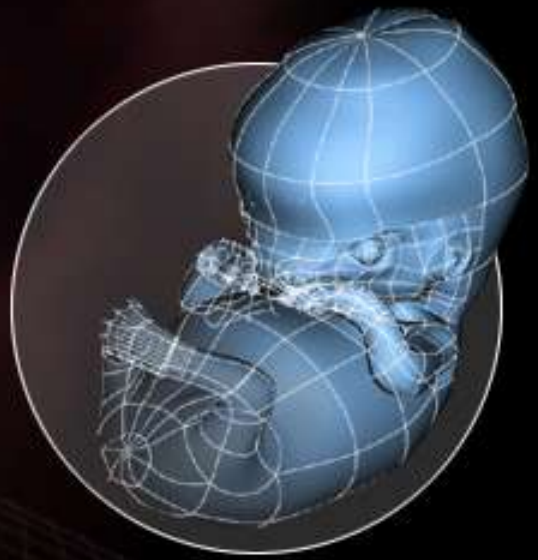
EMBRYOLOGY

OOGENESIS



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S.B.K.S.M.I. & R.C.

Competency

- AN 77.3- Oogenesis

Specific learning objective

- Describe Definition, site, time, and duration of oogenesis
- Explain Process of oogenesis
- Describe Ovulation
- Describe Test for ovulation

REPRODUCTIVE ORGANS/ GLANDS

Primary reproductive organ

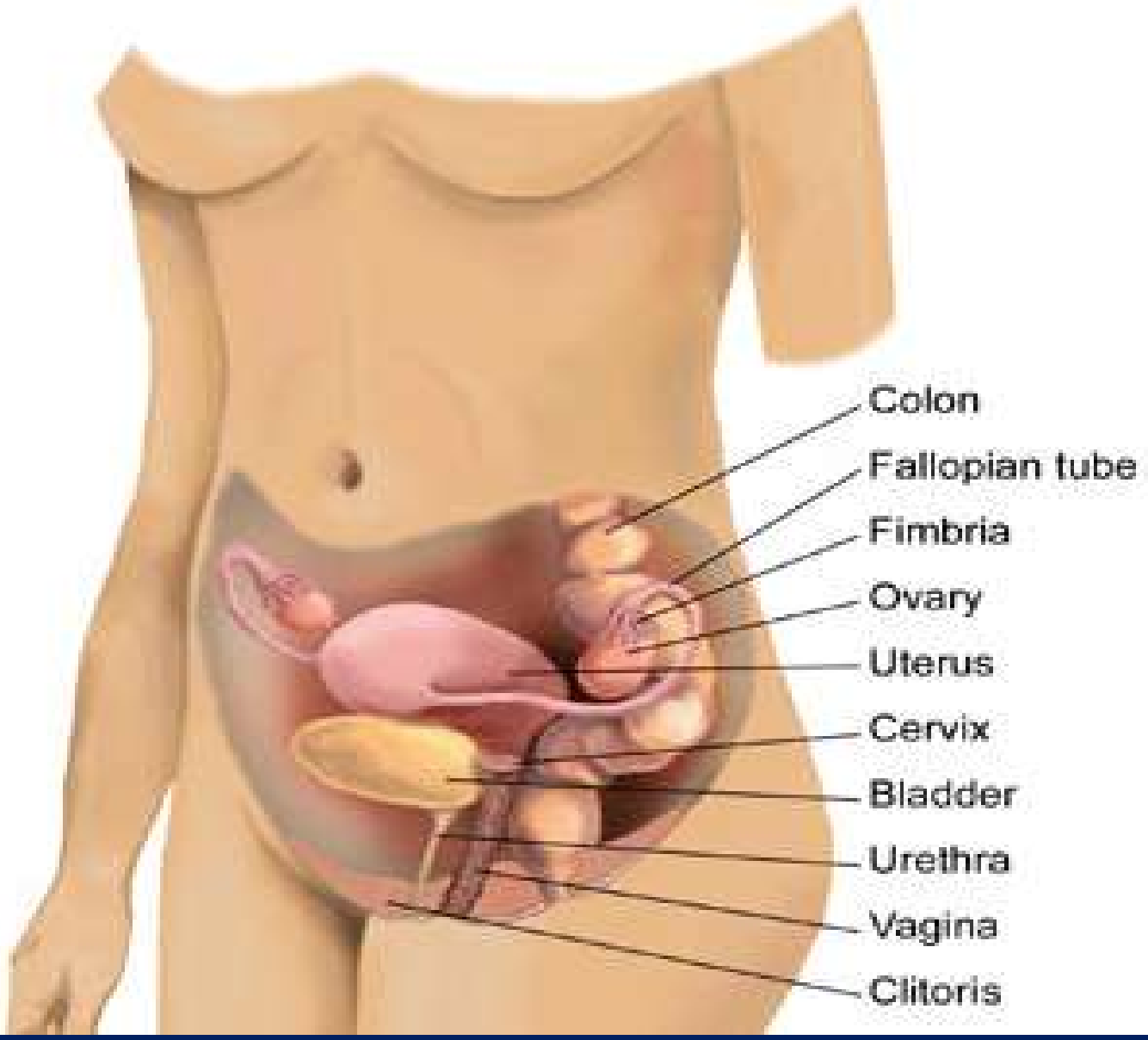
- **Ovary :**

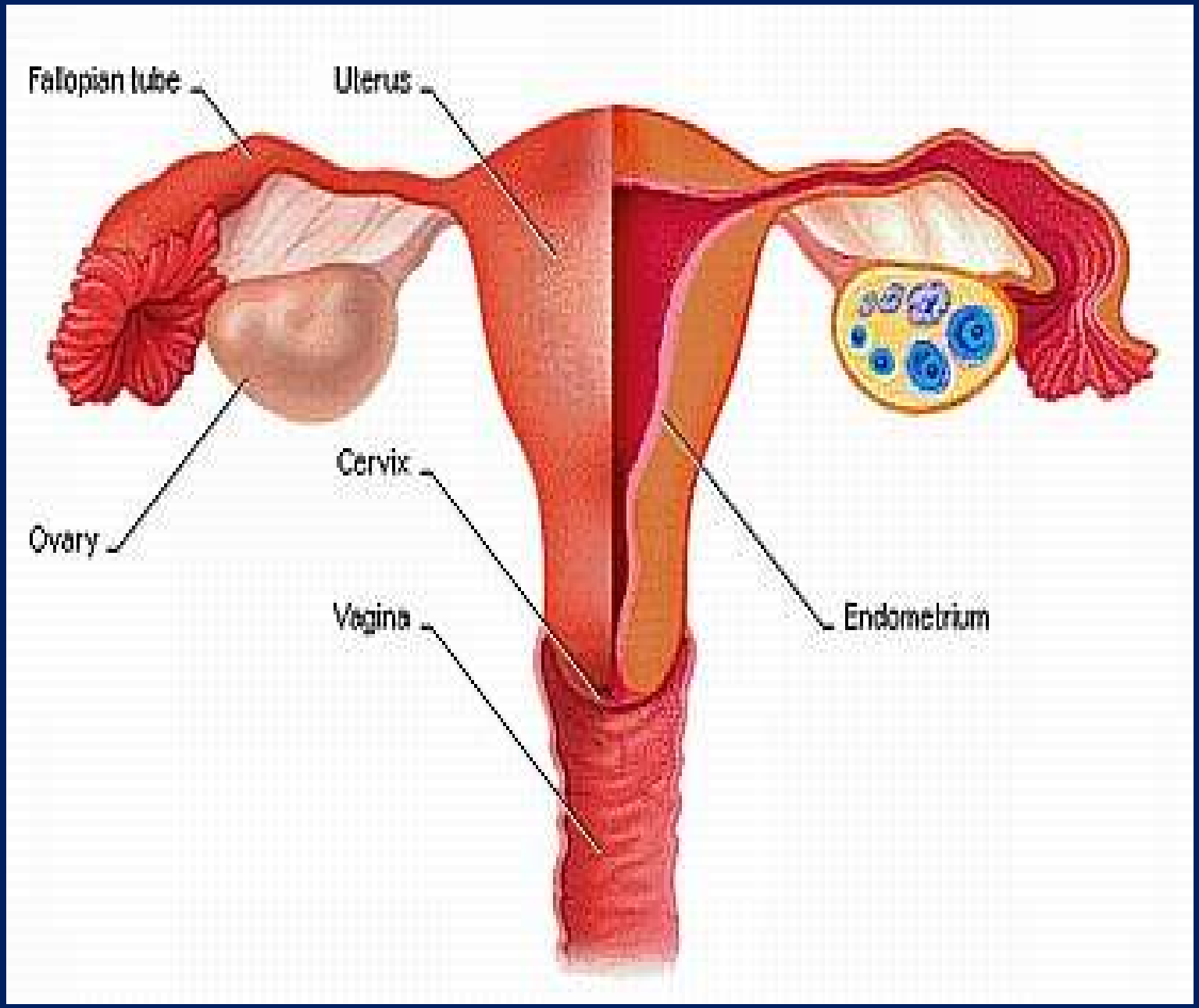
  Produces oocytes, estrogens and progesterone

Accessory reproductive organs/ glands –

- **Fallopian tubes: Transport of Gametes & Fertilization**
- **Uterus: Implatation & Growth of fetus**
- **Vagina : external genitalia**
- **Mammary glands: Feeding of newborn**

The Female Reproductive System




Fallopian tube
Uterus
Ovary
Cervix
Vagina
Endometrium

OOGENESIS

Defination:Sequence of events by which oogonia are transformed into mature oocytes.

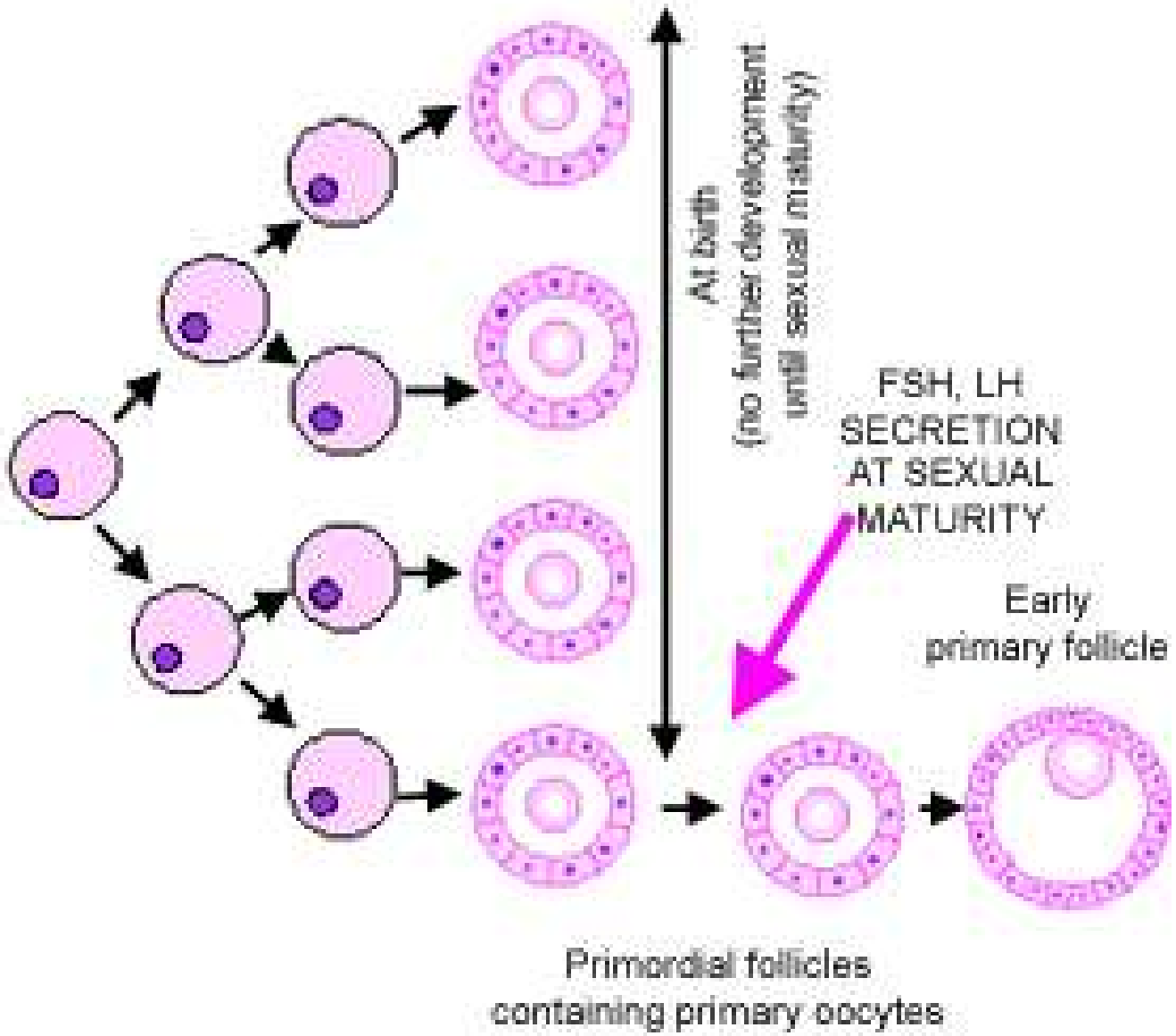
- **Begins before birth and is completed after puberty and continues till menopause.**

1)Prenatal maturation of oocytes.

2)Postnatal maturation of oocytes.

Prenatal Maturation of Oocyte

- Primordial germ cells differentiate into oogonia
- The oogonia undergo a number of mitotic divisions to form a cluster of cells (3rd month intra uterine life)
- Oogonia enlarged to from primary oocyte before birth
- Primary oocyte get surrounded by flattened cell– primordial follicle
- These primary oocyte enter meiosis I and arrest their cell division in prophase


At birth
(no further development until sexual maturity)
FSH, LH SECRETION AT SEXUAL MATURITY
Early primary follicle
Primordial follicles containing primary oocytes

Oogenesis

- **At the time of birth all primary oocytes have started prophase but stop at diplotene stage called resting stage.**

- **Total number of primary oocytes at birth are 600000—800000.**
- **At puberty only 400000 are present, rest degenerate.**

- **During reproductive phase approx. 500 will be ovulated**

- **Each month approx. 15 -20 primordial follicles begin to mature.**

Postnatal maturation of oocyte

- No primary oocytes form after birth in females
- Further maturation of primordial follicles begins during puberty
- A group of follicles begins to develop, one follicle ovulation will ovulate each month
- Primary oocyte completes first meiotic division just before ovulation,cytoplasm division unequal

Maturation of Primordial Follicle

- **There are three phases of maturation –**

  1) Primary follicle

  2) Secondary follicle

  3) Graffian follicle

Primary Follicle

- Primary oocyte is surrounded by flat follicular cells.
- These cells are separated from ovarian stroma by basement membrane
- Flat follicular cells become cuboidal and then stratified
- These stratified cells are called granulosa cells.
- The granulosa cells and oocyte secrete a glycoprotein which forms a layer called zona pellucida

Primary Follicle

- Zona pellucida is separated from oocyte by previtelline space.
- Granulosa cells and oocyte form microvilli which penetrate and interdigitate within the zona pellucida
- Thus a primary follicle is formed.
- Therefore a primary follicle has following structure inside out--

  a) Primary oocyte

  b) Previtelline space

  c) Zona Pellucida

  d) Granulosa cells.

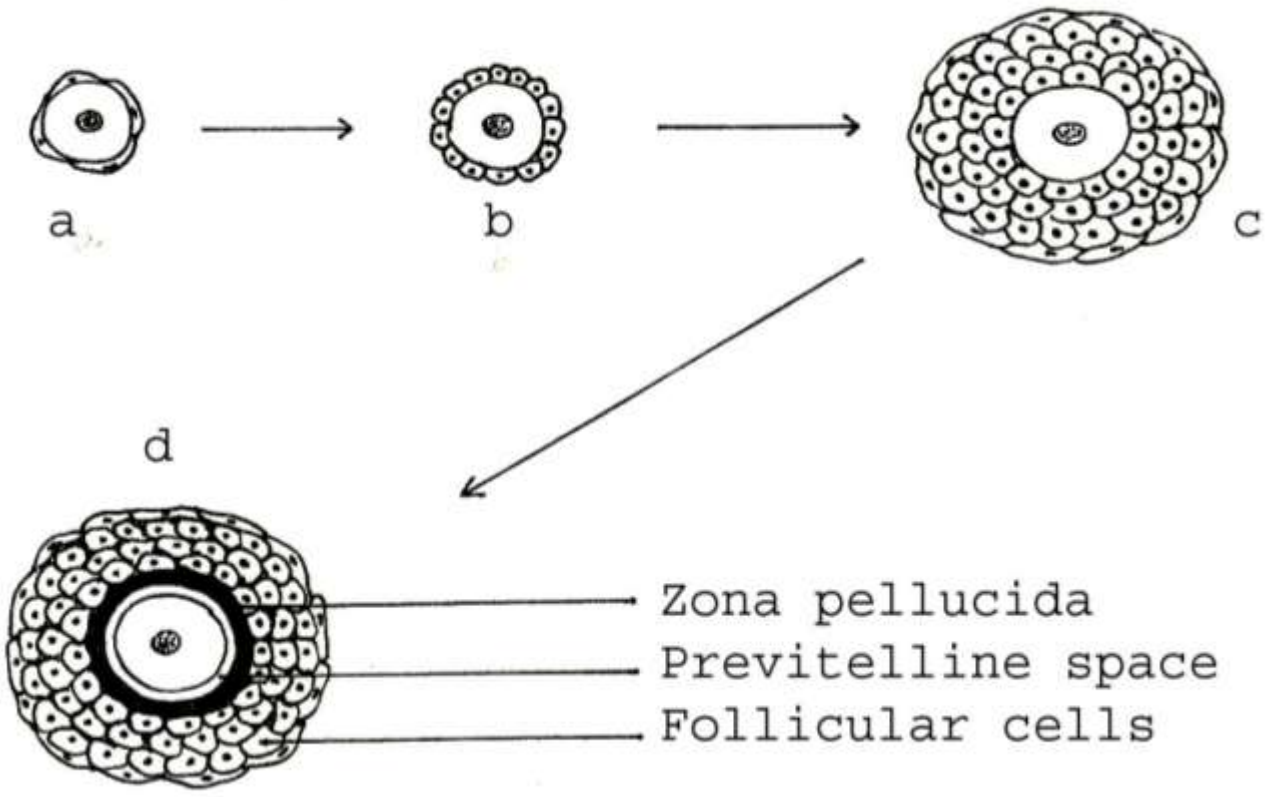
Primary Follicle

- **The ovarian stroma cells around primary follicle differentiate to form theca folliculi (box) which has two layers --**

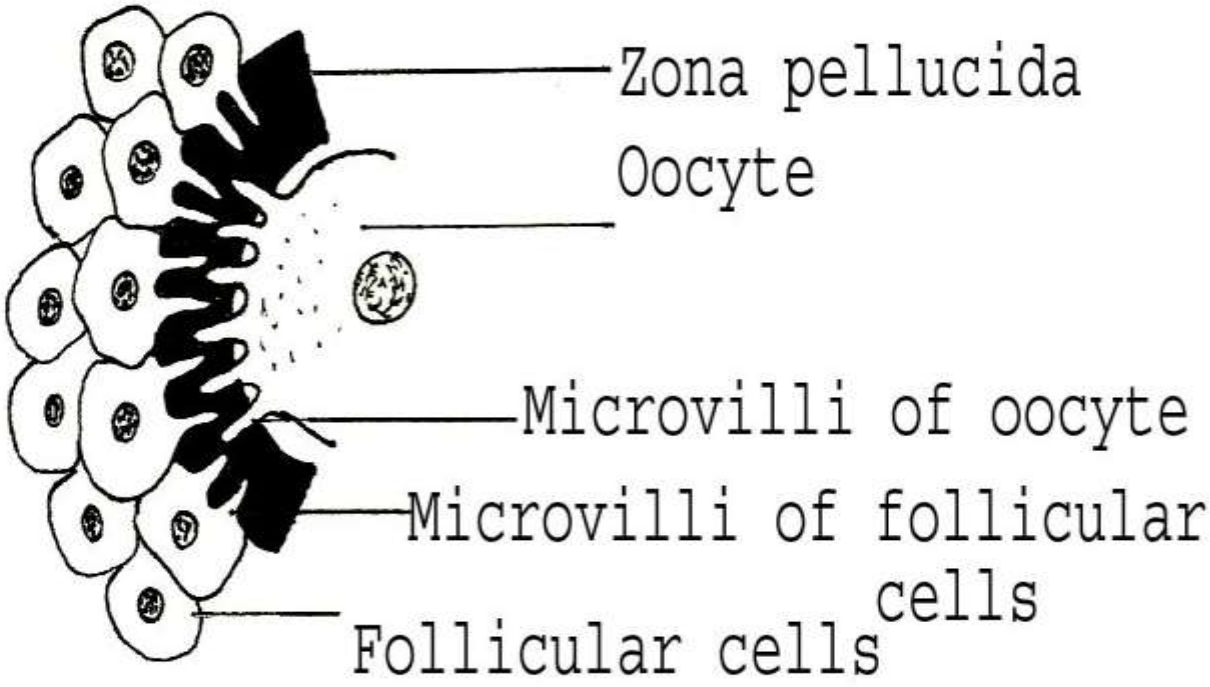
  a) Inner – Secretory called theca interna which is vascular and produces follicular fluid, estrogen and progesterone.

  b) Outer –Fibrous capsule called theca externa which merges with ovarian stroma

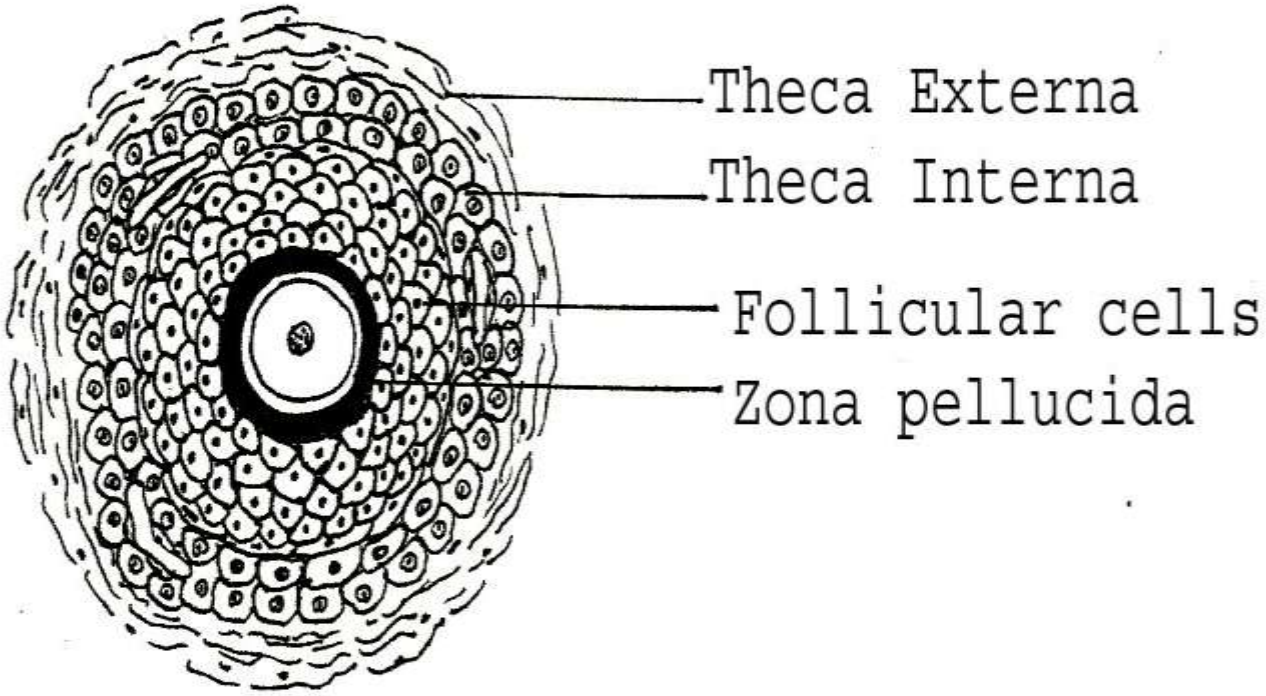
Primary Follicle



Primary Follicle

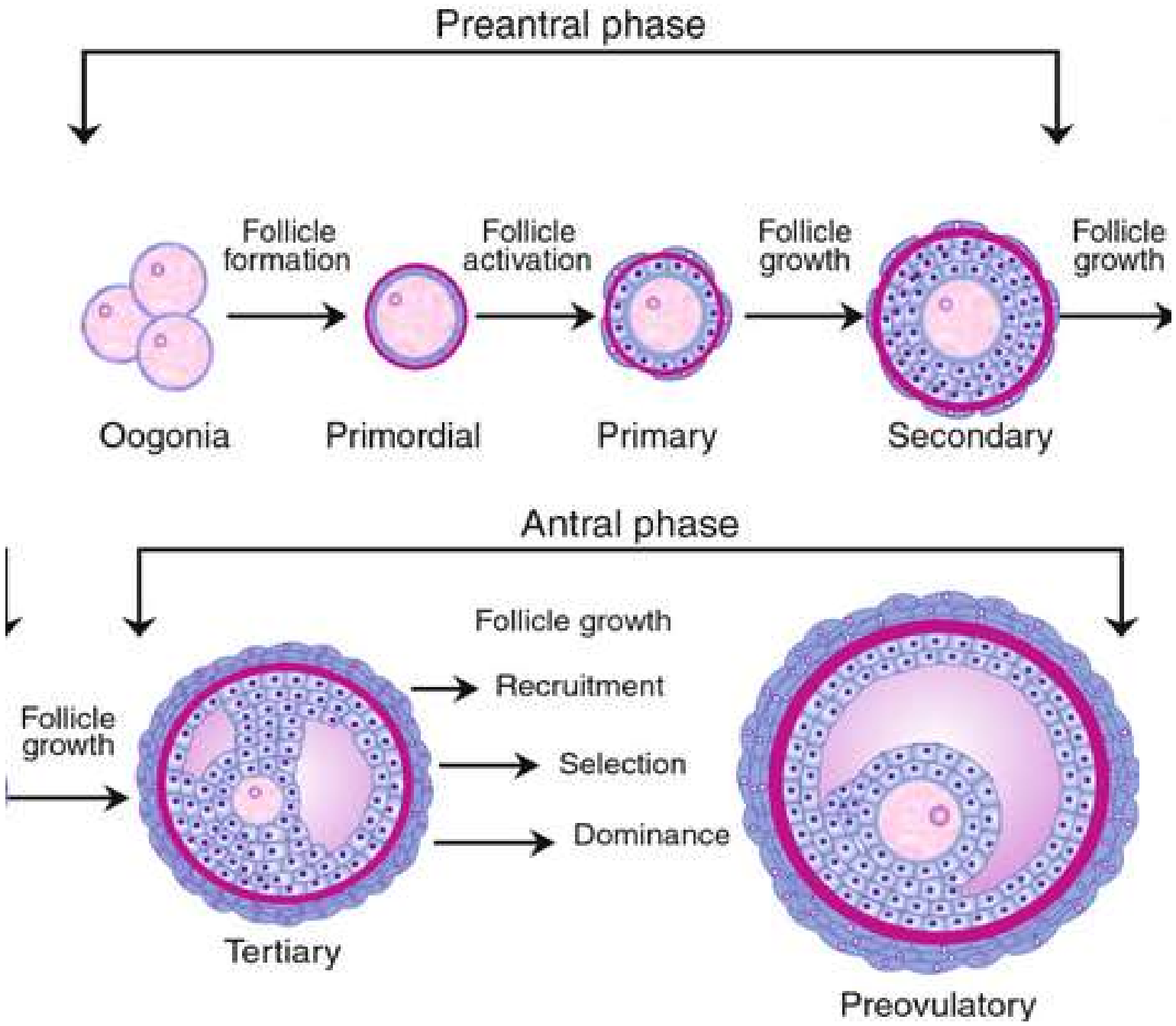


Development of Theca



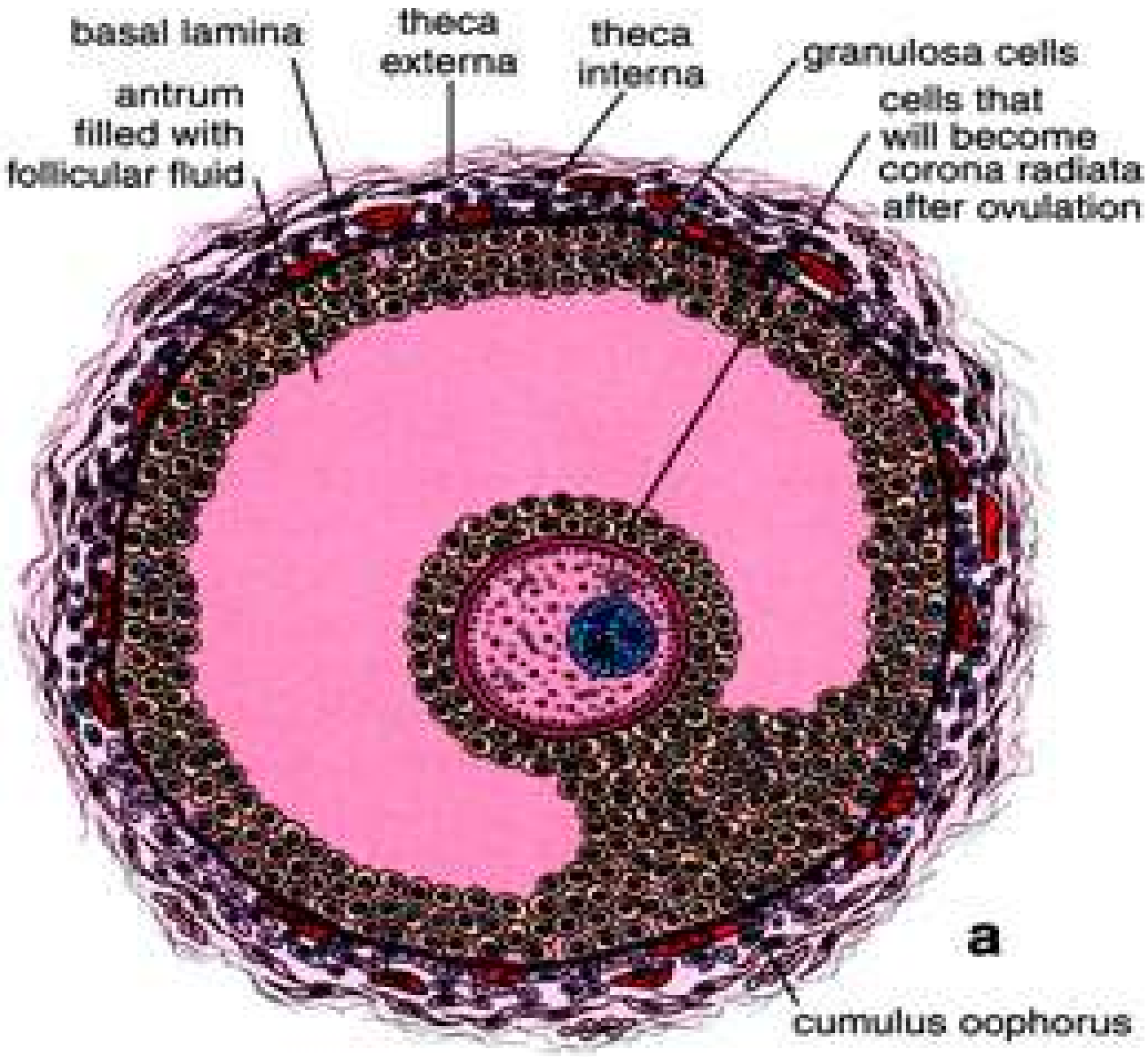
Secondary follicle

- Fluid filled spaces appear in granulosa cells (a)
- These spaces fuse to form follicular antrum containing follicular fluid. (b)
- As the follicular antrum enlarges, the primary oocyte is pushed to one side.
- The granulosa cells surround the oocyte and project into follicular antrum
- These granulosa cells form cumulus oophorus


Preantral phase
Follicle formation
Follicle activation
Follicle growth
Follicle growth
Oogonia
Primordial
Primary
Secondary
Antral phase
Follicle growth
Follicle growth
Recruitment
Selection
Dominance
Tertiary
Preovulatory

Graffian follicle

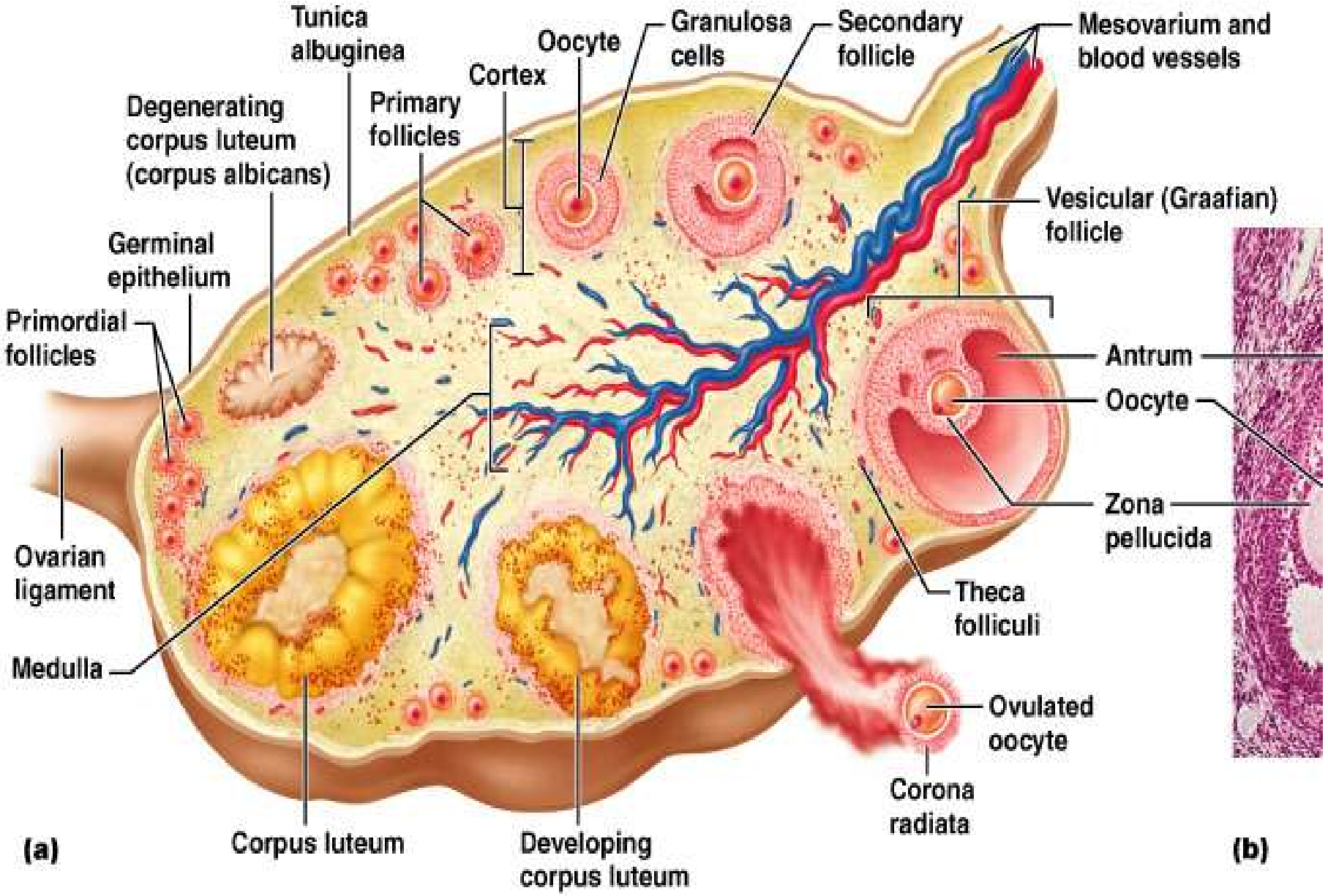
- **Under the effect of increased LH the mature secondary follicle undergoes Pre-ovulatory growth period.**
- **Meiosis I is completed, one daughter cell is big (1n) and is called secondary oocyte.**
- **The other daughter cell is shed in previtelline space as first Polar body**
- **The secondary oocyte then enters meiosis II but before ovulation is arrested (metaphase II).**
- **It is completed only if fertilization occurs.**
- **With each ovarian cycle only one Graffian follicle reaches full maturity, rest degenerate.**



MATURE GRAAFIAN FOLLICLE

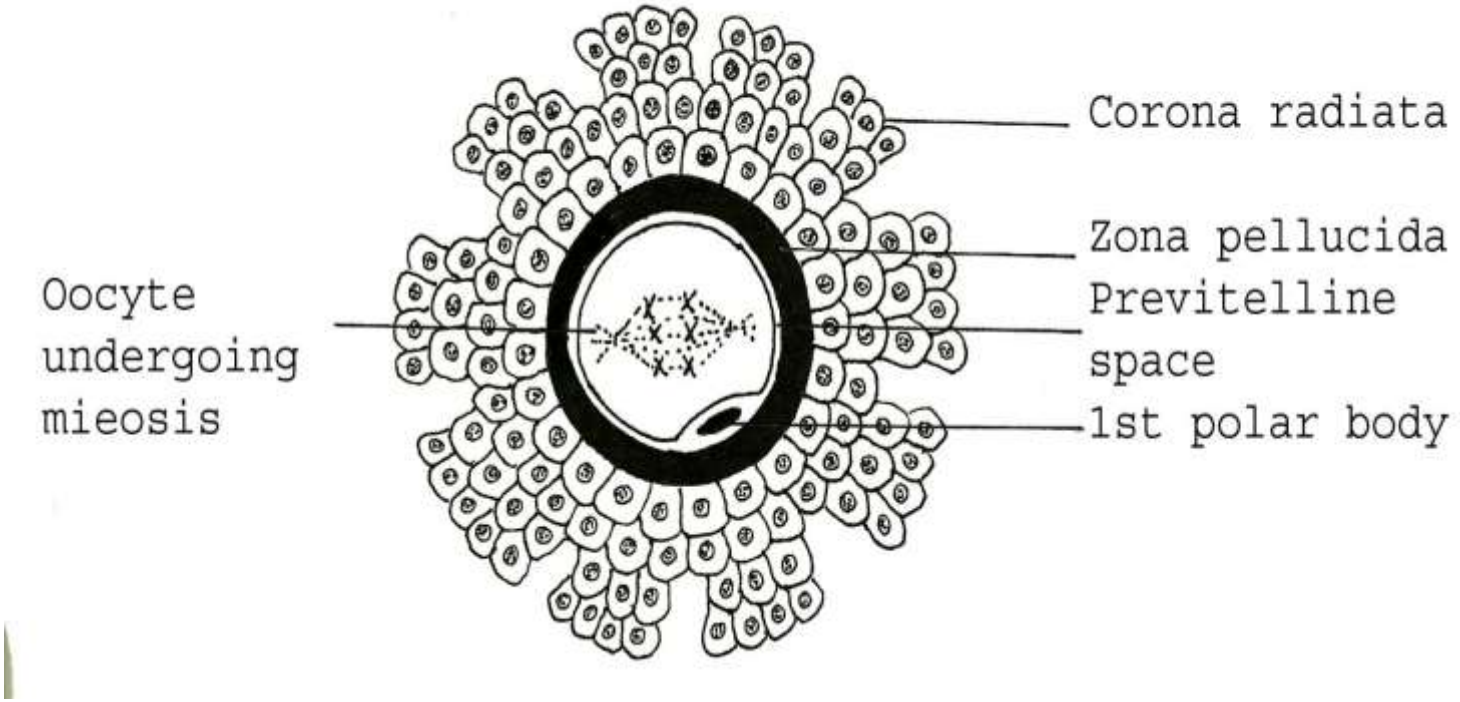
OVULATION

- Sudden increase in growth of Graffian follicle
- Results in swelling and stigma on the surface of ovary
- Smooth muscle in theca externa contract which increases intra follicular pressure
- This causes the separation of secondary oocyte along with cumulus oophorus and floats in follicular fluid
- Enzymatic digestion of follicular wall causes stigma to rupture



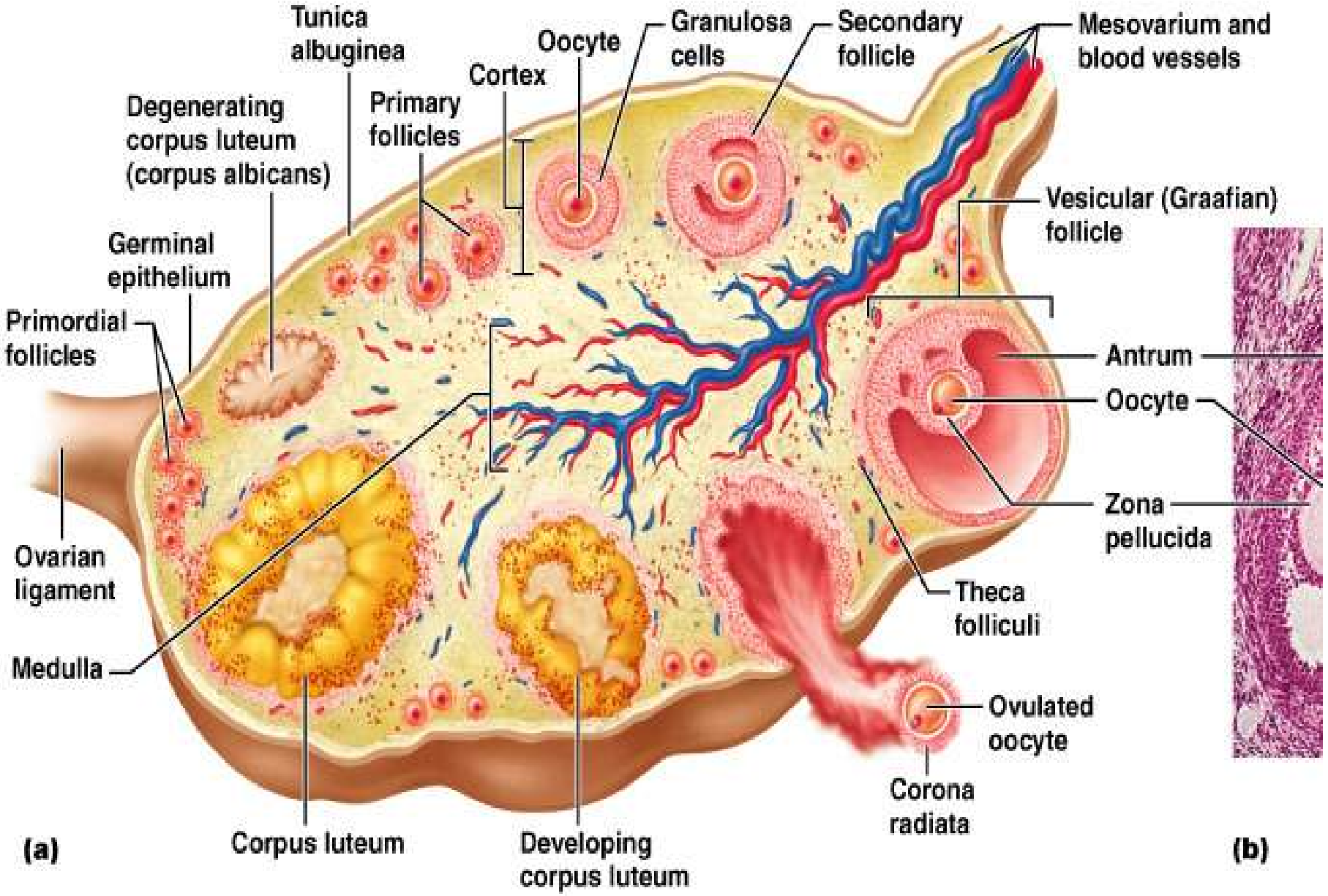
- Thus the secondary oocyte surrounded by cumulus cells is expelled out with follicular fluid
- After ovulation the follicular (cumulus) cells get radially arranged and are called corona radiata

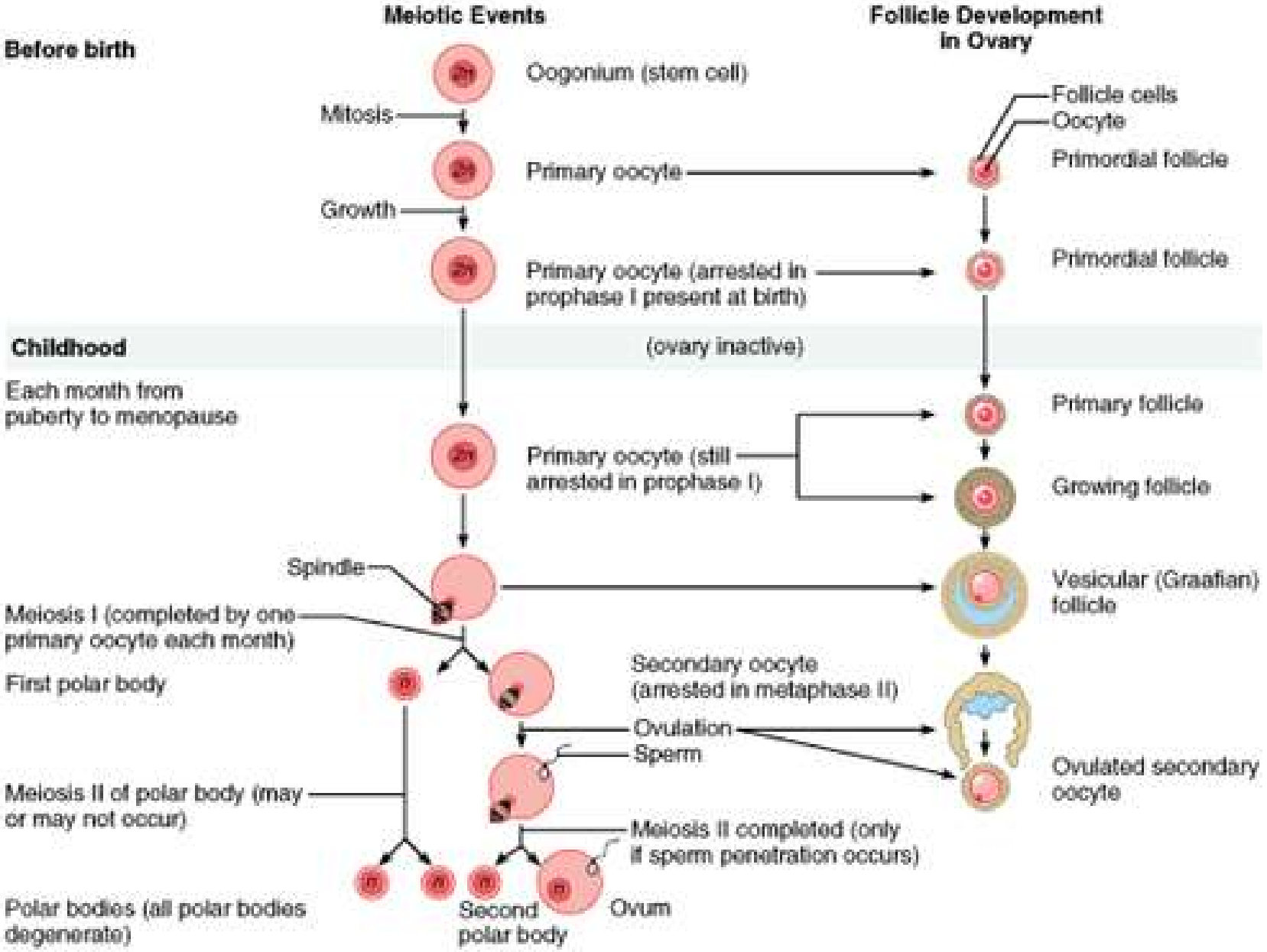
OOCYTE WITH CORONA RADIATA

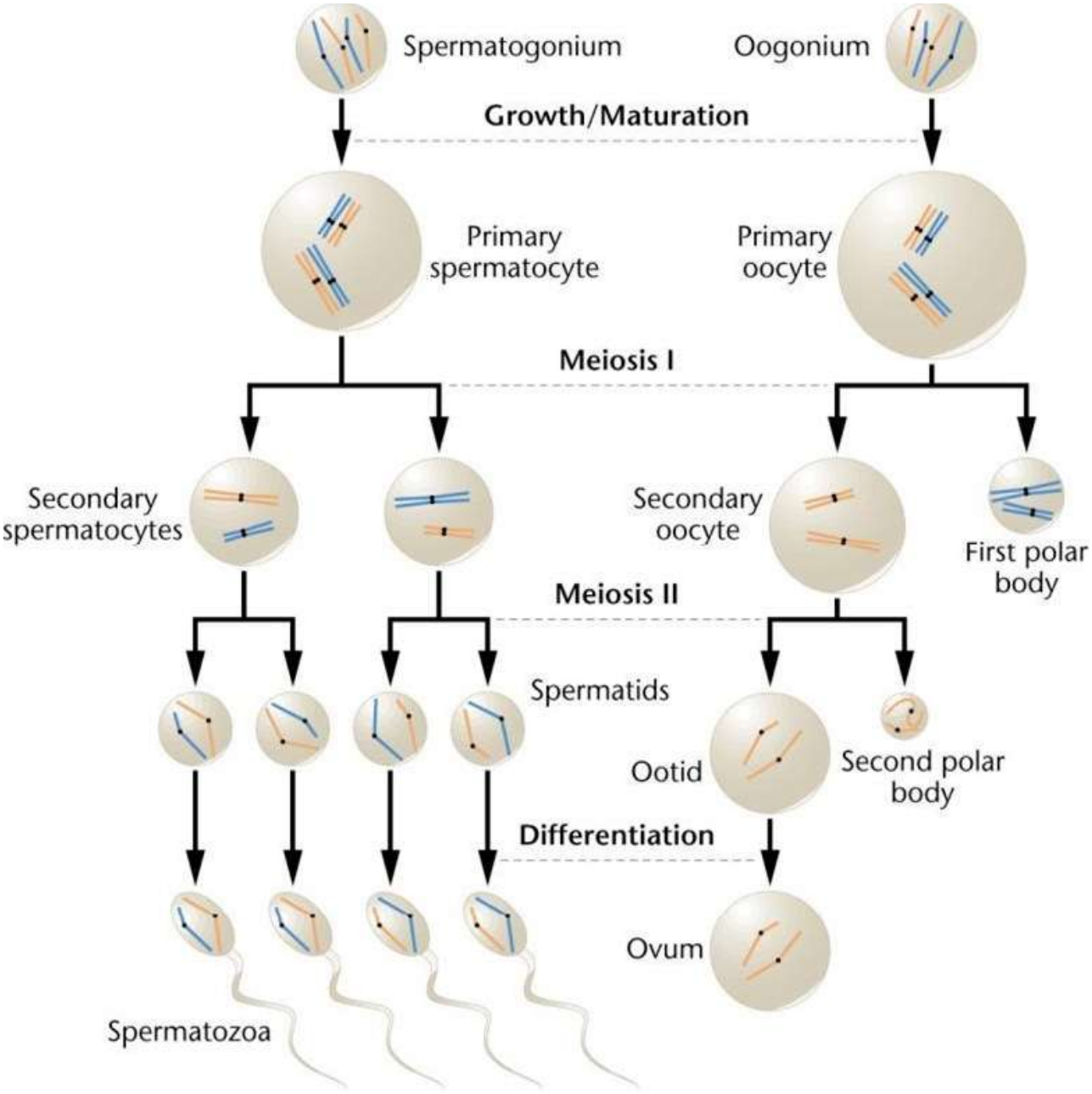


Atretic follicle

- Several ovarian follicles start maturing during each ovarian cycle, but only one attains full maturity and undergoes ovulation.
- The other follicles degenerate and form atretic follicles




Meiotic Events
Follicle Development in Ovary
Before birth
Oogonium (stem cell)
Mitosis
Follicle cells
Oocyte
Primordial follicle
Primary oocyte
Growth
Primordial follicle
Primary oocyte (arrested in prophase I present at birth)
Childhood
(ovary inactive)
Each month from puberty to menopause
Primary follicle
Primary oocyte (still arrested in prophase I)
Growing follicle
Spindle
Vesicular (Graafian) follicle
Meiosis I (completed by one primary oocyte each month)
First polar body
Secondary oocyte (arrested in metaphase II)
Ovulation
Sperm
Ovulated secondary oocyte
Meiosis II of polar body (may or may not occur)
Meiosis II completed (only if sperm penetration occurs)
Polar bodies (all polar bodies degenerate)
Second polar body
Ovum


Spermatogonium
Oogonium
Growth/Maturation
Primary spermatocyte
Primary oocyte
Meiosis I
Secondary spermatocytes
Secondary oocyte
First polar body
Meiosis II
Spermatids
Ootid
Second polar body
Differentiation
Ovum
Spermatozoa

	Spermatogenesis	Oogenesis
Process		
Location	Occurs *entirely* in testes	Occurs *mostly* in ovaries
Meiotic divisions	Equal division of cells	Unequal division of cytoplasm
Germ line epithelium	Is involved in gamete production	Is not involved in gamete production
Gametes		
Number produced	Four	One (plus 2 – 3 polar bodies)
Size of gametes	Sperm smaller than spermatocytes	Ova larger than oocytes
Timing		
Duration	Uninterrupted process	In arrested stages
Onset	Begins at puberty	Begins in foetus (pre-natal)
Release	Continuous	Monthly from puberty (menstrual cycle)
End	Lifelong (but reduces with age)	Terminates with menopause

MCQ

Q. 1 Follicular cells are derived from

a) **Surface epithelium of ovary**
b) **Fibroblast**
c) **By division of oocyte**
d) **From capillaries**

MCQ

Q. 2 Zona pellucida is produced by

a) Oocyte
b) Follicular cells
c) Oocyte and Follicular cells
d) None of the above

MCQ

Q. 3 First polar body lies in

a) **Oocyte**
b) **Previtelline space**
c) **Zona pellucida**
d) **Follicular cells**

MCQ

Q. 4 The ovum released during ovulation is

a) **Primary Oocyte arrested in meiosis**
b) **Secondary oocyte arrested in meiosis**
c) **Primary oocyte which has complete first meiotic division**
d) **secondary oocyte which has complete second meiotic division**

MCQ

Q. 5 False about oogenesis is

a) **First polar body receives little cytoplasm**
b) **Secondary oocyte will complete second meiotic division only if ovum is fertilized**
c) **Oogeneisi begins at puberty**
d) **No oogenesis after menopause**

Corpus Luteum

- After ovulation the wall of the follicle collapses and gets thrown into folds.
- The follicular cells enlarge and become polyhedral in shape. The cytoplasm is filled with yellow pigment and are now called lutein cells.
- The corpus luteum ***secretes progesterone***

Corpus luteum of Menstruation

- The fate of the corpus luteum depends on whether the ovum is fertilized or not.
- The corpus luteum persists for 12-14 days if there is no fertilization and secretes progesterone. (the corpus luteum of menstruation)
- It then degenerates and becomes a mass of fibrous tissue called the ***corpus albicans***.

Corpus luteum of preganancy

- It the ovum is fertilized and pregnancy occurs then for four months it is called the corpus luteum of pregnancy.
- The progesterone secreted is ***essential to maintain the pregnancy*** during the first few months till the placenta takes over the function of secretion of progesterone.
- After that it degenerates to form corpus albicans.

Symptoms of ovulation –

1) Mittelschmerz – Sudden constant pain in inferolateral part of abdomen caused by slight bleeding in the peritoneal cavity during ovulation.

2) Basal body temperature slightly falls followed by sustained rise after ovulation.

Comparison of Gametes

Secondary Oocyte	Spermatozoa
• Large in size	• Small in size
• Immotile	• Highly motile
• Large amount of cytoplasm	• Very little cytoplasm
• Contains yolk granules	• No yolk granules
• Regular shape of cell with cell organelles	• Has a specific shape having head and tail with limited organelles
• Sex chromosomes only of one kind	• Sex chromosomes of two kinds
• 22 X	• 22X/22Y

FEMALE REPRODUCTIVE CYCLE

- Commencing at puberty & continuing throughout the reproductive years , monthly reproductive cycles
- These monthly cycles prepare the reproductive system for pregnancy.
- Consists of 1)Ovarian cycle

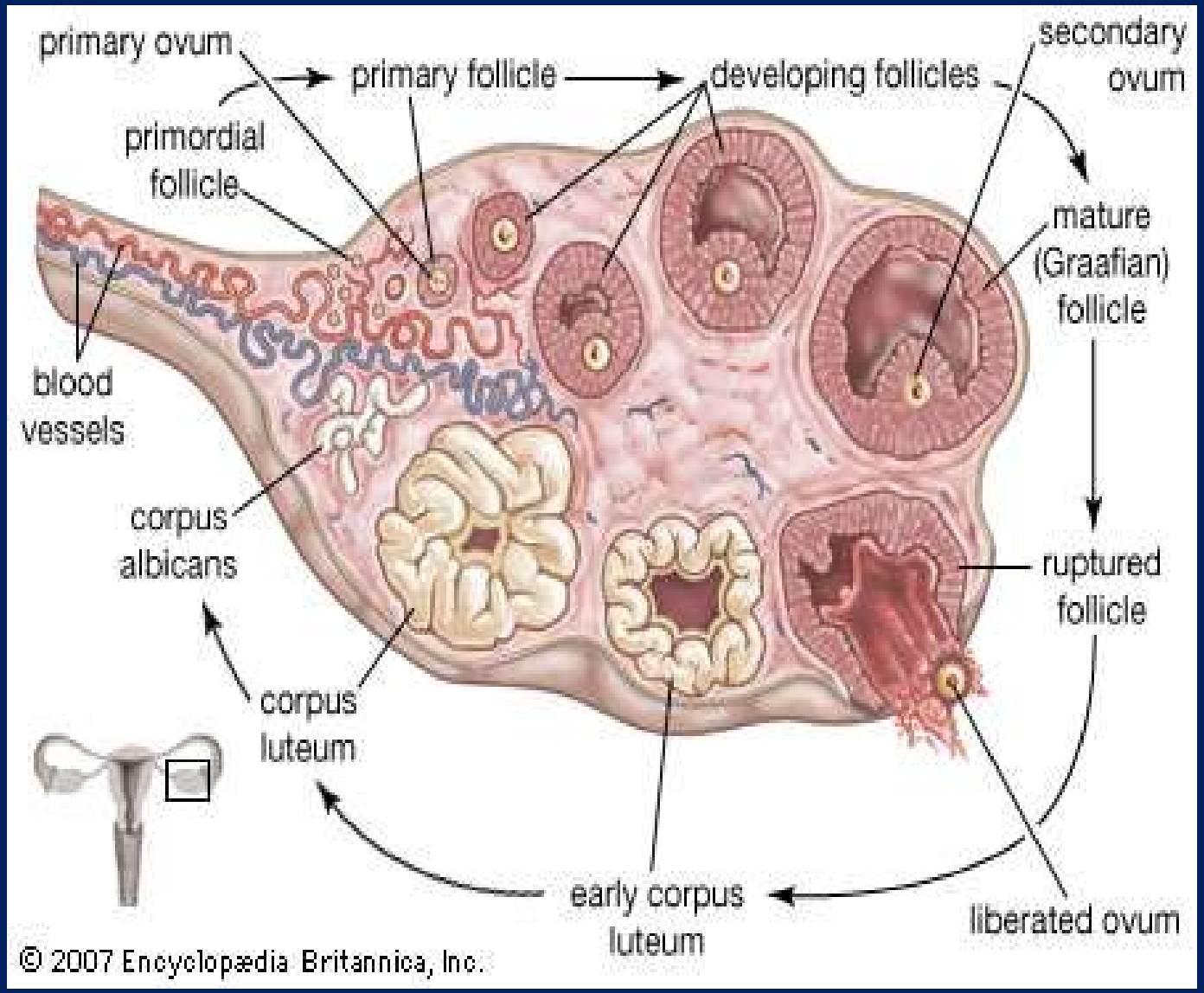
  2)Endometrial (menstrual) cycle

Ovarian Cycle

- Each cycle-FSH, LH
- Follicular development
- One will mature and ruptures through the surface of the ovary (Ovulation)
- Copus luteum

Follicular Development

- Growth and differentiation of primary oocyte
- Proliferation of follicular cells
- Formation of zona pellucida
- Development of the theca folliculi


primary ovum
primary follicle
developing follicles
secondary ovum
primordial follicle
mature (Graafian) follicle
blood vessels
corpus albicans
ruptured follicle
corpus luteum
early corpus luteum
liberated ovum
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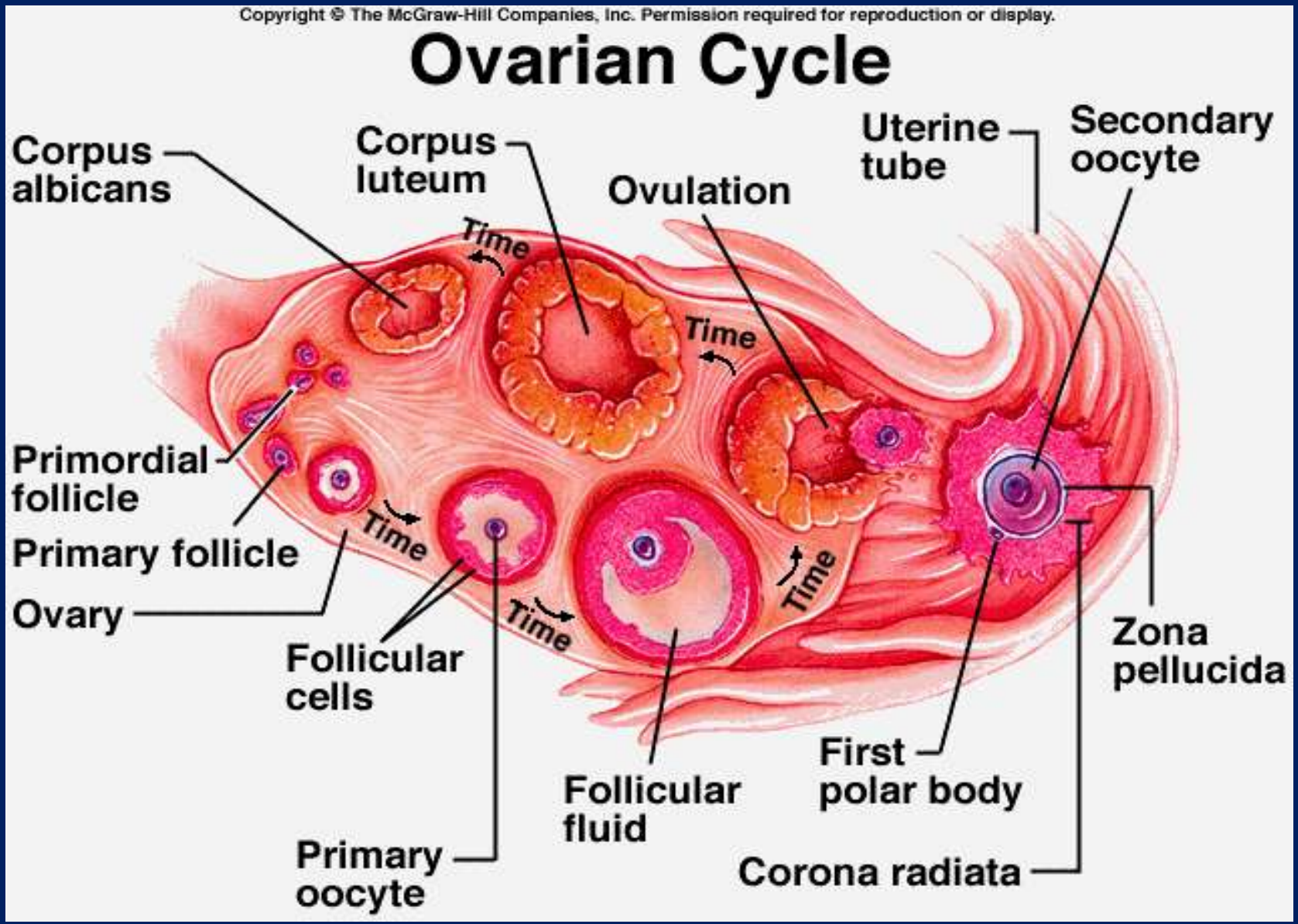
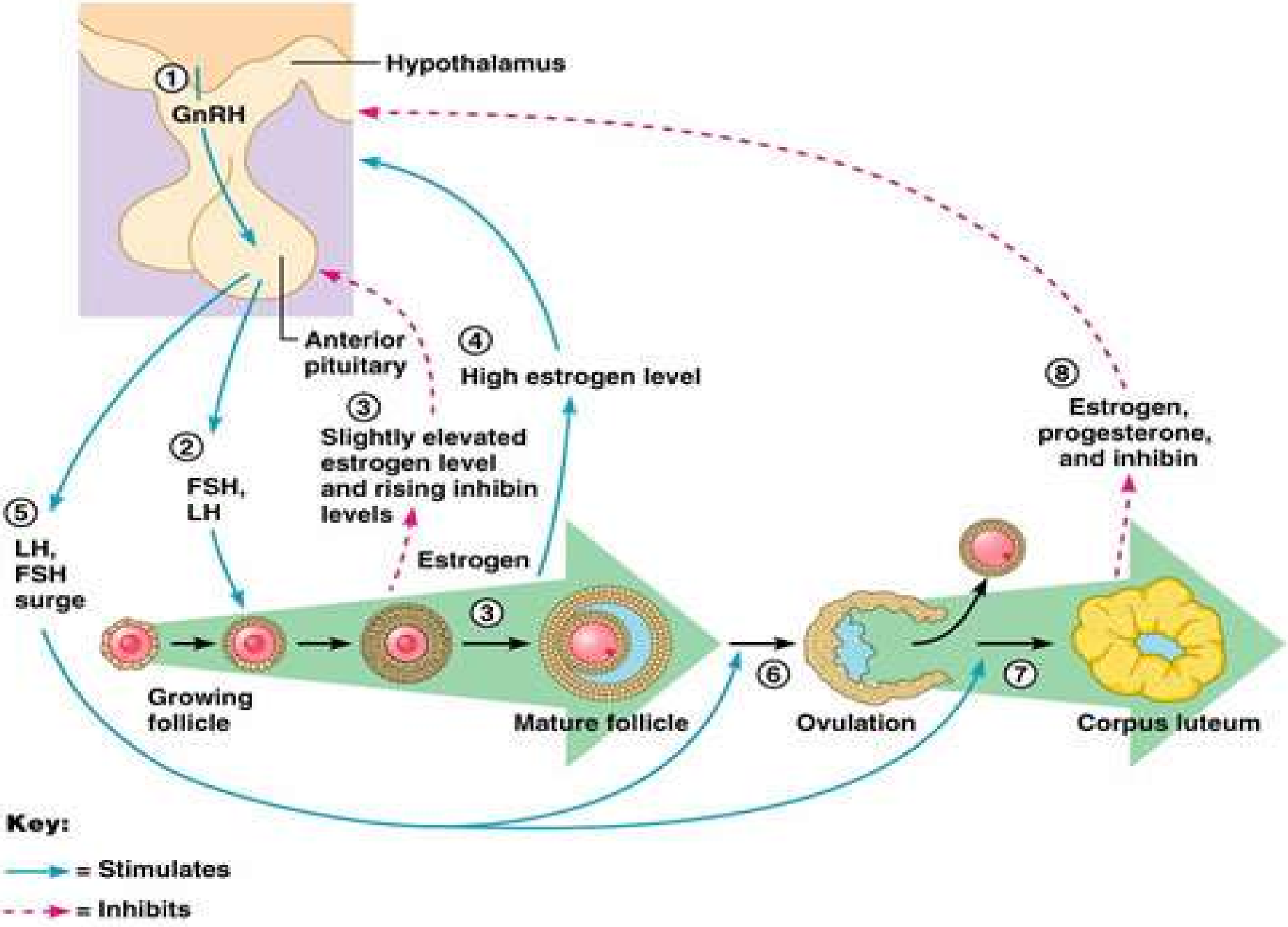
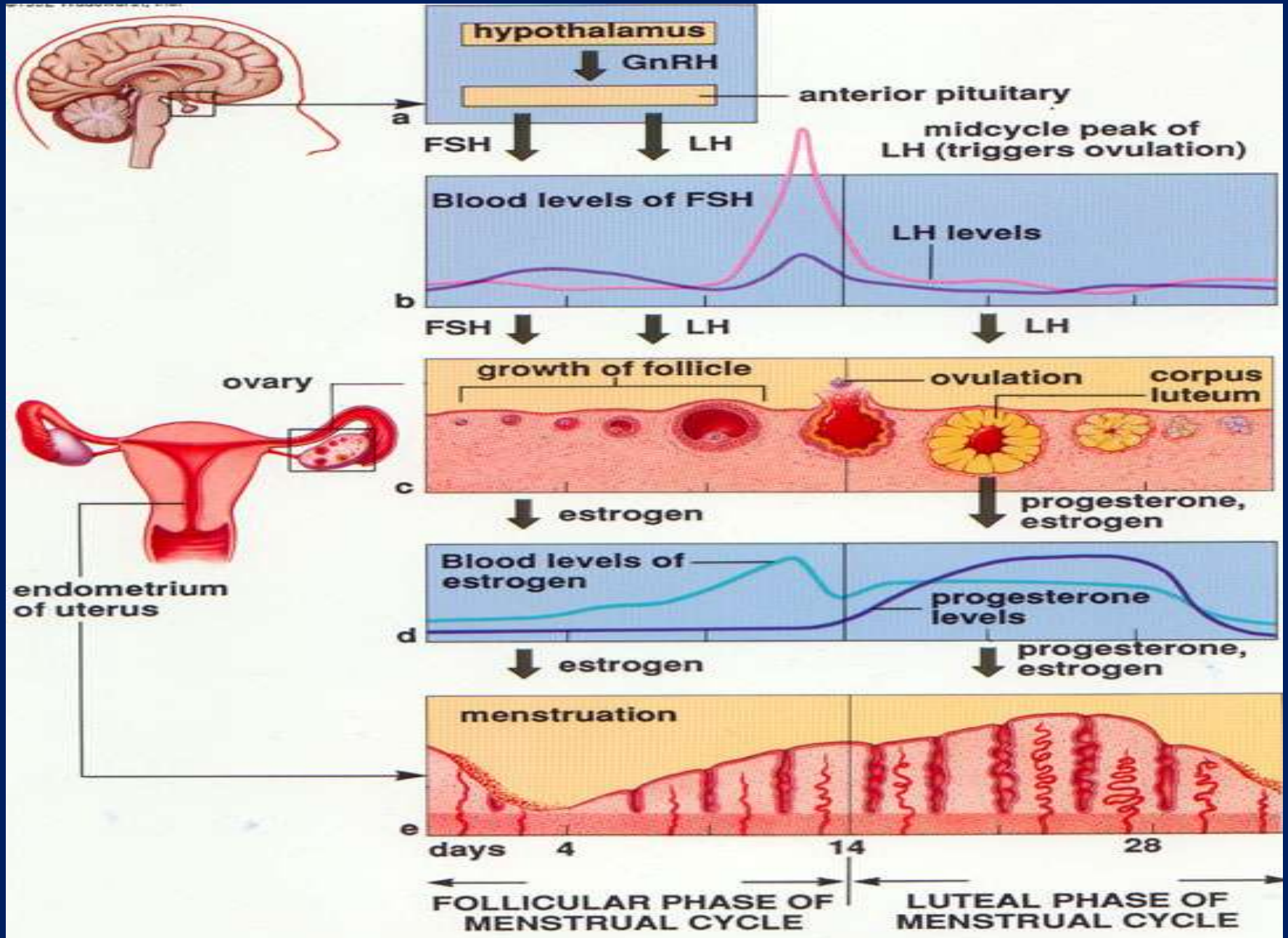
Ovarian Cycle







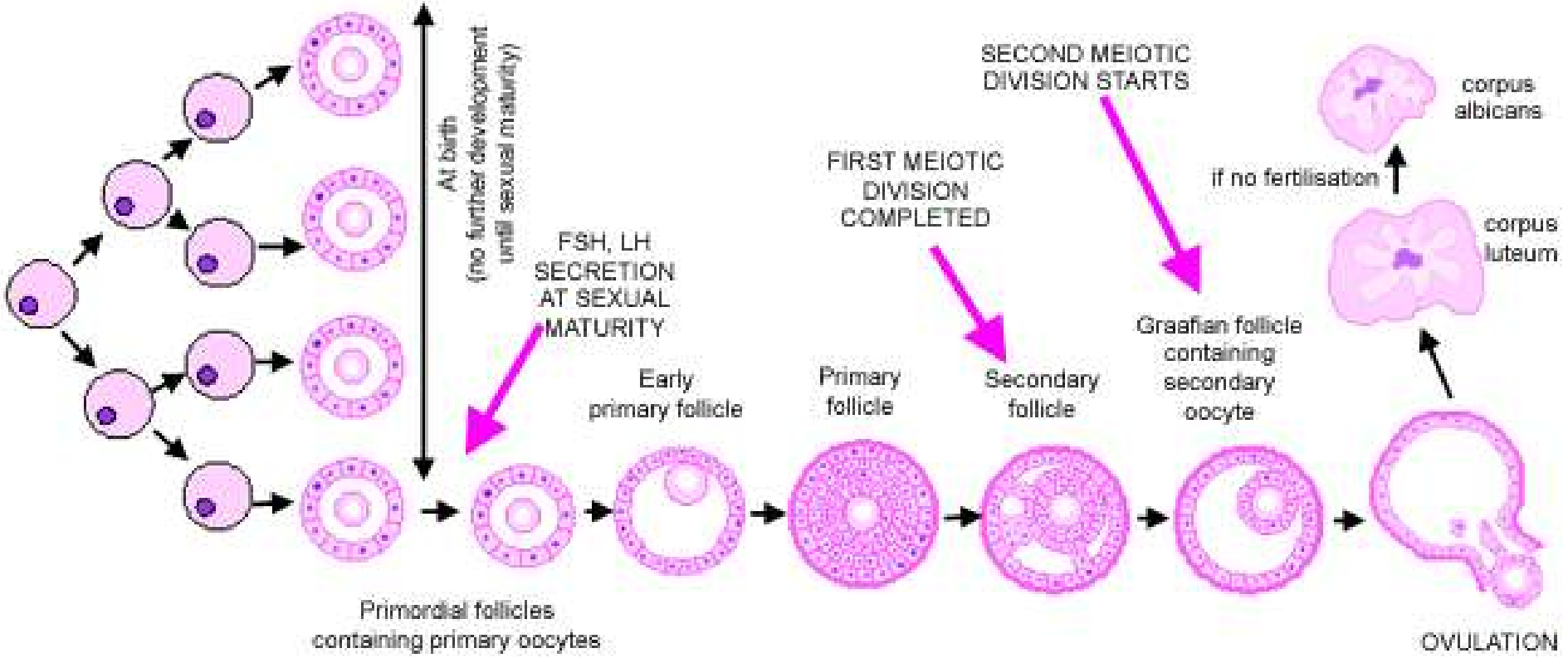
Changing hormone levels during the menstrual cycle.

The Menstrual Cycle

ANSWERS

- 1. a
- 2. c
- 3. d
- 4. b
- 5. d

Title	Author/ Journal	Material	Result	Summary
The bottleneck: mitochondrial imperatives in oogenesis and ovarian follicular fate	Robert P.S Jansen, Kylie de Boer Molecular and Cellular Endocrinology Volume 145, Issues 1–2, 25 October 1998, Pages 81–88	We review here in detail the passage of mitochondria through the female germ cell line.	maintaining the integrity of mitochondrial inheritance is such a strong evolutionary imperative that we should expect at least some features of ovarian follicular formation, function and loss to be primarily adapted to this specific purpose.	that to prevent accumulation of mild mitochondrial genomes in the population there is a need for physiological female sterility prior to total depletion of ovarian oocytes, a phenomenon for which there is empirical evidence and which we term the oöpause


At birth
(no further development until sexual maturity)
FSH, LH SECRETION AT SEXUAL MATURITY
Early primary follicle
Primary follicle
FIRST MEIOTIC DIVISION COMPLETED
Secondary follicle
SECOND MEIOTIC DIVISION STARTS
Graafian follicle containing secondary oocyte
OVULATION
if no fertilisation
corpus albicans
corpus luteum
Primordial follicles containing primary oocytes

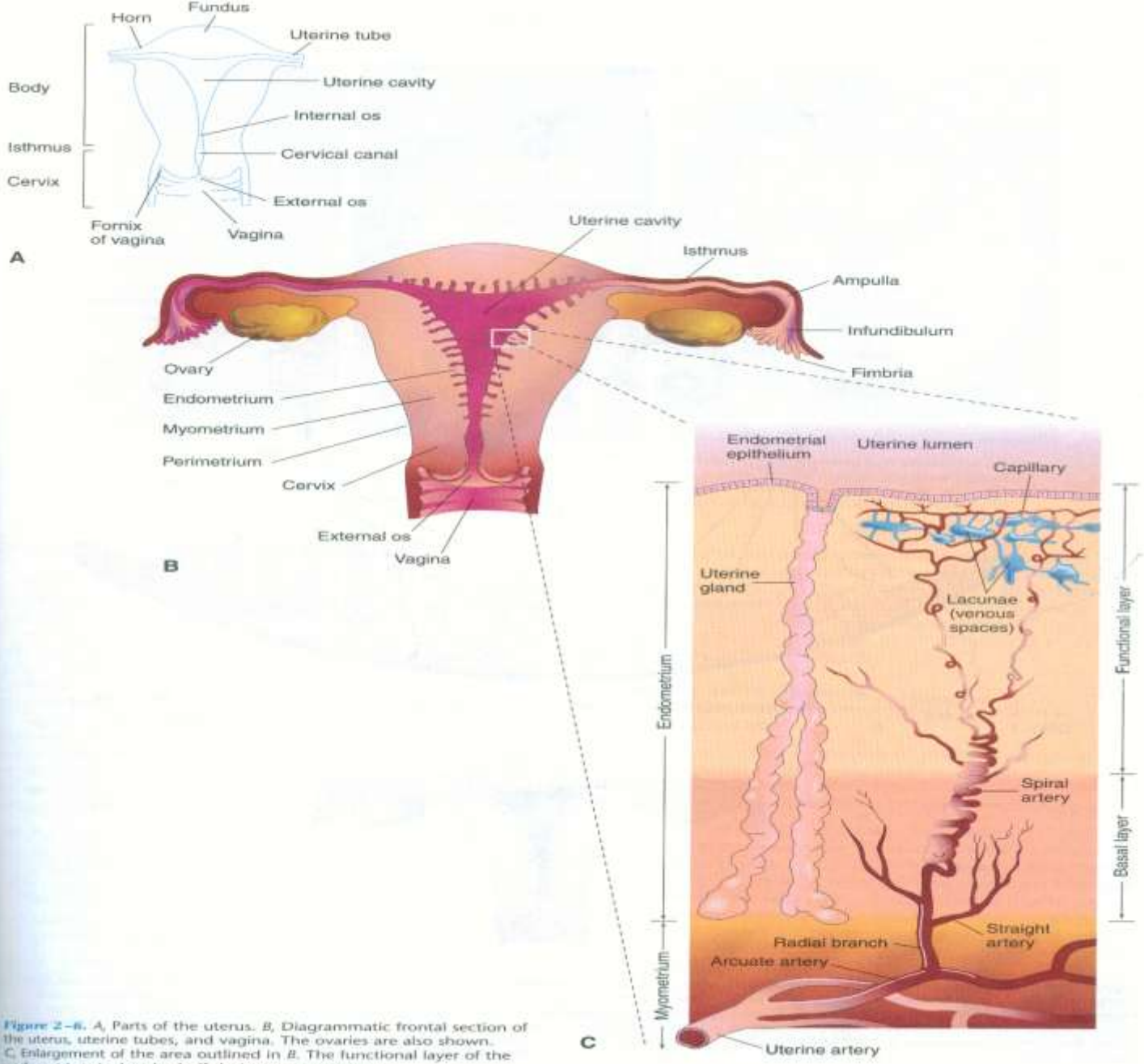
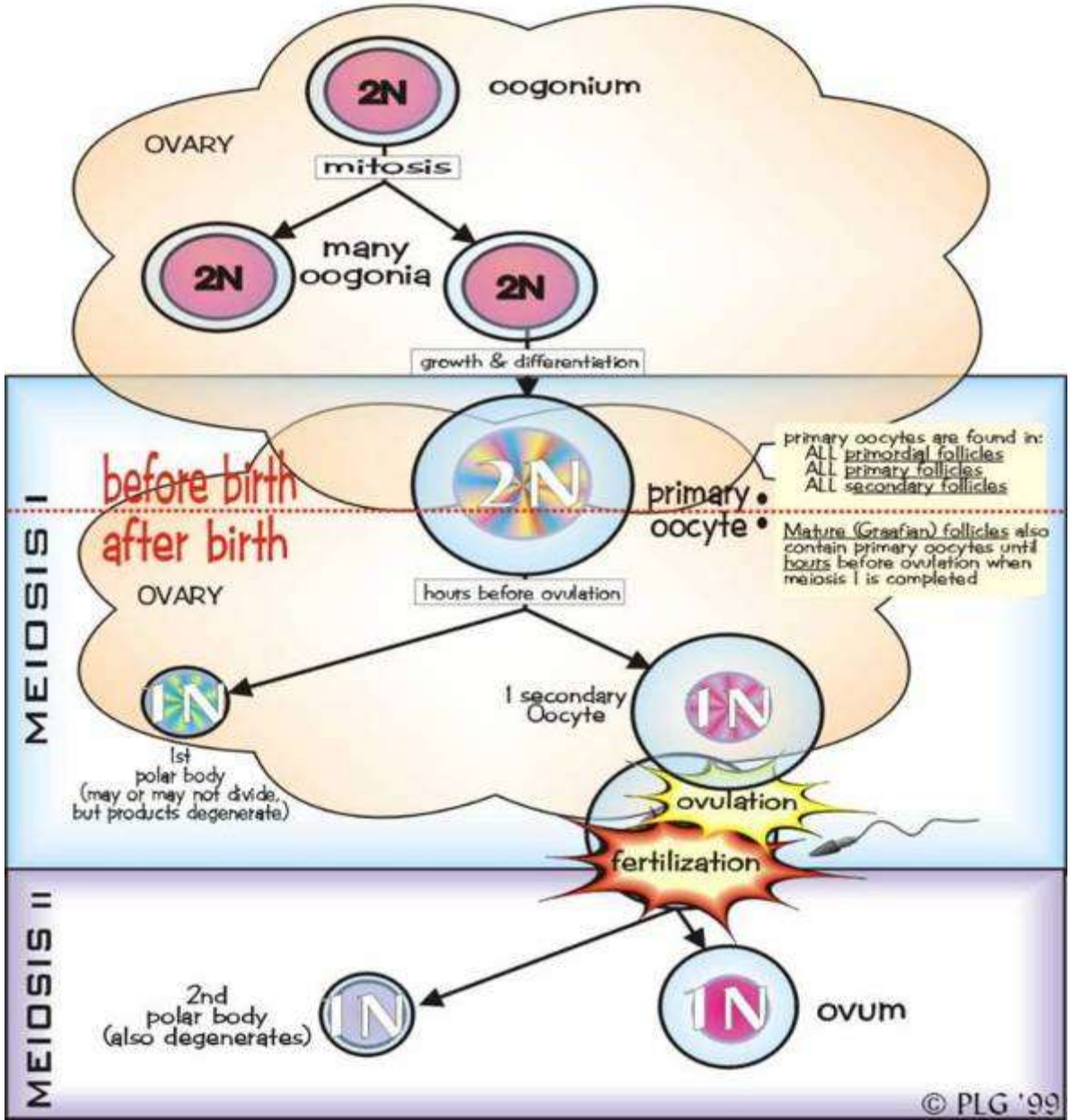


Figure 2–6. *A*, Parts of the uterus. *B*, Diagrammatic frontal section of the uterus, uterine tubes, and vagina. The ovaries are also shown. *C*, Enlargement of the area outlined in *B*. The functional layer of the endometrium is sloughed off during menstruation.

OOGENESIS


2N
oogonium
OVARY
mitosis
2N
many oogonia
2N
growth & differentiation
2N
primary oocyte
primary oocytes are found in:
ALL primordial follicles
ALL primary follicles
ALL secondary follicles
Mature (Graafian) follicles also contain primary oocytes until hours before ovulation when meiosis I is completed
before birth
after birth
OVARY
hours before ovulation
MEIOSIS I
1N
1st polar body (may or may not divide, but products degenerate)
1 secondary Oocyte
1N
ovulation
fertilization
MEIOSIS II
2nd polar body (also degenerates)
1N
1N
ovum
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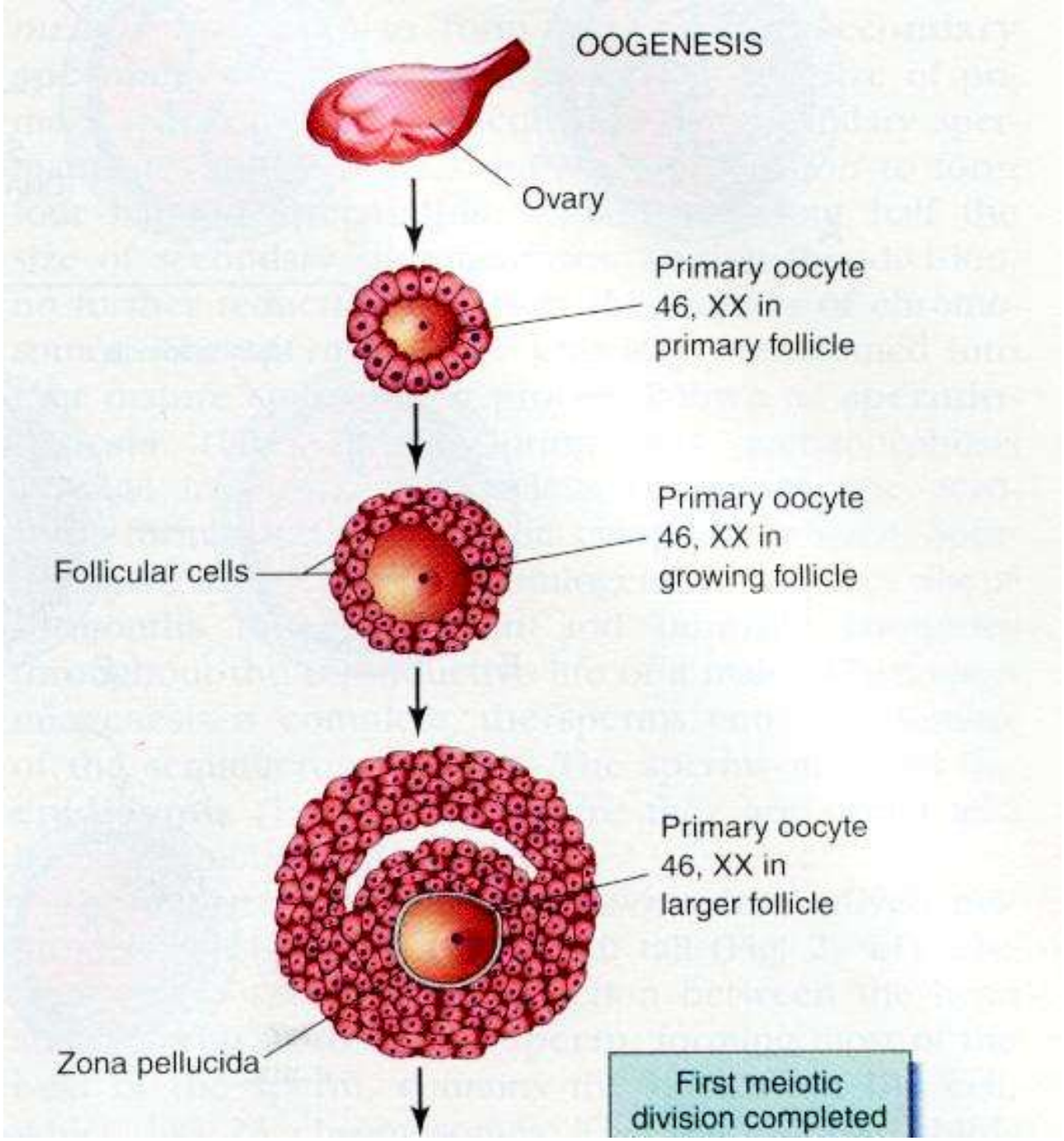
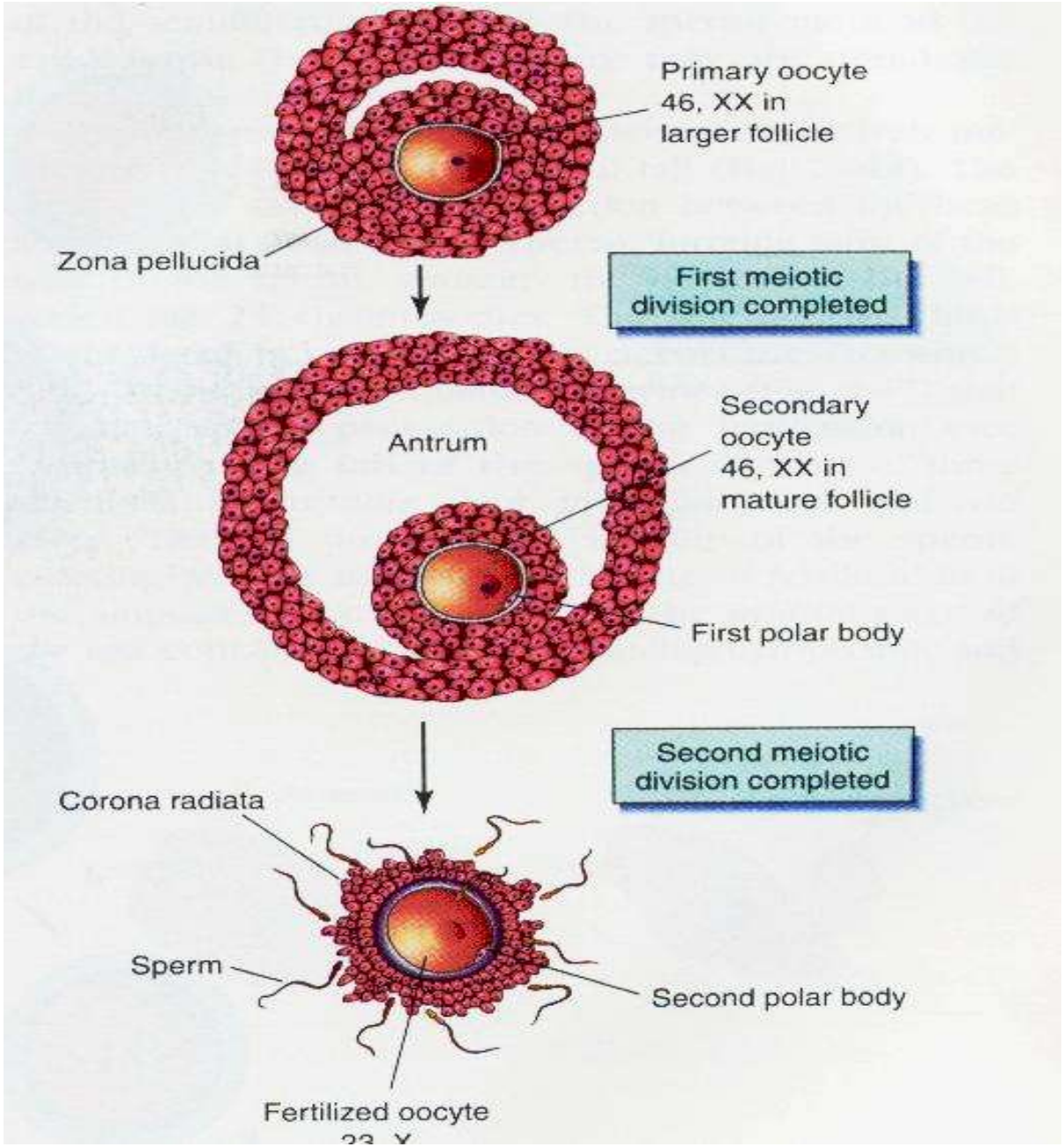

OOGENESIS
Ovary
Primary oocyte
46, XX in
primary follicle
Follicular cells
Primary oocyte
46, XX in
growing follicle
Primary oocyte
46, XX in
larger follicle
Zona pellucida
First meiotic
division completed


Primary oocyte
46, XX in
larger follicle
Zona pellucida
First meiotic
division completed
Antrum
Secondary
oocyte
46, XX in
mature follicle
First polar body
Second meiotic
division completed
Corona radiata
Sperm
Second polar body
Fertilized oocyte