

CHAPTER 4. OVARIAN CYCLE

3.1. Definition:

The ovarian cycle refers to the cyclical changes in the ovaries during the 28-day female reproductive cycle. It results in the release of a single mature ovum (ovulation) and is regulated by anterior pituitary gonadotrophic hormones — **follicle-stimulating hormone (FSH)** and **luteinizing hormone (LH)**.

3.2. Phases of the Ovarian Cycle

The ovarian cycle is divided into three main phases:

1. **Preovulatory Phase**
2. **Ovulatory Phase**
3. **Postovulatory Phase**

1. Preovulatory Phase

- **Duration:** Extends from Day 5 to Day 14 (approx. 8–10 days) in a typical 28-day cycle, but can vary from 10–25 days depending on individual cycle length.
- **Hormonal Influence:** Initially regulated by **FSH**, and later by both **FSH and LH**.
- **Process:** 10–15 **primordial follicles** begin to mature in a process called **folliculogenesis**. Only one follicle typically reaches full maturity; the rest undergo **atresia** (degeneration).

1.1.Folliculogenesis

1.1.1. Definition:

The process of maturation of ovarian follicles through several stages, resulting in the release of a mature ovum.

1.1.2. Stages of Follicular Development

A. Primordial Follicles

- Formed during intrauterine life (~10th week of development).
- Consist of a **primary oocyte** surrounded by **flattened follicular cells**.

- Around **200,000** primordial follicles are present in each ovary at birth.
- At puberty, about **40,000** remain, of which only **400–450** mature and ovulate during a woman's reproductive years.

B. Primary Follicles

- Under the influence of FSH and LH during puberty, several primordial follicles mature each month.
- Each consists of a primary oocyte surrounded by **cuboidal or low columnar follicular cells**.
- A **zona pellucida** (glycoprotein layer) forms between the oocyte and follicular cells.

C. Secondary (Multilaminar) Follicles

- Follicular cells proliferate into **multiple layers**, now called **granulosa cells**.
- The primary oocyte grows and is nourished by granulosa cells.

D. Preantral Follicles

- **Fluid-filled spaces** begin to appear between granulosa cells, secreted by these cells.

E. Tertiary (Antral) Follicles

- Fluid spaces merge to form a single **follicular antrum** filled with **liquor folliculi**.
- The oocyte and surrounding granulosa cells are pushed to one side of the follicle.

F. Mature (Graafian) Follicle

- By Day 7 of the cycle, one dominant follicle enlarges and becomes the **Graafian follicle** (~3–5 mm).
- Other follicles degenerate.
- The Graafian follicle projects to the ovarian surface.
- Key structures include:
 - **Corona radiata**: cells immediately surrounding the oocyte.
 - **Cumulus oophorus**: granulosa cells attaching oocyte to follicle wall.
 - **Theca interna**: secretes estrogen.

- **Theca externa:** fibrous outer layer.

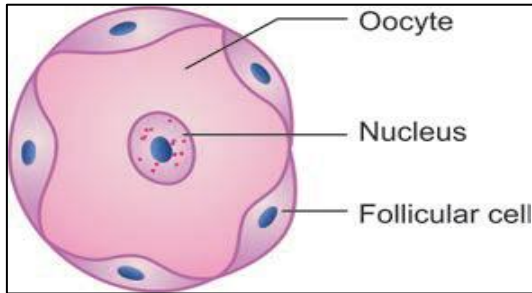


Fig. 13: Primordial follicle

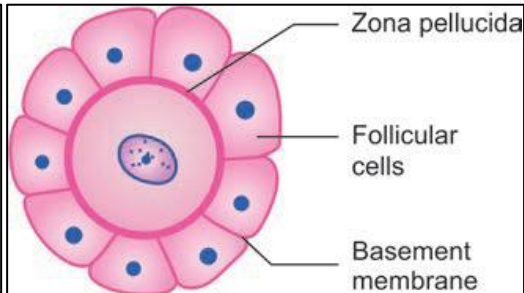


Fig. 12: Primary follicle

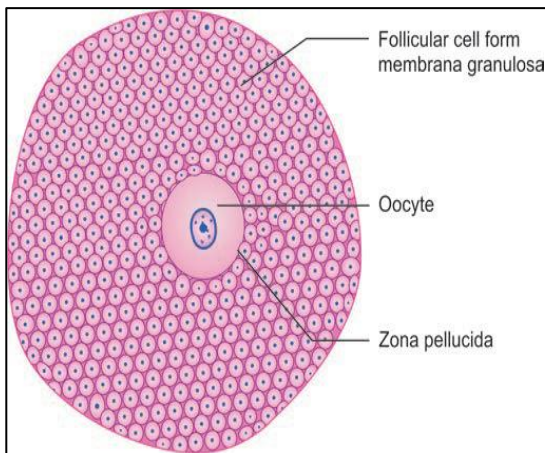


Fig. 14: Secondary follicle

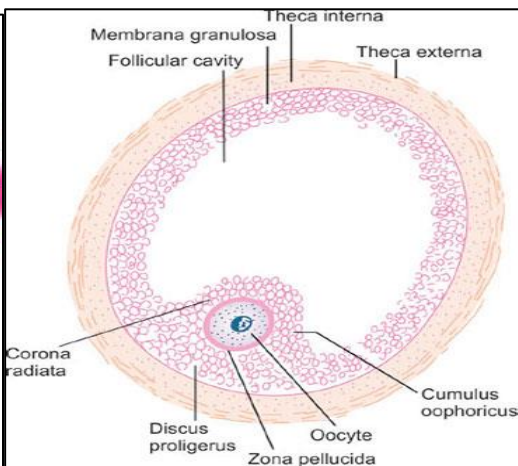


Fig. 15: Preantral follicle

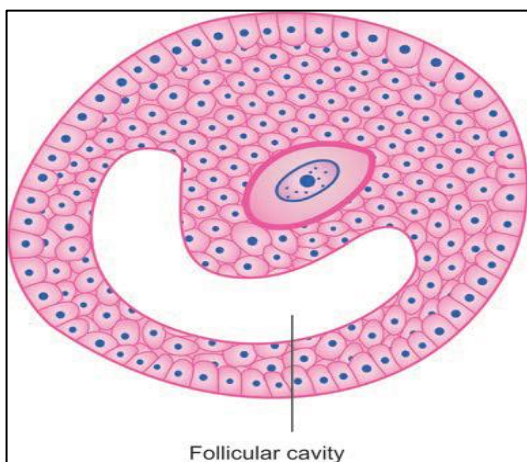


Fig. 16: Tertiary/Antral follicle

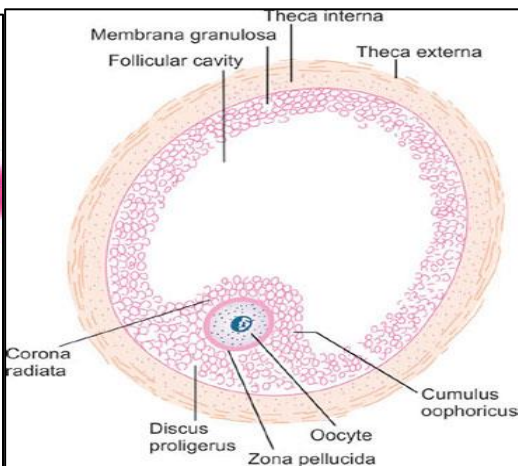


Fig. 17: Mature graafian follicle

2. Ovulatory Phase

Meiotic Events in the Ovary

- The **primary oocyte** inside the mature **Graafian follicle** is diploid (46 chromosomes).
- Just before ovulation, it completes **Meiosis I**, producing:
 - A **secondary oocyte** (larger cell)
 - A **first polar body** (smaller cell)
- Each of these cells contains a **haploid number of chromosomes (23)**.
- The **secondary oocyte** then begins **Meiosis II**, but this process is **arrested at metaphase II** until fertilization occurs.

2.1. Ovulation

Definition:

Ovulation is the process by which the **secondary oocyte** is released from the **ovary** into the **pelvic cavity**.

➤ Key Features of Ovulation:

- As the **Graafian follicle matures**, it enlarges and eventually forms a **bulge on the surface of the ovary**.
- At full maturity, the follicle may reach up to **15 mm in diameter**.
- The **stroma** and **theca** layers at the bulging point become very thin.
- An **avascular area** called the **stigma** appears at the most convex point of the follicle.
- The **cumulus oophorus** cells (granulosa cells surrounding the oocyte) loosen due to fluid accumulation.

➤ Rupture and Release:

- The **follicle ruptures**, releasing:
 - The **secondary oocyte** (still in metaphase II)
 - The **first polar body**

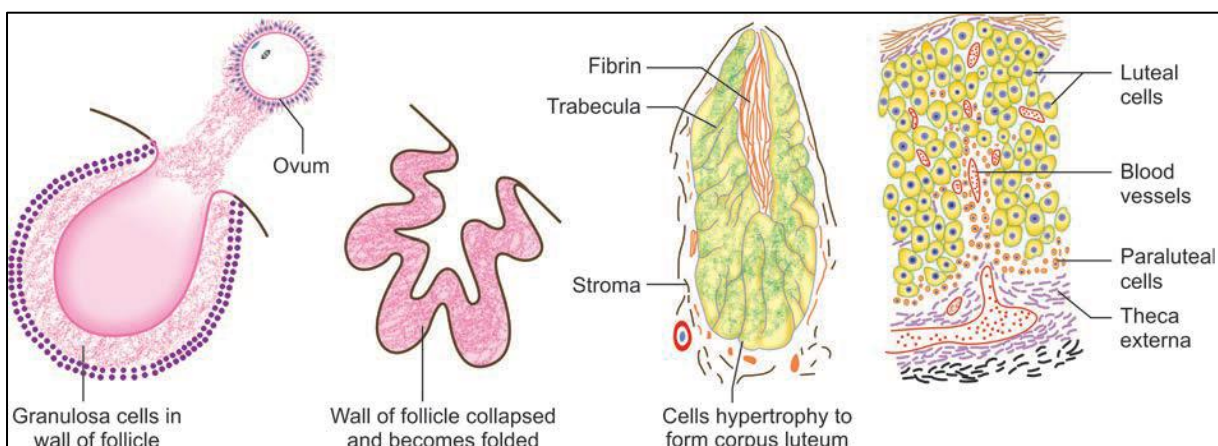
- Surrounding **corona radiata cells**
- The oocyte is released into the **pelvic cavity** and is swept toward the **fimbrial end of the fallopian tube** by ciliary action.

➤ **Fertilization and Completion of Meiosis II:**

- In the **ampulla** of the fallopian tube:
 - Several **sperm surround** the secondary oocyte.
 - **One sperm** penetrates the **corona radiata** and **zona pellucida**, initiating the **completion of Meiosis II** in the secondary oocyte.
 - This results in the formation of a **second polar body** and a **mature ovum** ready for fertilization.

Important Notes:

- **Stage of Meiosis at Ovulation:**
 - The oocyte has completed **Meiosis I**.
 - It is **arrested in metaphase II** of **Meiosis II** until fertilization.
- **Timing of Ovulation:**
 - Ovulation typically occurs **14 days ± 1** before the onset of the **next menstrual cycle**.



Figs. 18: Stages in the formation of corpus luteum and transformation of follicular cells to luteal cells

2.2. Structure of the Ovum at Ovulation

Maturity Status

- The ovum released during ovulation is **not fully mature**.
- It is a **secondary oocyte**, which is in the process of completing **Meiosis II**.
- Meiosis II is **arrested at metaphase**, and will only be completed if **fertilization occurs**.
- At this stage, the oocyte is preparing to **shed the second polar body**.

➤ **Structural Components of the Ovum**

1. Zona Pellucida

- A thick, transparent glycoprotein layer surrounding the oocyte.
- Plays a key role in fertilization by facilitating sperm binding and protecting the oocyte.

2. Corona Radiata

- Layers of granulosa cells attached to the outer surface of the zona pellucida.
- These cells remain surrounding the ovum after ovulation and assist in its nourishment and fertilization.

3. Perivitelline Space

- A clear space located between the zona pellucida and the oocyte's plasma membrane (also called the **vitelline membrane**).
- The **first polar body** is usually found within this space.

4. Spindle Apparatus

- Although a nucleus is **not visible** (because the nuclear membrane has broken down during meiosis),
- A **meiotic spindle** is present inside the cytoplasm, indicating the cell is in metaphase of Meiosis II.

Size of the Ovum

- The ovum is **exceptionally large**, measuring approximately **100–120 μm in diameter**.
- In contrast, most other human cells measure less than **10 μm**.
- (1 micrometer or μm = 1/1000 of a millimeter.)

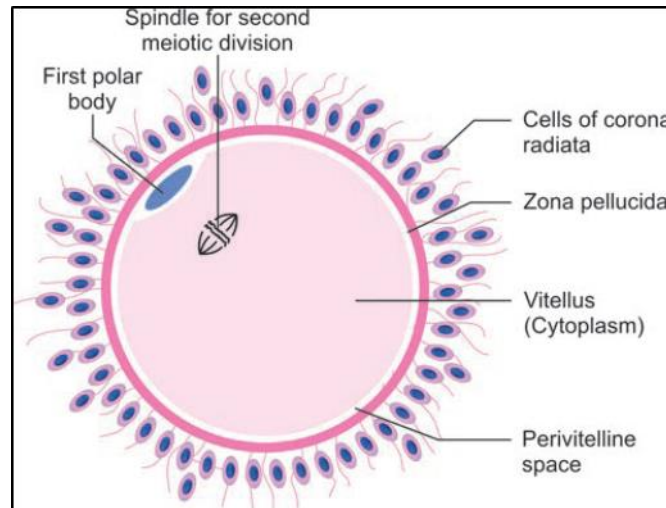


Fig. 19: Structure of ovum at the time of ovulation

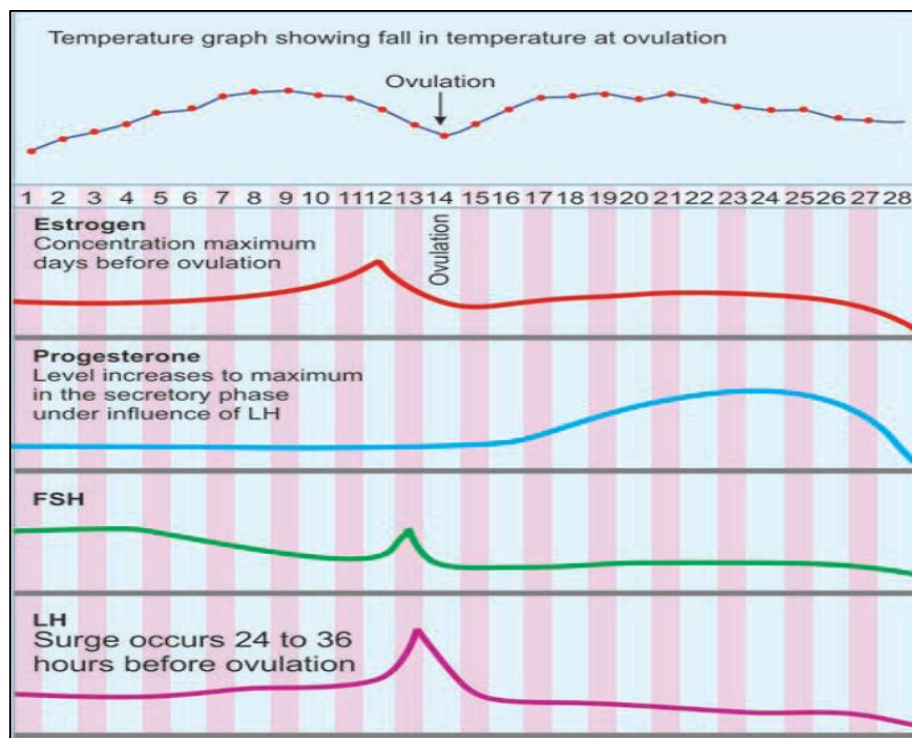


Fig. 20: Morning temperature and concentration of hormones

FSH, LH, estrogen and progesterone during normal menstrual

cycle.

3. Postovulatory Phase

3.1. Fate of the Ovum

- After ovulation, the **secondary oocyte** is captured by the **fimbriated end** of the **uterine (fallopian) tube**.
- It is transported into the tube by:
 - The **follicular fluid** released during ovulation.
 - The **beating of cilia** lining the fallopian tube.
- The oocyte travels through the uterine tube towards the uterus, which takes **3–4 days**.
- **If Fertilization Occurs:**
 - **Spermatozoa** deposited in the vagina swim into the uterus and reach the **ampulla** of the uterine tube.
 - One sperm penetrates the oocyte and **fertilization** occurs.
 - The **fertilized ovum (zygote)** begins to divide and forms an embryo.
 - The embryo continues its journey to the uterus and becomes **implanted in the uterine wall**.
- **If Fertilization Does Not Occur:**
 - The **secondary oocyte** degenerates within **12–24 hours**.
 - It passes through the uterus and is **discharged via the vagina**.

3.2. Corpus Luteum

Formation:

- After ovulation, the ruptured **Graafian follicle** transforms into the **corpus luteum**.
- This transformation involves:
 - **Collapse and folding** of the follicle wall.
 - **Enlargement of follicular cells**, which now become **luteal cells**, containing yellow pigment **lutein**.

- **Some theca interna cells** also enlarge and become **paraluteal cells**, contributing to hormone production.
- The corpus luteum becomes richly **vascularized** by blood vessels from the theca interna.

Function:

- The corpus luteum acts as a temporary endocrine gland.
- It primarily secretes **progesterone** and also a small amount of **estrogen**.
- **Progesterone** is essential for:
 - Preparing the endometrium for implantation.
 - **Maintaining early pregnancy**.

Fate of the Corpus Luteum:

➤ **If Fertilization Does Not Occur**

The corpus luteum formed is known as the **corpus luteum of menstruation**.

- It **persists for approximately 14 days** after ovulation.
- During this time, it secretes **progesterone**, which supports the uterine lining.
- If fertilization does not take place, the corpus luteum **degenerates** and is replaced by a whitish, fibrous scar tissue called the **corpus albicans**.

➤ **If Fertilization Occurs**

The corpus luteum is now called the **corpus luteum of pregnancy**.

- It remains **active for 3 to 4 months** during early pregnancy.
- The corpus luteum **grows significantly**, sometimes occupying **up to half the ovary**.
- It continues to secrete **progesterone**, which is essential for maintaining the uterine lining and supporting early pregnancy.
- Its degeneration is **prevented by human chorionic gonadotropin (hCG)**, a hormone secreted by the developing embryo.
- After the **placenta is fully developed**, it takes over the production of progesterone, and the corpus luteum eventually degenerates.

3.3. Fate of Other Ovarian Follicles

- In each cycle, although **multiple follicles** begin development, only **one reaches full maturity**.

- The others **undergo atresia** (degeneration) and do not persist.
- In these atretic follicles:
 - The **oocyte and granulosa cells** disappear.
 - The **theca interna cells** proliferate to form **interstitial glands** or **corpora atretica**, which may secrete **estrogens**.
 - Eventually, these structures also become **scar tissue** indistinguishable from the corpus albicans.

4. Hormonal Regulation

- The ovarian cycle is regulated by hormones from the **anterior pituitary (hypophysis cerebri)**:
 - **FSH (Follicle-Stimulating Hormone)**
 - **LH (Luteinizing Hormone)**
- Hormones produced by:
 - **Theca interna cells** (estrogen)
 - **Corpus luteum** (progesterone and estrogen)
- These ovarian hormones, in turn, regulate the **uterine (menstrual) cycle** by preparing the endometrium for implantation.

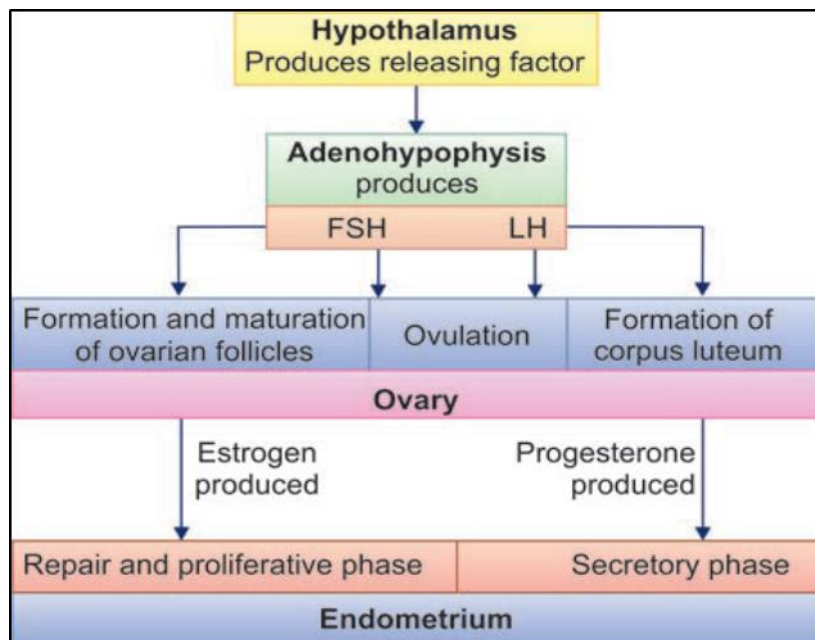


Fig. 21: Hormonal control of ovulation and uterine cycles

5. Menstrual Cycle (Uterine Cycle)

5.1. Definition

The **menstrual cycle** refers to the **cyclical changes** that occur in the **endometrium (lining of the uterus)** every month.

It is also known as the **uterine cycle**.

5.2. Cycle Length and Duration of Bleeding

- **Length of the Cycle:**

Typically lasts **28 days**, but can vary between **21 to 40 days**.

- The **first day of menstrual bleeding** marks **Day 1** of the cycle.
- The **last day** is the **day before the next cycle begins**.

- **Duration of Menstrual Blood Flow:**

- Menstruation (visible bleeding) usually lasts for **3 to 6 days**.

5.3. Purpose of the Menstrual Cycle

The main purpose of the menstrual cycle is to **prepare the endometrium for the implantation of a fertilized ovum**.

If fertilization does not occur, the prepared endometrium is **shed** during menstruation.

5.4. Hormonal Control

The menstrual cycle is regulated by the interaction of four key hormones:

- **Estrogen**
- **Progesterone**
- **Follicle-Stimulating Hormone (FSH)**
- **Luteinizing Hormone (LH)**

5.5. Endometrial Changes During the Cycle

Throughout the cycle, the endometrium undergoes several significant changes:

1. **Increase in thickness**
2. **Growth of uterine glands**
3. **Changes in epithelial cells** lining the glands

4. Increase in thickness and fluid content of the endometrial stroma

5.6. Onset of Menstruation

- Just before menstruation, the **blood supply to the superficial endometrium is cut off**.
- As a result, the **superficial layer of the endometrium is shed**, leading to bleeding.
- This shedding marks the **beginning of a new menstrual cycle**.

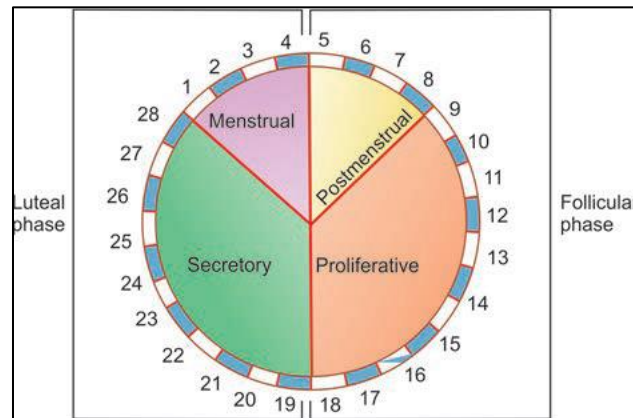


Fig. 22: Phases of menstrual cycle