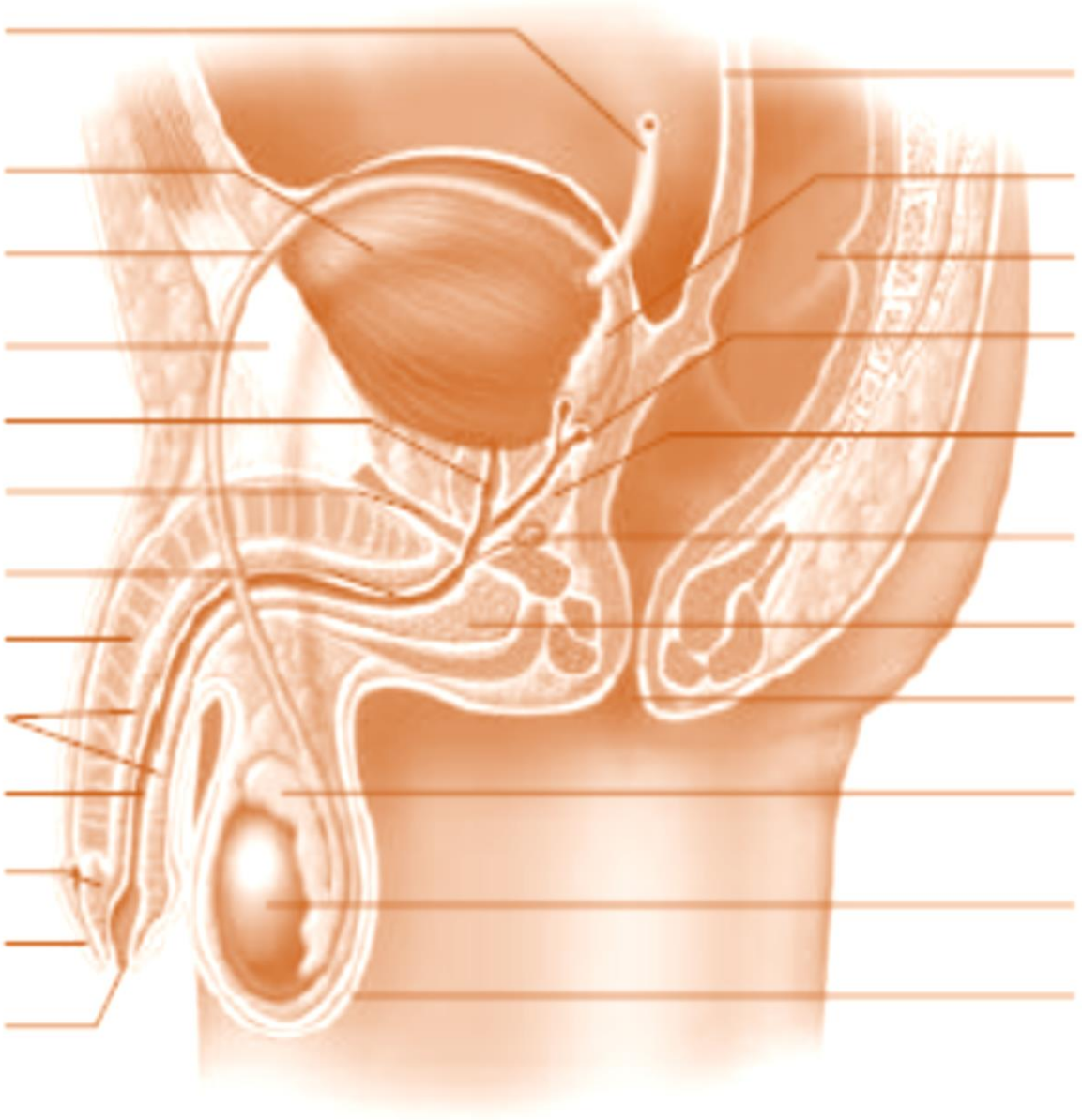
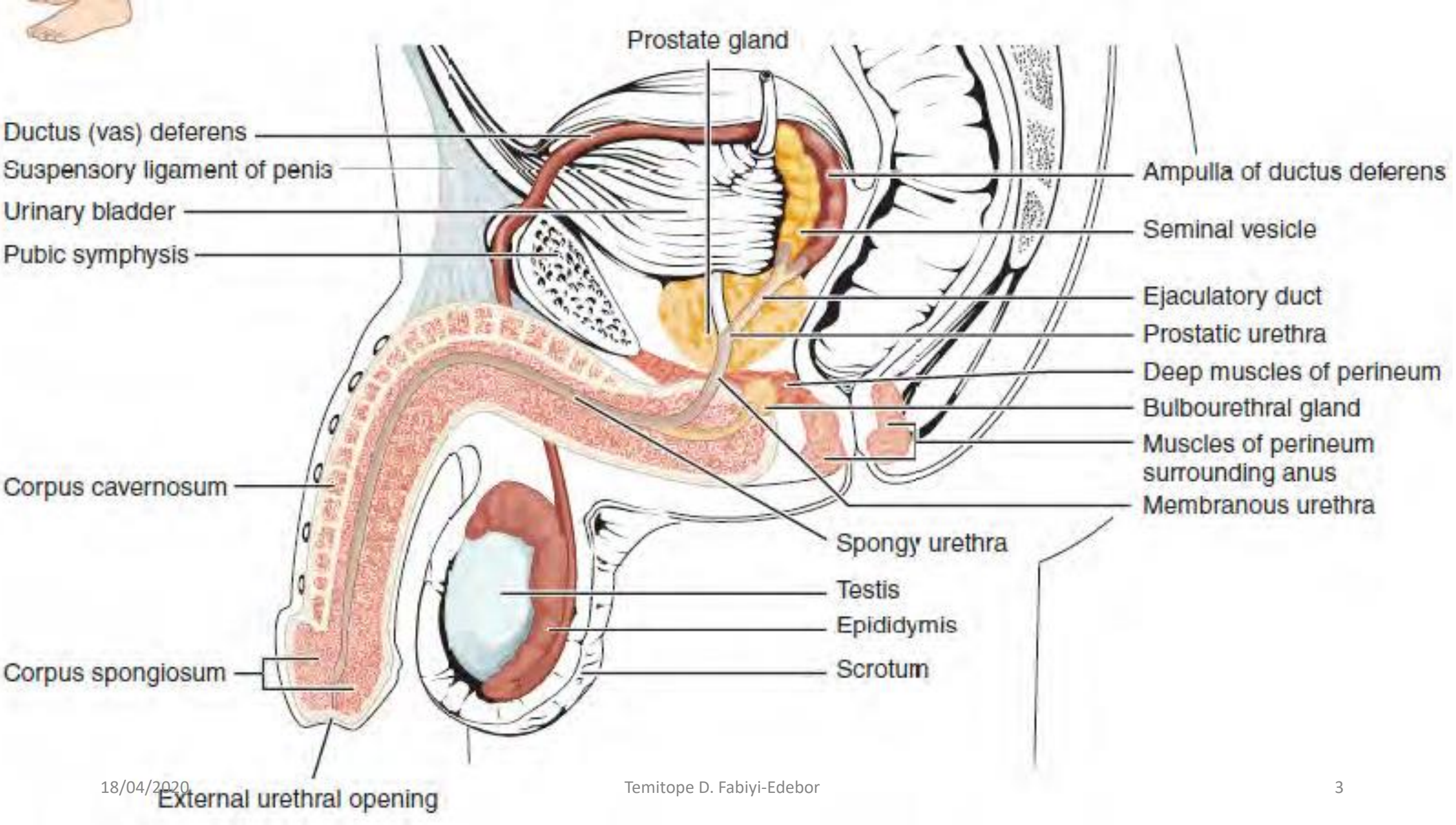
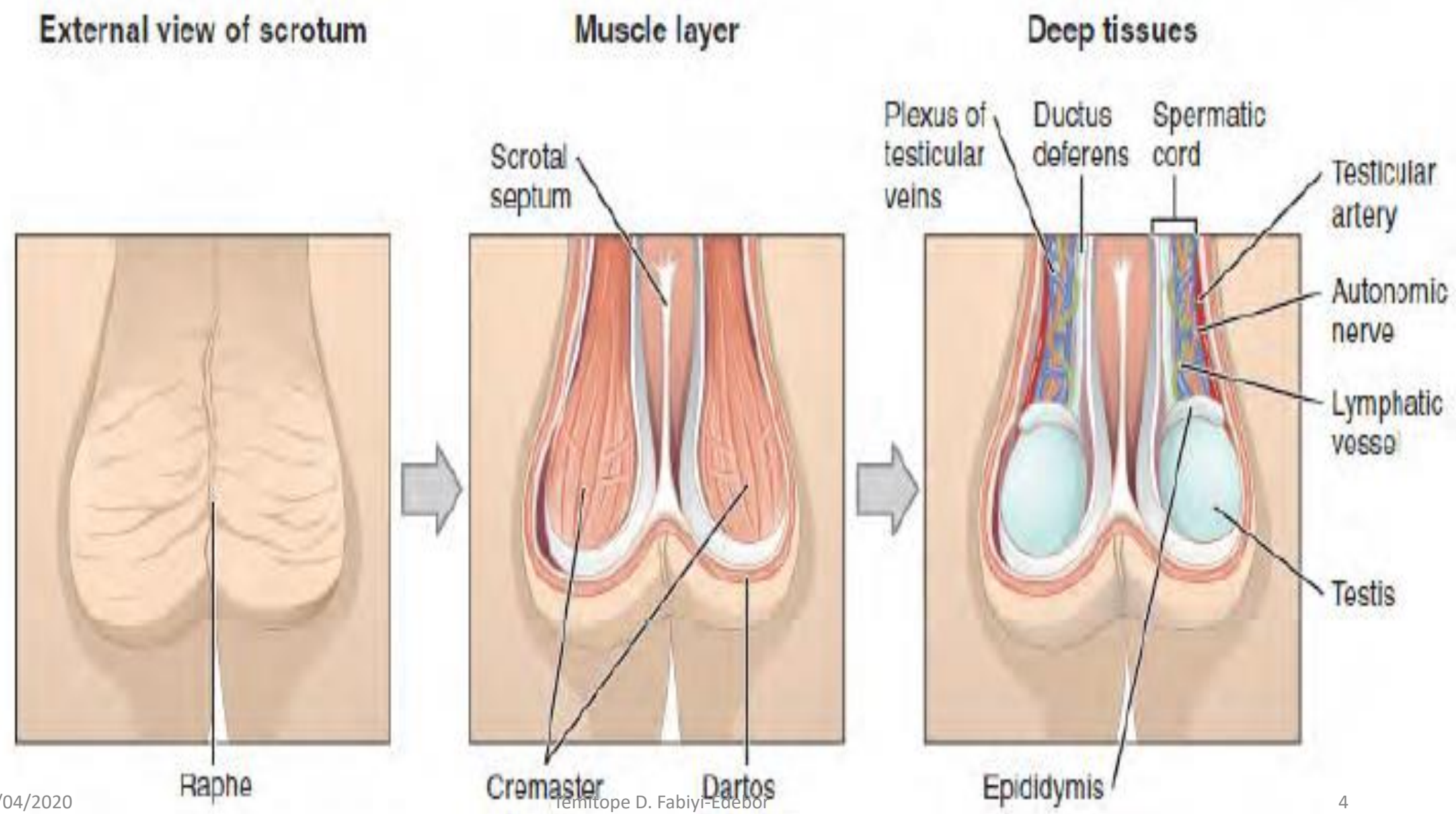
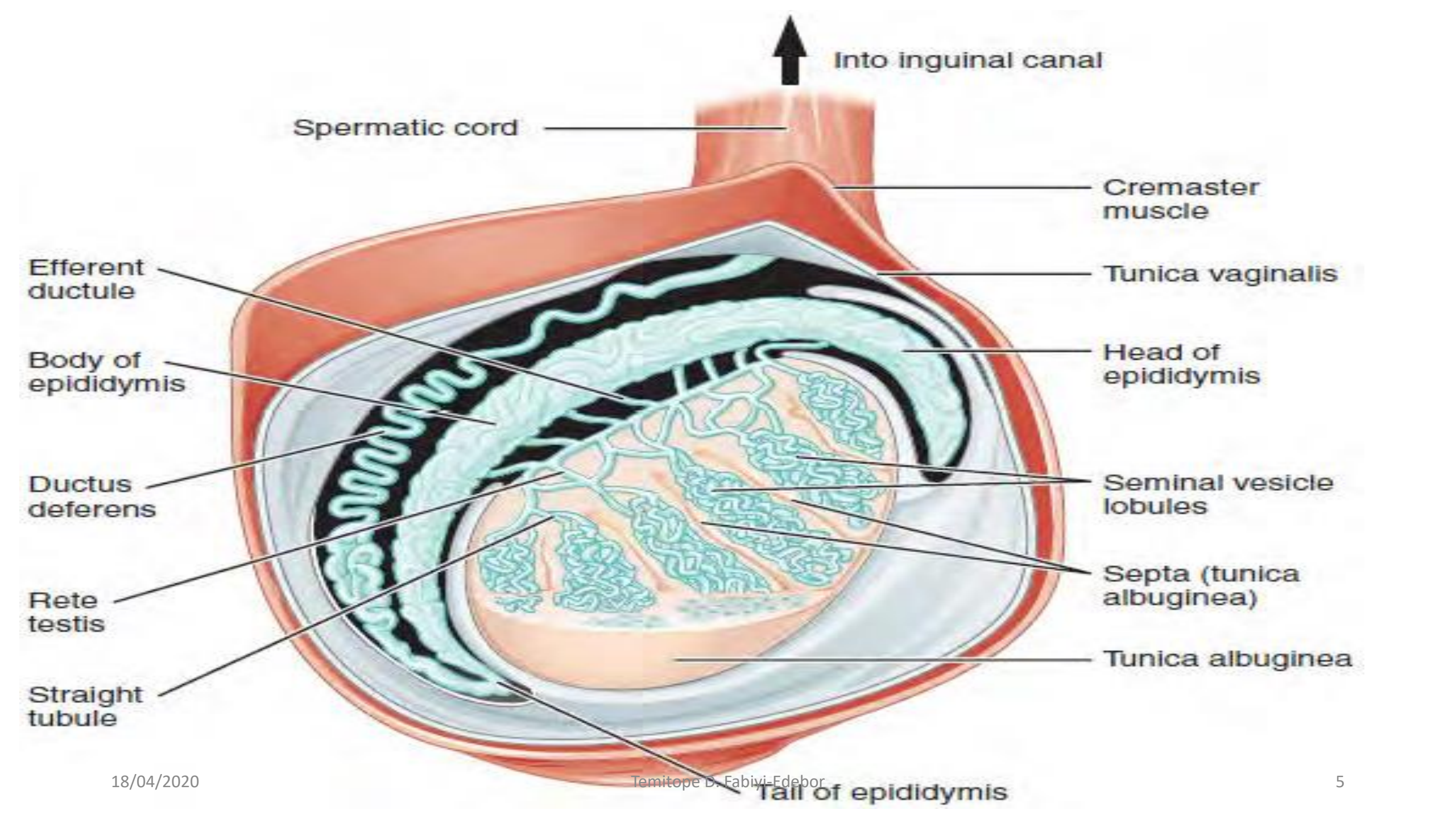
# REPRODUCTIVE PHYSIOLOGY

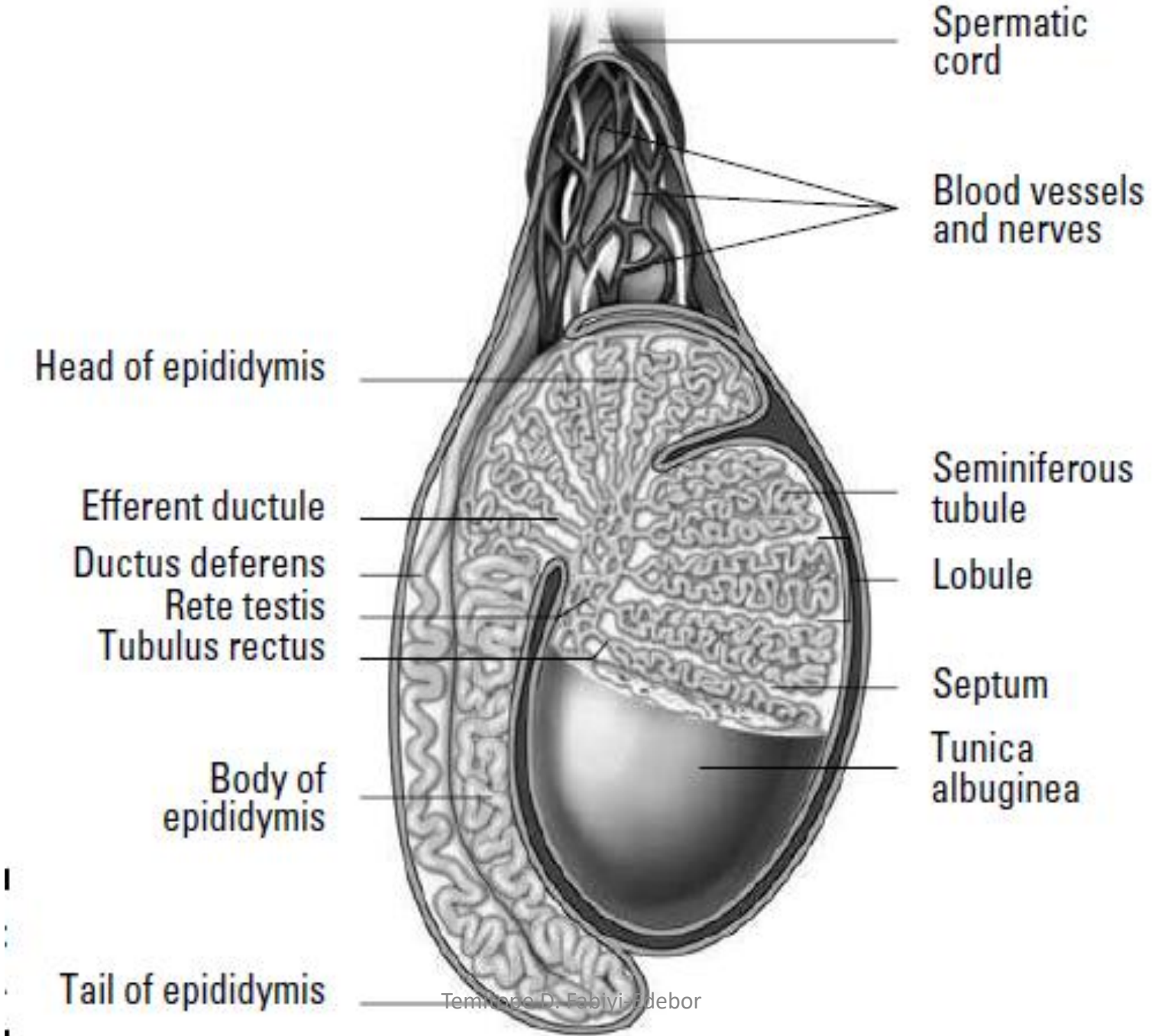
BY DR EDEBOR.

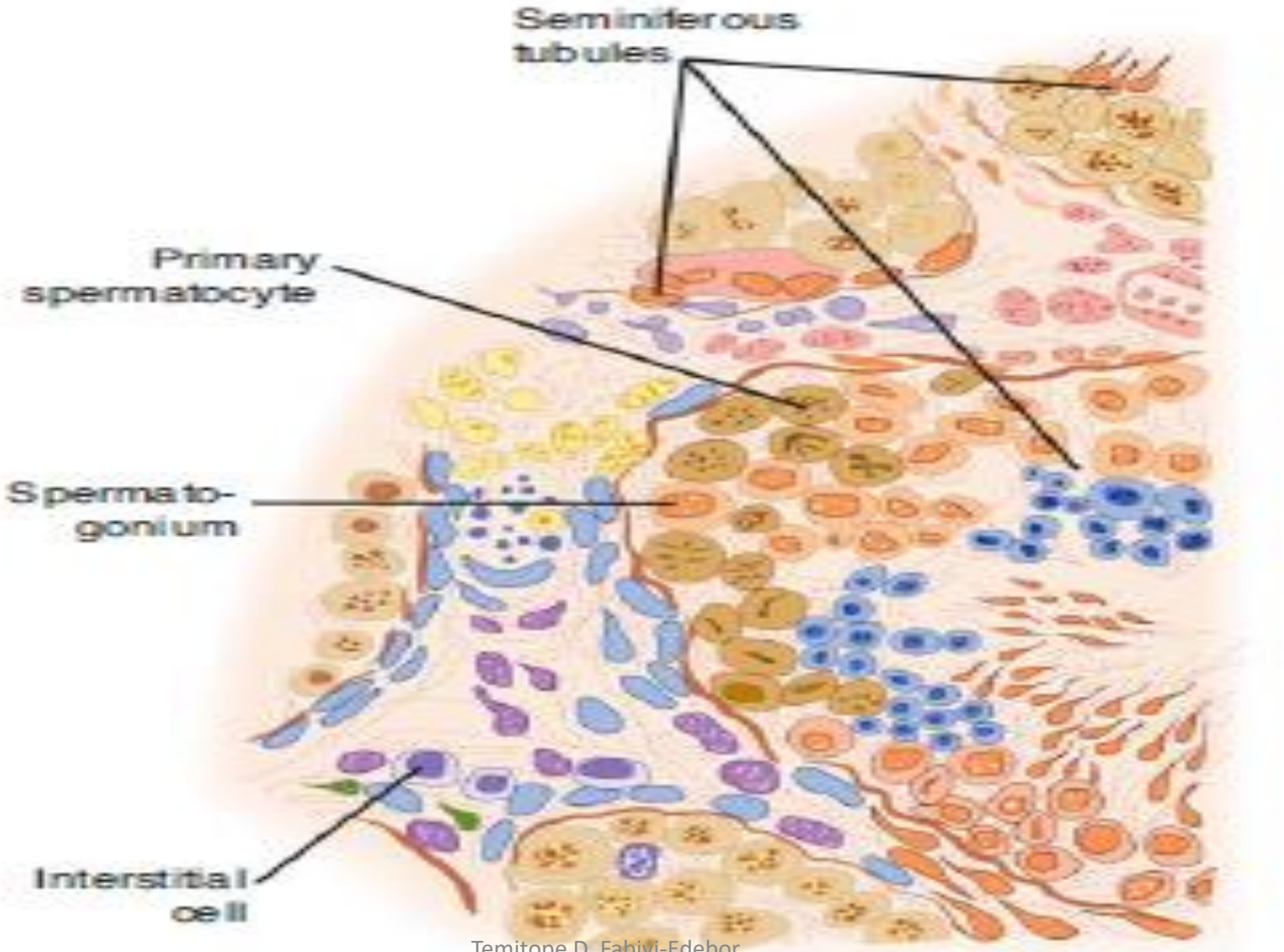

Ureter
Urinary bladder
Ductus deferens
Pubis
Prostatic urethra
Urogenital diaphragm
Membranus urethra
Corpus cavernosum
Corpus spongiosum
Cavernous urethra
Glans penis
Prepuce
External urethral orifice
Peritoneum
Seminal vesicle
Rectum
Ejaculatory duct
Prostate gland
Bulbourethral gland
Bulb of penis
Anus
Epididymis
Testis
Scrotum


Prostate gland
Ductus (vas) deferens
Suspensory ligament of penis
Urinary bladder
Pubic symphysis
Ampulla of ductus deferens
Seminal vesicle
Ejaculatory duct
Prostatic urethra
Deep muscles of perineum
Bulbourethral gland
Muscles of perineum surrounding anus
Membranous urethra
Corpus cavernosum
Spongy urethra
Testis
Epididymis
Scrotum
Corpus spongiosum
External urethral opening


External view of scrotum
Muscle layer
Deep tissues
Raphe
Scrotal septum
Cremaster muscles
Dartos muscles
Plexus of testicular veins
Ductus deferens
Spermatic cord
Testicular artery
Autonomic nerve
Lymphatic vesse
Testis
Epididymis


Into inguinal canal
Spermatic cord
Cremaster muscle
Efferent ductule
Tunica vaginalis
Body of epididymis
Head of epididymis
Ductus deferens
Seminal vesicle lobules
Septa (tunica albuginea)
Rete testis
Tunica albuginea
Straight tubule
Tail of epididymis


Spermatic cord
Blood vessels and nerves
Head of epididymis
Seminiferous tubule
Efferent ductule
Ductus deferens
Lobule
Rete testis
Tubulus rectus
Septum
Tunica albuginea
Body of epididymis
Tail of epididymis


Seminiferous tubules
Primary spermatocyte
Spermato-gonium
Interstitial cell

# Functions of the male gonad (testes)

- The testes are made up of loops of convoluted seminiferous tubules, in the walls of which the spermatozoa are formed from the primitive germ cells and Sertoli cells (for spermatogenesis).

- Sertoli cells are glycogen containing and nourish the germ cells. They have tight junctions at the basal lamina which form a **blood–testis-barrier** that prevents many large molecules from passing to the lumen
- Blood-testes-barrier maintains fluid composition (androgens, estrogens, K+, inositol, glutamic & aspartic acids) in the lumen of the seminiferous tubules

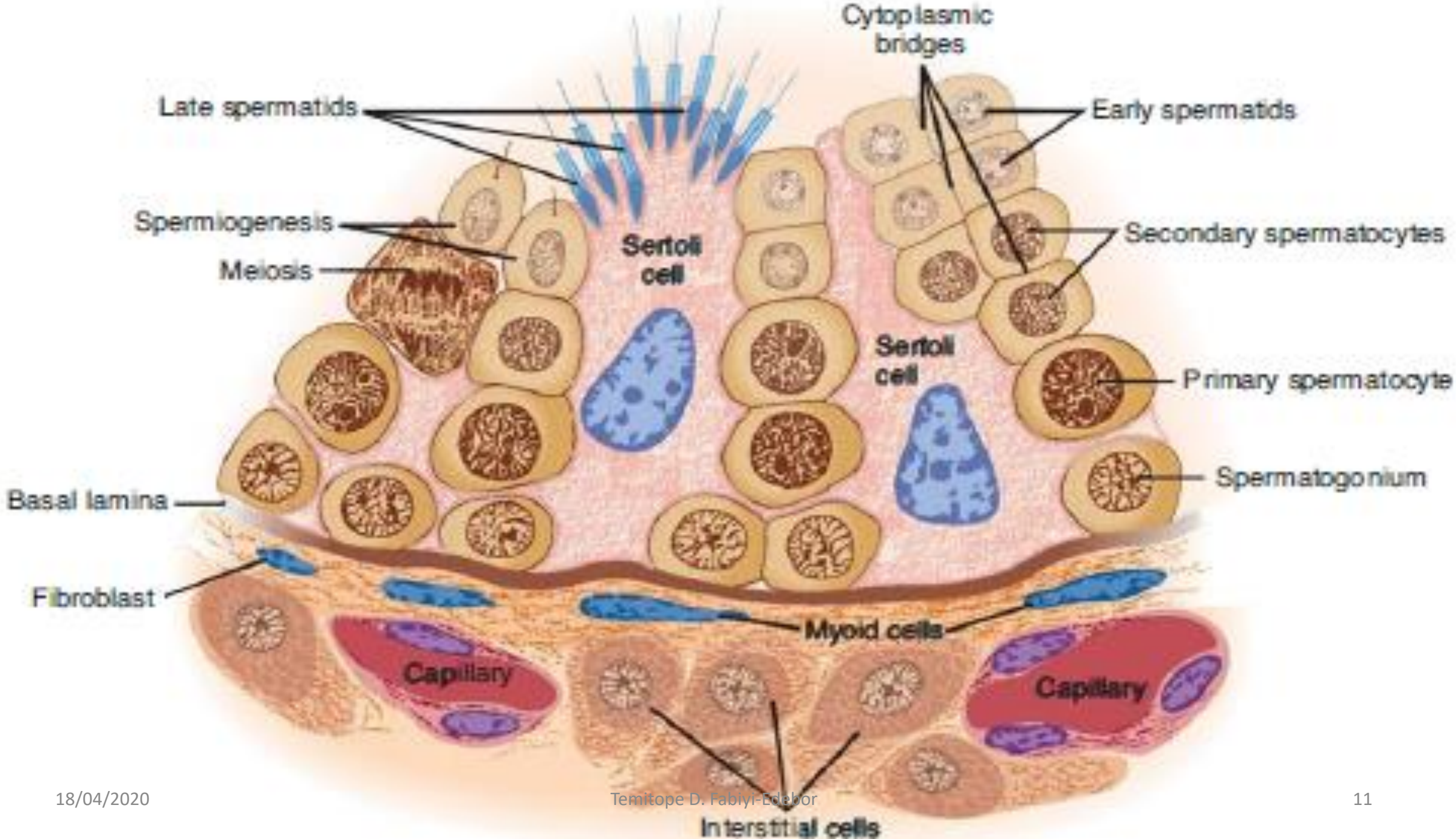
- The barrier also protects the germ cells from bloodborne noxious agents, prevents antigenic products of germ cell division and maturation from entering the circulation and generating an autoimmune response, and may help establish an osmotic gradient that facilitates movement of fluid into the tubular lumen.

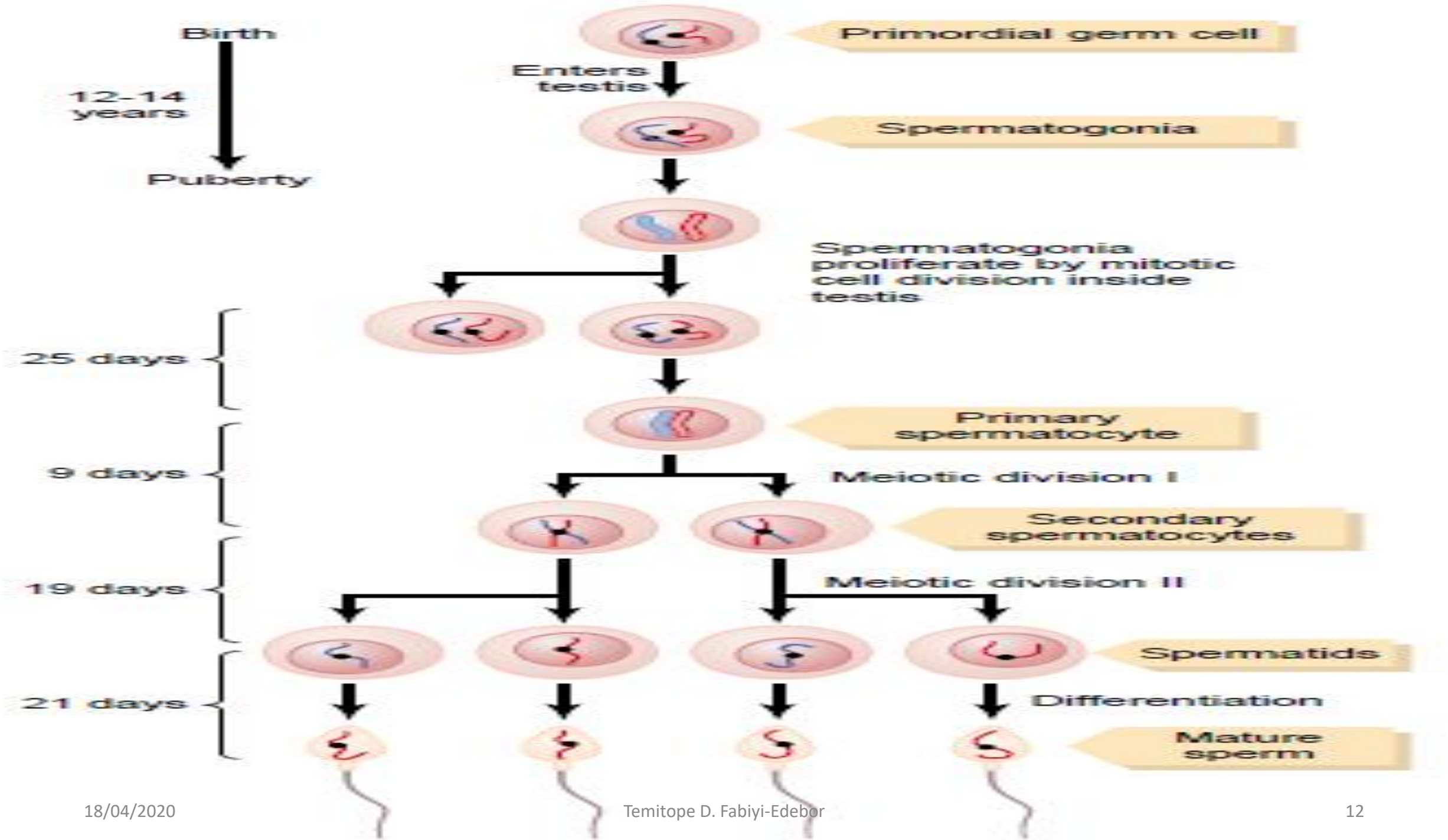
- spermatozoa pass through the tail of the epididymis into the vas deferens through the ejaculatory ducts into the urethra in the body of the prostate at the time of ejaculation.

- Between the tubules in the testes are nests of cells containing lipid granules, the interstitial cells of Leydig, which secrete testosterone into the bloodstream.

# Spermatogenesis

- Orderly process of sperm formation from primitive germ cells
- Begins at puberty (adolescence)
- **Spermatogonia,** the primitive germ cells next to the basal lamina of the seminiferous tubules, mature into **primary spermatocytes** which undergo meiosis (46/2=23 chromosomes) to form **secondary spermatocytes** and **spermatids**. These stages are androgen-independent.
- Spermatids mature into spermatozoa (sperms) in Sertoli cells (androgen dependent).
- About 512 spermatids are formed from a single spermatogonium and 120million sperm are produced in both testes each day.
- The process takes 74 days for a mature sperm to be formed
- FSH and androgens maintain the gametogenic function of the testis
- FSH acts on the Sertoli cells to facilitate the last (androgen dependent) stages of spermatid maturation
- LH produces a high local concentration of androgen in the testes, and this maintains spermatogenesis

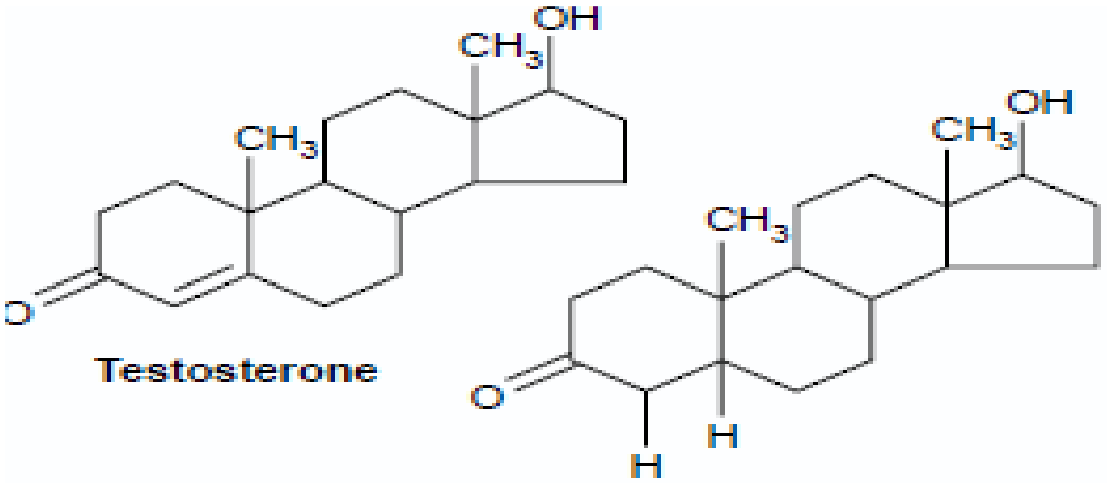

Cytoplasmic bridges
Late spermatids
Early spermatids
Spermiogenesis
Meiosis
Sertoli cell
Secondary spermatocytes
Sertoli cell
Primary spermatocyte
Spermatogonium
Basal lamina
Fibroblast
Myoid cells
Capillary
Capillary
Interstitial cells

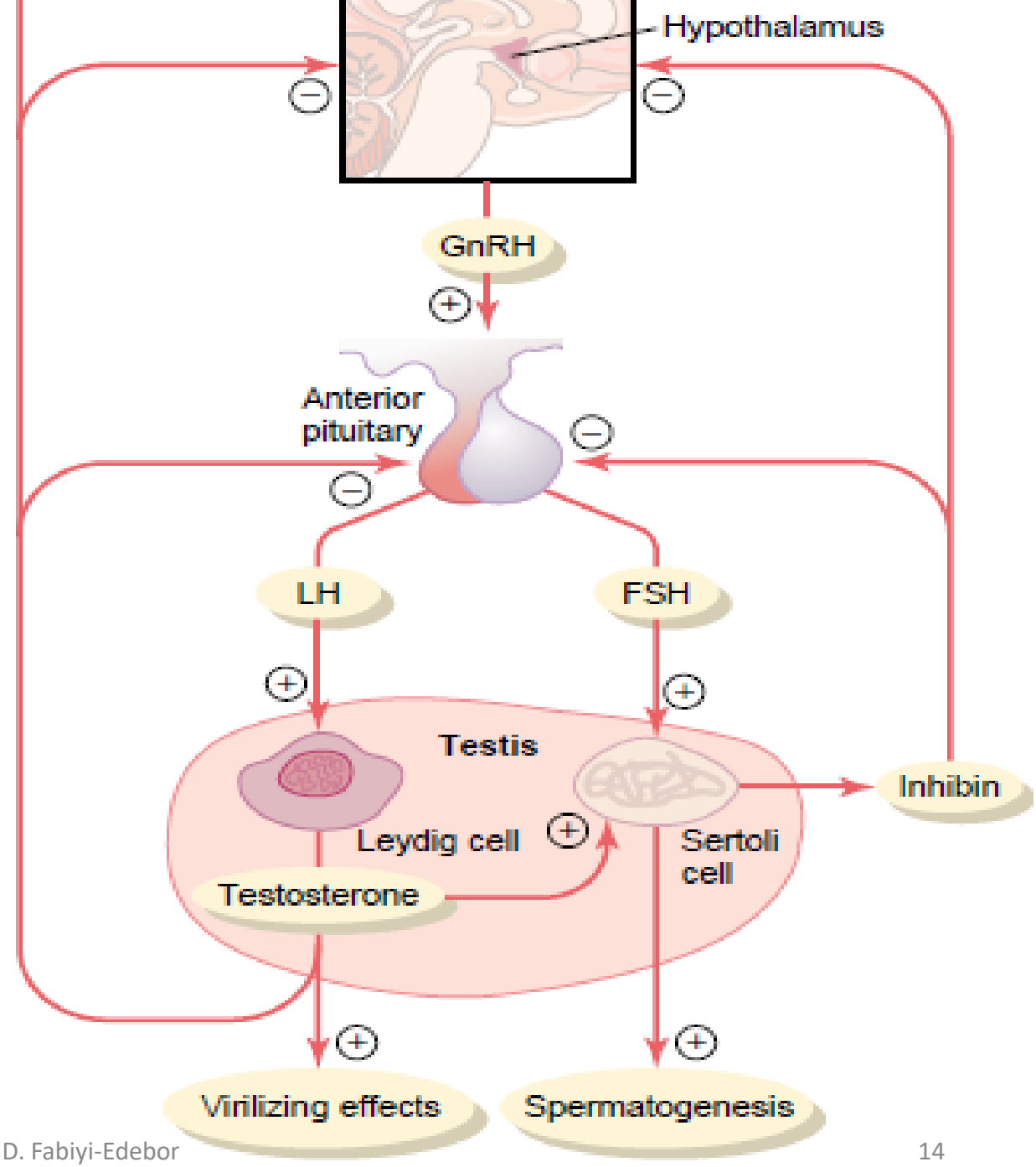

Birth
12-14 years
Puberty
Primordial germ cell
Enters testis
Spermatogonia
Spermatogonia proliferate by mitotic cell division inside testis
25 days
Primary spermatocyte
9 days
Meiotic division I
Secondary spermatocytes
19 days
Meiotic division II
Spermatids
21 days
Differentiation
Mature sperm

# Hormonal Factors That Stimulate Spermatogenesis

- *Testosterone*, secreted by the *Leydig cells* in the interstitium of the testis, is essential for growth and division of the testicular germinal cells, which is the first stage in forming sperm
- *Luteinizing hormone* stimulates the Leydig cells to secrete testosterone.
- *Follicle-stimulating hormone* stimulates the *Sertoli cells*; without this stimulation, the conversion of the spermatids to sperm (the process of spermiogenesis) will not occur.
- *Estrogens*, formed from testosterone by the Sertoli cells when they are stimulated by follicle stimulating hormone, are probably also essential for spermiogenesis.
- Growth hormone specifically promotes early division of the spermatogonia themselves; in its absence, as in pituitary dwarfs, spermatogenesis is severely deficient or absent, thus causing infertility.

# Hormonal control




## Other functions of testosterone:

Primary & Sec. sexual xtics

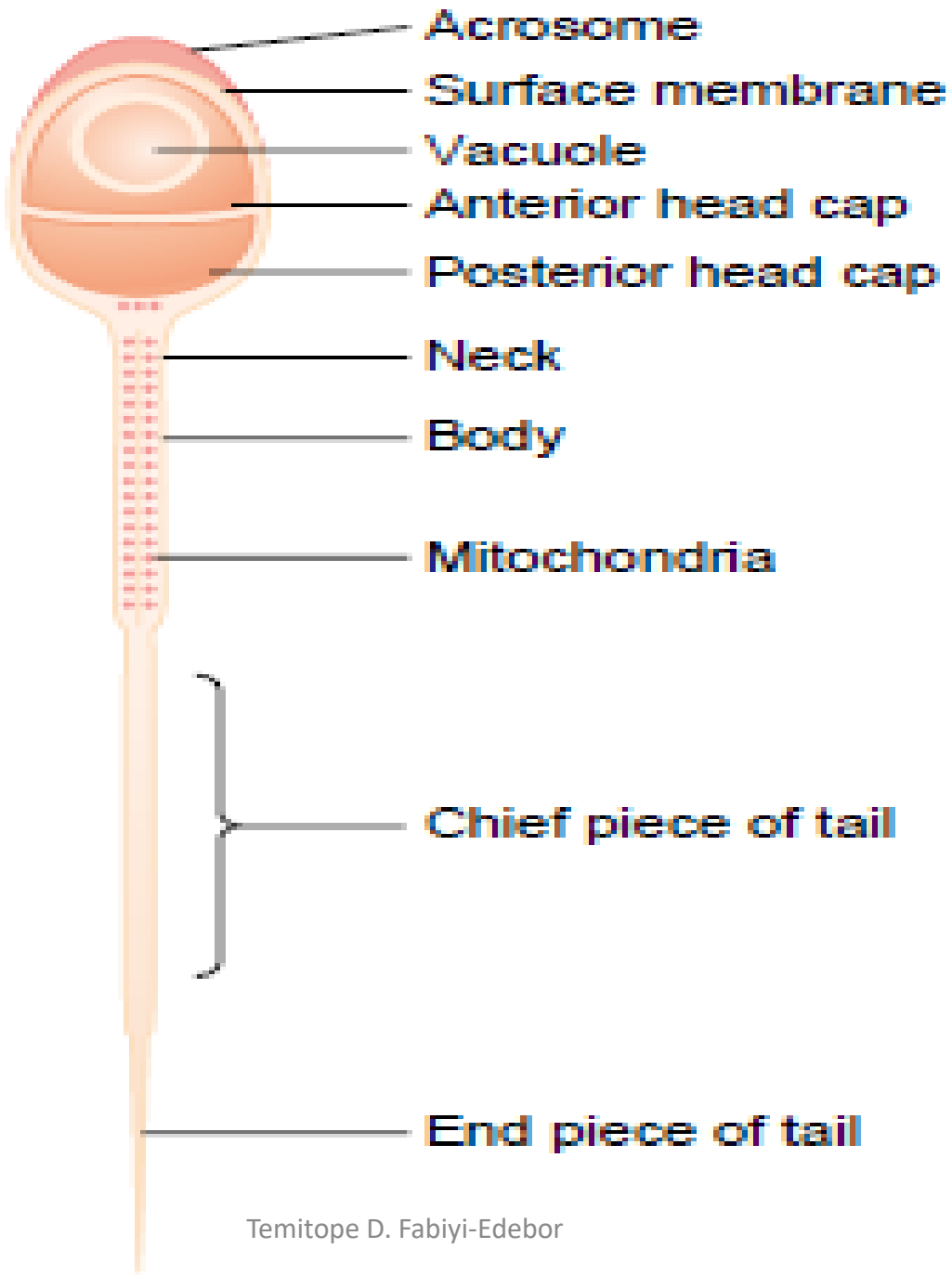
Anaolic, Protein formation, growth

↑ increased BMI, erythropoiesis, bone matrix,

# Spermatozoon

- HEAD – nucleus with haploid [(22+ X) or (22+Y)] chromosomes, acrosome, enzymes such as hyaluronidase
- Middle piece – Mitochondria rich
- Tail (*flagellum)* - components: (1) a central skeleton constructed of 11 microtubules, collectively called the *axoneme*—the structure of this is similar to that of cilia (2) a thin cell membrane covering the axoneme; and (3) a collection of mitochondria surrounding the axoneme in the proximal portion of the tail provides energy for movement.

- Back-and-forth movement of the tail (flagellar movement) provides motility for the sperm.
- Normal sperm move in a fluid medium at a velocity of 1 to 4 mm/min. This allows them to move through the female genital tract in quest of the ovum.


Acrosome
Surface membrane
Vacuole
Anterior head cap
Posterior head cap
Neck
Body
Mitochondria
Chief piece of tail
End piece of tail

Sperm develop capability of motility in the epididymis but this ability is suppressed until after ejaculation

After ejaculation and in the female reproductive tract, the sperm become motile, a process called *maturation*.

In the female, the spermatozoa move up the uterus to the isthmus of the uterine tubes, where they slow down and undergo **capacitation ( increased motility and acrosome breakdown).**
capacitated spermatozoa move rapidly to the tubal ampullas, where fertilization takes place

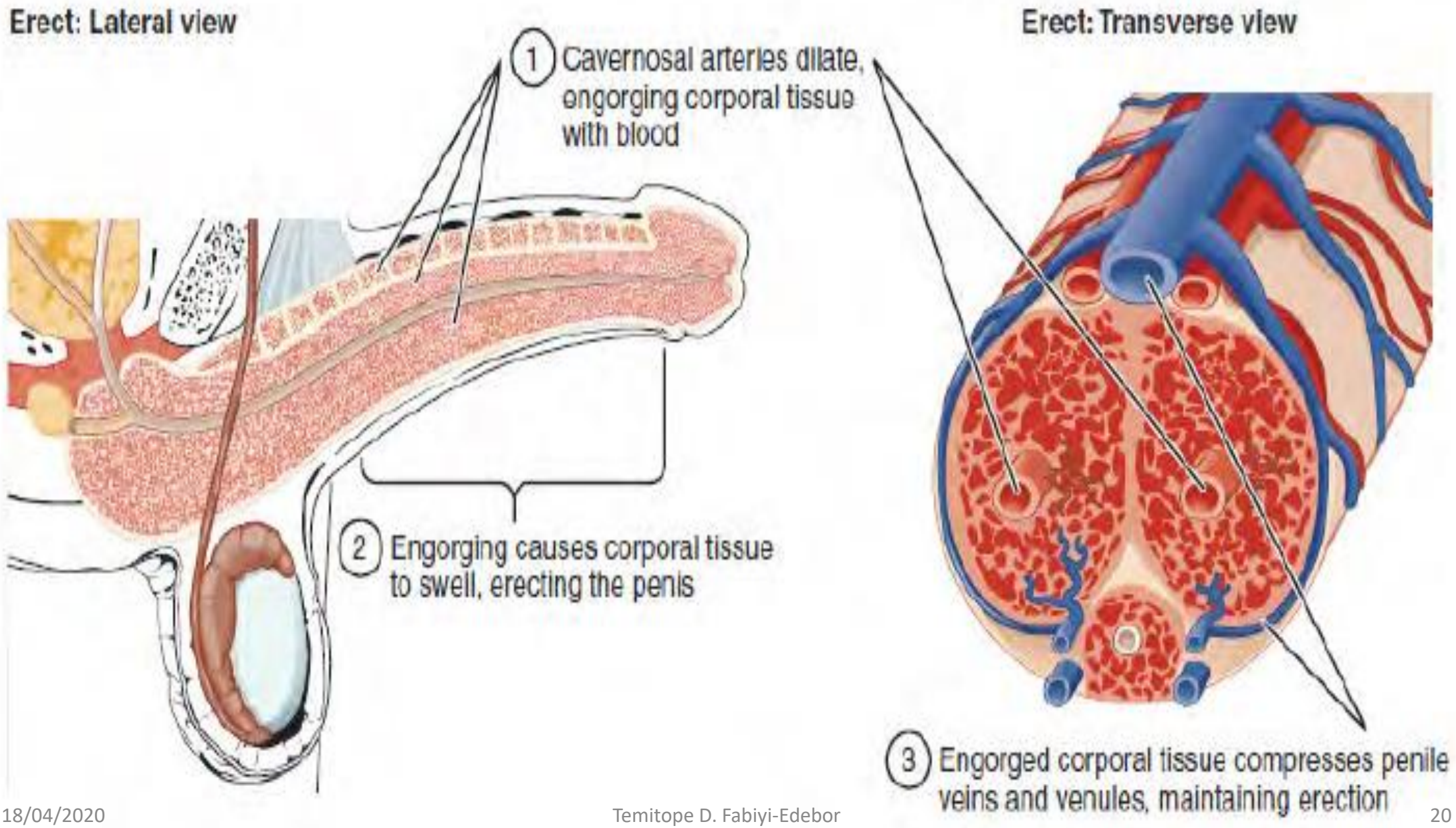
The activity of sperm is greatly enhanced in a neutral and slightly alkaline medium, as exists in the ejaculated semen

# SEMEN

- composed of the fluid and sperm from the vas deferens (about 10 per cent of the total),
- fluid from the seminal vesicles (almost 60 per cent),
- fluid from the prostate gland (about 30 per cent), and
- small amounts from the mucous glands, especially the bulbourethral glands
- pH – 7.35-7.5, colour – white (opalescent), specific gravity – 1.028,
- Life span – Many weeks in the male genital duct, 1-2 days after ejaculation into the female, years when frozen.
- Sperm count: Average about 100 million/mL, with fewer than 20% abnormal forms
- Other components: Fructose (1.5-6.5 mg/mL), Phosphorylcholine, Ergothioneine, Ascorbic acid, Flavins, Prostaglandins, Spermine; Citric acid, Cholesterol, phospholipids, Fibrinolysin, fibrinogenase, Zinc, Acid phosphatase, Phosphate, Bicarbonate,Hyaluronidase

# MALE ORGASM

- Stages of male sexual act: penile **erection, emission and ejaculation**.
- Erection is initiated by dilation of the arterioles of the penis. As the erectile tissue of the penis fills with blood, the veins are compressed, blocking outflow and adding to the turgor of the organ.
- The integrating centers in the lumbar segments of the spinal cord are activated by impulses in afferents from the genitalia and descending tracts that mediate erection in response to erotic psychologic stimuli.
- The efferent parasympathetic fibers are in the pelvic splanchnic nerves. They release vasodilators such as NO, Ach and VIP
- NO also relaxes the corpora cavernosa and corpus spongiosum (erectile smooth muscles) in the shaft of the penis


Erect: Lateral view
1 Cavernosal arteries dilate, engorging corporal tissue with blood
2 Engorging causes corporal tissue to swell, erecting the penis
Erect: Transverse view
3 Engorged corporal tissue compresses penile veins and venules, maintaining erection

Emission and ejaculation are the culmination of the male sexual act. When the sexual stimulus becomes extremely intense, the reflex centers of the spinal cord begin to emit *sympathetic impulses* that leave the cord at T-12 to L-2 and pass to the genital organs through the hypogastric and pelvic sympathetic nerve plexuses to initiate *emission*, the forerunner of ejaculation.

Emission begins with contraction of the vas deferens to cause expulsion of sperm into the prostatic urethra. The muscular coat of the prostate gland contract followed by the seminal vesicles to expel prostatic and seminal fluid also into the urethra, forcing the sperm forward. All these fluids mix in the internal urethra with mucus already secreted by the bulbourethral glands to form the semen. The process to this point is *emission*.

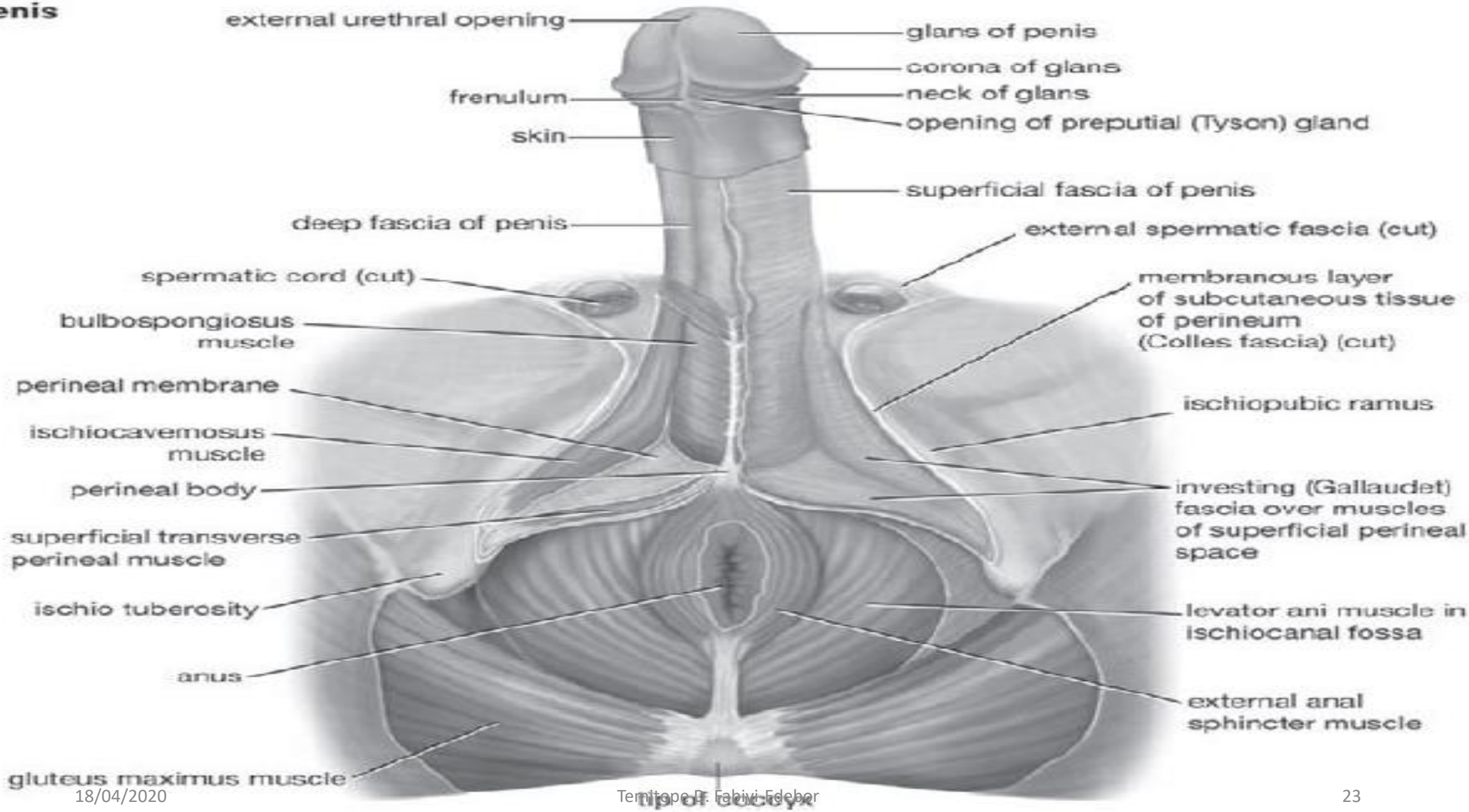
The filling of the internal urethra with semen elicits sensory signals that are transmitted through the pudendal nerves to the sacral regions of the cord, giving the feeling of sudden fullness in the internal genital organs.

These sensory signals further excite rhythmical contraction of the internal genital organs and cause contraction of the ischiocavernosus and bulbocavernosus muscles that compress the bases of the penile erectile tissue.

These effects together cause rhythmical, wavelike increases in pressure in the erectile tissue of the penis, genital ducts and urethra, which “ejaculate” the semen from the urethra to the exterior. This final process is called ejaculation.

Ejaculation thus occurs as a result of sympathetic signals causing spasmodic contractions of the ischiocavernosus, bulbospongiosus and levator ani muscles.

# Penis


external urethral opening
glans of penis
corona of glans
frenulum
neck of glans
opening of preputial (Tyson) gland
skin
superficial fascia of penis
deep fascia of penis
external spermatic fascia (cut)
spermatic cord (cut)
membranous layer of subcutaneous tissue of perineum (Colles fascia) (cut)
bulbospongiosus muscle
perineal membrane
ischiopubic ramus
ischiocavemosus muscle
perineal body
investing (Gallaudet) fascia over muscles of superficial perineal space
superficial transverse perineal muscle
ischio tuberosity
levator ani muscle in ischiocanal fossa
anus
external anal sphincter muscle
gluteus maximus muscle
tip of coccyx

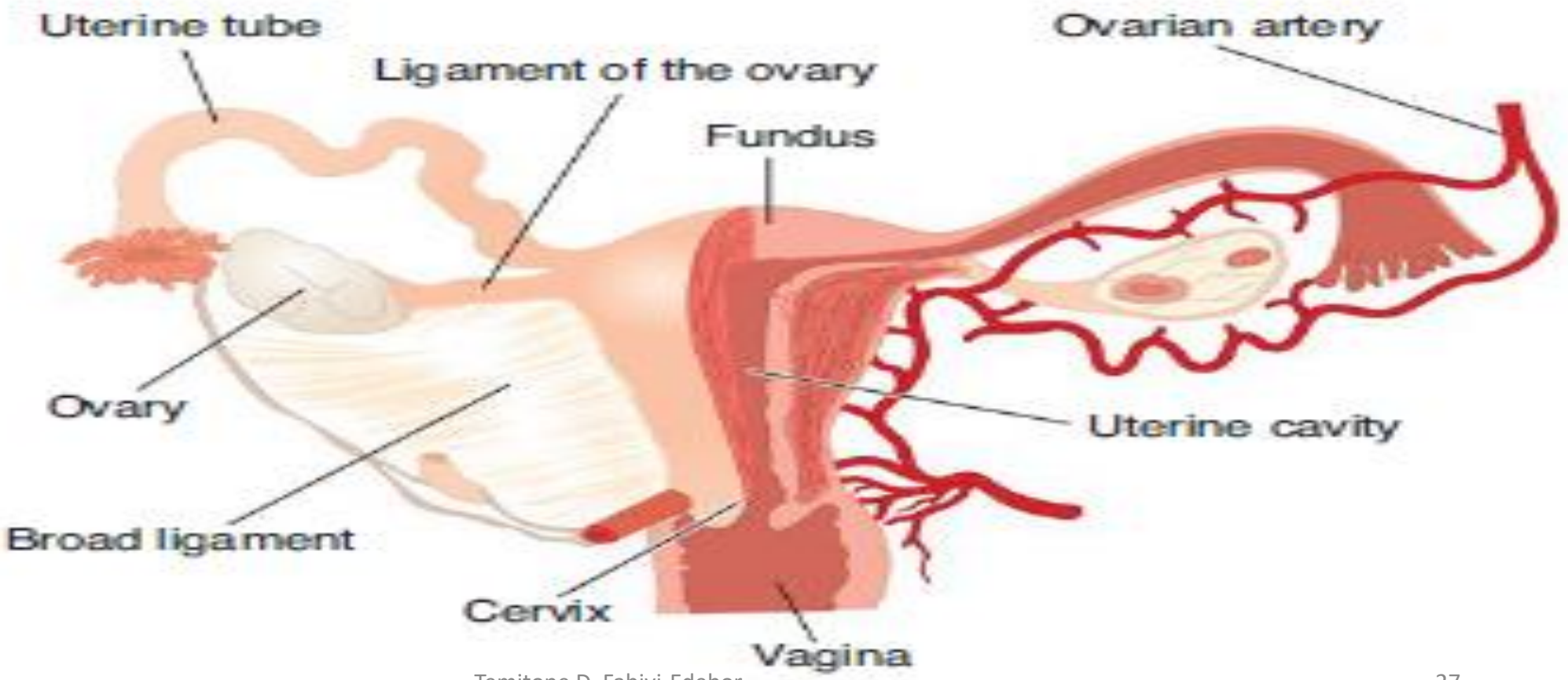
The correct sequence for the movement of sperm is:

**a.** Seminiferous tubules  Tubuli recti  Rete testis  Epididymis  Ductus deferens
Ejaculatory duct  Urethra
**b.** Seminiferous tubules  Tubuli recti  Rete testis  Ejaculatory duct  Epididymis
Duct deferens  Urethra
**c.** Epididymis  Ejaculatory duct  Tubuli recti  Rete testis  Seminiferous tubules
Ductus deferens  Urethra
**d.** Seminiferous tubules  Ejaculatory duct  Tubuli recti  Rete testis  Epididymis
Ductus deferens  Urethra

# FEMALE REPRODUCTIVE SYSTEM

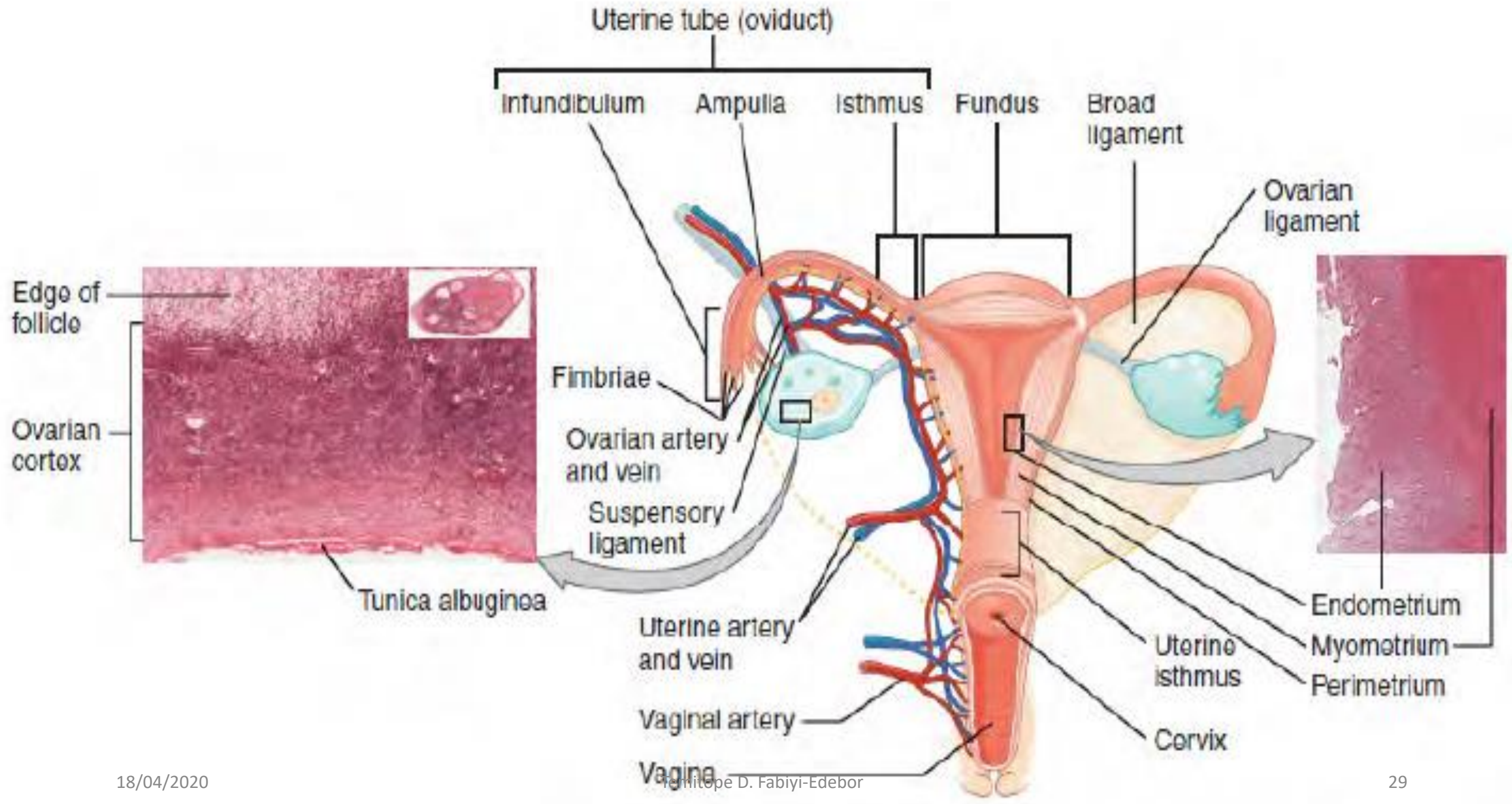
Female reproductive functions can be divided into two major phases:

- preparation of the female body for conception and pregnancy. This involves regular cyclic changes – ovarian, menstrual and uterine cycles
- The period of pregnancy itself

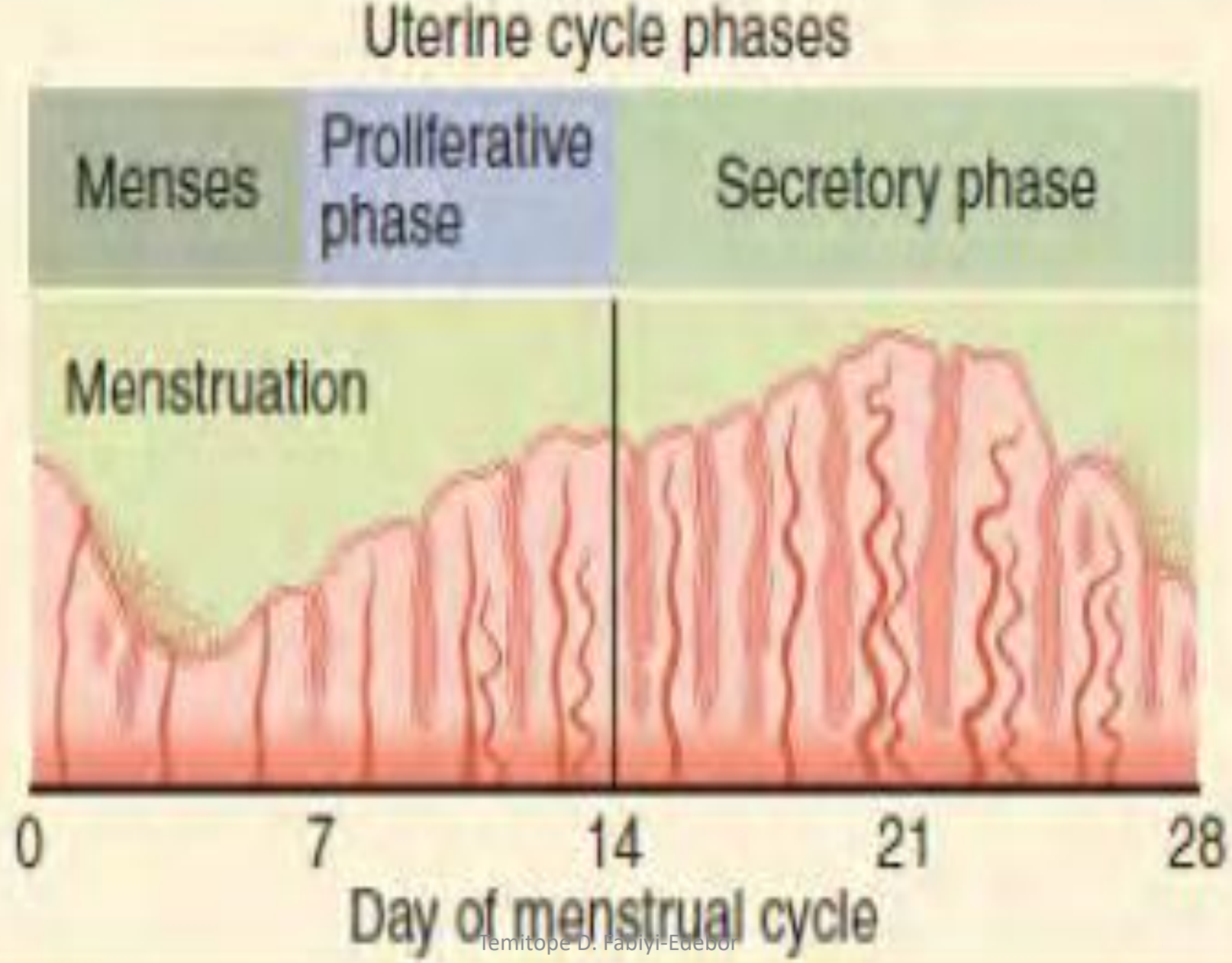


# MENSTRUAL CYCLE

- endometrial cycle in the lining of the uterus. It is the series of changes in which the uterine lining is shed, rebuilds, and prepares for implantation.
- Stages/Phases of menstrual cycle
- (1) proliferation of the uterine endometrium (Proliferative/follicular/preovulatory phase);
- (2) development of secretory changes in the endometrium (Secretory or luteal phase);
- (3) desquamation of the endometrium, which is known as *Menstruation (Menses phase)*


Uterine tube (oviduct)
Infundibulum
Ampulla
Isthmus
Fundus
Broad ligament
Ovarian ligament
Edge of follicle
Ovarian cortex
Fimbriae
Ovarian artery and vein
Suspensory ligament
Tunica albuginea
Uterine artery and vein
Vaginal artery
Vagina
Uterine isthmus
Cervix
Endometrium
Myometrium
Perimetrium

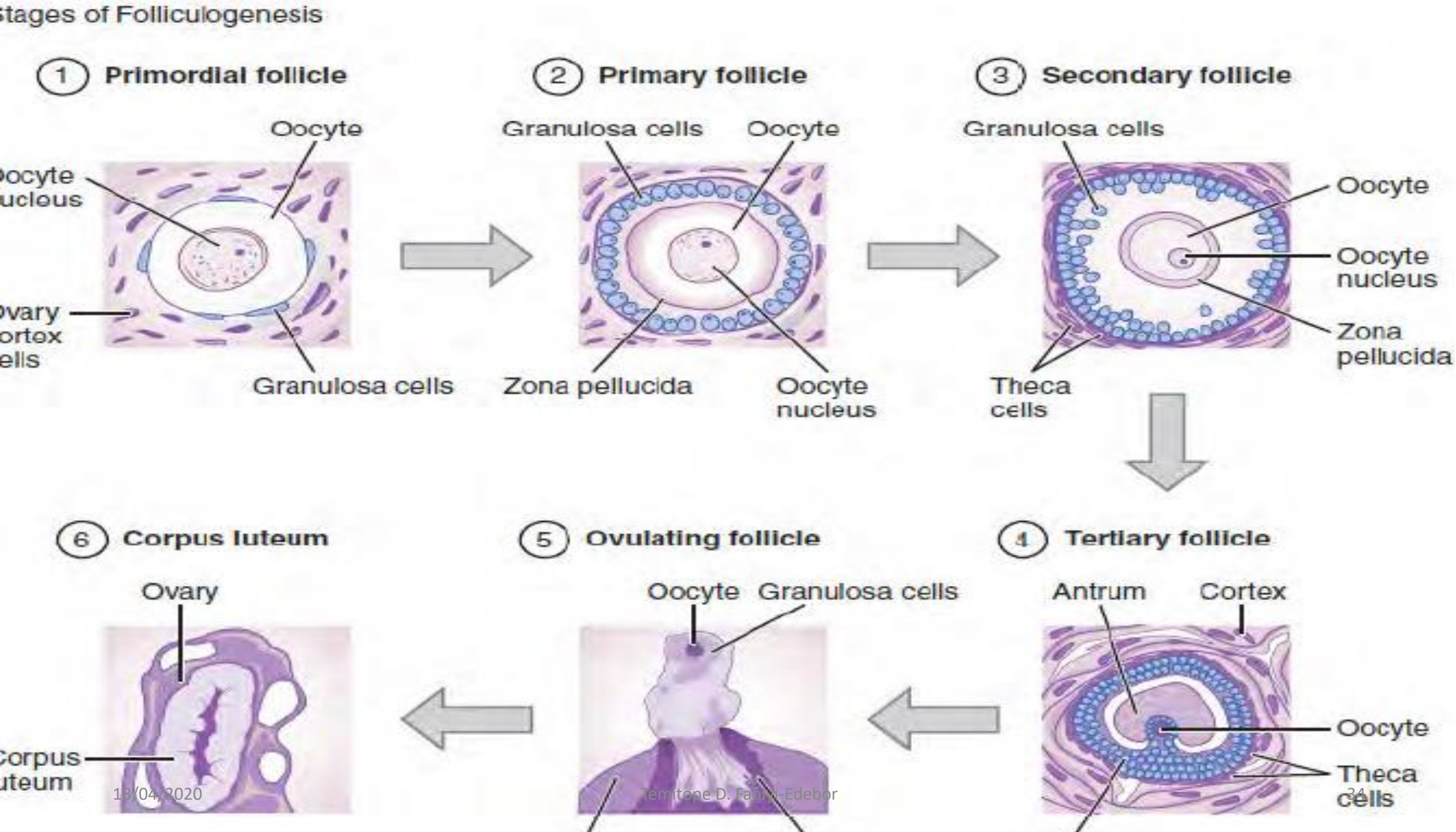
- The wall of the uterus is made up of three layers.
- The most superficial layer - is the serous membrane, or perimetrium, which consists of epithelial tissue that covers the exterior portion of the uterus.
- The middle layer, or myometrium - is a thick layer of smooth muscle responsible for uterine contractions.
- The innermost layer of or endometrium - The endometrium contains a connective tissue lining, the lamina propria, which is covered by epithelial tissue that lines the lumen. Structurally, the endometrium consists of two layers: the stratum basalis and the stratum functionalis (the basal and functional layers).
- The **stratum functionale,** is supplied by long, coiled **spiral arteries**, the **stratum basale,** is supplied by short, straight **basilar arteries.**
- The stratum basalis layer does not shed during menses. In contrast, the thicker stratum functionalis layer contains the glandular portion of the lamina propria and the endothelial tissue that lines the uterine lumen. It is the stratum functionalis that grows and thickens in response to increased levels of estrogen and progesterone.
- And is shed when hormonal support for the endometrium is withdrawn


Uterine cycle phases
Menses
Proliferative phase
Secretory phase
Menstruation
0
7
14
21
28
Day of menstrual cycle

- Menstrual blood is predominantly arterial, with only 25% of the blood being of venous origin. It contains tissue debris, prostaglandins, and relatively large amounts of fibrinolysin from endometrial tissue. The fibrinolysin lyses clots, so that menstrual blood does not normally contain clots unless the flow is excessive.
- The usual duration of the menstrual flow is 3 to 5 days. Flows as short as 1 day and as long as 8 days can occur in normal women.
- The amount of blood lost may range normally from slight spotting to 80 mL; the average amount lost is 30 mL. Loss of more than 80 mL is abnormal.
- The amount of flow can be affected by the thickness of the endometrium, medication, and diseases that affect the clotting mechanism.
- The normal menstrual cycle is between 20-35 days averagely 28days.
- First Menses occurs at puberty and is called Menarche and ceases at menopause. Menstrual cycle could be ovulatory or anovulatory

# OVARIAN CYCLE

- Primordial follicles
- Primary follicles
- Secondary **(graafian)** follicles
- Dominant (tertiary) follicle
- Atretic follicles
- Ovulating follicle
- Ovulation
- Corpus luteum
- (If no fertilization) Corpus haemorrhagicum and corpus albican
- (If fertilization occurs) Corpus luteum of pregnancy

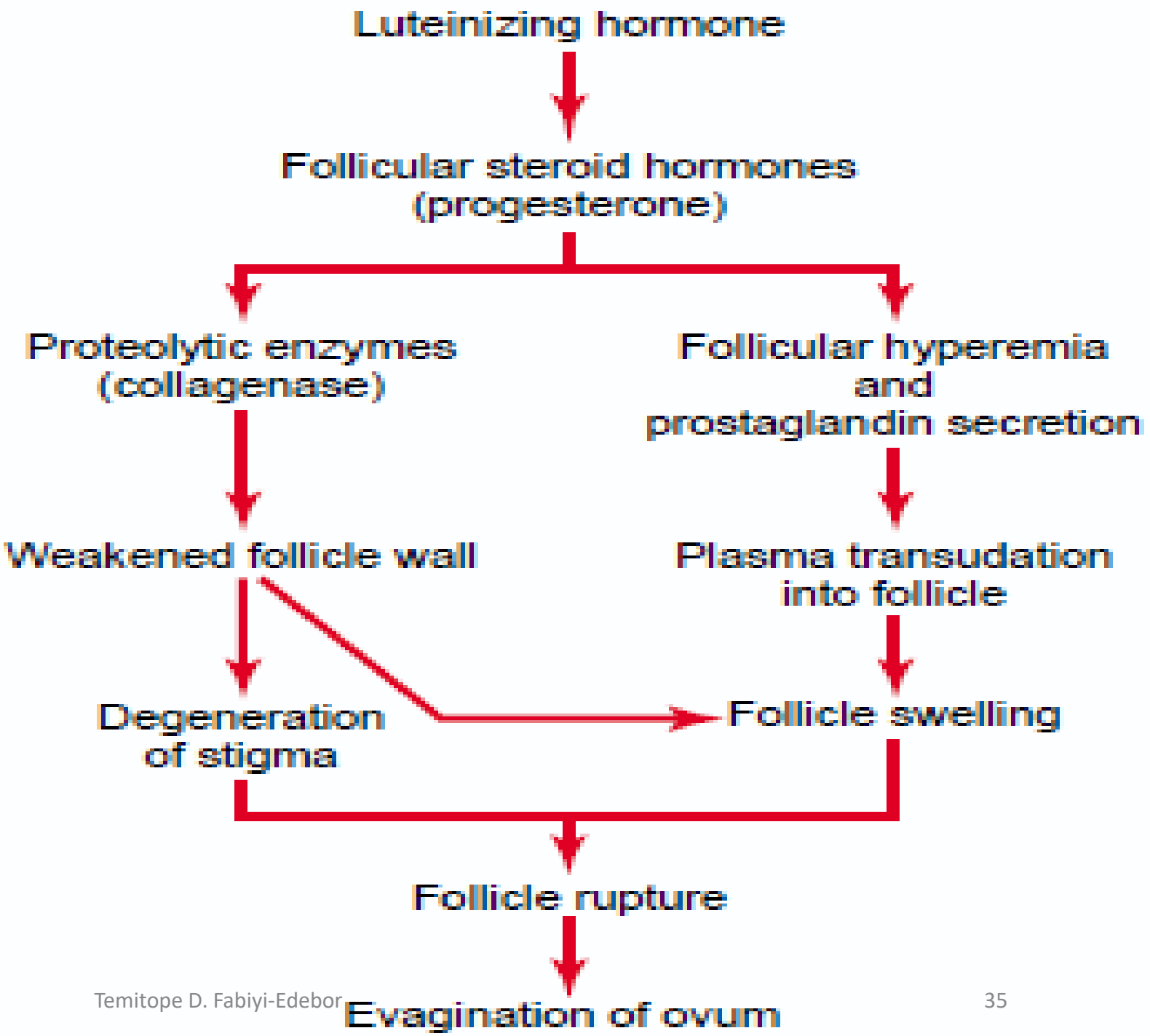

tages of Folliculogenesis
1 Primordial follicle
Oocyte
ocyte
ucleus
vary
ortex
ells
Granulosa cells
2 Primary follicle
Granulosa cells
Oocyte
Zona pellucida
Oocyte
nucleus
3 Secondary follicle
Granulosa cells
Oocyte
Oocyte
nucleus
Zona
pellucida
Theca
cells
4 Tertiary follicle
Antrum
Cortex
Oocyte
Theca
cells
5 Ovulating follicle
Oocyte
Granulosa cells
6 Corpus luteum
Ovary
Corpus
uteum

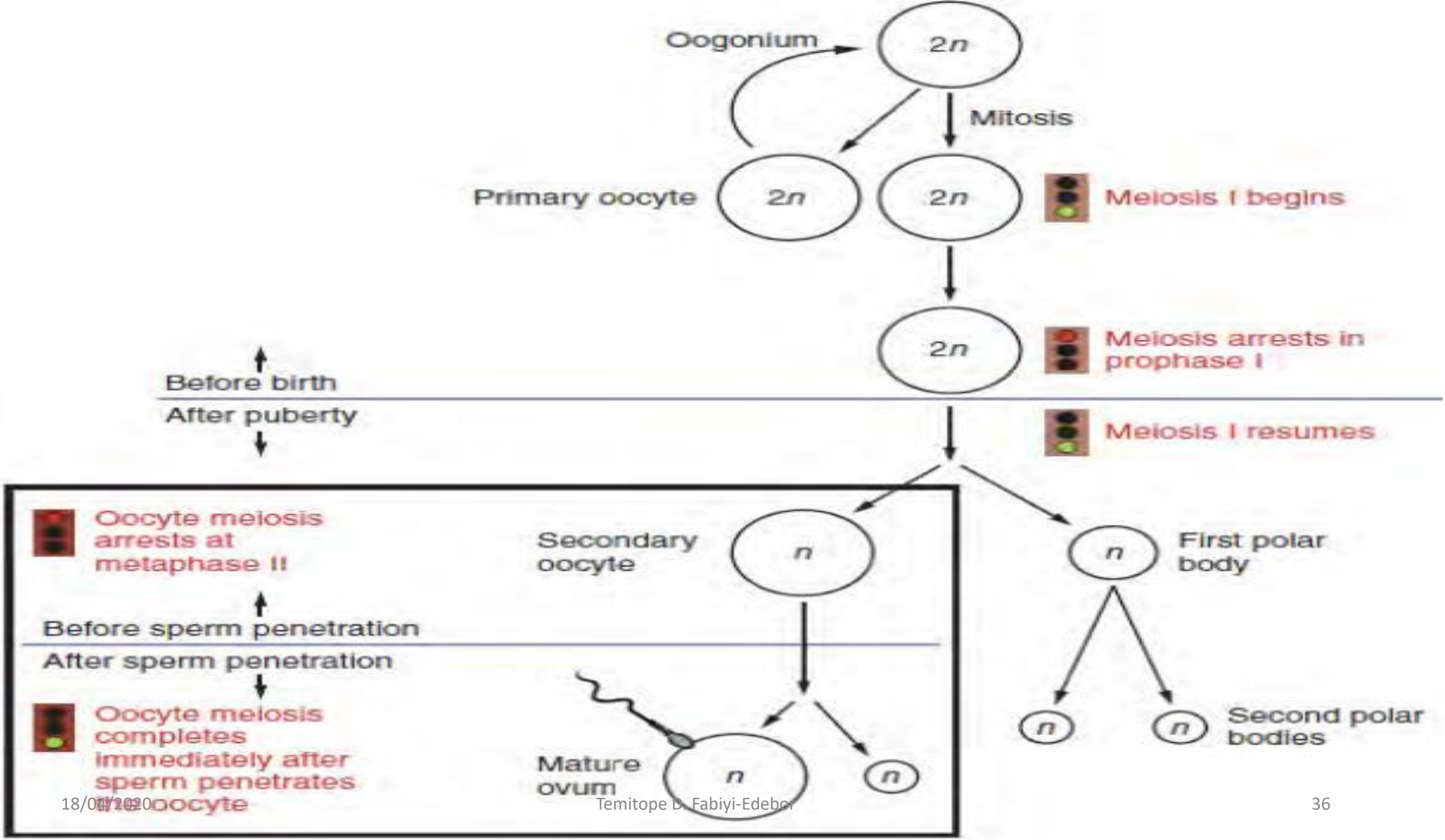
# Ovulation

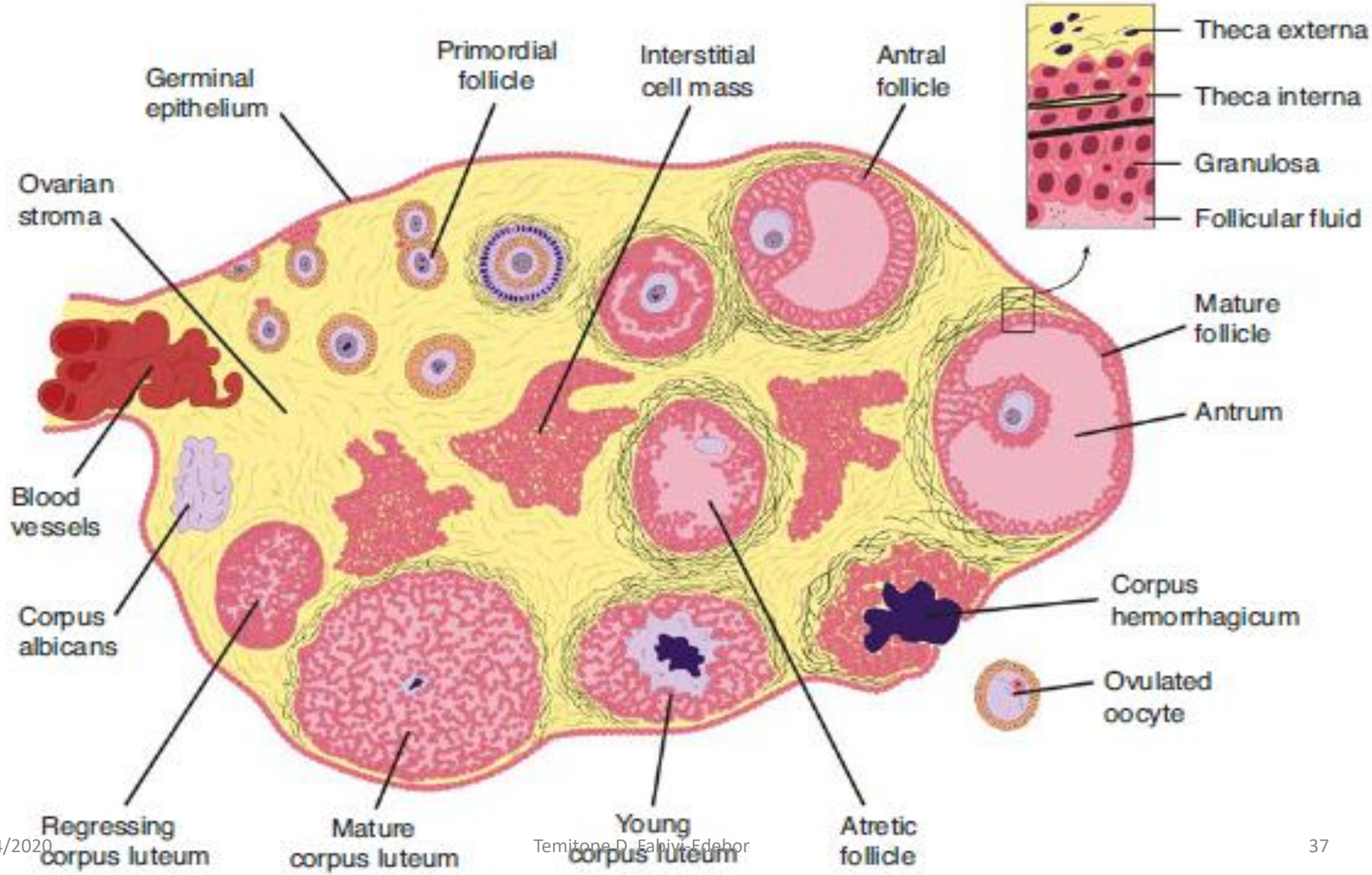
LH surge is responsible
for resumption of meiosis
In primary oocyte to form
secondary oocyte

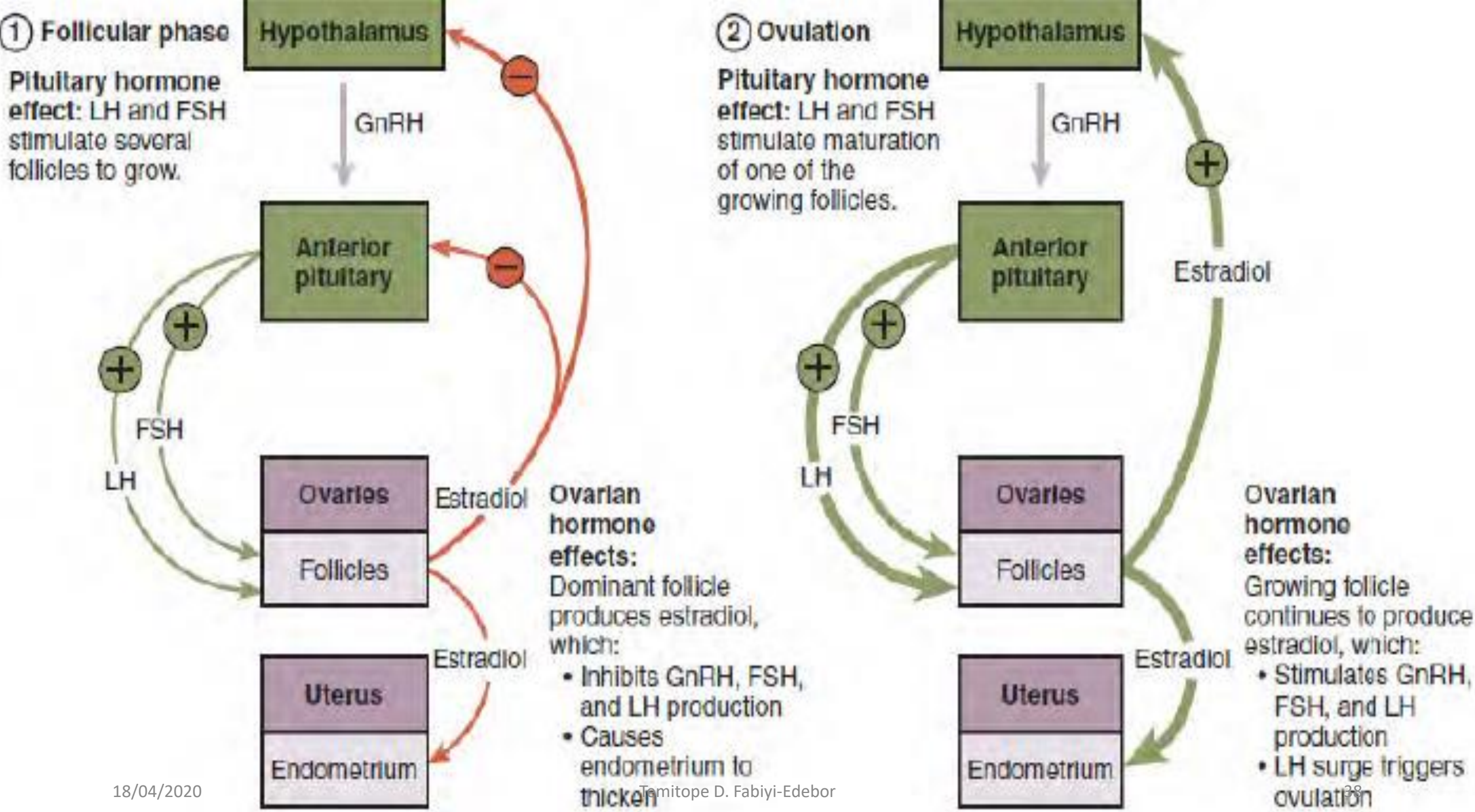
Breakdown of ovary wall
Closest to dominant follicle

Ovulation



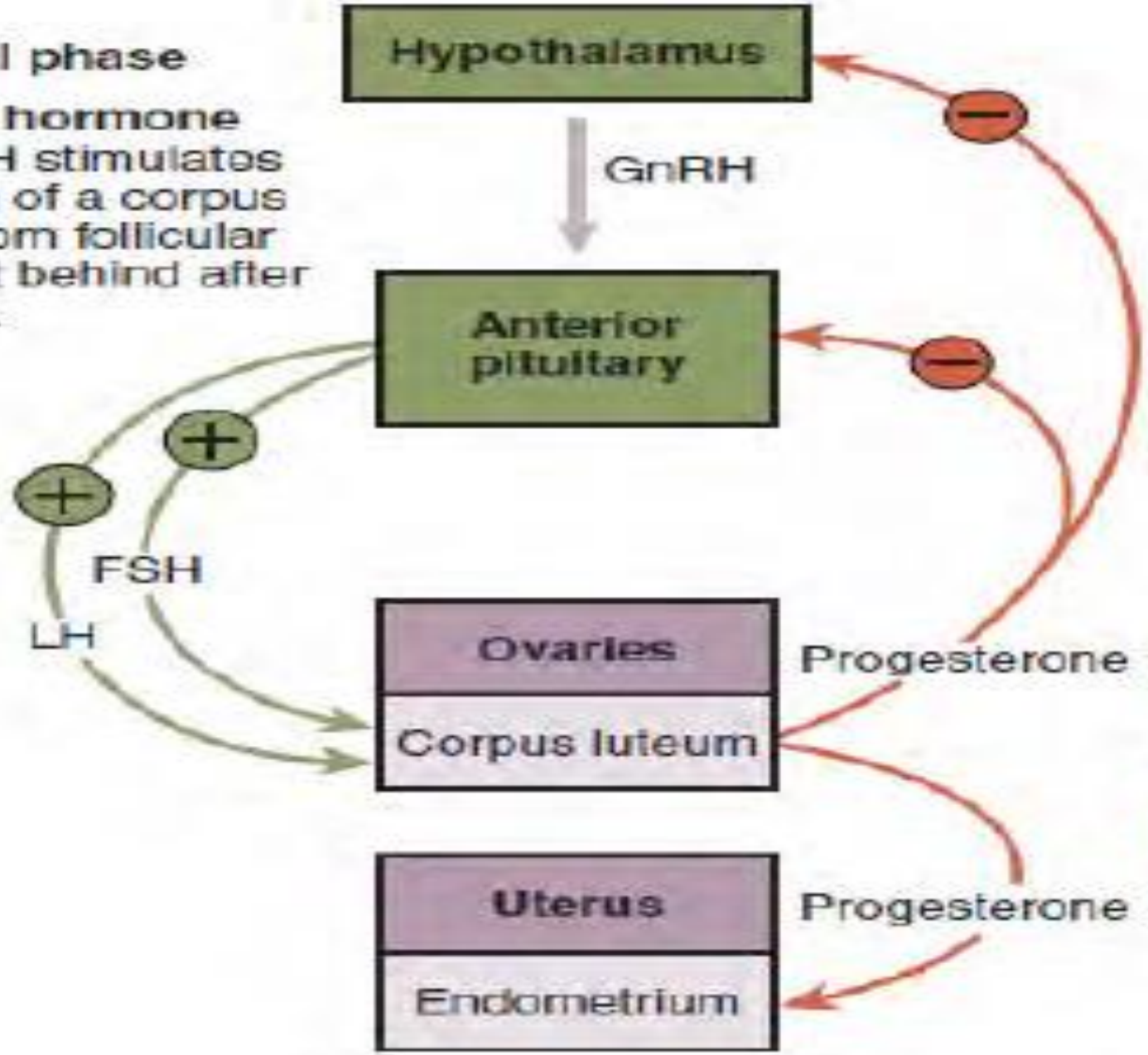

Oogonium
2n
Mitosis
Primary oocyte
2n
2n
Melosis I begins
2n
Meiosis arrests in prophase I
Before birth
After puberty
Meiosis I resumes
Oocyte meiosis arrests at metaphase II
Secondary oocyte
n
n
First polar body
Before sperm penetration
After sperm penetration
Oocyte meiosis completes immediately after sperm penetrates the oocyte
Mature ovum
n
n
n
n
Second polar bodies


Germinal epithelium
Primordial follicle
Interstitial cell mass
Antral follicle
Theca externa
Theca interna
Granulosa
Follicular fluid
Ovarian stroma
Mature follicle
Antrum
Blood vessels
Corpus albicans
Corpus hemorrhagicum
Ovulated oocyte
Regressing corpus luteum
Mature corpus luteum
Young corpus luteum
Atretic follicle


1 Follicular phase
Hypothalamus
Pituitary hormone effect: LH and FSH stimulate several follicles to grow.
GnRH
Anterior pituitary
FSH
LH
Ovaries
Follicles
Estradiol
Estradiol
Uterus
Endometrium
Ovarian hormone effects:
Dominant follicle produces estradiol, which:
• Inhibits GnRH, FSH, and LH production
• Causes endometrium to thicken
2 Ovulation
Hypothalamus
Pituitary hormone effect: LH and FSH stimulate maturation of one of the growing follicles.
GnRH
Anterior pituitary
Estradiol
FSH
LH
Ovaries
Follicles
Estradiol
Uterus
Endometrium
Ovarian hormone effects:
Growing follicle continues to produce estradiol, which:
• Stimulates GnRH, FSH, and LH production
• LH surge triggers ovulation

## ③ Luteal phase

**Pituitary hormone effect:** LH stimulates formation of a corpus luteum from follicular tissue left behind after ovulation.

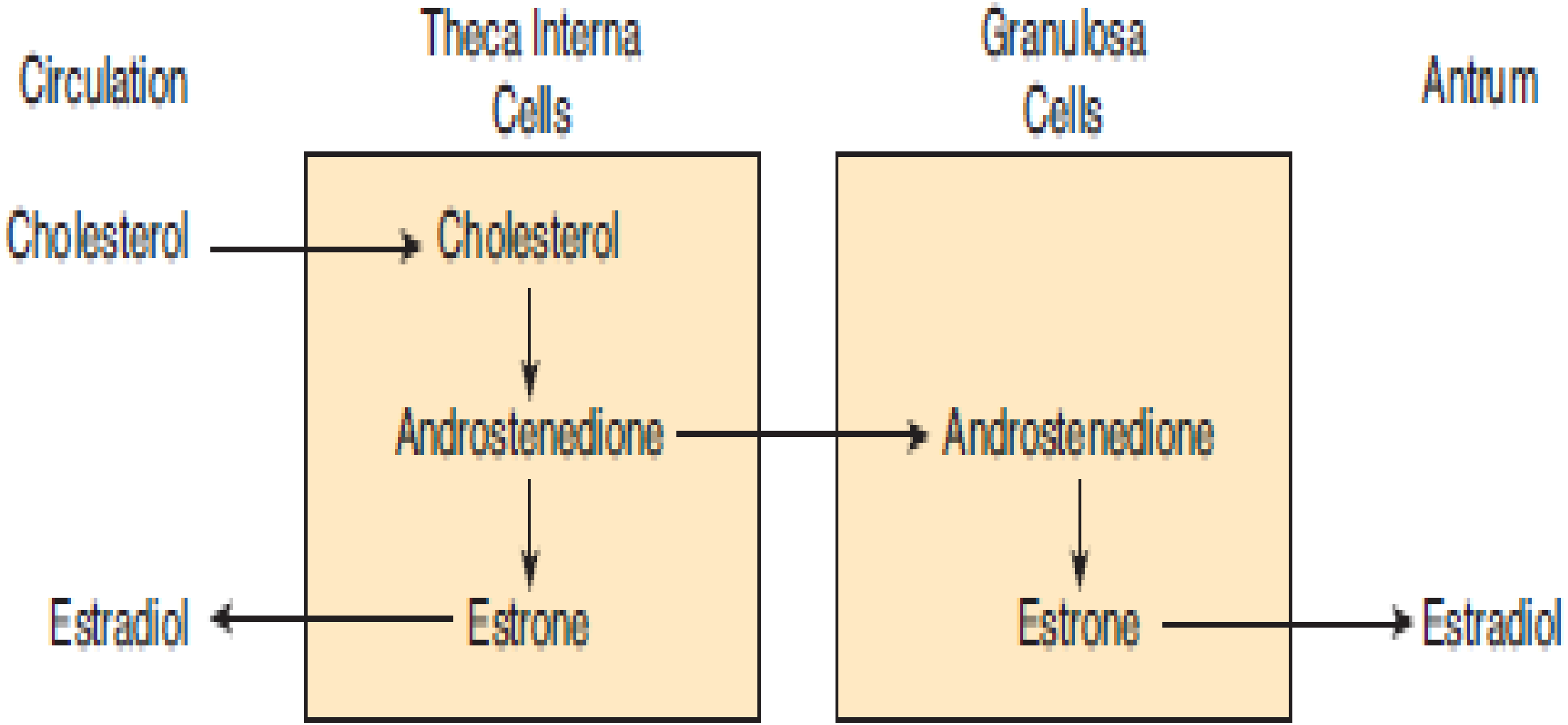



**Ovarian hormone effects:**

The corpus luteum secretes progesterone, which:

- Inhibits GnRH, FSH, and LH production
- Maintains the endometrium; as the corpus luteum degrades, progesterone declines, initiating sloughing of the stratum functionalis

# Ovarian Hormones



- Oestrogens - 17β-estradiol, estrone, and estriol. They are C18 steroids secreted primarily by the granulosa cells of the ovarian follicles, the corpus luteum, and the placenta. Their biosynthesis depends on the enzyme aromatase (CYP19), which converts testosterone to estradiol and androstenedione to estrone.
- Theca interna cells have many LH receptors, and LH acts via cAMP to increase conversion of cholesterol to androstenedione. The theca interna cells supply androstenedione to the granulosa cells which make estradiol secreted into the follicular fluid.
- Granulosa cells have many FSH receptors, and FSH facilitates their secretion of estradiol by acting via cAMP to increase their aromatase activity. Mature granulosa cells also acquire LH receptors, and LH also stimulates estradiol production.
- Two percent of the circulating estradiol is free, and the remainder is bound to protein: 60% to albumin and 38% to the same gonadal steroid-binding globulin (GBG) that binds testosterone.

# Functions of oestrogen

- Growth of ovarian follicles
- Motility of uterine tubes, Uterine contractions and blood flow
- Feminizing hormone
- Breast growth, enlargement, ductal growth and areolar pigmentation
- Slight salt and water retension esp b4  menstruation
- Estrous behaviour and Increased libido
- Protein anabolism
- Bone growth and Epiphysial closure
- Post-coital contraception via interference with implantation and increased angiotensinogen secretion

# Daily production rates of sex hormones in women at different stages of the menstrual cycle

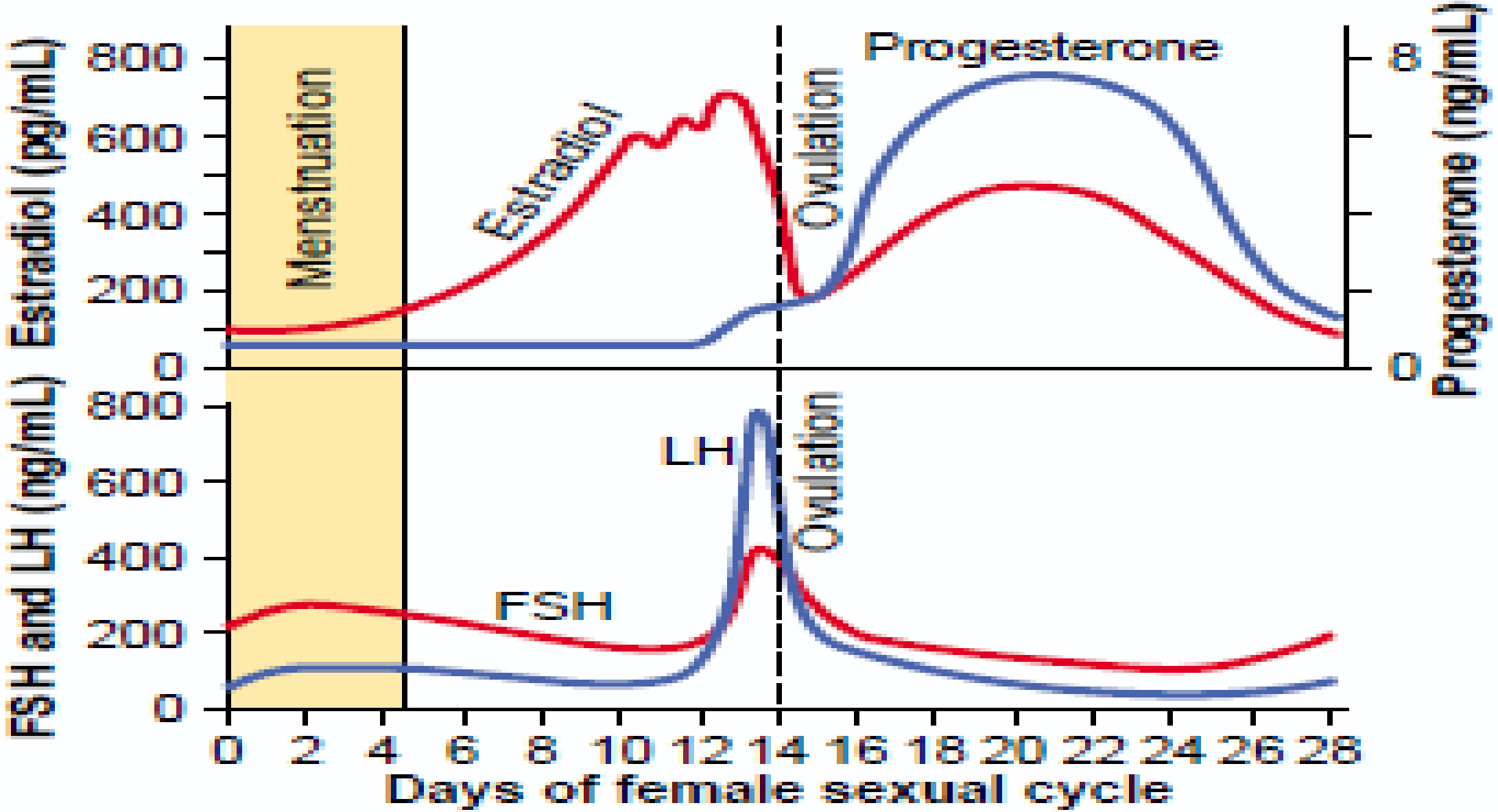
| Sex Steroids | Early Follicular | Preovulatory | Midluteal |
|---|---|---|---|
| Progesterone (mg) | 1.0 | 4.0 | 25.0 |
| 17-hydroxyprogesterone (mg) | 0.5 | 4.0 | 4.0 |
| Dehydroepiandrosterone (mg) | 7.0 | 7.0 | 7.0 |
| Androstenedione (mg) | 2.6 | 4.7 | 3.4 |
| Testosterone (µg) | 144.0 | 171.0 | 126.0 |
| Estrone (µg) | 50.0 | 350.0 | 250.0 |
| Estradiol (µg) | 36.0 | 380.0 | 250.0 |

# Progesterone

- Progesterone is a C21 steroid secreted by the corpus luteum, the placenta, and (in small amounts) the follicle.
- In women, the level is approximately 0.9 ng/mL (3 nmol/L) during the follicular phase of the menstrual cycle due to secretion of progesterone by cells in the ovarian follicles; theca cells provide pregnenolone to the granulosa cells, which convert it to progesterone. Late in the follicular phase, progesterone secretion begins to increase.
- During the luteal phase, the corpus luteum produces large quantities of progesterone thus plasma progesterone is markedly increased to a peak value of approximately 18 ng/mL (60 nmol/L)

# Function of Progesterone

- Progesterone is responsible for the progestational changes in the endometrium and the cyclic changes in the cervix and vagina.
- It has an antiestrogenic effect on the myometrial cells, decreasing their excitability, their sensitivity to oxytocin, and their spontaneous electrical activity while increasing their membrane potential. It also decreases the number of estrogen receptors in the endometrium and increases the rate of conversion of 17β- estradiol to less active estrogens.
- Breast – Lobules and alveoli development. Secretion during lactation
- Thermogenic effect – temperature rise during ovulation
- Stimulates respiration and reduces alveolar PCO2 during pregnancy and lactation
- Pregnancy hormone – sustains pregnancy


Progesterone
Estradiol
Menstruation
Ovulation
Estradiol (pg/mL)
Progesterone (ng/mL)
800
600
400
200
0
8
0
LH
FSH
Ovulation
FSH and LH (ng/mL)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Days of female sexual cycle

# ASSIGNMENT

CYCLIC CHANGES IN THE CERVIX, VAGINA AND BREASTS

# FERTILIZATION & PREGNANCY

Next class