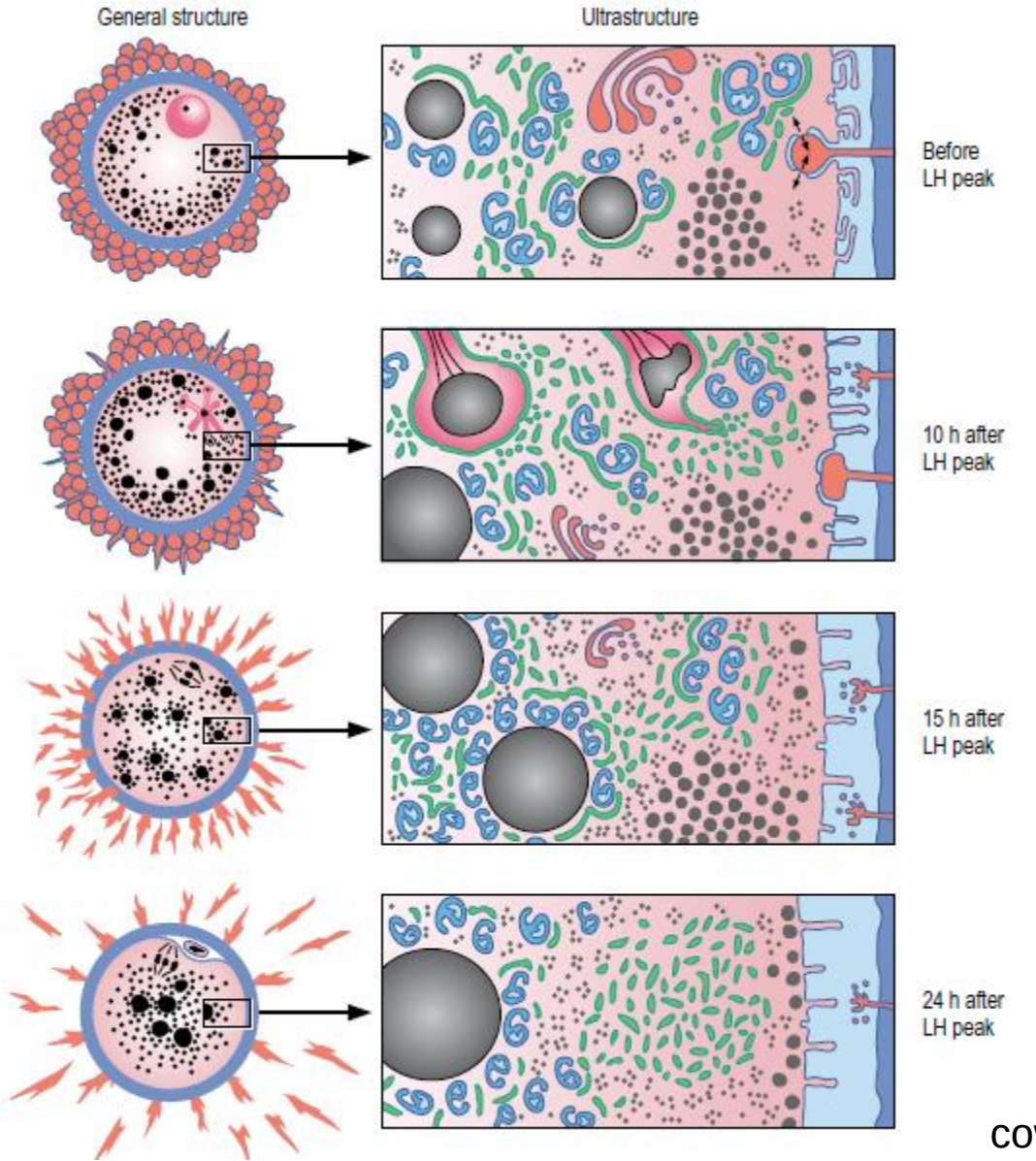


TERTIARY or ANTRAL FOLLICLES

PERIOVULATORY ANTRAL FOLLICLES

DOMINANT FOLLICLE

Cytoplamic oocyte maturation

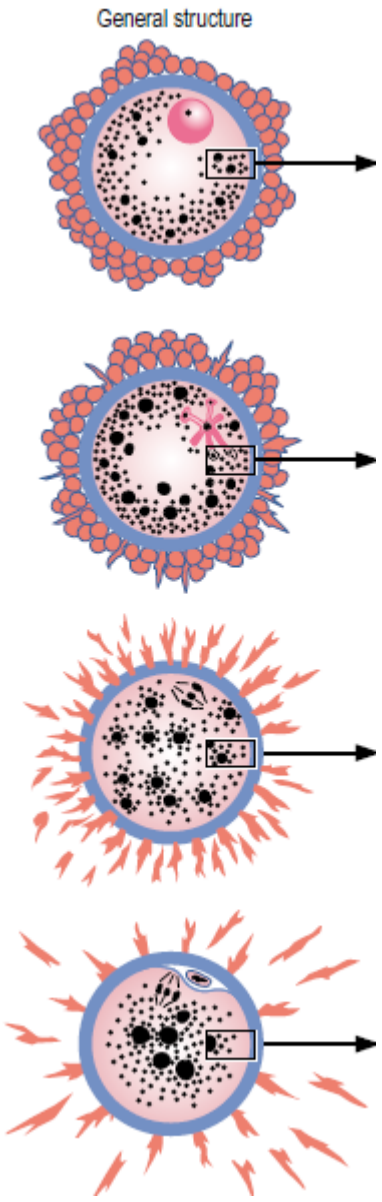


COW

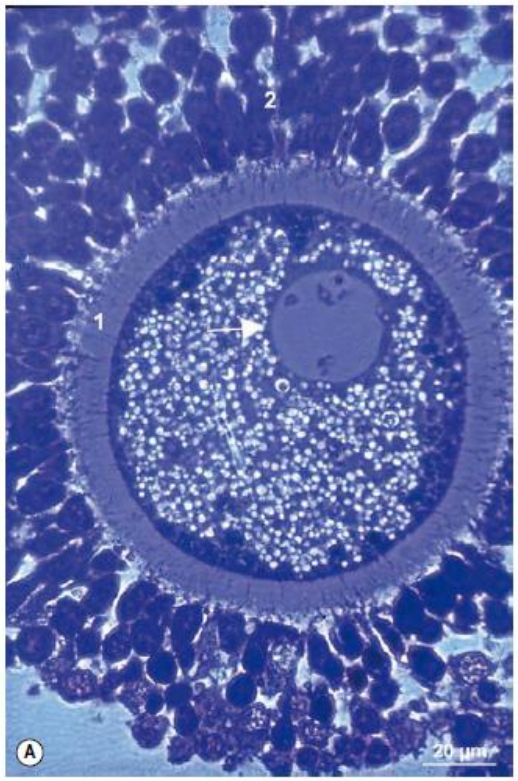
TERTIARY or ANTRAL FOLLICLES

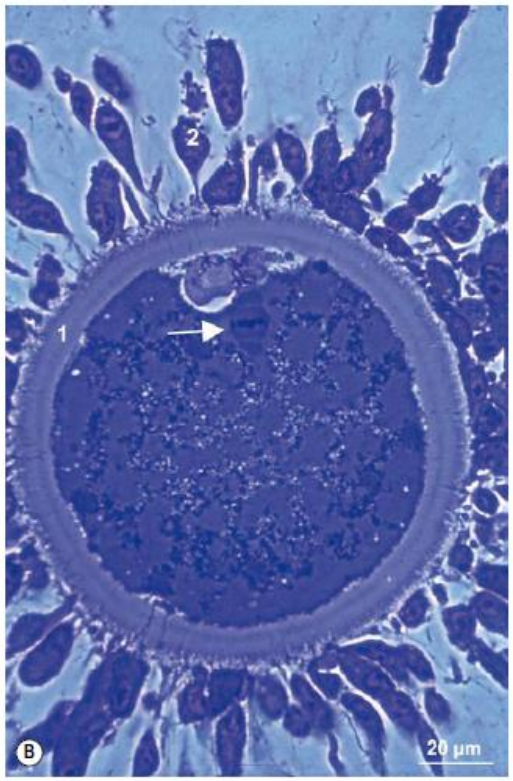
PERIOVULATORY ANTRAL FOLLICLES

DOMINANT FOLLICLE



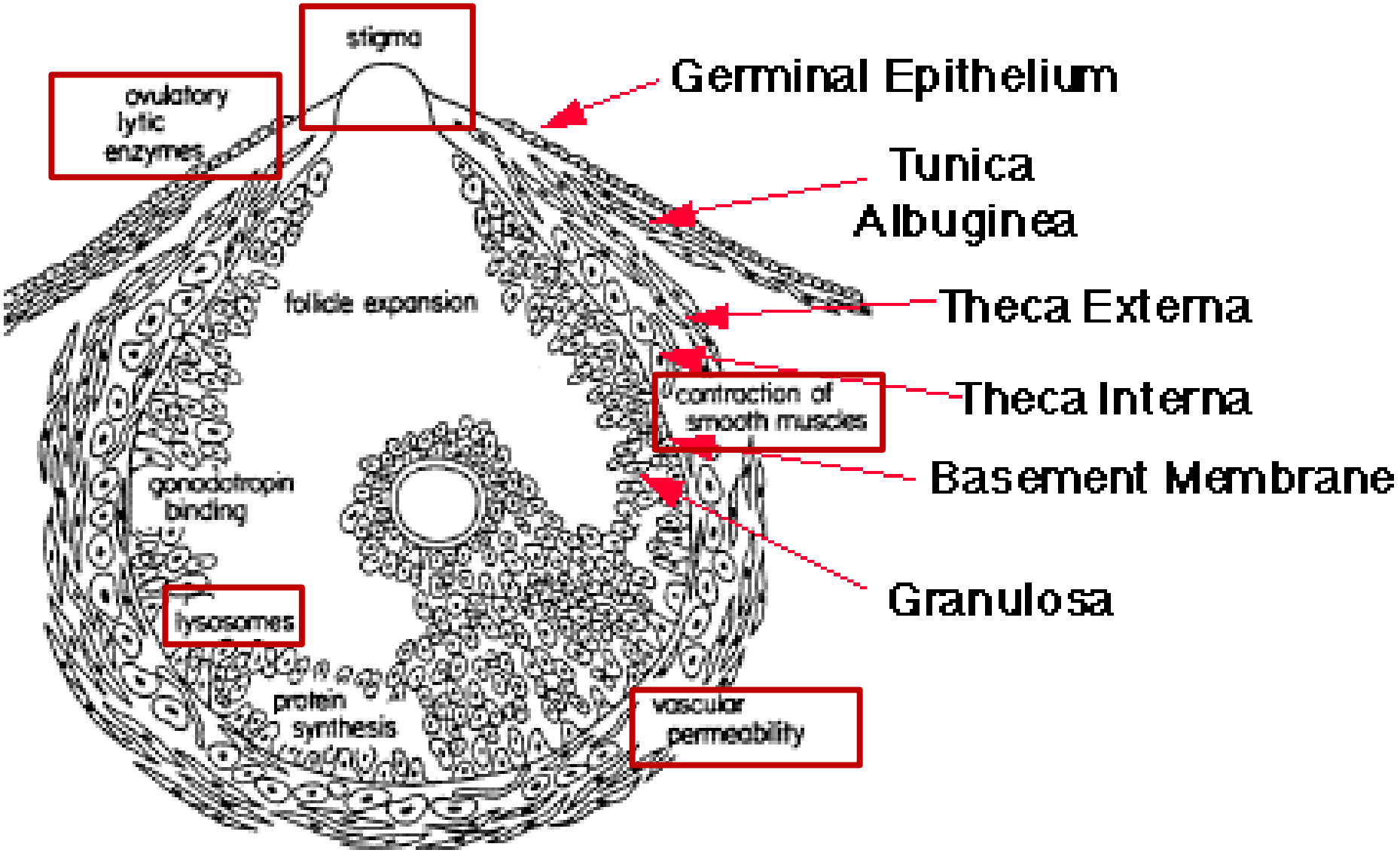
Nuclear oocyte maturation





OVULATION

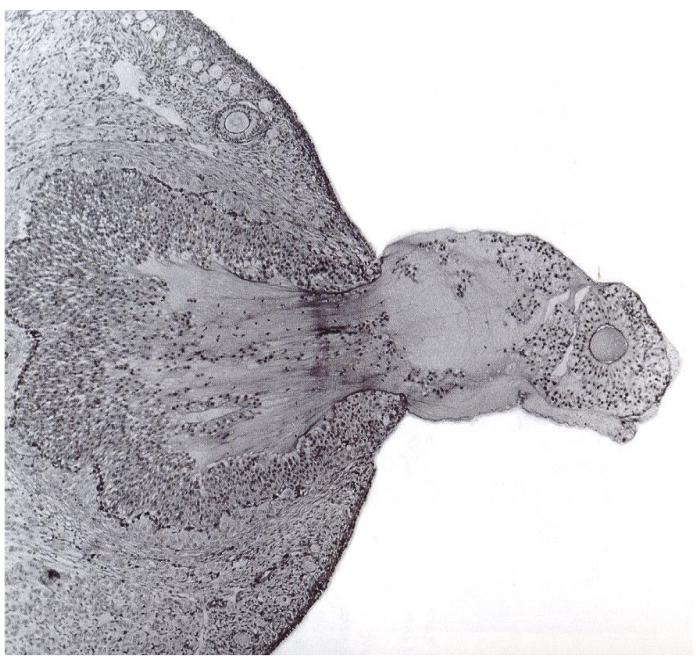
OVULATION


stigma
ovulatory
lytic
enzymes
Germinal Epithelium
Tunica
Albuginea
follicle expansion
Theca Externa
contraction of
smooth muscles
Theca Interna
Basement Membrane
gonadotropin
binding
Granulosa
lysosomes
protein
synthesis
vascular
permeability

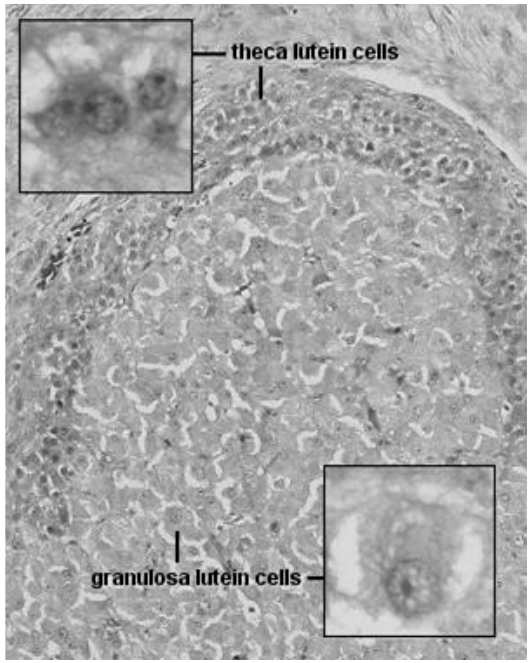
OVULATION

- An increase of intrafollicular pressure,
- Proteolytic enzyme activity on the follicular wall,
- Morphological changes in the stigma,
- Perifollicular ovarian smooth muscle contractions and
- Vascular modifications in the perifollicular vessels.

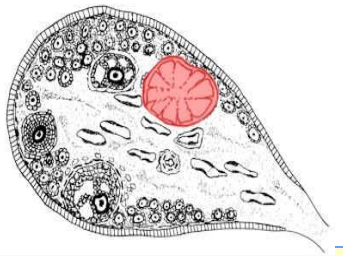
CORPUS LUTEUM



TRANSFORMATION



OVULATION



Corpus Luteum hemorrhagicum

Mature Corpus Luteum

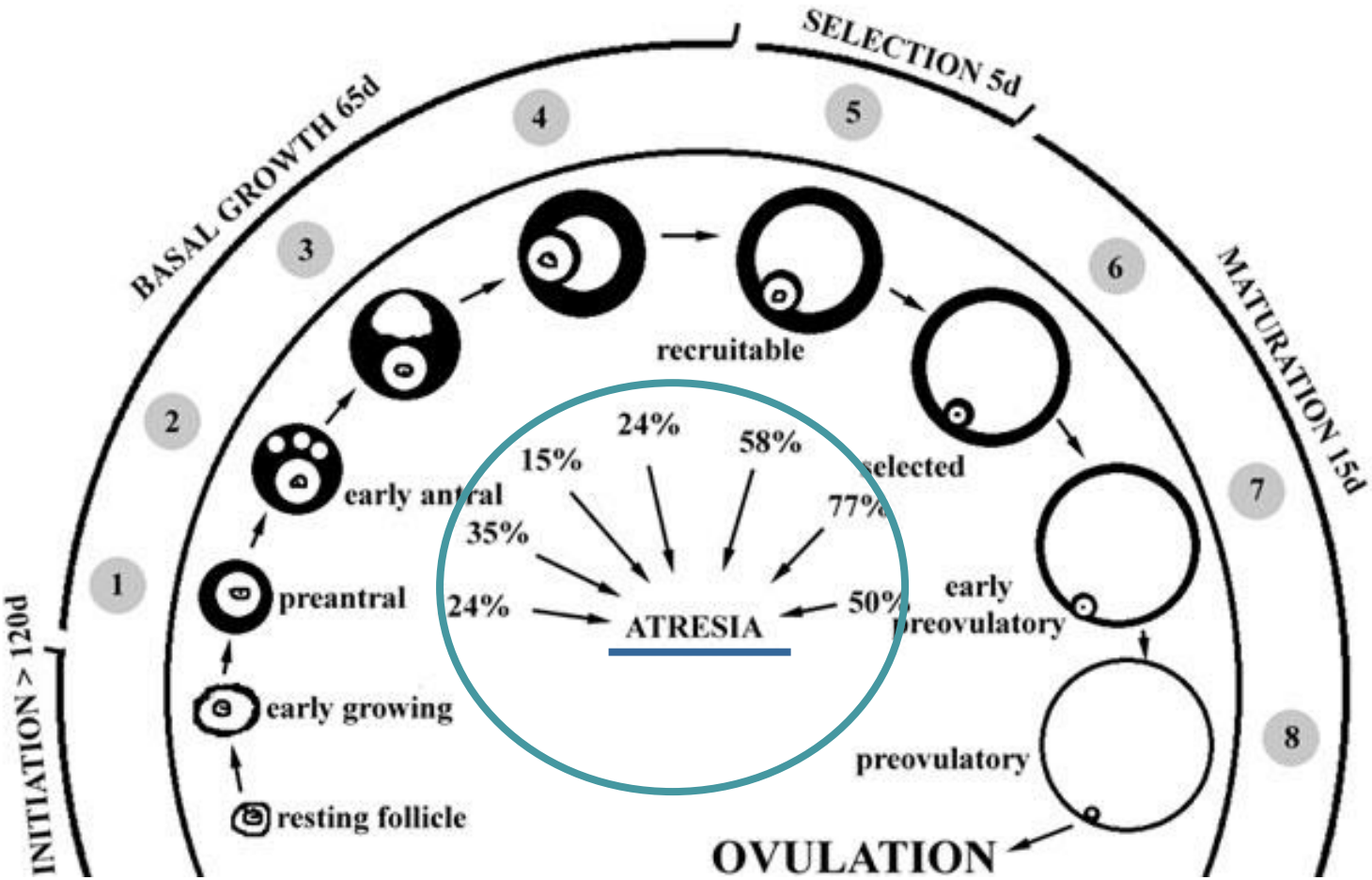
Regression Corpus Luteum

Corpus Albicans

Corpus Luteum

Corpus Luteum graviditatis

ATRETIC FOLLICLES



Each reproductive cycle a pool of follicles will grow (folliculogenesis), but only one (mono-ovulatory species) or few (poli-ovulatory species) will ovulate; most of them will undergo to atresia

STAGES OF ATRESIA

Healthy (non-non atretic) follicle

- many dividing granulosa cells (high mitotic index)
- No/very low % pyknotic granulosa cells
- follicle fluid “clean” without cell debris
- oocyte in the resting stage of prophase MI
- theca extensively vascularized

Atresia

- no dividing granulosa cells
- 10-30% pyknotic granulosa cells
- detachment of granulosa cells from basement membrane
- follicle fluid contains many cell debris or atretic bodies

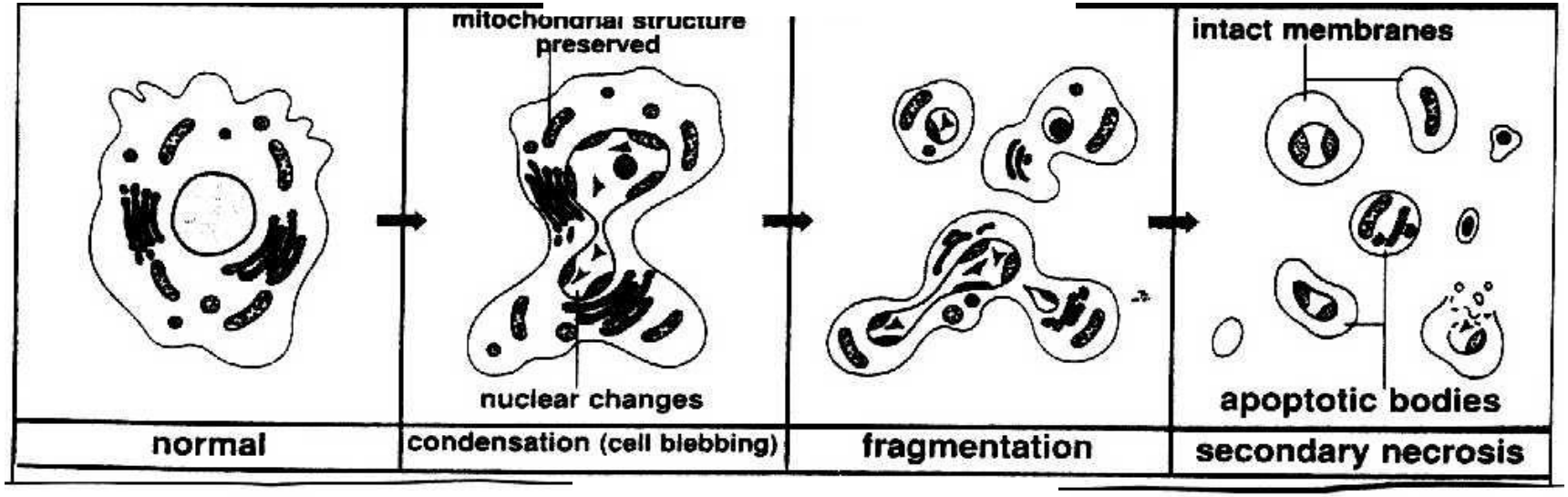
- reduction in number of granulosa cells
- oocyte fragmentation
- connective tissue invasion into follicle fluid
- follicle starts to collapse

Atretic follicles

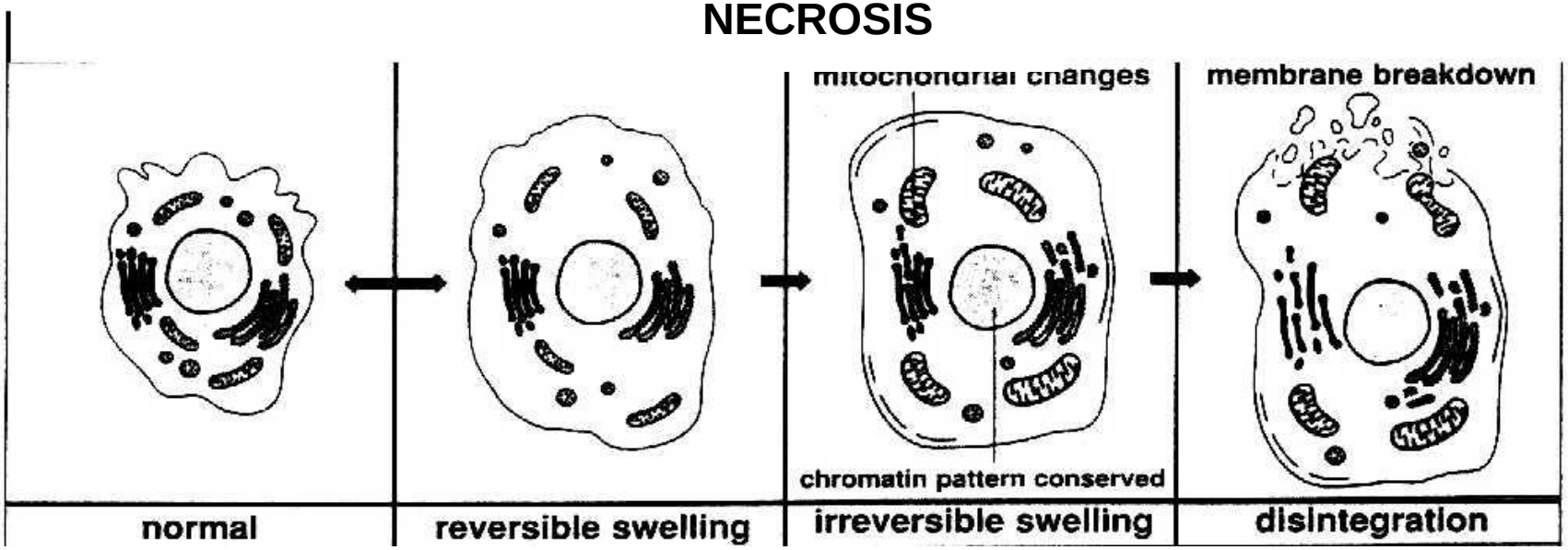
Detachment and apoptosis of granulosa cells

Apoptosis-programmed cell death

APOPTOSIS



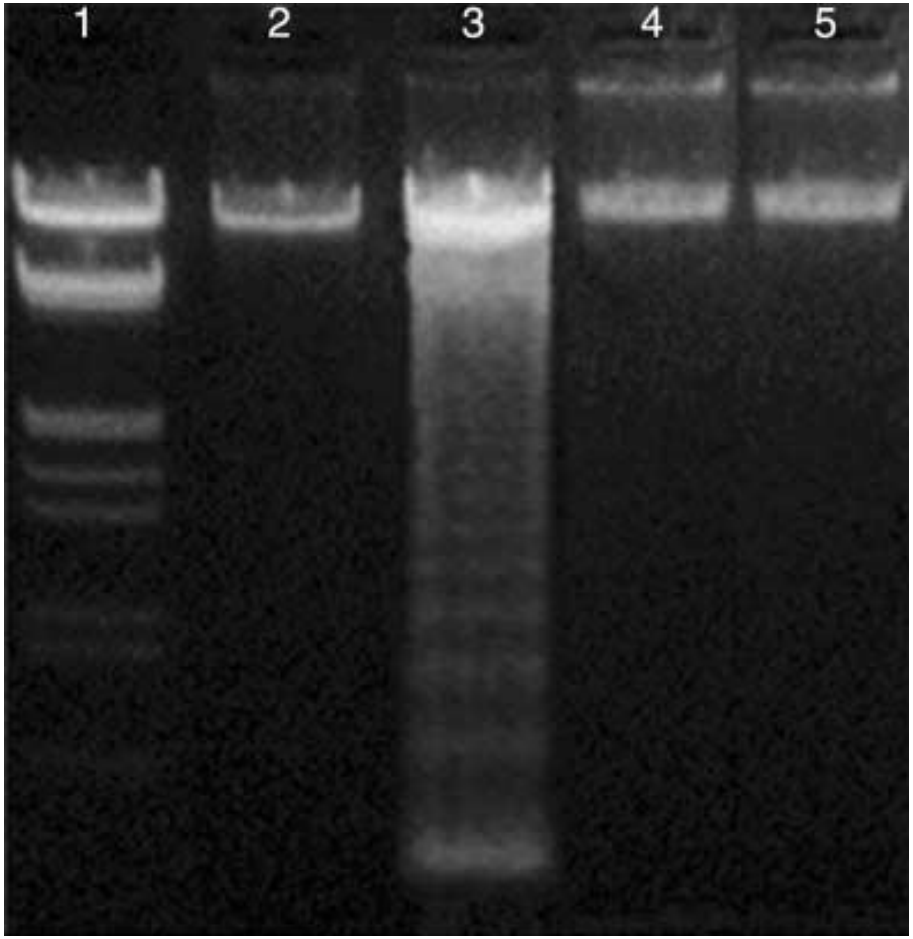
NECROSIS



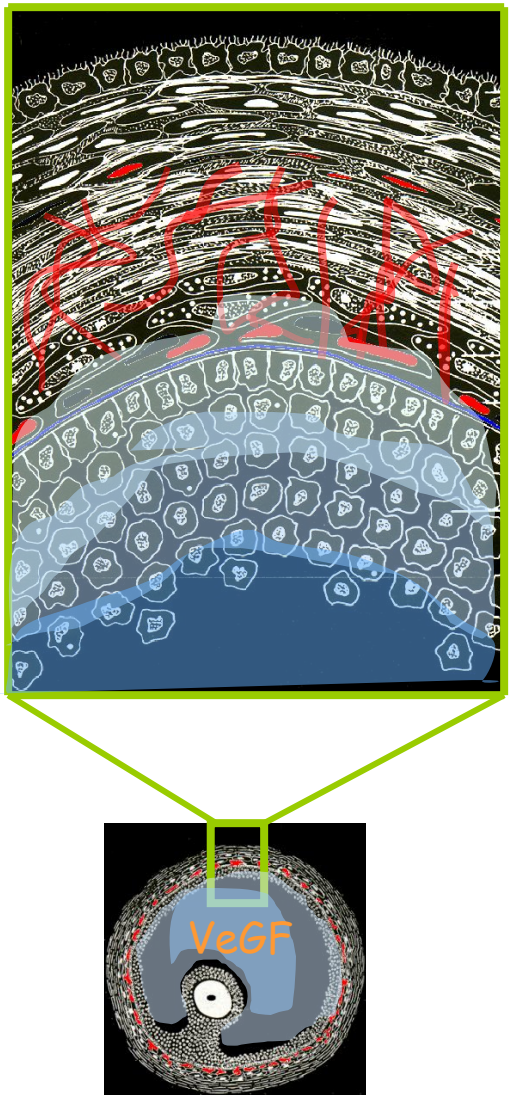
APOPTOSIS	NECROSIS
AFFECTS SCATTERED INDIVIDUAL CELLS	AFFECTS TRACTS OF CONTINGUOUS CELLS
CHROMATIN AND CYTOPLASMIC CONDENSATION CELL SHRINKAGE	CELL SWELLING AND RUPTURE OF PLASMA MEMBRANE
MAY REQUIRE mRNA AND PROTEIN SYNTHESIS	NOT DEPENDENT UPON NEW mRNA OR PROTEIN SYNTHESIS
NORMAL ATP LEVEL	DECREASED ATP LEVEL
NO INFLAMMATION	ELICITS INFLAMATORY RESPONSE
ENDONUCLEASE ACTIVATION AND DNA CLEAVAGE (ladder pattern)	ACTIVATION OF NONSPECIFIC Dnases (smearing)

DNA FRAGMENTATION (ladder pattern)

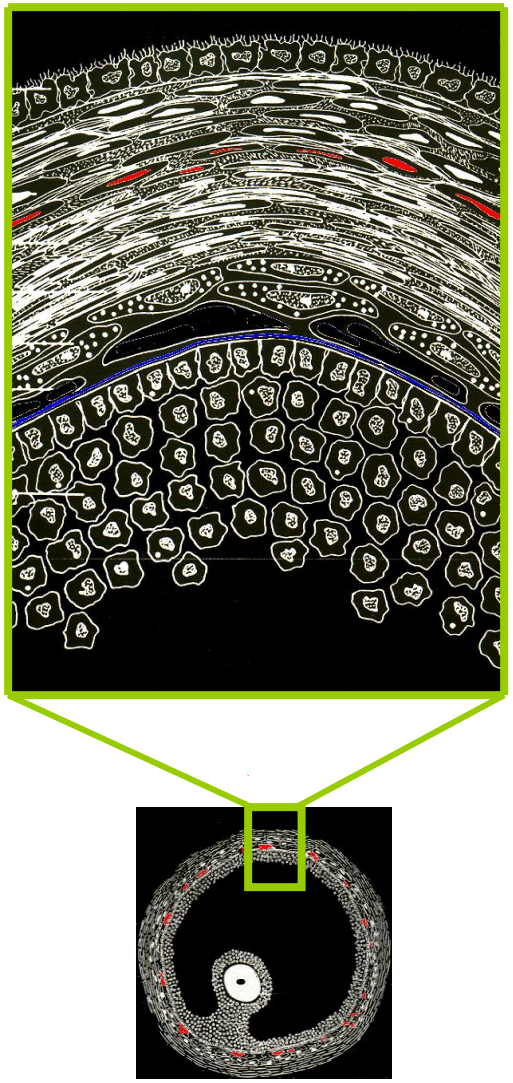
Fig. 1. Analysis of extracted DNA from granulosa and theca layers of 4–5 mm antral and atresic follicles by 2% agarose gel electrophoresis with ethidium bromide staining. Lane 1: control (λ Eco/Hind); lane 2: healthy antral granulosa; lane 3: atretic granulosa; lane 4: healthy antral theca; lane 5: atretic theca.



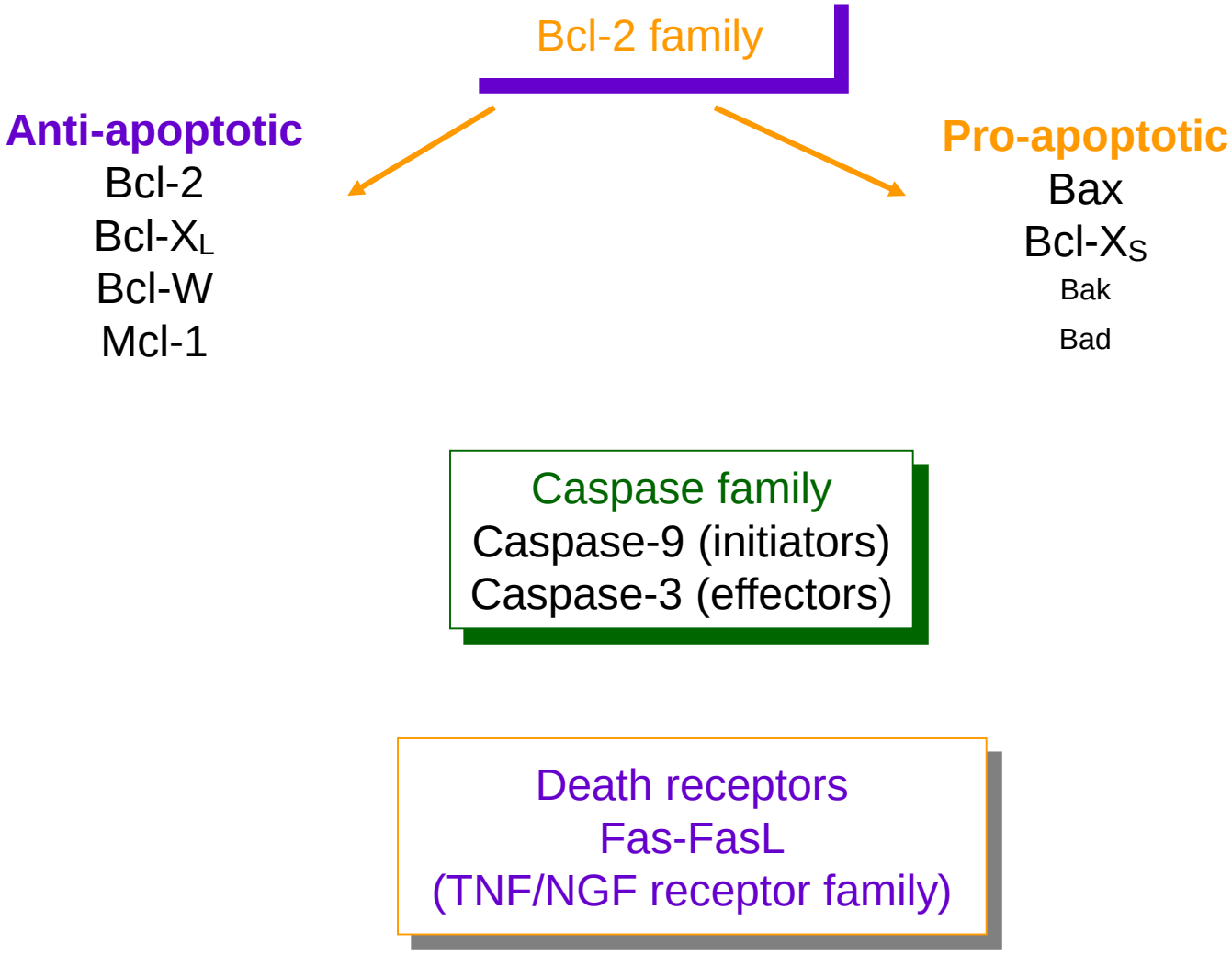
Antral Follicle



Atretic Follicle



APOPTOSIS IN FOLLICULAR GRANULOSA CELLS



Caspase3 - TUNEL