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بسم الله الرحمن الرحيم

DOPAMINE SCIENTIFIC TEAM

Female Physiology before Pregnancy (pt.1)

FINAL | Lecture 1

﴿ قُلْ بِفَضْلِ ٱللَّهِ وَبِرَحْمَتِهِۦ فَبِذَٰلِكَ فَلْيَفْرَحُوا۟ هُوَ خَيْرٌ مِّمَّا يَجْمَعُونَ ﴾

Written by: Leen Mamoon
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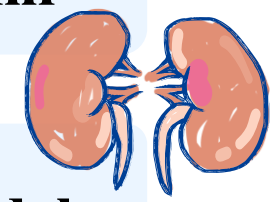


فريق دوبامين العلمي - THE SCIENTIFIC TEAM OF DOPAMINE - APPROVED 0500361

GUYTON & HALL, CHAPTER 82
EBAA M ALZAYADNEH,PHD ASSOCITAE PROF.

PHYSIOLOGY OF OVARIAN CYCLE

"اللَّهُمَّ إِنِّي أَسْأَلُكَ فَهْمَ النَّبِيِّينَ، وَحِفْظَ الْمُرْسَلِينَ، وَإِلْهَامَ الْمَلَائِكَةِ الْمُقَرَّبِينَ، بِرَحْمَتِكَ يَا أَرْحَمَ الرَّاحِمِينَ"

By the end of this lecture, you should be able to:

- List the hormones of female reproduction and describe their physiological functions
- Describe the changes that occur in the **ovaries** during the menstrual cycle
- Describe the hormonal control of the development of ovarian follicles, mature oocytes and corpus luteum
- Recognize the *pituitary-ovarian-axis* and the changes that occur in the ovaries leading to ovulation

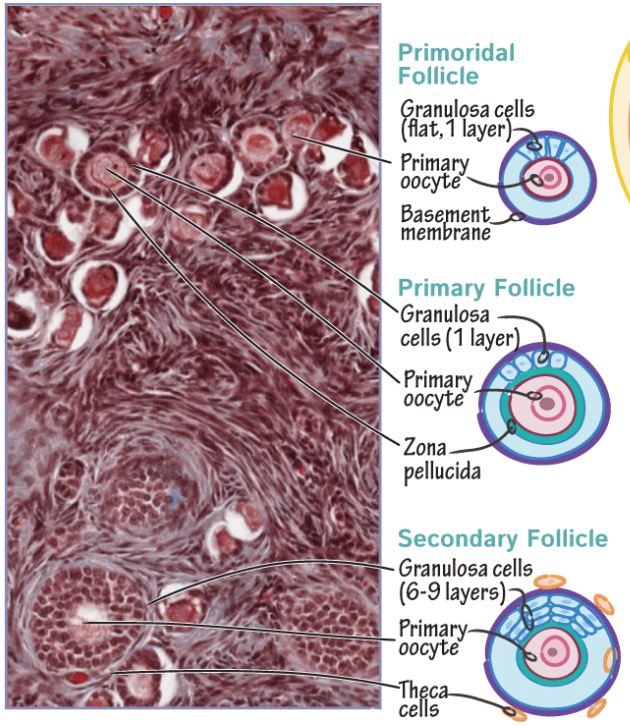
Recall from general Embryology Lectures

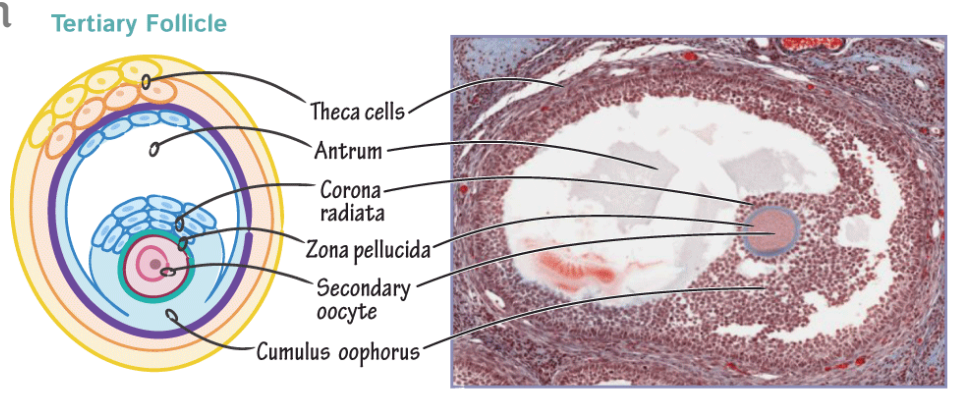
Key structures to remember:

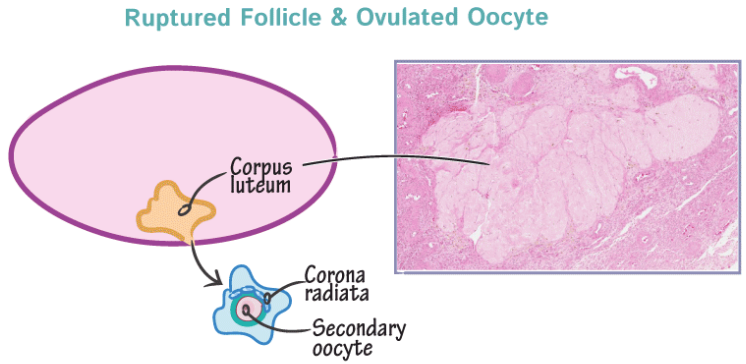
- **Granulosa cells** → inner follicular cells surrounding the oocyte; mainly respond to FSH.
- **Theca cells** → outer follicular cells; mainly respond to LH and produce androgens.
- **Zona pellucida** → acellular glycoprotein layer surrounding the oocyte.
- **Basement membrane** → separates granulosa cells from theca cells.
- **Antrum** → fluid-filled cavity seen in growing follicles.
- **Corona radiata** → granulosa cells directly adjacent to the zona pellucida.

OVARY & OVA

Extra diagram

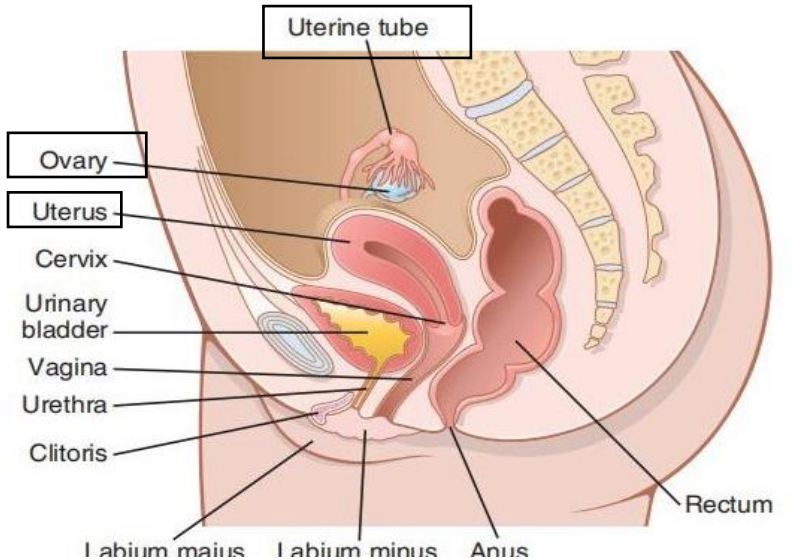


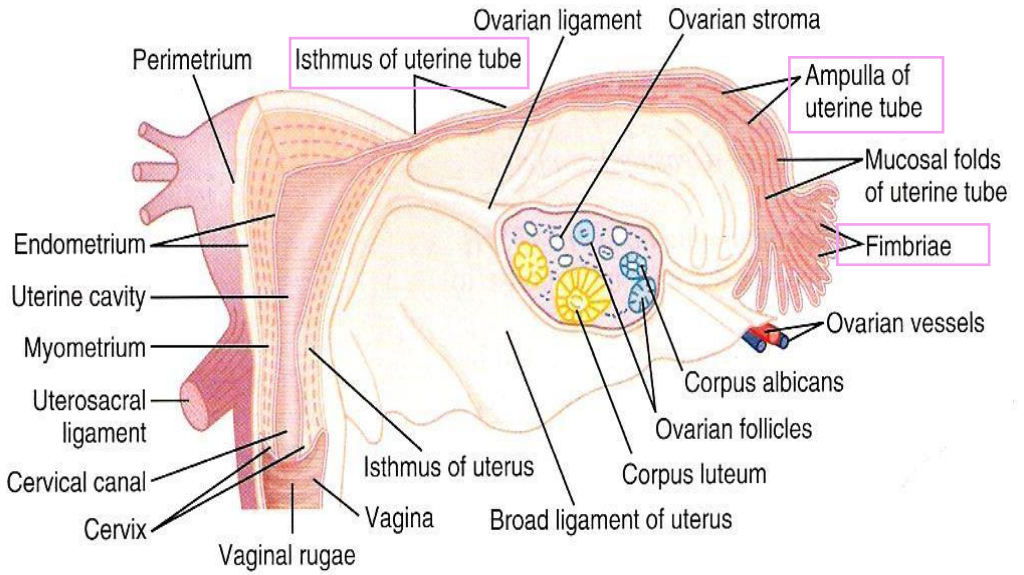




Make sure to check resources in the last slides.

Physiologic Anatomy of the Female Sexual Organs





- The primary organs of the female reproductive system are the **ovaries** where the female gametes develop and mature. The **uterine (fallopian) tubes** are composed mainly of several segments, these include the infundibulum, which is the open end of the tube, and contains finger-like projections known as fimbriae. These projections receive the ovum during ovulation and guide it into the uterine tube, other segments of the uterine tube include the ampulla, which is the longest part of the tube, and the isthmus and the intramural part which connects the uterine tube with the **uterus.**
- The **uterus** consists of the body, fundus, cervical canal and cervix.

Monthly Reproductive "Menstrual" Cycle

- Normal reproductive age of female → Monthly **rhythmical changes** in the rates of secretion of female hormones & corresponding physical changes in the ovaries & other sexual organs, this monthly cycle is referred to as **the female reproductive cycle,** or sometimes **the menstrual cycle,** this is not precise term since the ovarian cycle is the most important component of the process.

- **Duration of the cycle** averages **28 days** (20-45 days).

- **There are 2 results of the female sexual cycle:**
- *Single* ovum is released from the ovaries each month
- Uterine endometrium is prepared for implantation of the fertilized ovum.

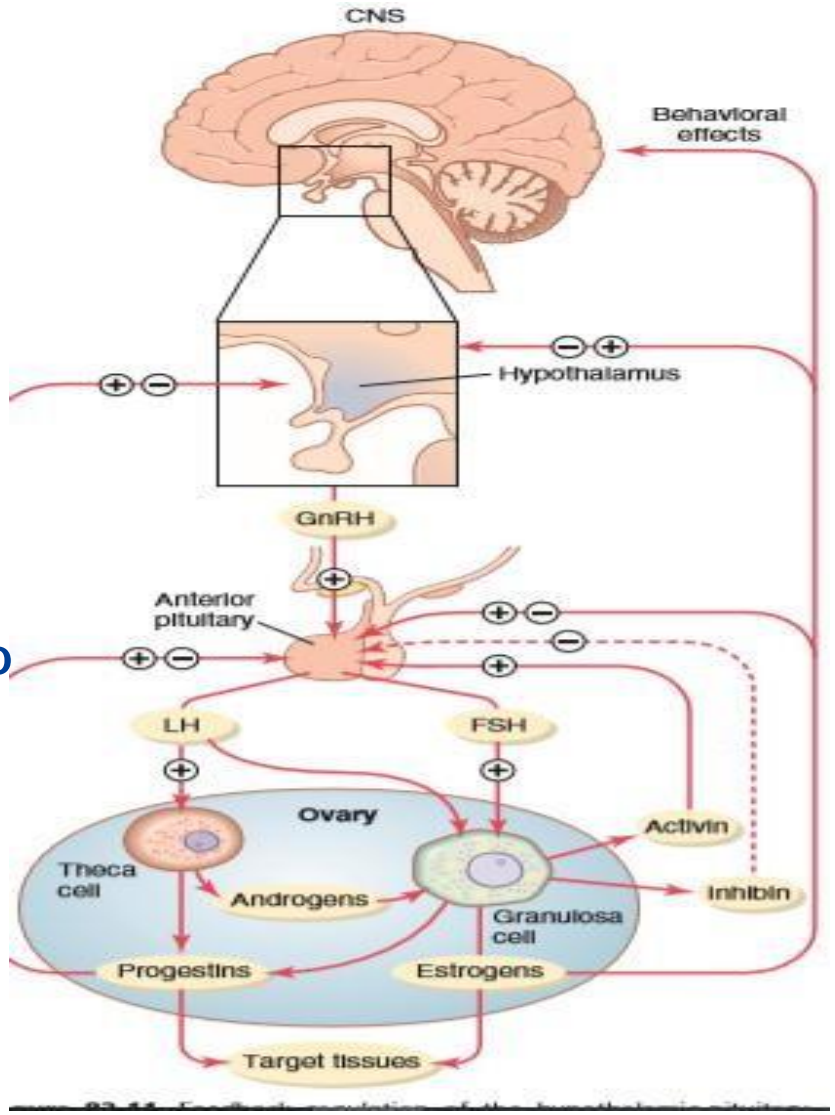
GONADOTROPIC HORMONES AND THEIR EFFECTS ON THE OVARIES -1

- As with any hormonal system, regulation and feedback mechanisms are always involved in controlling hormone secretion. In the female reproductive cycle, the hormones themselves are part of the feedback system.

- The axis begins in the **central nervous system**, specifically the **hypothalamus**, which secretes **gonadotropin-releasing hormone (GnRH).**

- **GnRH** secretion begins in significant amounts at **puberty**. This is due to maturation processes in the brain that lead to the initiation of GnRH release at this stage, this typically occurs around the age of 13–14 years.

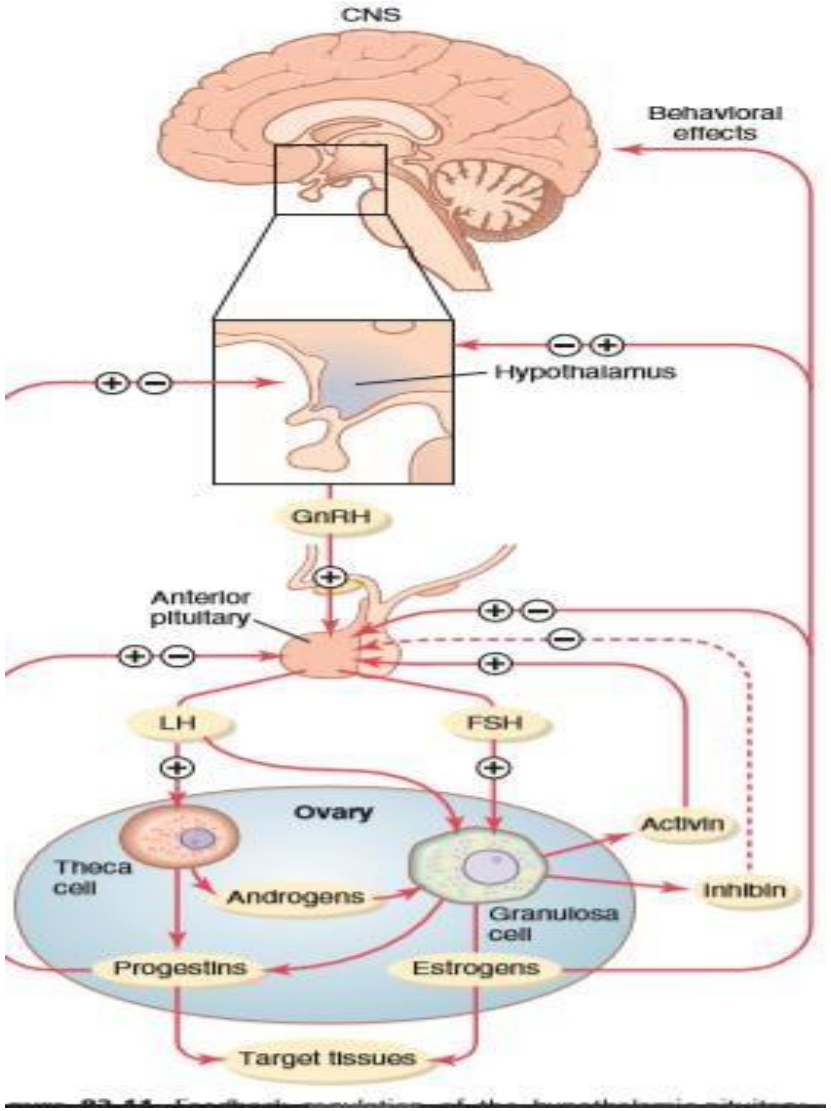
- **GnRH** then stimulates the **anterior pituitary** gland to release two main hormones: **Luteinizing hormone (LH), Follicle-stimulating hormone (FSH).**



GONADOTROPIC HORMONES AND THEIR EFFECTS ON THE OVARIES-2

- These hormones are released in a specific pattern, where **FSH is secreted earlier than LH**, and its level increases at the beginning of the cycle, the beginning of the cycle is considered day #1, which is the first day of menstruation (first day of bleeding), at the beginning of the female cycle, FSH levels begin to rise, and this has an effect on the ovaries.

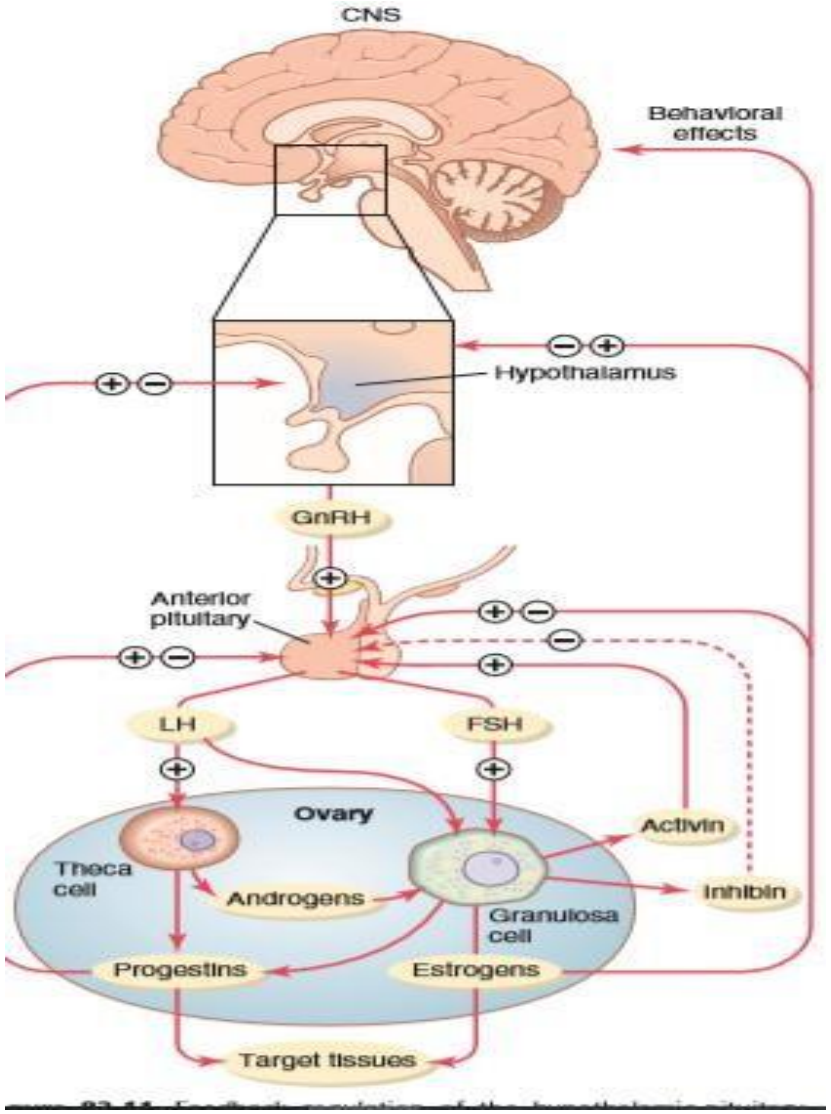
- FSH and LH act on receptors located on two types of cells, **granulosa cells** and **theca cells**, which are found within the ovarian follicle, a sac-like structure containing the oocyte. The **oocyte** is centrally located and surrounded by a single layer of **granulosa cells** in primordial follicles *next slide**, with further development, an outer layer of **theca cells** is formed surrounding the granulosa layer.



GONADOTROPIC HORMONES AND THEIR EFFECTS ON THE OVARIES -3

- *Female are born with thousands of follicles in their ovaries, known as **primordial follicles**. At birth, these follicles are not developed and are in a latent state while at puberty, they begin to develop, growth and enlarge under the effect of **LH & FSH** binding, and the **oocytes** within them also undergo further development. *This will be discussed in more detail later.*

- When **FSH** binds to its receptors on **granulosa cells**, it stimulates them to produce ***estrogen***, mainly through the conversion of **androgens** into **estrogen** via enzymatic activity (aromatase). ***Estrogen*** is then released as part of follicular function and hormonal regulation. Note that the follicle is acting like a gland, secreting female hormones.



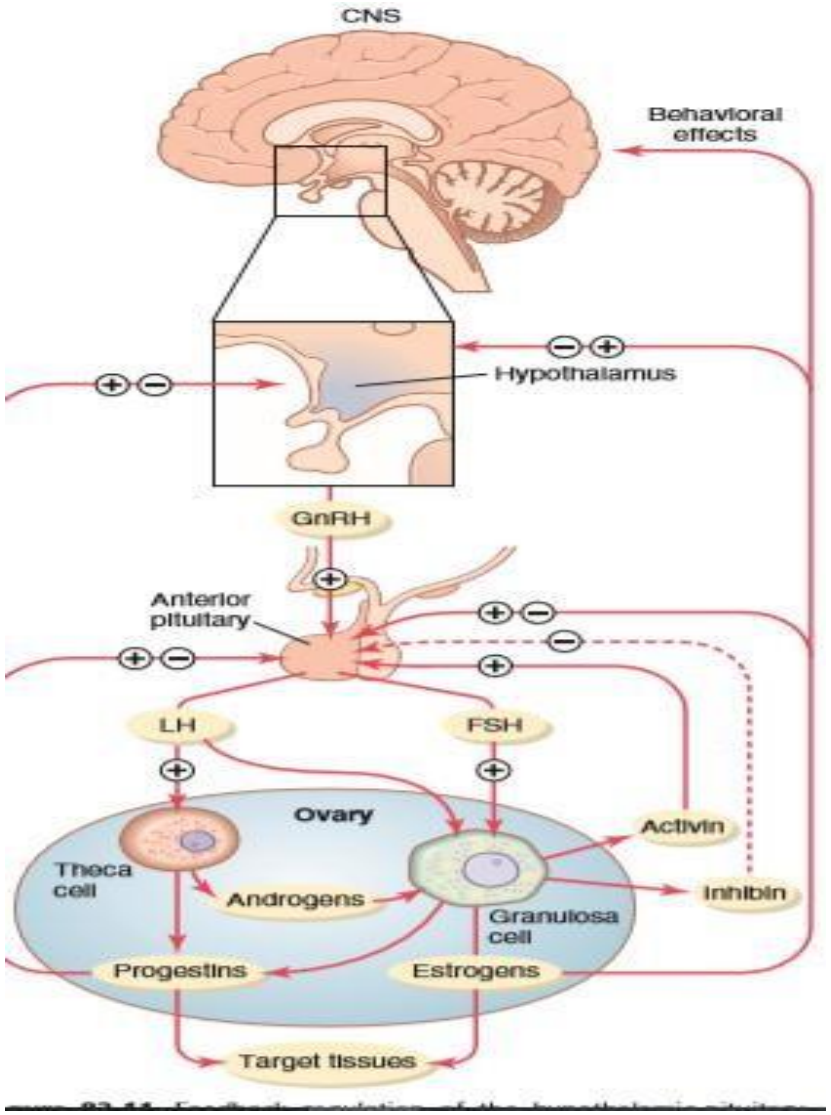
GONADOTROPIC HORMONES AND THEIR EFFECTS ON THE OVARIES -4

- **LH** has receptors on both cell types, but its main action is on the **theca cells**. At the peak of the cycle, ***estrogen*** is released in higher amounts, while in the second half of the cycle, ***progesterone*** is secreted in higher levels with a lower amount of estrogen.

- Both FSH and estrogen contribute to follicular growth and maturation. Rising estrogen levels from the dominant follicle stimulate the mid-cycle LH surge, which triggers ovulation.

- ***Estrogen*** exerts a negative feedback effect on the anterior pituitary gland as well as the hypothalamic center, forming part of the regulatory feedback mechanism, ***Progesterone*** also exerts feedback, but its effect is less potent compared to estrogen.

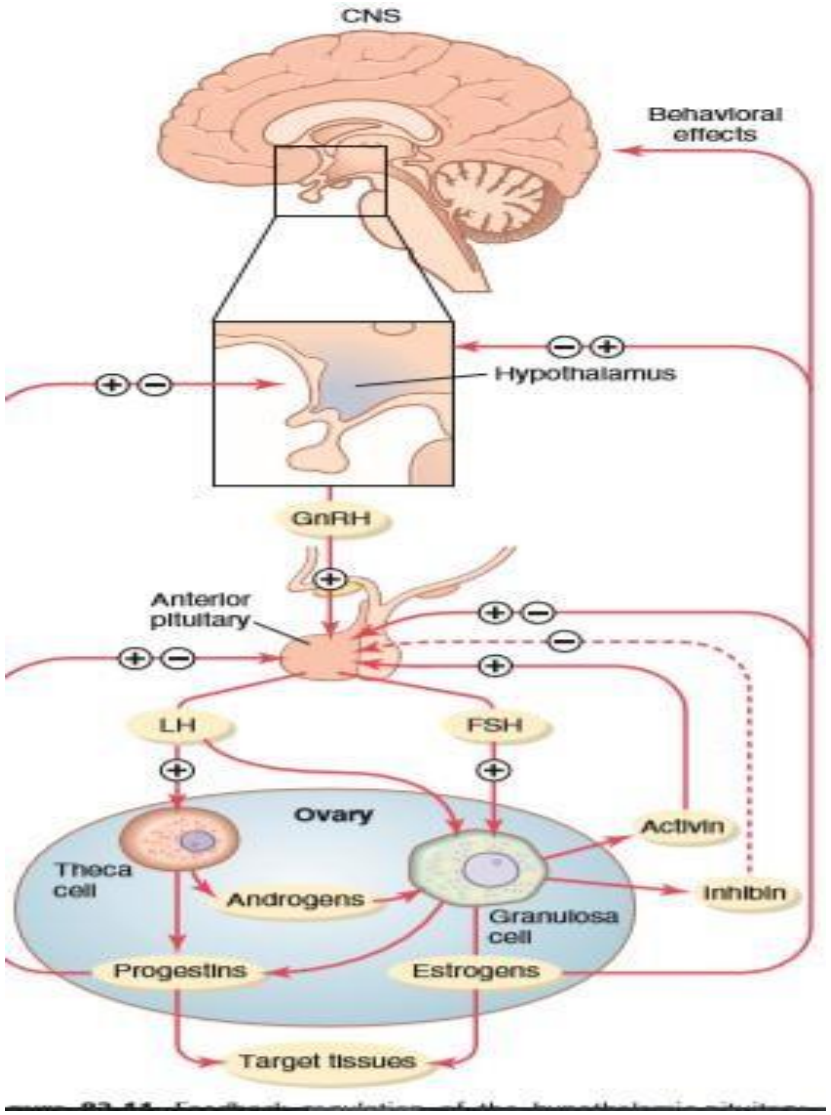
- In addition, **granulosa cells** secrete ***inhibin***, a hormone that exerts **negative feedback** on the anterior pituitary gland, suppressing FSH secretion.



GONADOTROPIC HORMONES AND THEIR EFFECTS ON THE OVARIES

- The **ovarian changes** during the sexual cycle depend completely on FSH & LH secreted by AP.

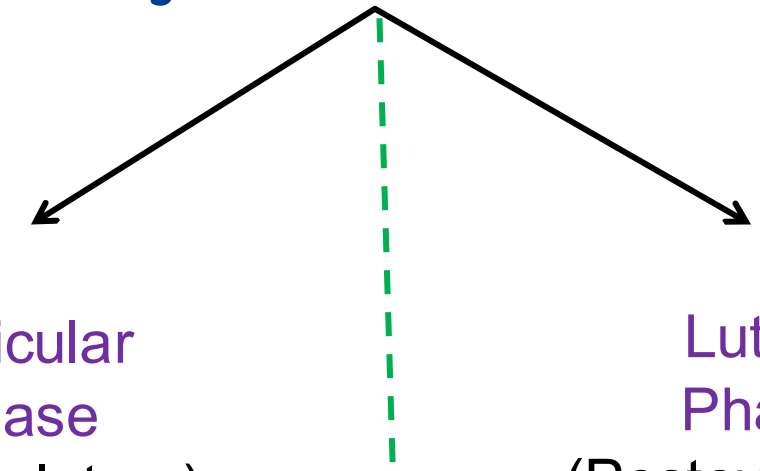
- **Both FSH and LH** stimulate their ovarian target cells by combining with highly specific receptors leading to an increase in the cells rates of secretion, growth & proliferation.



Ovarian Cycle

Before starting, remember that **two** synchronized **cycles** occur **simultaneously**: the **ovarian cycle** and the **uterine cycle**. **Pay close attention** to the **phases** of each cycle and how they correlate with one another.

The ovarian cycle consists of three main phases:



- ✓ The first phase is ***the follicular phase*** which involves the development of the follicle, beginning from primordial (primitive) follicles and progressing through further stages of growth. This phase is also referred to as the **pre-ovulatory phase**, as it occurs before ovulation.

The second phase is ***ovulation***, which is the process involving **rupture** of the **follicle** and **release** of the **oocyte**.

- ✓ The third phase is ***the luteal phase***. During this phase, the remaining part of the follicle transforms into the **corpus luteum** under the stimulation of luteinizing hormone **(LH)**, the cells in the remaining follicle (GC & TC) become **lutein cells**, characterized by **yellow** coloration due to lipid (fat) droplets. These cells are highly secretory and produce **progesterone**, as well as **inhibin** and estrogen.

Ovarian follicle growth -1

"Follicular" phase of the ovarian cycle:

- In female child each ovum is surrounded by single granulosa cell sheath called *primordial follicle* which provides nourishment for the ovum & secrete oocyte *maturation-inhibiting factor* which keeps the ovum in its primordial state.

- After puberty, AP secretes FSH and LH under the effect of GnRH resulting in ovum to increase in size & growth of additional layers of granulosa cells of some follicles known as primary follicles

Ovarian follicle growth -2

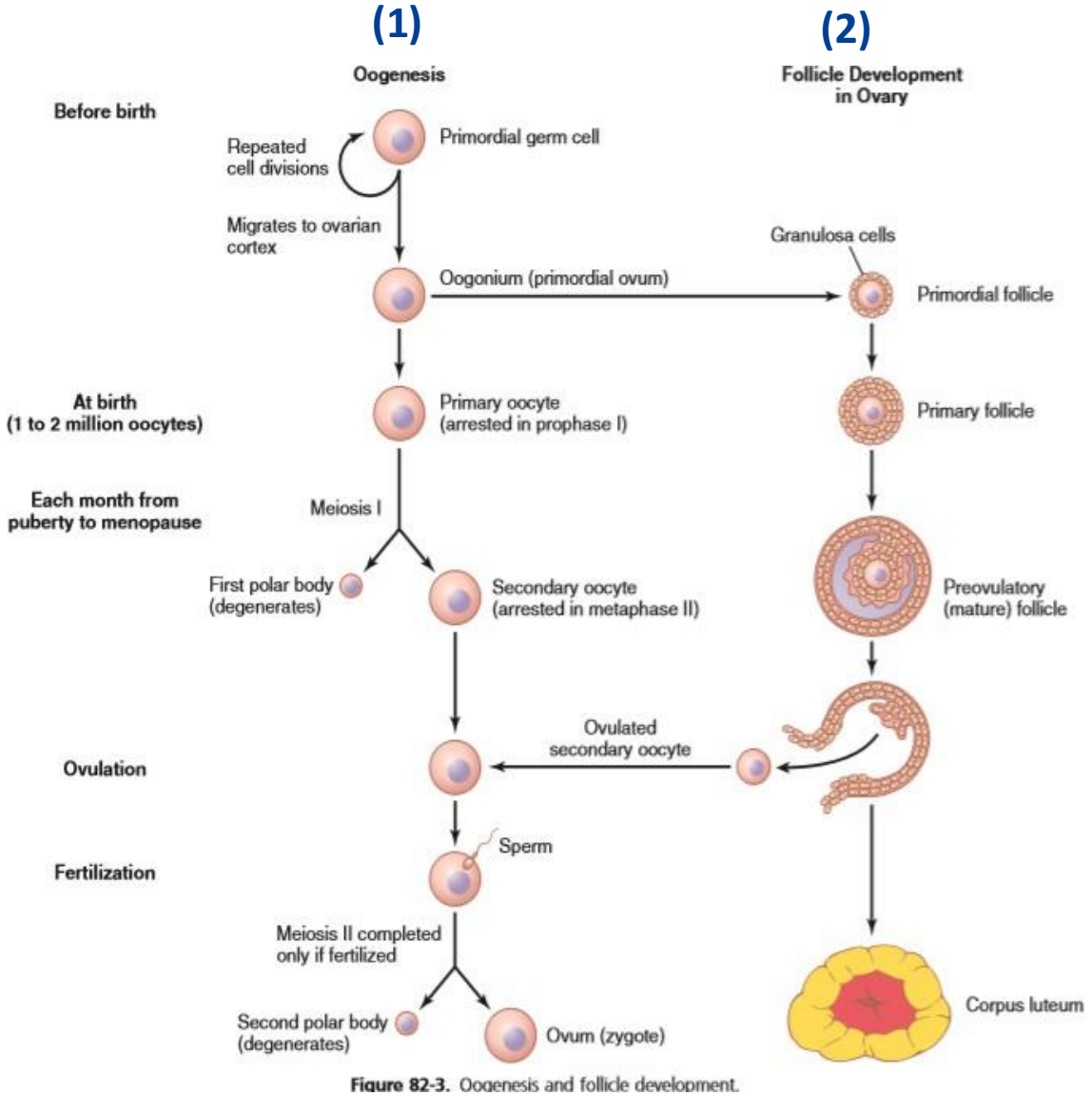


Figure 82-3. Oogenesis and follicle development.

- 1) **Oogenesis** is the process of development of the oocyte, **beginning** from the **embryonic stage** and progressing from primordial germ cells to oogonium (primordial ovum), and ultimately to the mature ovum. These phases involve *mitosis* and *meiosis* and occur at different stages of female development.

- 2) This represents **follicular development,** which includes the events occurring in the ovary associated with the oocyte.

✓ **Oogenesis** in females begins before birth, during intrauterine life, unlike **spermatogenesis** in males, which begins after puberty.

Ovarian follicle growth -3

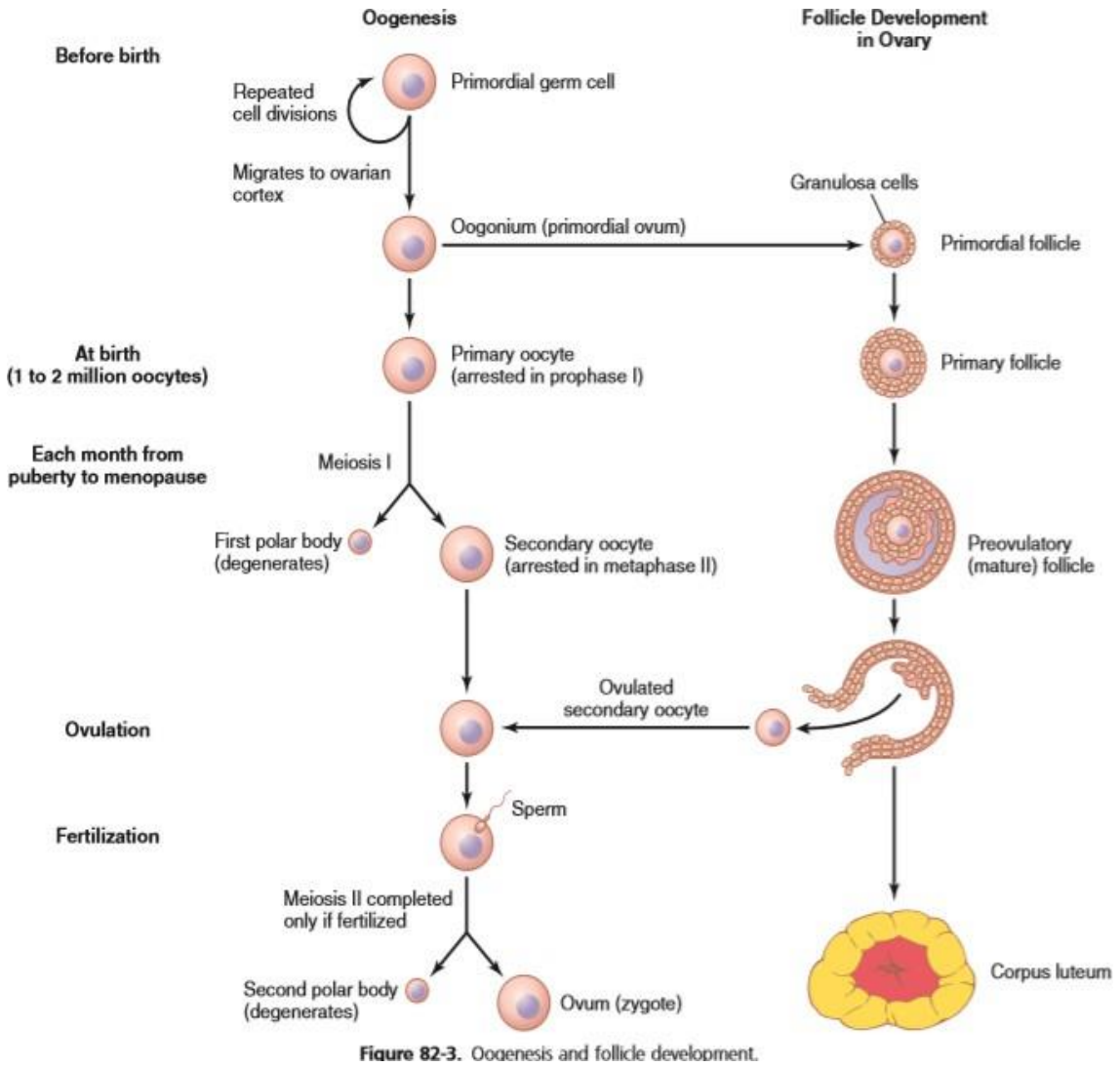


Figure 82-3. Oogenesis and follicle development.

- During **embryological development,** primordial germ cells **migrate from the yolk sac** to the ovaries, specifically to the **ovarian cortex**, **before** migration, these cells undergo **mitosis**, increasing in number.
- After reaching the ovarian cortex, they become **surrounded by stromal cells**, which **differentiate into granulosa cells**, these granulosa cells organize to form the **primordial follicle**, a structure that surrounds the oocyte and provides support.
- At this stage, the oocyte begins **meiosis I** but does not complete it. Instead, it becomes **arrested** in **prophase I** and remains as a **primary oocyte**. These primary oocytes are diploid and persist in a dormant (latent) state within the primordial follicle.

Ovarian follicle growth -4

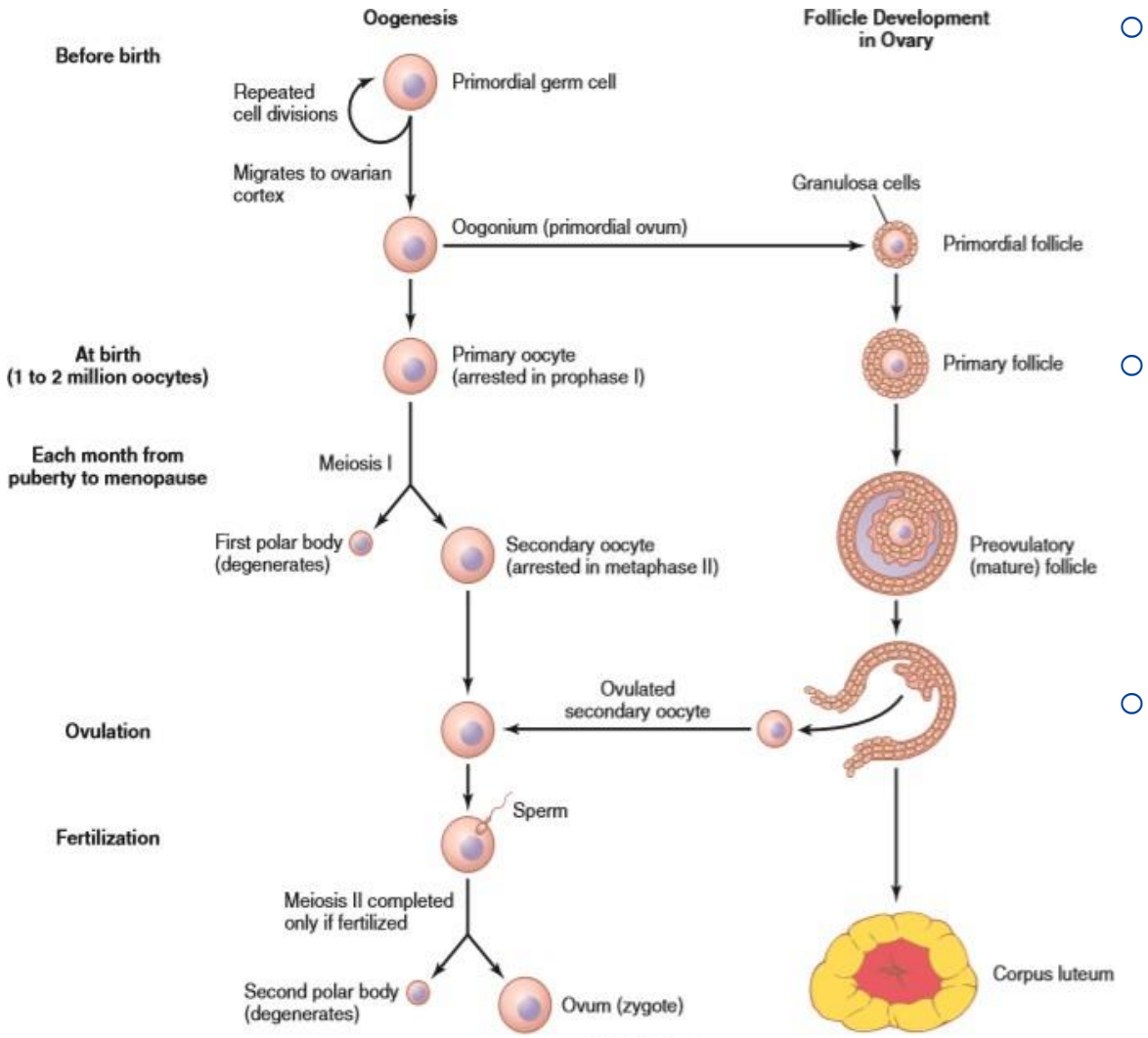


Figure 82-3. Oogenesis and follicle development.

- At birth, a female has approximately one to two million oocytes within primordial follicles, oogenesis begins during fetal life and is arrested at this stage; therefore, there is no further development of follicles or oocytes after birth until puberty.
- **After puberty,** under the influence of hormonal stimulation, especially FSH and LH, follicles begin to grow and **undergo development**. This is associated with increased proliferation of granulosa cells, leading to follicular enlargement.
- Follicular development proceeds through stages, where the primary follicle develops into a secondary follicle, during this process, fluid secreted by granulosa cells accumulates to form a fluid-filled cavity called the **antrum**.

Ovarian follicle growth -5

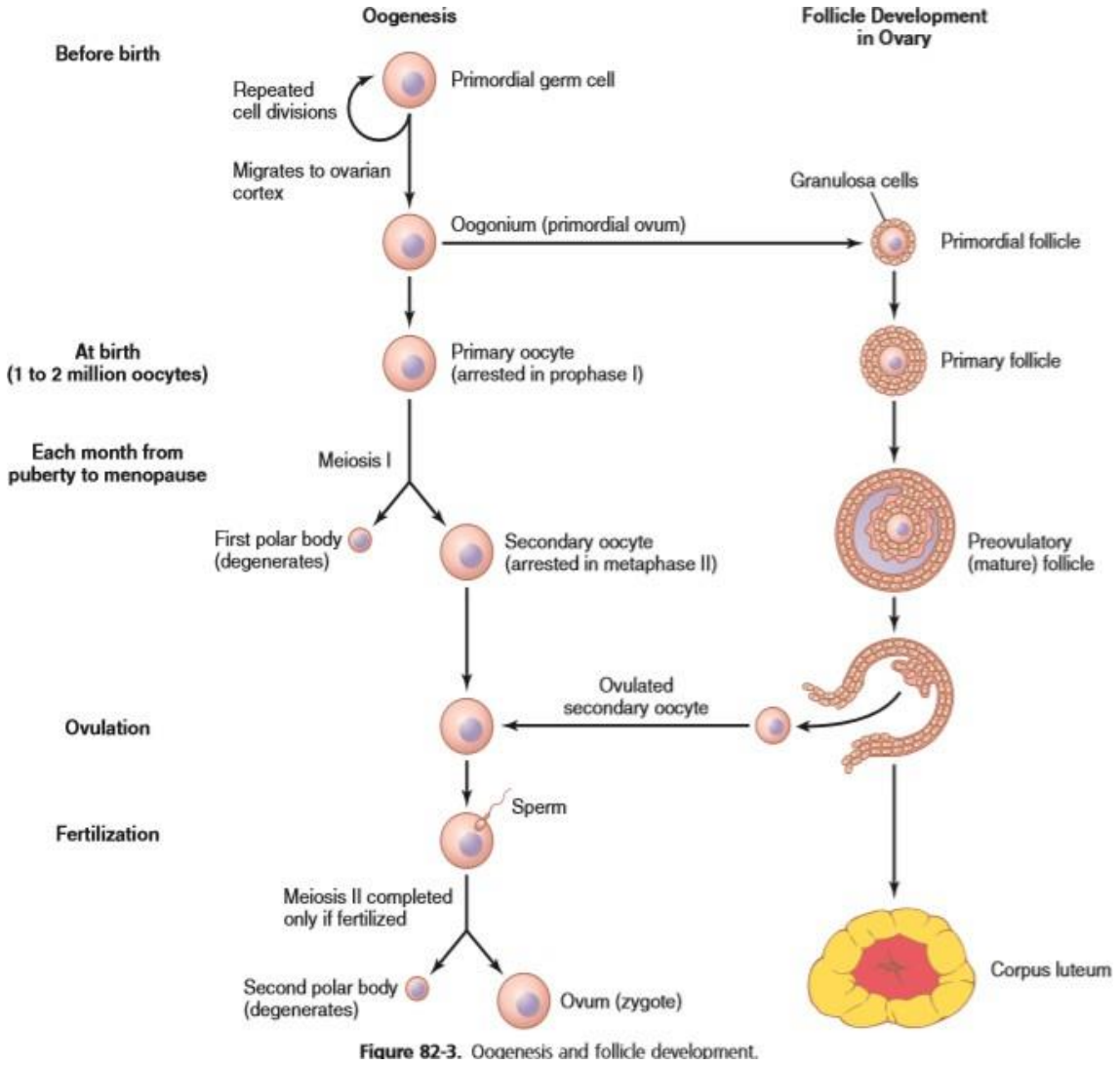


Figure 82-3. Oogenesis and follicle development.

- As the follicle grows, the oocyte remains located at one pole of the follicle and is surrounded by granulosa cells forming the **corona radiata.**
- Layers derived from the ovarian stroma (interstitium) differentiate to form the **theca layer, which develops into theca interna and theca externa,** The *theca interna* is more cellular and epithelial-like in appearance, similar to granulosa cells, while the **theca externa** is more fibrous, consisting mainly of collagen and connective tissue and containing blood vessels.

Ovarian follicle growth -6

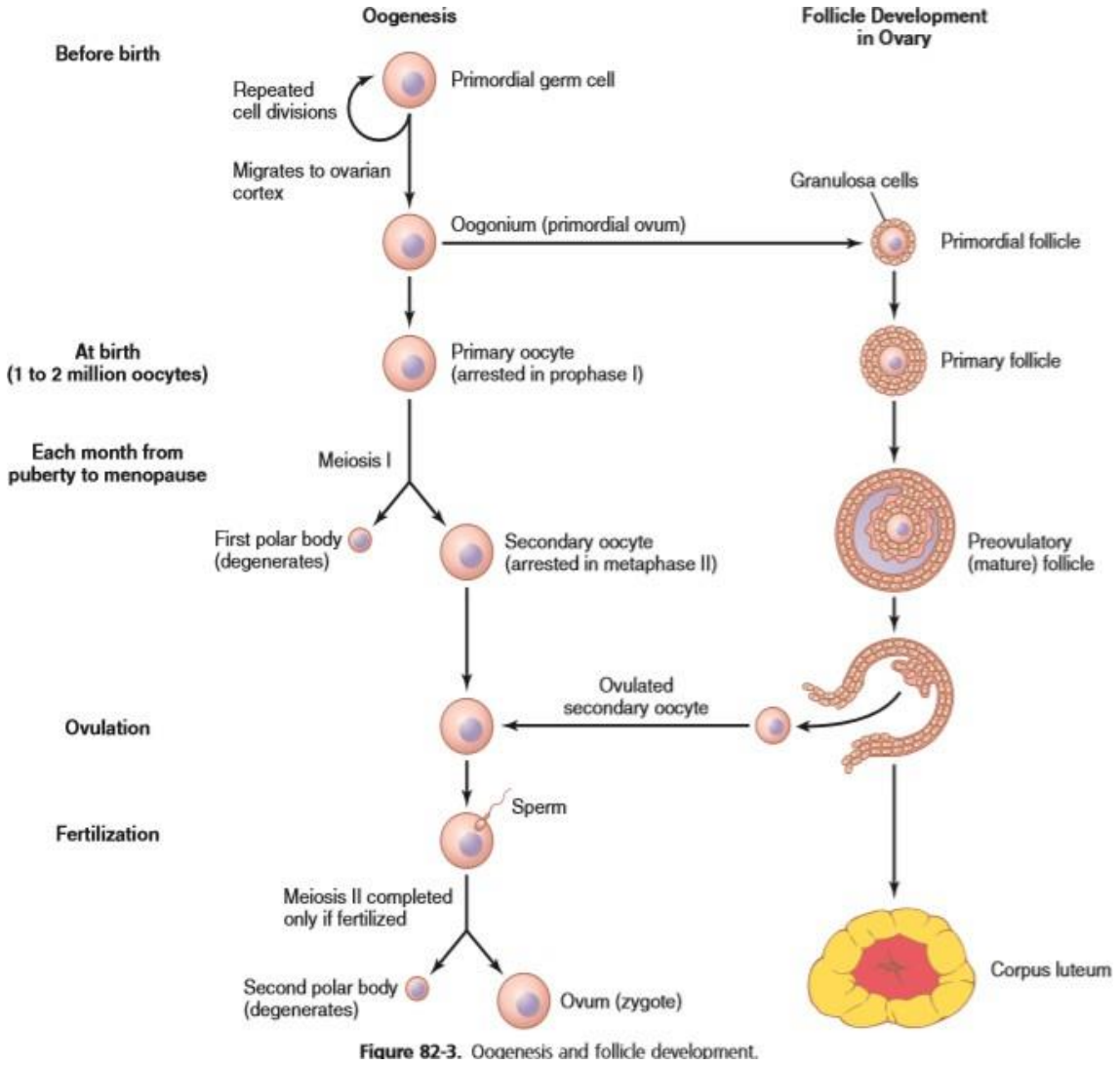


Figure 82-3. Oogenesis and follicle development.

- After puberty, the primary oocyte remains arrested in prophase I until just before ovulation. Shortly before ovulation, it completes meiosis I, resulting in an unequal division that produces a **large secondary oocyte** (haploid) and a **small first polar body,** the first polar body is discarded and has no functional role other than reducing the chromosome number.

- The secondary oocyte is then released from the mature Graafian follicle at mid cycle.

✓ Usually, in each monthly cycle, only one follicle reaches full maturation, and consequently one secondary oocyte is released.

Ovarian follicle growth -7

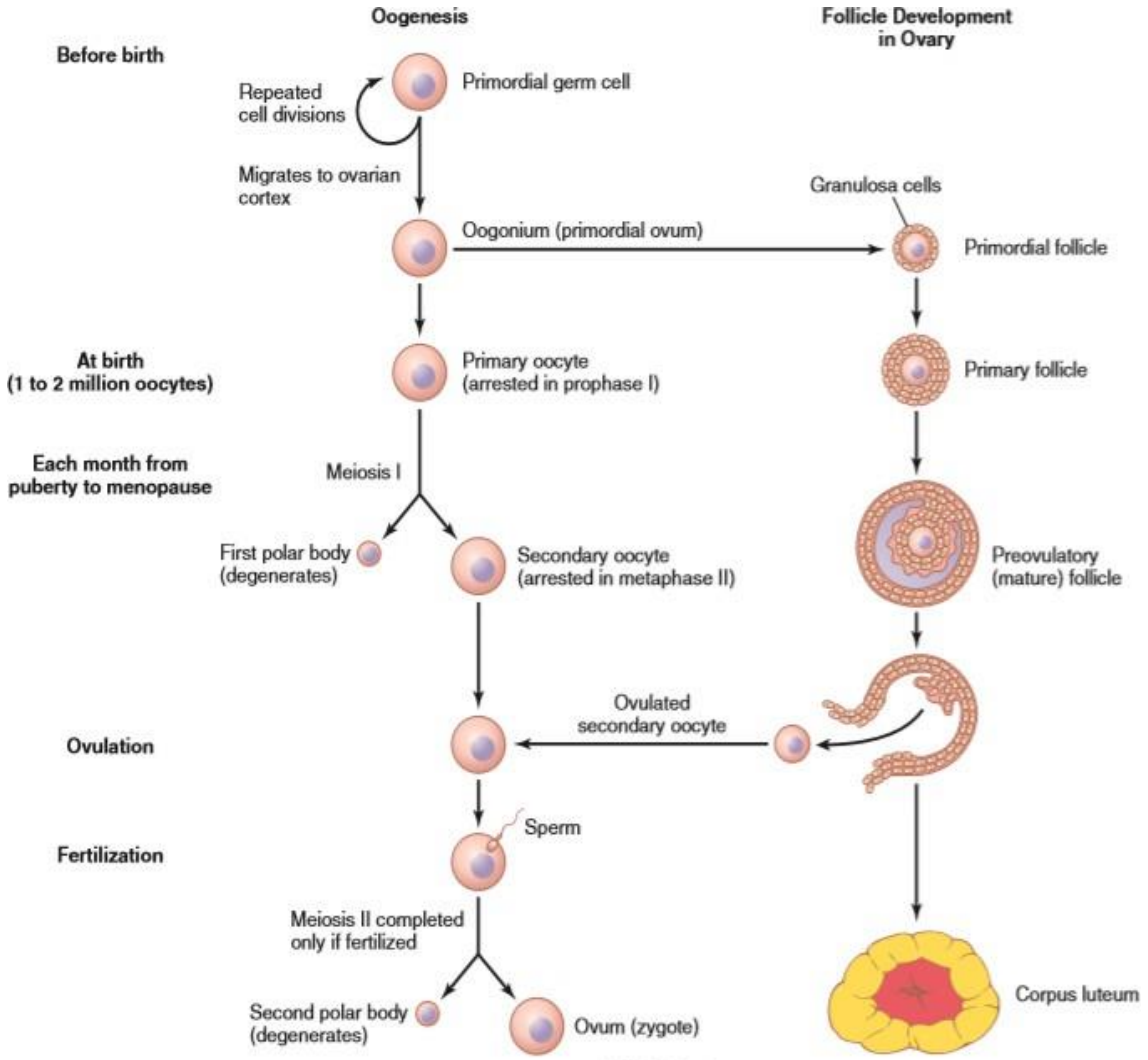


Figure 82-3. Oogenesis and follicle development.

- The secondary oocyte is arrested in metaphase II at the time of ovulation. After ovulation, it is released from the mature Graafian follicle and transported into the fallopian tube (uterine tube), usually the ampulla, where fertilization may occur if a sperm is present.
- **Meiosis II is not completed unless fertilization occurs.** When a sperm penetrates the secondary oocyte, meiosis II resumes and the second division occurs, during which sister chromatids separate from each other resulting in the formation of a mature ovum and the second polar body.
- The male and female pronuclei then fuse together, leading to the formation of a fertilized zygote, at this stage, the zygote is diploid (2n), because it contains one haploid set of chromosomes (n) from the sperm and one haploid set (n) from the oocyte.

Ovarian follicle growth -8

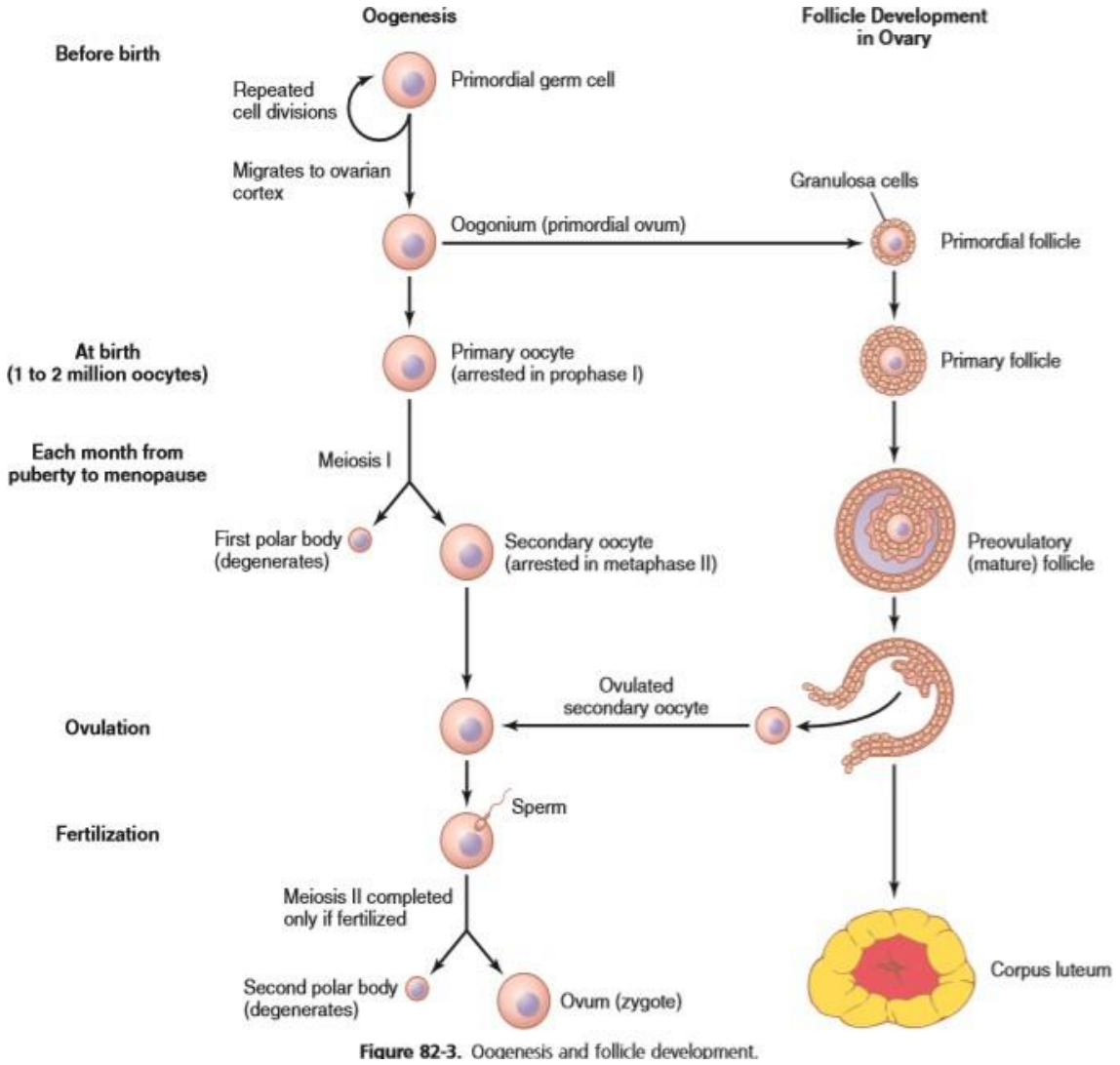


Figure 82-3. Oogenesis and follicle development.

- After ovulation, the remnants of the ruptured follicle are transformed into the **corpus luteum**. The corpus luteum continuously secretes high amounts of **progesterone**, as well as estrogen.

- If **fertilization does not occur**, the corpus luteum has a limited lifespan and eventually **degenerates** into corpus albicans. However, if fertilization occurs, it is maintained by hCG for a longer period than usual and continues to secrete progesterone and estrogen during the early stages of pregnancy, approximately for the first 2–3 months until placenta is sufficiently developed to take over hormone production.

Ovarian follicle growth سبحان الله

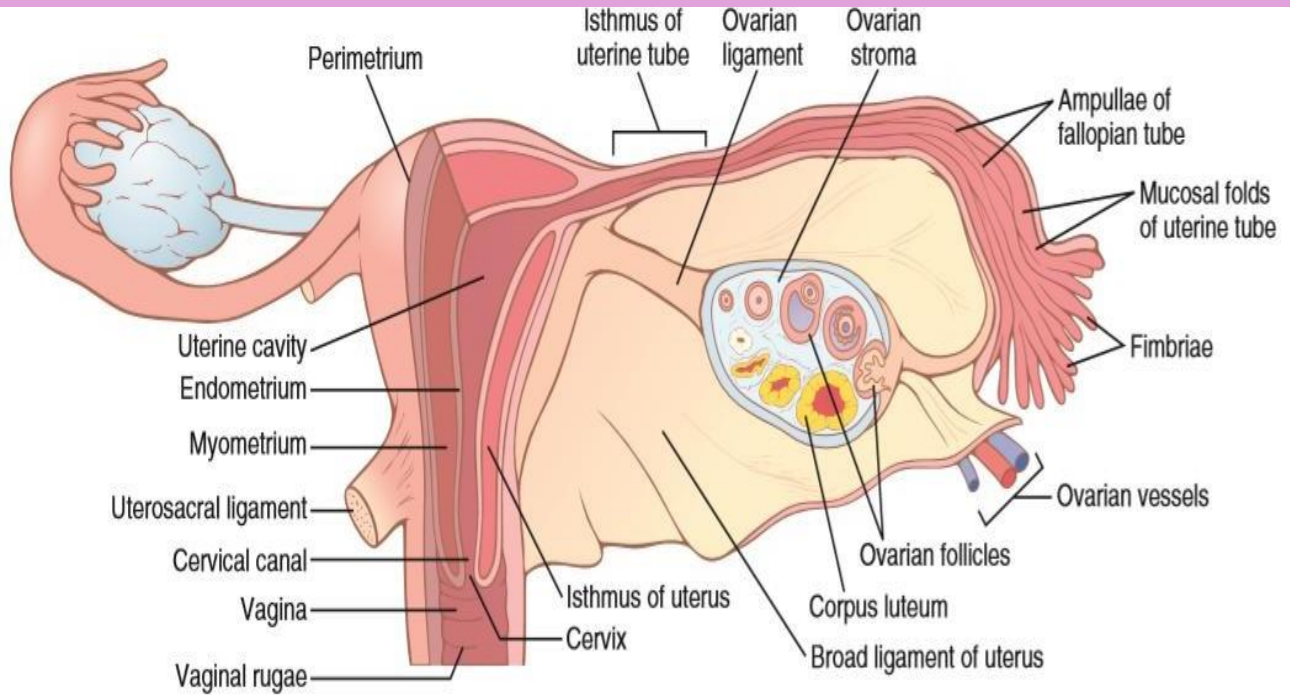
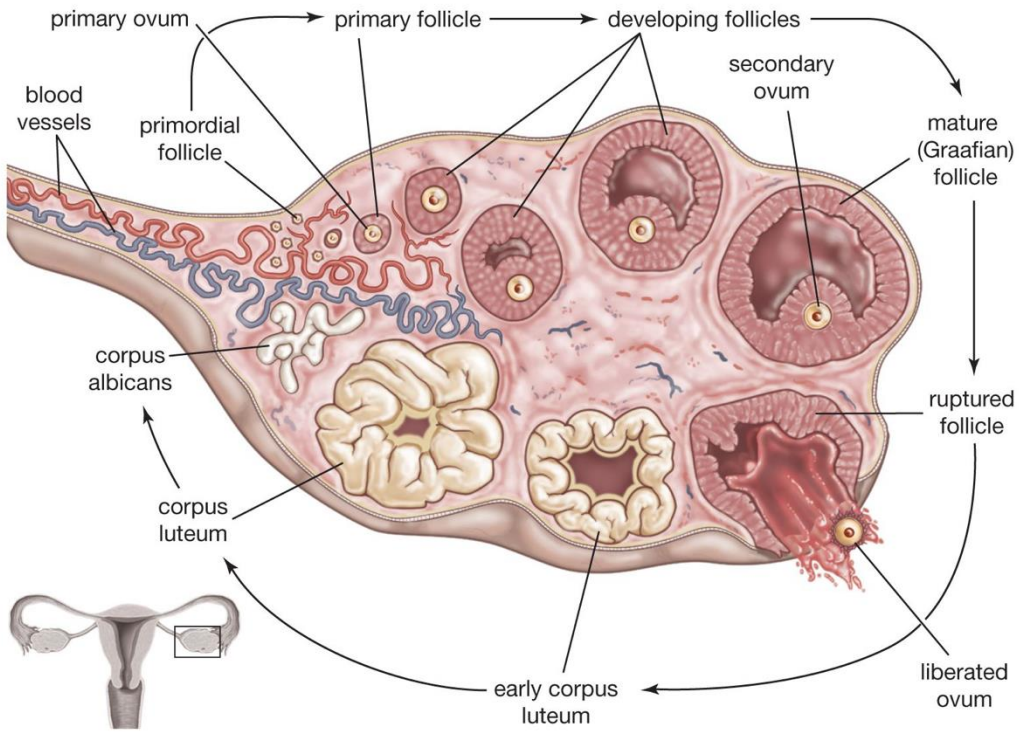
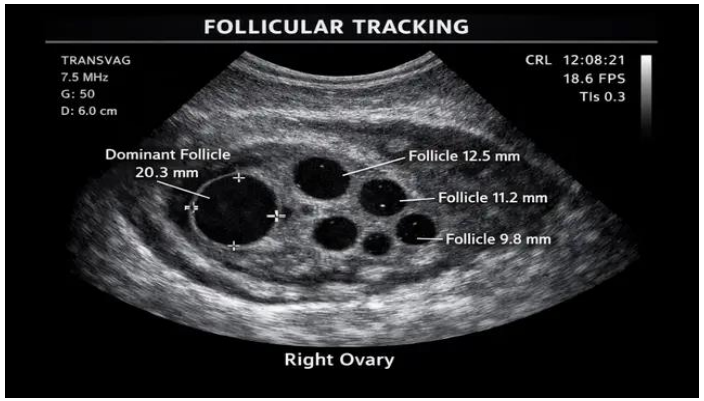


Figure 82-2. Internal structures of the uterus, ovary, and a uterine tube.

Extra diagram



Extra diagram



More than 5–10 follicles begin to develop during each ovarian cycle; however, usually only one becomes the dominant follicle and reaches ovulation, while the remaining follicles undergo atresia.

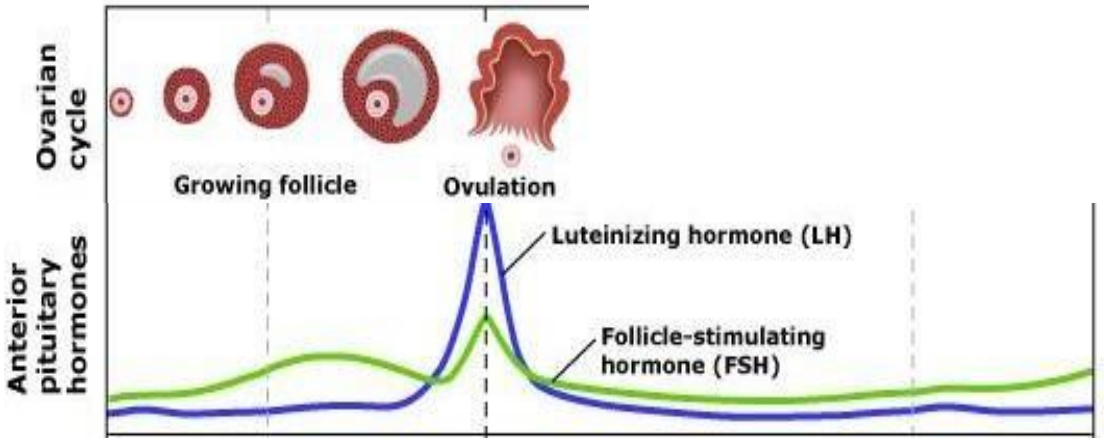
Ovarian follicle growth-9

During ***the first few days*** of the monthly female sexual cycle there is an increase secretion of **FSH and slightly LH** after initially starting with lower levels**.**

- **FSH** increase is slightly more & earlier than LH which causes the acceleration of growth of many primary follicles each month
- There is proliferation of the granulosa cells to many layers.
- The ovary interstitium collects in several layers outside the granulosa cells to form a second mass of cells called **theca**

Theca is divided into 2 layers:

1. ***theca interna***
2. ***theca externan***



Ovarian follicle growth-10

Menstrual Cycle and Ovarian Regulation

1. Menstrual Phase (Start of Cycle)

At the beginning of the menstrual cycle, during menstruation, estrogen and progesterone levels become very low because the corpus luteum from the previous cycle degenerates. Normally, estrogen and progesterone exert **negative feedback** on the hypothalamus and anterior pituitary gland, meaning they suppress the release of GnRH, FSH, and LH. Therefore, **when their levels drop at the start of menstruation**, this inhibitory effect is removed. As a result, **FSH** secretion starts to increase, then LH also rises slightly.

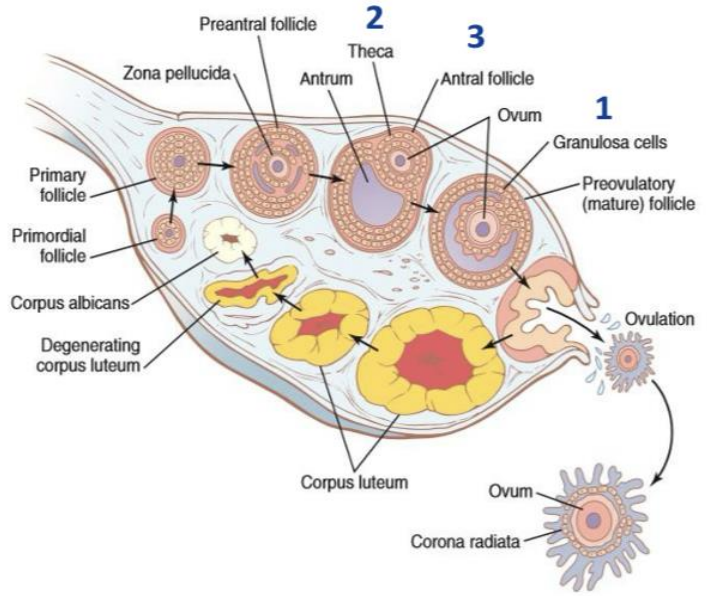
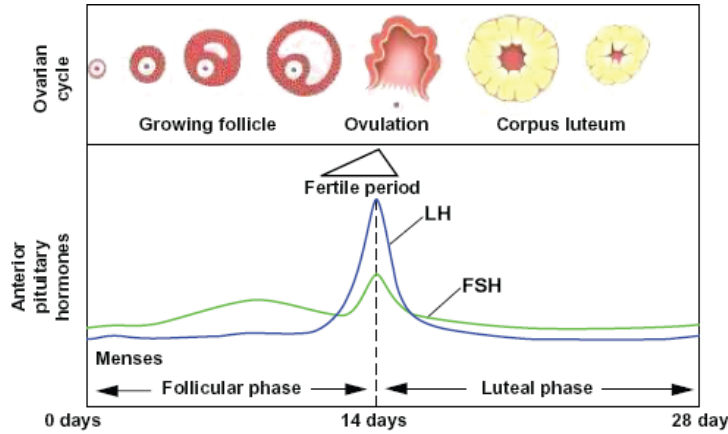


Figure 82-5. Stages of follicular growth in the ovary, also showing formation of the corpus luteum.

2. Early Follicular Phase (Follicle Development)

The increase in **FSH** is very important because it stimulates the development of ovarian follicles. Several primordial or primary follicles begin to grow and develop. During this process, **granulosa (1) cells proliferate, and the surrounding theca (2) cells also develop.**

The follicles gradually progress through stages of development until they form **secondary and then antral follicles(3).**



Ovarian follicle growth-11

3. Theca-Granulosa Interaction

The theca cells have LH receptors, so they are stimulated by **LH**. Under this stimulation, they produce progesterone and androgens from cholesterol. These androgens are then secreted and diffuse into the surrounding granulosa cells.

Granulosa cells mainly have **FSH** receptors, so they are primarily stimulated by FSH. As the follicle develops, they may also develop LH receptors. Their main role is to **convert the androgens** coming from theca cells **into estrogens** using the aromatase enzyme.

As granulosa cells proliferate, the follicle increases in size and begins to form a fluid-filled cavity called the antrum. This follicular fluid is rich in estrogen, and its accumulation contributes to enlargement of the follicle.

As **estrogen production increases**, its level rises in the blood and supports further follicular development. Eventually, one dominant follicle becomes large and tense, forming the mature **Graafian follicle (1-1.5cm in diameter) that is ready for ovulation.**

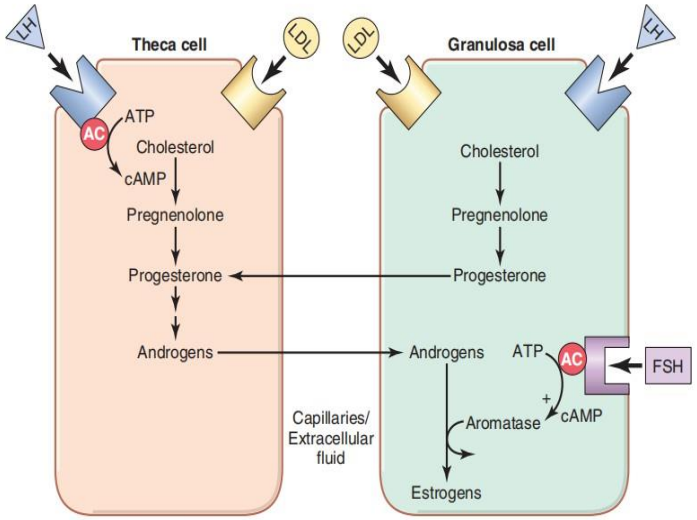
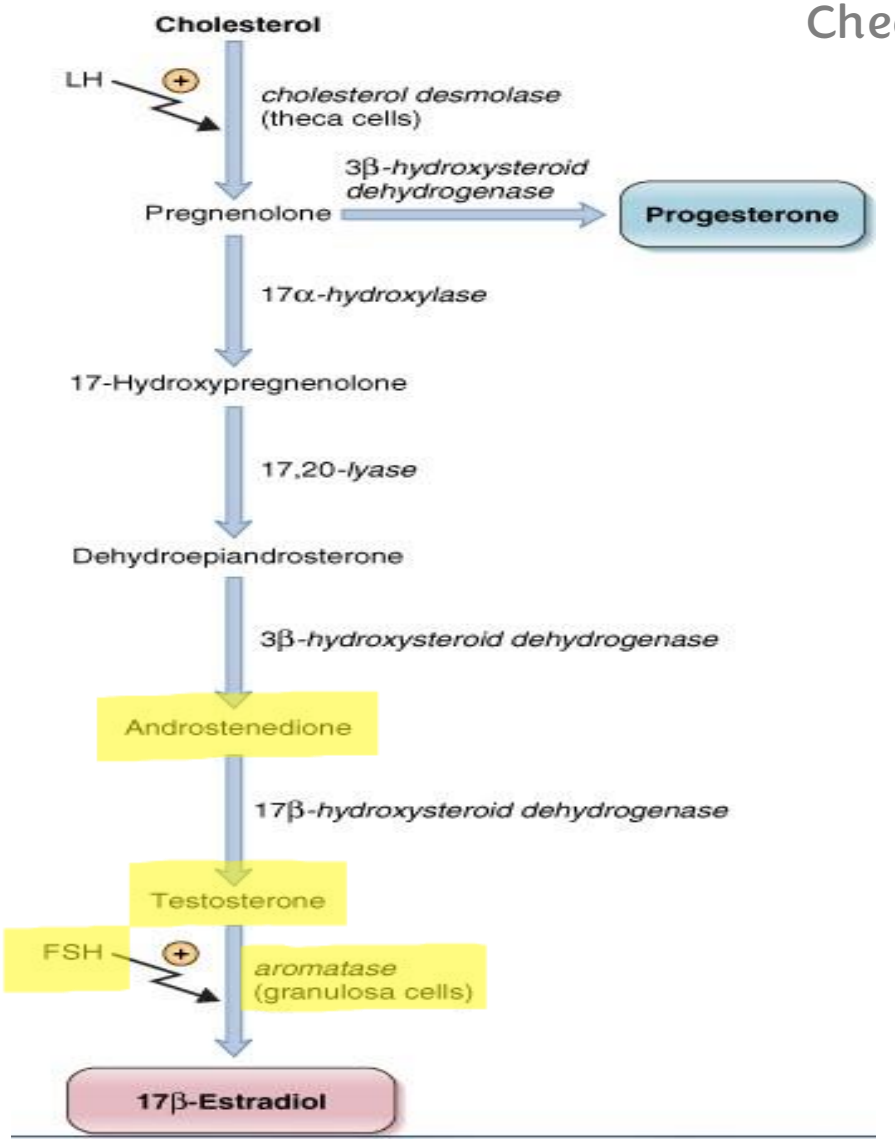


Figure 82-8. Interaction of follicular theca and granulosa cells for production of estrogens. The theca cells, under the control of luteinizing hormone *(LH)*, produce androgens that diffuse into the granulosa cells. In mature follicles, follicle-stimulating hormone *(FSH)* acts on granulosa cells to stimulate aromatase activity, which converts the androgens to estrogens. AC, adenylate cyclase; ATP, adenosine triphosphate; cAMP,

Hormonal production in the follicle



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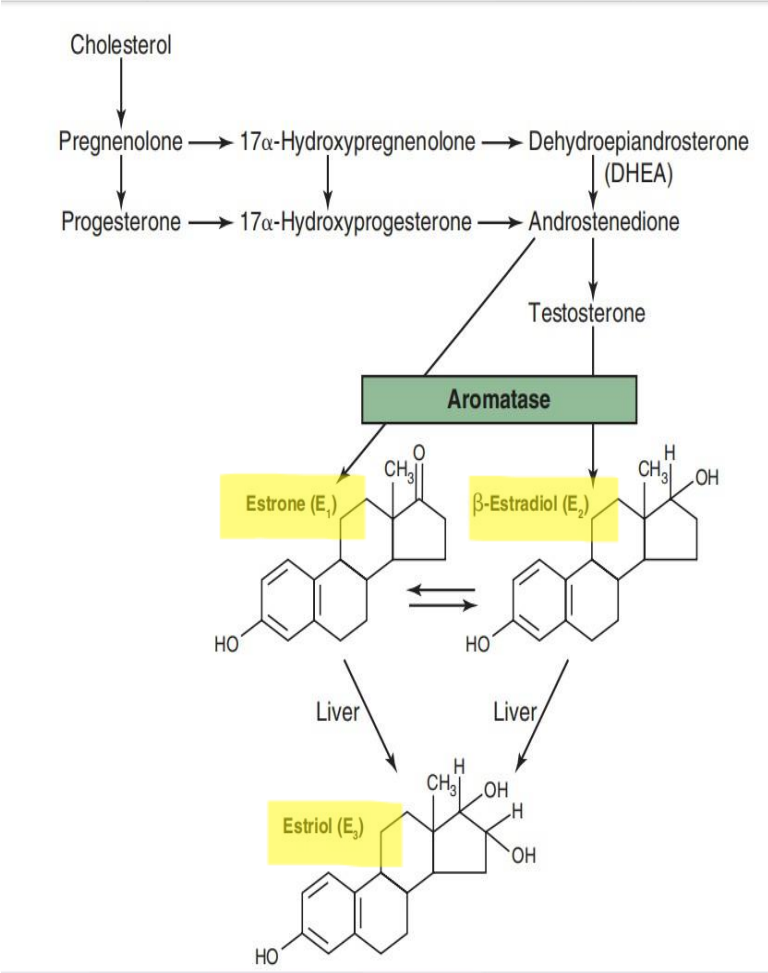


Hormonal production in the follicle

Steroid hormone production in ovarian follicles

1. Basic precursor
•All female sex hormones are derived mainly from **cholesterol**
•(Acetyl-CoA can contribute indirectly by forming cholesterol)

2. Theca cells (LH-dependent)
•Stimulated by **LH**
•Convert cholesterol into:
- **Progesterone**
- **Androgens** (DHEA, androstenedione, testosterone)

3. Granulosa cells (FSH-dependent)
•Stimulated mainly by **FSH**
•Receive androgens from theca cells
•Contain **aromatase enzyme**
•Convert androgens → **estrogens**

4. Estrogen production
•Main estrogen produced: β –**Estradiol (E2)** → most potent
•Other forms:
Estrone (E1) and Estriol (E3)

5. Additional granulosa function
•Can produce **small amounts of progesterone**
•Especially after **luteinization (around ovulation)**

6. Hormone metabolism
•Estrogens are metabolized mainly in the **liver**
•Excreted via the **kidneys**
•Some are converted into weaker forms (estrone, estriol)

Ovarian follicle growth-12

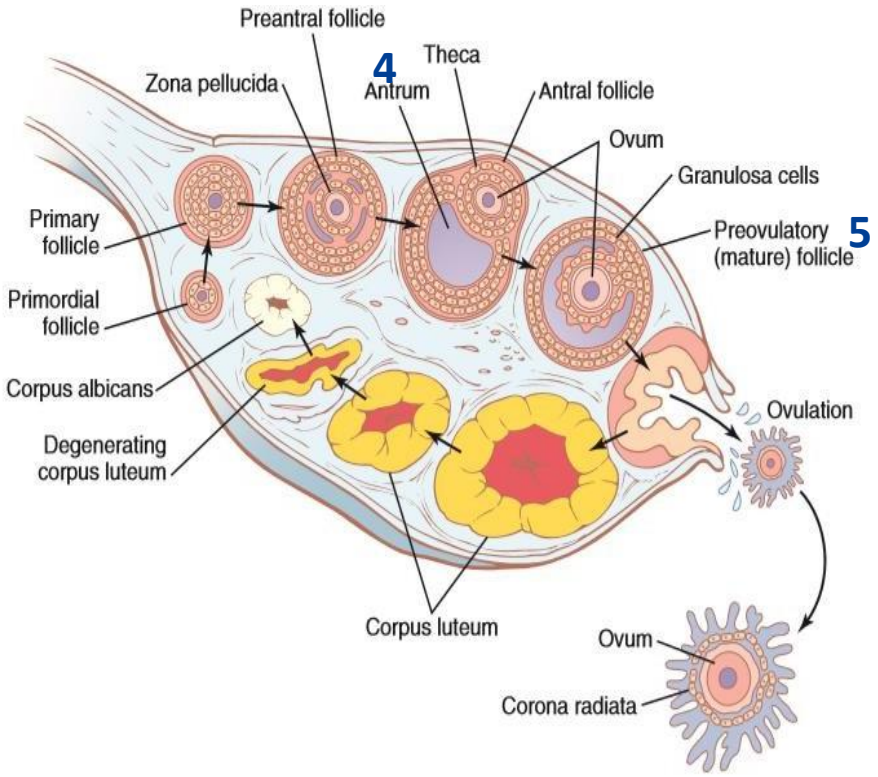


Figure 82-5. Stages of follicular growth in the ovary, also showing formation of the corpus luteum.

4. Antral follicular development

As the follicle enlarges, an **antrum** (4) **forms**. The antrum is a fluid-filled cavity containing follicular fluid that is rich in estrogen and other substances secreted by granulosa cell, and its accumulation contributes to enlargement of the follicle. The follicle becomes progressively larger and more prominent as it approaches ovulation due to **accelerated growth** (check the next slide to learn about the underlying cause).

Usually, one follicle becomes dominant and continues maturation into the mature **Graafian (preovulatory) follicle**(5).

Ovarian follicle growth-13

5. Late Follicular Phase (Positive Feedback and LH Surge)

- In the late follicular phase, **estrogen** produced by **granulosa cells** helps **increase** the expression of **FSH receptors** on granulosa cells themselves. This makes the follicle more sensitive to FSH and promotes further follicular growth and maturation, furthermore, rising estrogen levels from the dominant follicle begin to exert a **positive feedback effect** on the hypothalamus and anterior pituitary. This increases GnRH sensitivity and leads to a marked increase in LH secretion, known as the **LH surge**. Note that this is the only exception where estrogen has a positive rather than negative feedback.

- At the ovarian level, estrogen together with FSH promotes the **proliferation of granulosa cells** and increases their functional capacity. Granulosa cells mainly convert androgens from theca cells into estrogens via aromatase, so their increase further amplifies estrogen production.

- Estrogen and FSH also induce the **expression of LH receptors on granulosa cells**, allowing them to respond to LH later in follicular development. This is essential for final follicular maturation and preparation for ovulation.

- Meanwhile, theca cells esp theca interna continue to respond to LH by producing androgens, which diffuse into granulosa cells and are converted into estrogens, maintaining the estrogen rise, as well as producing progesterone.

- When estrogen remains elevated for a sustained period, the positive feedback mechanism becomes strong enough to trigger the **LH surge**, which leads to ovulation.

- The **LH surge** also stimulates the production of **proteolytic enzymes (proteases)** and prostaglandins within the follicle. These enzymes weaken and **digest the follicular wall**, while prostaglandins increase local blood flow and follicular pressure. As a result, the **mature follicle ruptures** and **releases the secondary oocyte during ovulation.**

FEMALE SEX HORMONES

- The granulosa cells in the corpus luteum develop extensive intracellular smooth endoplasmic reticula that form large amounts of the female sex hormones progesterone and estrogen (with more progesterone than estrogen during the luteal phase).
- The theca cells form mainly the androgens androstenedione and testosterone rather than female sex hormones.
- However, most of theca hormones are also converted by the enzyme aromatase in the granulosa cells into estrogens, the female hormones.

Ovarian follicle growth

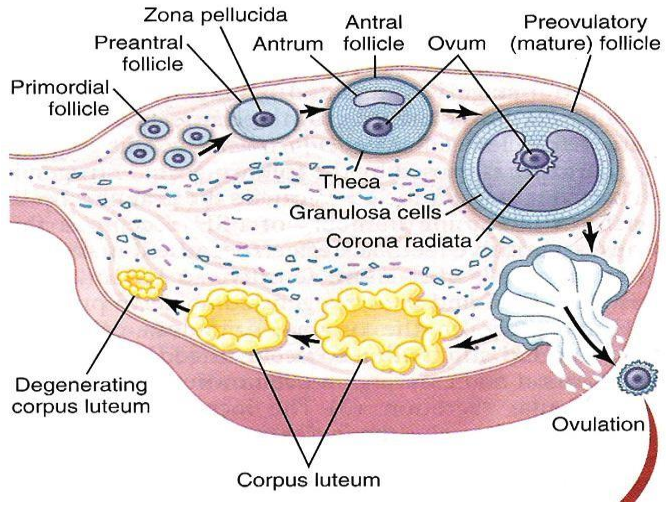
Few days after proliferation & growth of the follicles, the granulosa cells secrete follicular fluids that contain high concentration of **estrogen**.
This fluid accumulates to form **antrum** within the mass of the granulosa cells

The early growth of the primary follicle up to the antral stage is under FSH stimulation only.Then there is **accelerated growth** of the follicle to larger follicle called vesicular follicle (Graffian) caused by:

1. Estrogen secreted into the follicle caused the granulosa cells to increase FSH receptors (**positive feedback effect)**

2. Both estrogen & FSH promote LH receptors on granulosa cells in addition to FSH stimulation, allowing more rapid increase in follicular secretion.

3. Increasing estrogen from the follicle and increasing LH from the AP causes proliferation of the follicular theca cells & increase their secretion

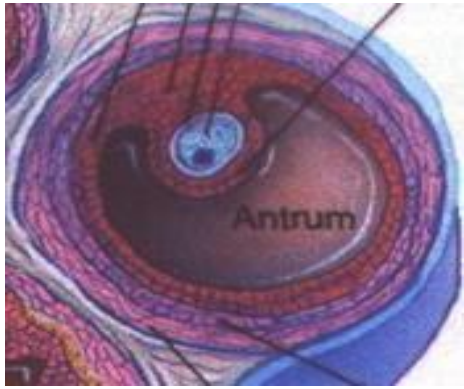


Ovarian follicle growth

The **antral follicles** begin to grow, the ovum enlarges & remains embedded at one pole of the granulosa cells of the follicle.

During all the reproductive years of adult life, between about 13 and 46 years of age, **400 to 500** of the primordial follicles develop enough to expel their ova—**one** each month.

The remaining follicles (5 to 11) undergo ***atresia*** or involute.



Hormones during normal female sexual cycle

1) At the end of the cycle, **estrogen and progesterone are low** →Loss of negative feedback → **FSH rises (moderate LH rise)** → start of cycle.

Correlation with the uterine cycle: A decline in estrogen and progesterone levels initiates menstruation by depriving the endometrium of hormonal support. This leads to prostaglandin release, vasoconstriction of the spiral arteries, endometrial ischemia, and subsequent shedding (sloughing) of the functional layer of the endometrium.

2) FSH stimulates follicle growth **(marking the start of follicular phase)**→ **estrogen starts to rise (negative feedback)**→ controls FSH/LH.

- During this time, progesterone remains low, till about day 12 of the cycle. The rising estrogen initially still exerts negative feedback, helping to control FSH and LH levels so that only one dominant follicle develops, hence, we say that estradiol keeps FSH and LH low.

IMPORTANT GRAPH

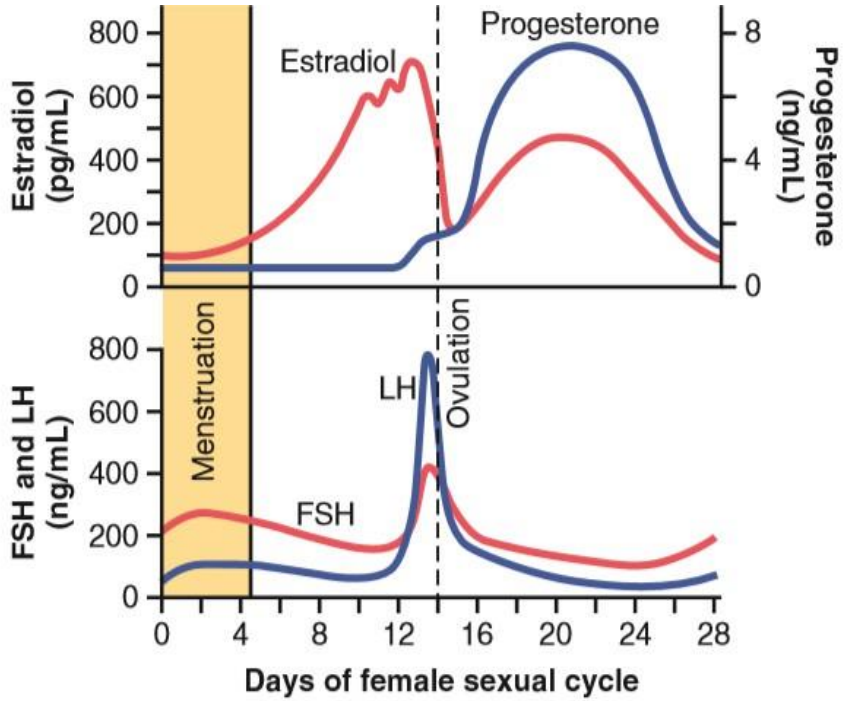


Figure 82-4. Approximate plasma concentrations of the gonadotropins and ovarian hormones during the normal female sexual cycle. FSH, follicle-stimulating hormone; LH, luteinizing hormone.

Hormones during normal female sexual cycle

3) As estrogen becomes **high and sustained accompanied by slight increase in the progesterone**, feedback switches to **positive feedback→ LH surge (peak level) for about 16-24 hours before ovulation → leading eventually to ovulation.**

- When Estradiol remains high for a sustained period (peaks), along with the brief increase in progesterone, they switch from negative to positive feedback on the hypothalamus and anterior pituitary. This causes a sharp rise in LH (and a smaller rise in FSH), known as the LH surge, which is the peak of the cycle and triggers ovulation, without this surge, ovulation fails to occur, regardless of FSH secretion. This surge also initiates the next phase, where we say that LH lutenizes the cells.

4) After ovulation, **progesterone becomes dominant** (corpus luteum), Progesterone + estrogen → **negative feedback again → FSH/LH decrease.** (Check next slide)

IMPORTANT GRAPH

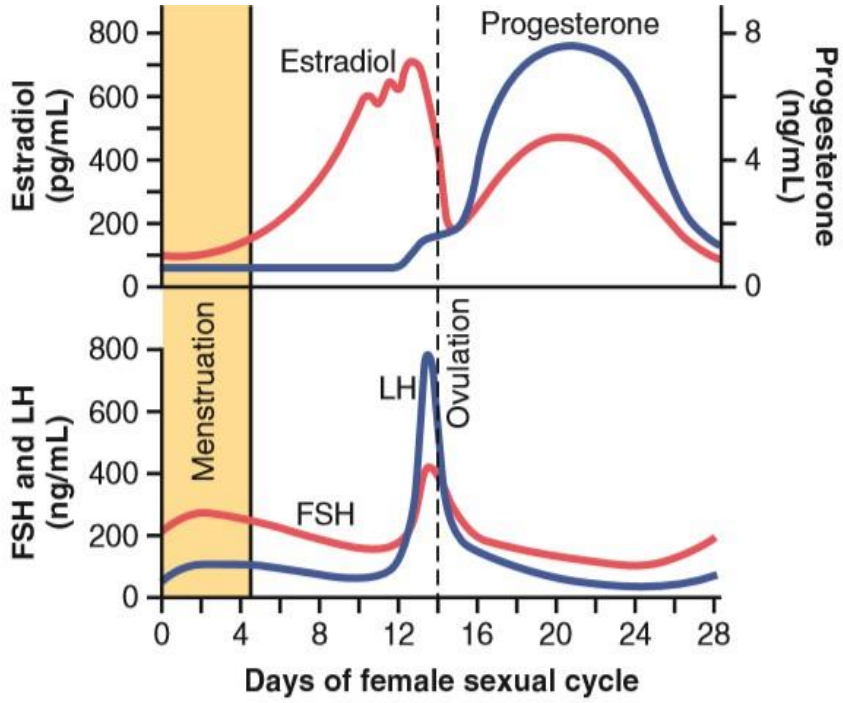
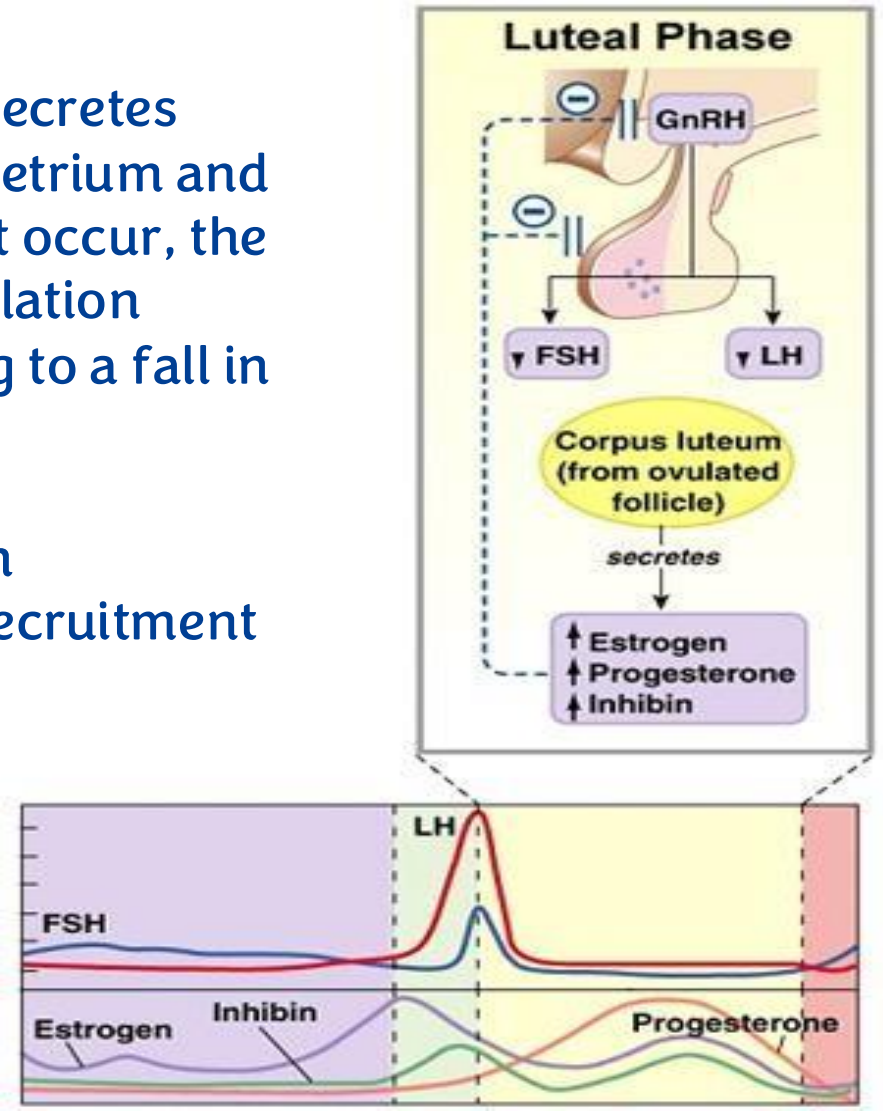


Figure 82-4. Approximate plasma concentrations of the gonadotropins and ovarian hormones during the normal female sexual cycle. FSH, follicle-stimulating hormone; LH, luteinizing hormone.

OVULATION

Luteal Phase (Corpus Luteum Phase) -explained again
In the second half of the cycle, the corpus luteum is active and secretes progesterone (and some estrogen), which maintains the endometrium and exerts negative feedback on FSH and LH. If fertilization does not occur, the corpus luteum gradually degenerates after about 14 days of ovulation (about day 26 of menstruation) into the corpus albicans, leading to a fall in progesterone and estrogen levels.

This hormonal drop removes the negative feedback, resulting in menstruation and the start of a new cycle with rising FSH and recruitment of new follicles.
If fertilization occurs, ***human chorionic gonadotropin (hCG)*** is produced by the trophoblast, which maintains the corpus luteum and prolongs its life. This allows continued secretion of high levels of progesterone and estrogen to support early pregnancy **until the placenta develops and becomes the main source of these hormones.**



OVULATION

- **LH is necessary for final follicular growth and ovulation:**

- 2 days before ovulation □ rate of LH secretion ↑to 6-16 fold & peaks, about 16 hrs before ovulation.

- LH Surge is necessary for final follicular growth and ovulation:

- FSH also ↑2 to 3 fold & acts synergistically with LH to cause swelling of the follicle before ovulation.

- LH has specific effect on the granulosa cells & theca cells converting them to *progesterone-secreting cells*
  → rate of estrogen secretion ↓about 1 day **before ovulation** while progesterone secretion begin to ↑

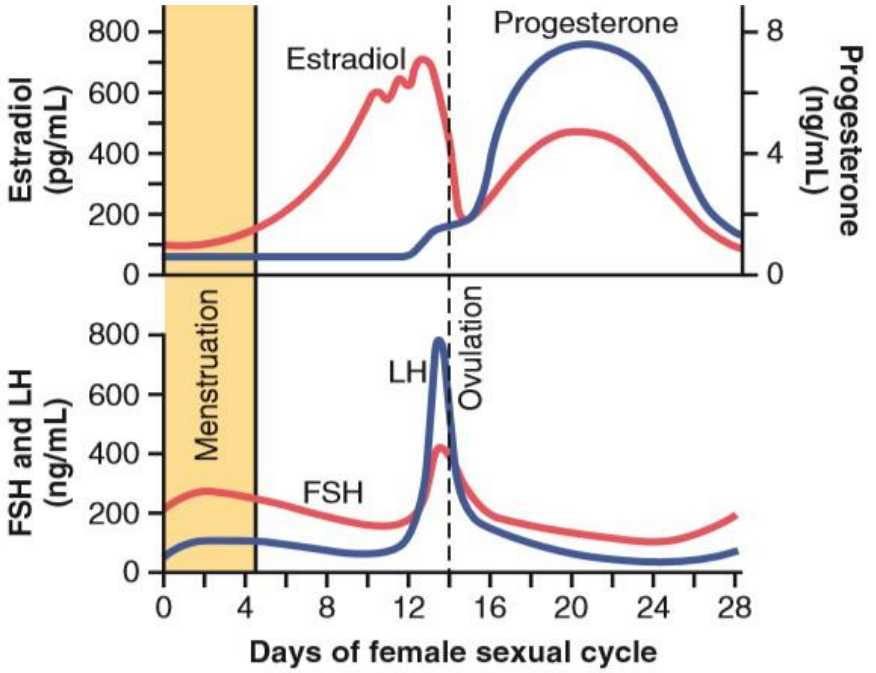
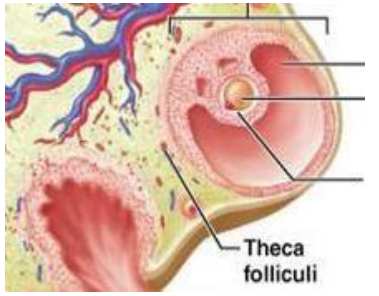


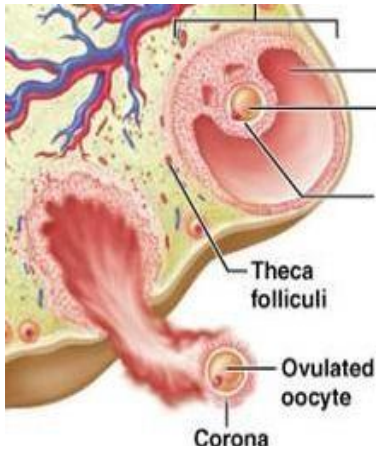
Figure 82-4. Approximate plasma concentrations of the gonadotropins and ovarian hormones during the normal female sexual cycle. FSH, follicle-stimulating hormone; LH, luteinizing hormone.

OVULATION

Surge of LH causes rapid secretion of progesterone from the follicle. Within a few hours 2 events occur which are necessary for ovulation:

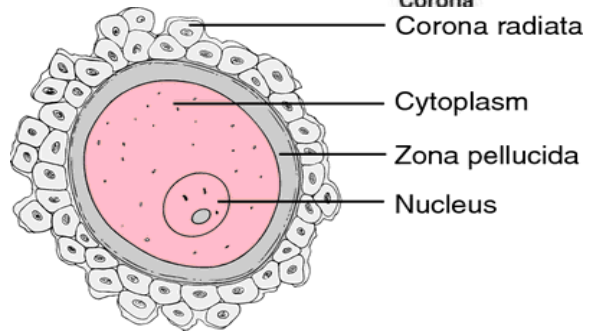


1. The **theca externa** begins to secrete proteolytic enzymes & causes weakening of the wall resulting in swelling of the follicle & degeneration of the stigma
2. Rapid growth of **new blood vessels** into the follicle wall & prostaglandins are secreted into the follicular tissue.



Ovulation occurs 14 days after the onset of menstruation in 28 days cycle.

During ovulation, stigma protrudes & fluids ooze from the follicle & the stigma ruptures allowing more viscous fluid outward carrying with it the ovum surrounded by mass of granulosa cells called corona radiata



OVULATION

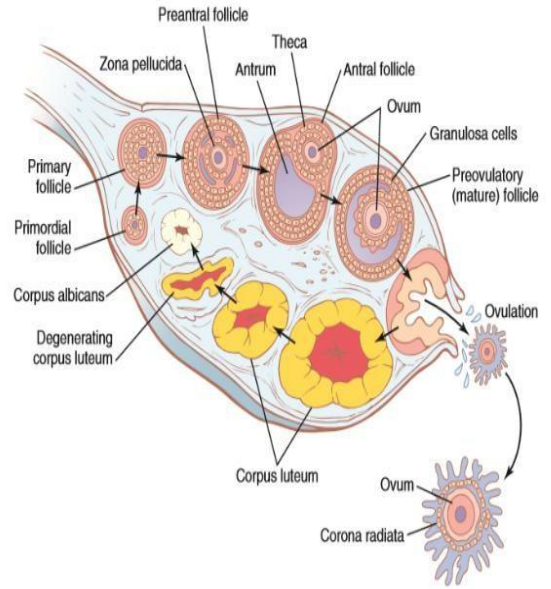


Figure 82-5. Stages of follicular growth in the ovary, also showing formation of the corpus luteum.

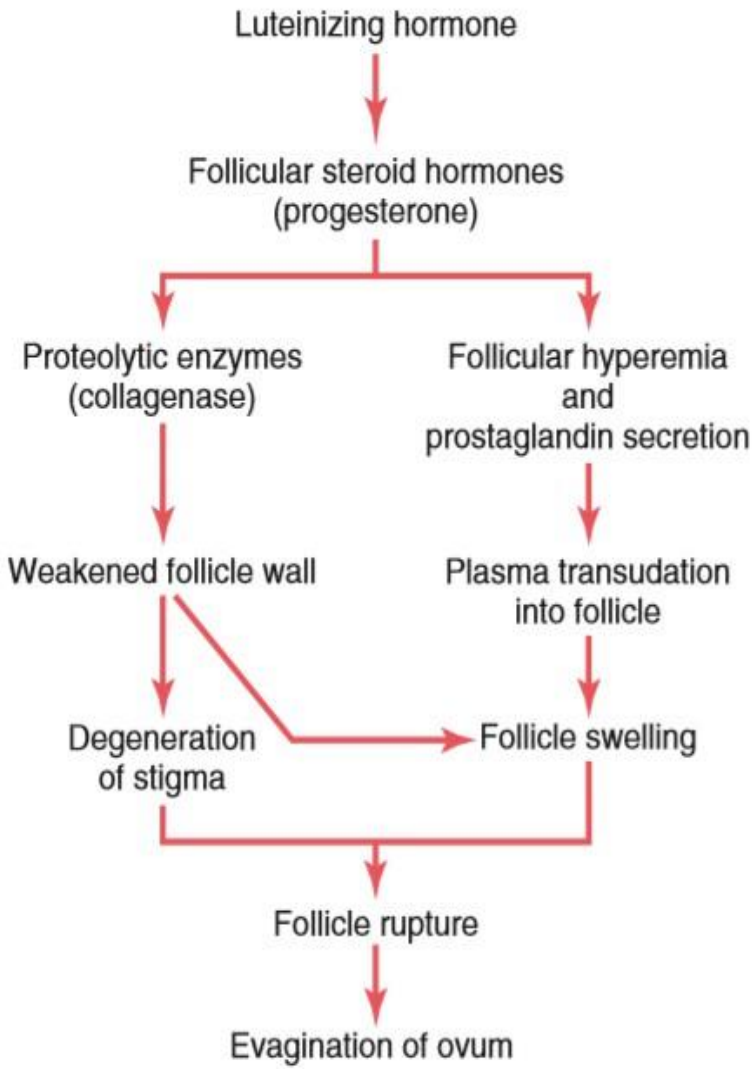
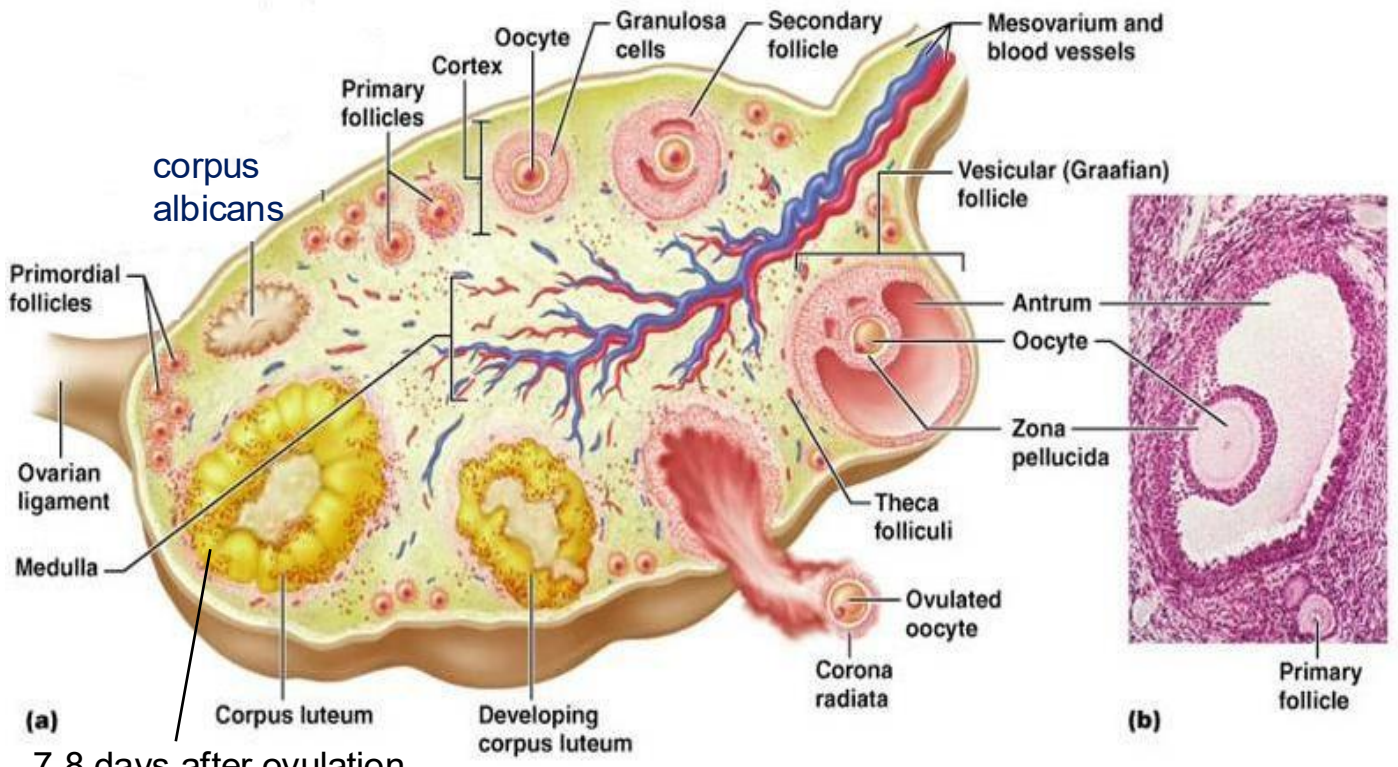


Figure 82-6. The postulated mechanism of ovulation.

Corpus Luteum



7-8 days after ovulation
~ 1.5 cm in diameter

The granulosa cells with the theca cells are called **corpus luteum.**

Corpus Luteum

''Luteal'' phase of the ovarian cycle

- After expulsion of the ovum from the follicle, the remaining granulosa & theca interna cells change to **lutein cells** & become filled with lipid inclusions giving them yellowish appearance.

- The granulosa cells in corpus luteum form large amount of progesterone & estrogen.The theca cells form mainly androgens which are converted by granulosa cells into female hormones.

Corpus Luteum

Luteinizing function of LH:

1 Extrusion of the ovum from the follicle.

2 Change of granulosa and theca interna cells into **lutein cells**.

3 Secretion of progesterone & estrogen from the corpus luteum.

- If pregnancy occurs, the hCG from the placenta acts on the corpus luteum to prolong its life for 2 to 4 months of pregnancy.

Corpus Luteum

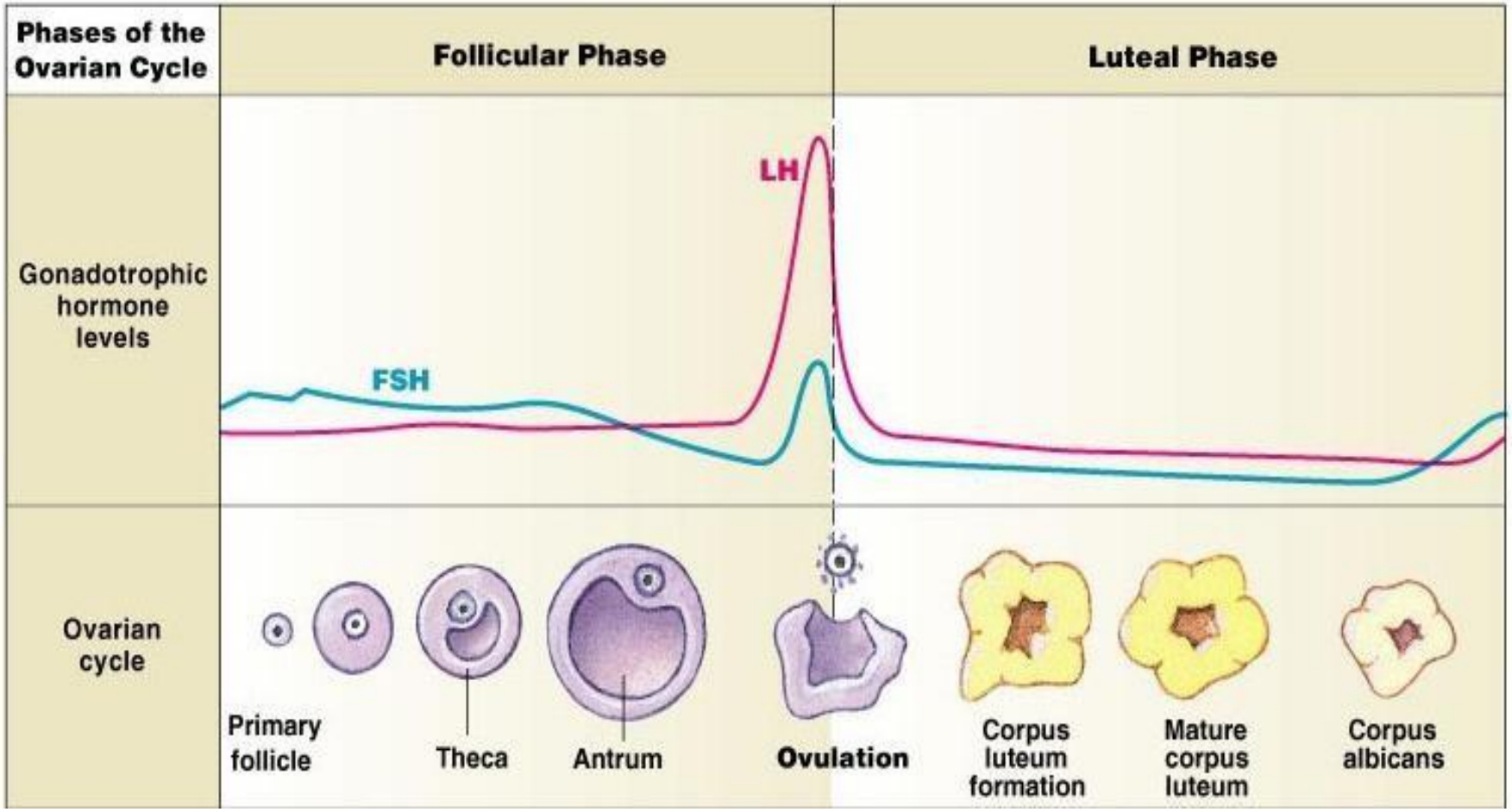
Involution of the corpus luteum and onset of the next ovarian cycle:

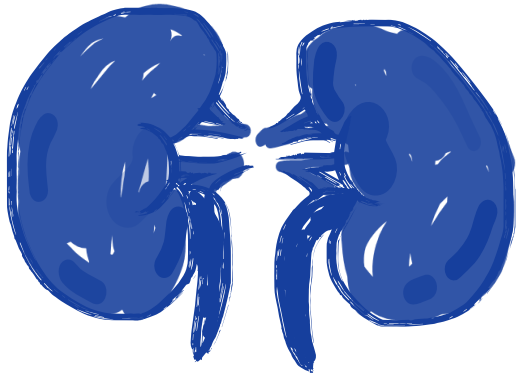
1 Estrogen & progesterone from corpus luteum (luteal phase) have strong negative feedback effect on AP to inhibit the secretion of FSH & LH.

2 The **lutein cells** secrete small amounts of inhibin which inhibit secretion of FSH by AP. ↓FSH & LH & loss of these hormones >> complete degeneration of corpus luteum (involution)

3 Around **26th days** of normal sexual cycle & after involution of corpus luteum, sudden cessation of estrogen, progesterone & inhibin removes the negative feedback inhibition of the AP & allowing ↑secretion of FSH & LH again.

FSH & LH initiate the growth of new follicles, beginning a new ovarian cycle.





PHYSIOLOGY QUIZ LECTURE 1

External Resources

رسالة من الفريق العلمي

1. Oogenesis, highly recommended
2. Ovulation by Ninja nerd

اللهم إن عمر عطية في ذمتك وحبل جوارك، فقِه من فتنة القبر وعذاب النار، أنت أهل الوفاء والحق، فاغفر له وارحمه إنك أنت الغفور الرحيم.

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Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			