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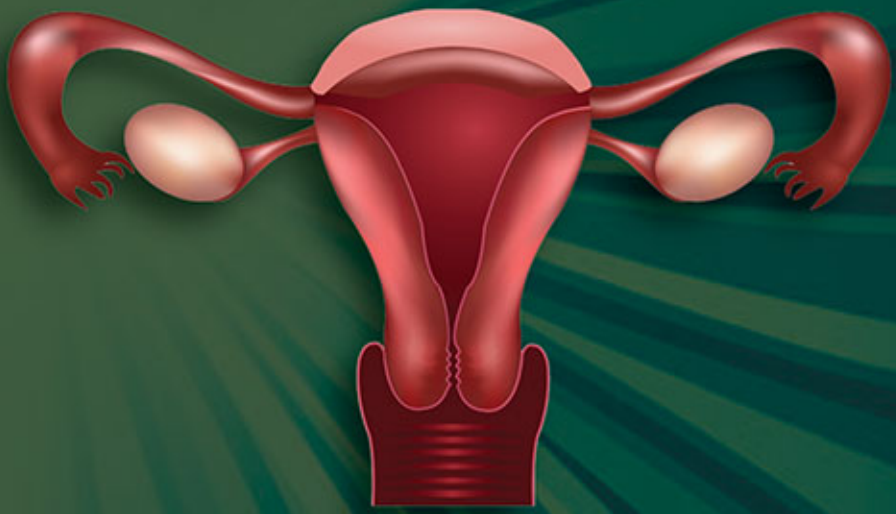
GYNAECOLOGY
for Nurses



Editor
Banasree Bhadra

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CHAPTER

2

Physiology of Female Reproductive System

Banasree Bhadra, Dhiren Dutta

PHYSIOLOGY OF MENSTRUATION

Menstruation is the periodic shedding of endometrium accompanied by loss of blood per vagina. It has derived its name from a Greek word "Men" which means month. Menstruation takes place at every 28 days interval for 4–5 days during reproductive life of women from menarche to menopause (Table 2.1). Normal menstruation occurs when hypothalamo-pituitary-ovarian (HPO) axis is intact, endometrium is responsive to ovarian hormones and outflow tract is patent.

Bleeding comes from oestrogen progesterone primed endometrium. Woman gets 13 menses in a year and around 400 menses in her reproductive life. The menstrual cycle of 28 days starts on day of onset of menstruation (day 1) and ends at day 28 on start of next menstruation. Menstruation signals that fertilisation and embedding of fertilised ovum have not occurred on the preceding menstrual cycle. Anovular menstruation is cyclical monthly bleeding from only oestrogen primed endometrium. This occurs for a few years after onset of menstruation (menarche) and before final cessation of menstruation (menopause).

Table 2.1: Characteristics of normal menstrual cycles

Term	*Description*
Beginning (menarche)	Average age of onset: 12–13 years
Interval between cycles	21–35 days with an average of 28 days
Duration of menstrual flow	Average flow: 3–5 days
Amount of menstrual flow	Difficult to estimate; average 30–80 ml per cycle
Colour of menstrual flow	Dark red; contains blood, mucus, and endometrial cells
Odour of menstrual flow	Marigold

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ENDOCRINE MECHANISM OF MENSTRUATION

Interplay of sex hormones from hypothalamus, anterior pituitary gland and ovary causes menstrual bleeding from uterine endometrium. This is called hypothalamo-pituitary-ovarian-uterine axis (Fig. 2.1). Four body structure involved in the physiology of the menstrual cycle:

- Hypothalamus
- Pituitary gland
- Ovaries
- Uterus.

Steps are:

1. In the brain, hypothalamus acts by secreting gonadotrophin releasing hormone (GnRH) which flows down from hypothalamus via pituitary portal vessels to anterior pituitary gland. Environment influences menstruation via cerebral cortex and hypothalamus.
2. Anterior pituitary gland (gonadotroph cells) liberate follicle-stimulating hormone (FSH) and luteinizing hormone (LH) in blood circulation to initiate growth of ovarian follicles in both ovaries.

OVARIAN CYCLE

The development and maturation of a follicle, ovulation and formation of corpus luteum and its degeneration constitute an ovarian cycle. All these events occur within 4 weeks.

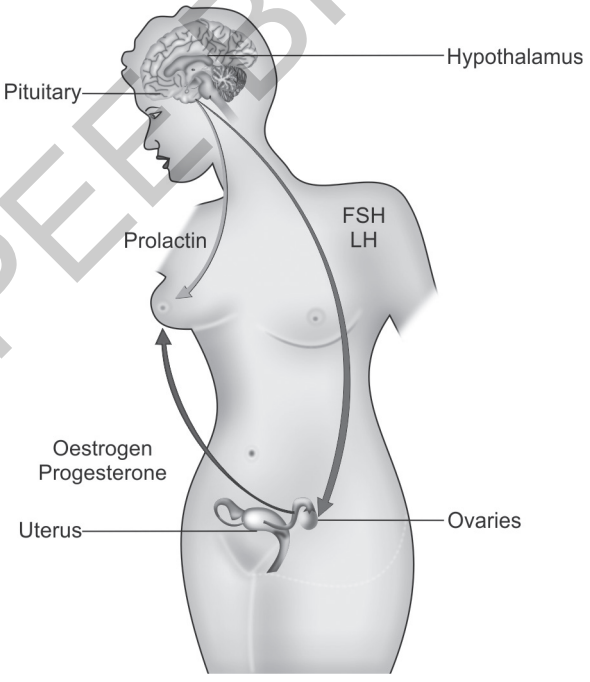

Figure 2.1: HPO axis

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The phases of ovarian cycle are characterised as follows:

1. Follicular phase: Hormonal feedback promotes the orderly development of a single dominant follicle, which should be mature at midcycle and prepared for ovulation. The average length of human follicular phase ranges from 10–14 days, and variability in this length is responsible for most variations in total cycle length.
2. Luteal phase: The time from ovulation to the onset of menses, with an average length of 14 days.

The regulation of ovarian function occurs through autocrine, paracrine and endocrine mechanisms. The growth and differentiation of ovarian cells are particularly influenced by the insulin-like growth factors (IGF). The IGF amplify the actions of gonadotrophin hormones on autocrine and paracrine growth factors found in the ovary. IGF-2 is the principal growth factor found in follicular fluid although other factors, including IGF-1, TNF-α, TNF-β and EGF also play important roles.

The ovaries have two functions: The production of ova; and the production of hormones. The latter is secondary to the former.

The production of ova: The primordial germ cells originate in the endoderm of the yolk sac, allantois and hindgut of embryo and migrate to the genital ridge where the ovary is formed. Oogenesis begins in the ovary at 6–8 weeks gestation, by 11–12 weeks oogonia transform to oocyte enter the first meiotic phase and arrest in prophase. The ovary of the female child at birth contains all the primary oocyte which it will ever possess and these are scattered amongst the mesenchymal stromal cells of the medulla and cortex. The total content of primary oocytes in both the ovaries at birth is estimated to be about 2 million. It is further reduced during childhood so that at puberty the figure is about 300000–500000. Of these not more than 500 are destined to mature during the individual's lifetime and the remainder will be lost by some form of degenerative process.

Ovulation is the process by which an ovum, in the form of a secondary oocyte, is discharged from the ovary to become a gamete. The adult ovary goes through a cycle of activity which occupies approximately 28 days. The cycle commences on the first day of menstruation and has two phases: The ripening of an ovum which occupies the first 14 days—The follicular phase; and the formation, activity, function, and degeneration of corpus luteum which occupies the second 14 days—The luteal phase. These two phases are separated by ovulation. The duration of the luteal phase is more constant than that of follicular phase and is generally 14±2 days. Thus the ovarian cycle consist of :

1. Recruitment of group of follicles
2. Selection of dominant follicle and its maturation
3. Ovulation
4. Corpus luteum formation
5. Demise of corpus luteum.

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Recruitment of Group of Follicles

The cohort of growing follicles undergoes a process of development and differentiation which takes about 85 days and spread over 3 ovarian cycles. The initial recruitment and growth of the primordial follicles is gonadotrophin independent and affects a cohort over several months. However, the stimuli responsible for the recruitment of a specific cohort of follicles in each cycle are unknown. At the primordial follicle stage, shortly after initial recruitment, FSH assumes control of follicular differentiation and growth and allows a cohort of follicles to continue differentiation. This process signals the shift from gonadotrophin-independent to gonadotrophin-dependent growth. It is presumed that at least 20 primordial follicle (about 5–10 per ovary) proceed to develop in each cycle.

During the several days following the breakdown of the corpus luteum, growth of the cohort of follicles continues, driven by the stimulation of FSH. The enlarging oocyte then secretes a glycoprotein rich substance, the zona pellucida, which separates it from the surrounding granulosa cells. At this stage of development, each of the seemingly identical cohort members must either be selected for dominance or undergo atresia.

Selection of Dominant Follicle and its Maturation

It starts with the recruitment of follicles and then at the time of menstruation there is selection of a cohort of follicles from which one becomes a dominant follicle. Hence to get one dominant follicle, many follicles are activated. As early as day 5–7, one of the follicles out of so many becomes dominant and undergoes further maturation. The one with highest antral concentration of oestrogen and lowest androgen: Oestrogen ratio and whose granulosa cells contain the maximum receptors for FSH becomes the dominant follicle. The rest of the follicle becomes atretic by day 8. Consequent to selection of the dominant follicle, peripheral level of oestradiol begins to rise significantly by day 7. The rising level of oestradiol exerts a negative feedback on the pituitary secretion of FSH. Autocrine and paracrine regulation also suppress FSH. Inhibin is an important inhibitor of FSH secretion, while follistatin suppresses FSH activity by binding activin which is thought to be stimulatory peptide. The decline in FSH leads to a decline in aromatase activity which leads to atresia of the other follicles. Only the dominant follicle which is the largest with more granulosa cells and FSH receptors, can maintain its growth at the low FSH levels. The fully mature follicle is called graafian follicle and just prior to ovulation it measures 20 mm. It composed of the following structures from outside inward:

a. Theca externa
b. Theca interna
c. Membrane granulosa
d. Granulosa cell layer

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e. Discus proligerus in which the ovum is incorporated with cells arranged radially (corona radiata)
f. Antrum containing vesicular fluid.

It takes 3 months for the follicle to grow and mature to ovulation—2 months to reach an antral stage measuring 1mm; 2 weeks to reach 5 mm; and another 2 weeks to reach 20 mm before ovulation.

Ovulation

It occurs as a result of thinning and degeneration of cyst wall, this being associated with the production of proteolytic enzymes, the activity of which is enhanced by progesterone. The progesterone induced midcycle rise in FSH also serves to free the oocyte from its follicular attachments. The dominant follicle, shortly before ovulation reaches the surface of ovary. The cumulus becomes detached from the wall so that the ovum with the surrounding cells (corona radiata) floats freely in the liquor folliculi. The oocyte completes the first meiotic division with extrusion of the first polar body. The follicular wall near the ovarian surface becomes thinner. The stigma develops as a conical projection which penetrates the outer surface layer of the ovary and persist for a while (½ –2 minutes) as a thin membrane. The cumulus escapes out of the follicle by a slow oozing processs, taking about 1–2 minutes along with varying amount of follicular fluid. The stigma is soon closed by a plug of plasma. Plasminogen activators activate plasmin which generates active collagenase leading to degeneration of collagen in the cell wall, especially at the follicular apex or stigma. Exit of the ovum may possibly be encouraged by contraction of micromuscle cells present in the theca externa and the stroma, those being activated by prostaglandins which are said to be essential to follicle rupture and the ovarian content of which is increased by the action of LH. As the time for ovulation approaches, the outer end of the fallopian tube moves towards the ovary so that the fimbriae tend to embrace it and are ready to catch the ovum. Peritoneal currents also tend to waft the ovum into the tube so it rarely gets free into the peritoneal cavity. Unless fertilized, the ovum survives only 12–24 hours and then disintegrates in the tube without leaving any trace.

Corpus Luteum Formation

After ovulation the ruptured graafian follicle develops into corpus luteum. Its life cycle can be divided into 4 stages:

Stage of proliferation

The collapsed wall of the empty follicle form convolutions. The opening through which the ovum escapes soon becomes plugged with fibrin. The granulosa cells undergo hypertrophy without multiplication (granulosa lutein cells), the colour of which is greyish yellow due to presence of lipids.

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Stage of vascularisation

Within 24 hours of rupture of the follicle, small capillaries grow into granulosa layer towards the lumen accompanied by lymphatics and fibroblasts. The vessels may rupture and bleed into the cavity.

Stage of maturation

By 4th day, the luteal cells attain maximum size. Approximately about 7–8 days following ovulation, the corpus luteum attains a size of about 1–2 cm and reaches its secretory peak. The lutein cells become greatly enlarged and develop lipid inclusion, giving the cells a distinctive yellowish colour. The colour is due to pigment carotene.

Stage of regression

On the day 22–23 of cycle, retrogression starts. The first evidence of degeneration is appearance of vacuolation in the cells. The lutein cells atrophy and the corpus luteum becomes corpus albicans. Regression of corpus luteum is due to the withdrawal of tonic LH support.

If there is fertilisation and pregnancy continues, there is hyperplasia of all the layers between 23–28 day due to chorionic gonadotrophin (hCG) and it is called corpus luteum of pregnancy. hCG stimulates the corpus lutem to secrete progesterone and helps to maintain pregnancy.

Demise of Corpus Luteum

Soon following the LH surge, the level of oestrogen drops down within an hour and the LH peak after 24 hours. LH initiates and maintaines the corpus luteum from which both progesterone and oestrogen are secreted. Progesterone attains its highest peak about 8 days after the LH peak. Progesterone acts to suppress new follicular growth. As the oestrogen and progesterone attains their highest peak, they exert a negative feedback effect on LH and FSH in an infertile cycle and the level of LH and FSH drops down to a minimum. The lysis of corpus luteum occurs and so the secretion of oestrogen and progesterone falls. The lifespan of corpus luteum is about 12–14 days.

Causes of ovulation:
The following are the possible explanation which may operate singly or in combination:

Endocrinal

- LH surge: LH surge initiates luteinisation acting through its receptors about 24 – 48 hours prior to ovulation. A trace amount of 17-α-hydroxy progesterone is formed which is probably responsible for completion of the first meiotic division of the oocyte and compounds the effect of oestrogen for LH surge. After the oestradiol reaches beyond the critical level of 200pg/ml and is sustained for about 48 hours, it exerts a positive feedback action to LH from the anterior pituitary (LH surge), (Fig. 2.2). Ovulation occurs approximately 10–12 hours after

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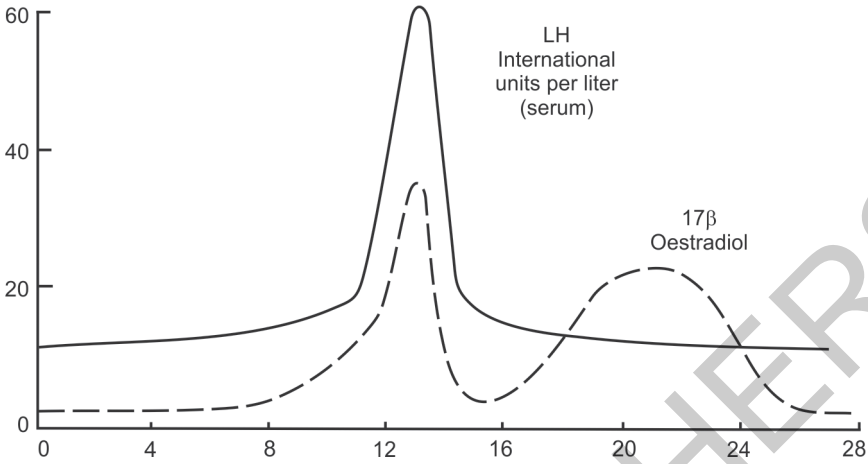

Figure 2.2: LH and oestradiol levels

the LH peak or 32–36 hours after the onset of LH surge. A threshold of LH surge generally persist for 24 hours. Ovulation coincides approximately 24–36 hours after the peak oestradiol level.

- FSH surge: Preovulatory rise of 17-α-hydroxy progesterone facilitates the positive feedback action of oestrogen to induce FSH surge which increases plasmin (helps lysis of the wall of the follicle).

Thus, the combined effect of LH/FSH midcycle surge is responsible for the final stage of maturation of the follicle, completion of the first meiotic division of the oocyte with extrusion of the first polar body and ovulation.

Stretching factor

It is more of passive stretching causing necrobiosis of the overlying tissue.

Contraction of the micromuscles

In the theca externa and ovular stroma due to increased local prostaglandin secretion.

UTERINE CYCLE

The endometrium is the inner lining of uterine corpus consisting of surface epithelium, glands, stroma and blood vessels. Two layers can be distinguished in the endometrium, the superficial functional and the basal. The basal layer of the endometrium measures 1mm and is situated deep, in direct contact with the myometrium. This layer is unresponsive to the hormonal stimuli and does not desquamate during menstruation. It provides the histologic elements from which a new functional layer grows when the menstrual bleeding ceases. The functional layer is the one that is entirely expelled and reconstructed at each menstrual cycle.

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It is highly responsive to the proliferative effect of the oestrogens and to the secretory transformation induced by progesterone.
Changes that take place during an ovulatory cycle are divided into 4 stages. These are:
a. Regenerative phase
b. Proliferative phase
c. Secretory phase
d. Menstrual phase.

Regenerative Phase

Prior to start of proliferative phase, repair phase runs with menstrual bleeding and ends by 48 hours after menstruation. New glands, stromal cells and blood vessels are regenerated from the basal zone. Endometrial thickness is 2 mm at this stage.

Proliferative Phase

Oestradiol from ovarian follicles causes proliferative changes in uterine endometrium (5–14 days) resulting in glandular proliferation and increase in thickness, as well as increase in vascularisation (Fig. 2.3). The thickness is 2 mm at this stage.

Secretory Phase

Progesterone (from corpus luteum) causes secretory changes in endometrium to receive fertilised ovum for embedding and also opposes excessive proliferative effects of the oestrogens, preventing the appearance of endometrial hyperplastic alterations. Glycogen appears as subnuclear vacuoles in endometrial gland followed by secretion of glycogen and mucus on the lumen of gland. Glands become corkscrew. Endometrial vessels become coiled, stroma becomes vascular and oedematous (Fig. 2.4). Endometrium thickens into three layers (a) superficial compact layer with neck of glands, (b) spongy layer with dilated glands, and (c) basal layer in contact with myometrial layer. Stage of regression occurs in secretory endometrium on day 27–28.

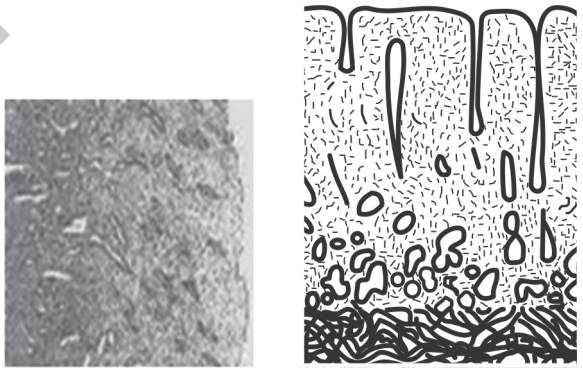

Figure 2.3: Proliferative endometrium

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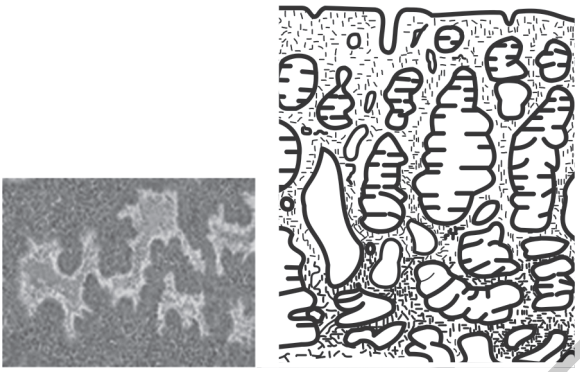

Figure 2.4: Secretory endometrium

Menstrual Phase

It occurs for 4–5 days after day 28 of the cycle due to necrosis and shedding away of endometrial bits and bleeding from endometrial bed. There is regression of secretory endometrium, overcoiling of endometrial spiral arterioles with stasis of circulation in the functional layer of endometrium and necrobiosis of vessels. Prostaglandins elaborated by endometrium also cause vasospasm of spiral vessels and ischaemic necrosis of endometrium. Bleeding occurs as (a) capillary bleeding with or without the formation of subepithelial hematoma, (b) venous haemorrhage, and (c) diapedesis. In the shedding process clotting and fibrinolysis (by plasmin) at bleeding site occur so that unclotted dark red blood with endometrial tissue bits are discharged.

Menstrual phase is caused by the sudden fall in the levels of progesterone and oestrogens that result from the involution of the corpus luteum in the absence of pregnancy. On the other hand, at the end of each anovulatory cycle, the exclusive oestrogenic fall, all by itself causes the menstrual desquamation of the endometrium.

Role of Reproductive Hormones:

1. Gonadotrophin-Releasing Hormone (GnRH)
   - Stimulates release of FSH and LH initiating puberty and sustaining menstrual cycle.
2. Follicle-Stimulating Hormone (FSH)
   - Secreted by anterior pituitary gland during the 1st half of menstrual cycle (Table 2.2).
   - Stimulate growth and maturation of graafian follicle before ovulation
   - Thins the endometrium.
3. Luteinizing Hormone (LH)
   - Secreted by the anterior pituitary gland
   - Stimulates final maturation of graafian follicle

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- Surge of LH about 14 days before next menstrual period causes ovulation (Table 2.2).
- Stimulates transformation of graafian follicle into corpus luteum
- Thickens the endometrium.

Table 2.2: Gonadotrophin secretion (International units per litre)

	Menstruation		*Follicular phase*		*Ovulation*		*Luteal phase*	
	Mean	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*
FSH	10	3–13	8	3–15	20	4–32	5	2– 0
LH	8	3–12	8	6–14	65	43–8	8	82–13

4. Oestrogen
   - Secreted primarily by the ovaries, corpus luteum, adrenal cortex and placenta in pregnancy
   - Considered the hormone of women
   - Stimulates thickening of the endometrium; causes suppression of FSH secretion
   - Responsible for the development of secondary sex characteristics
   - Stimulates uterine contractions
   - Increases water content of uterus
   - High oestrogen concentration inhibits secretion of FSH and prolactin but stimulates secretion of LH
   - Low oestrogen concentration after pregnancy stimulates secretion of prolactin.
5. Progesterone
   - Secreted by the ovary, corpus luteum and placenta during pregnancy
   - Inhibits secretion of LH
   - Has thermogenic effect (increases body temperature)
   - Relaxes smooth muscles thereby decreases contractions of uterus
   - Causes cervical secretion of thick mucus
   - Maintain thickness of endometrium
   - Allows pregnancy to be maintained = Hormone of pregnancy
   - Prepares breasts for lactation.
6. Prolactin
   - Secreted by the anterior pituitary gland
   - Stimulates secretion of milk.
7. Oxytocin
   - Secreted by the posterior pituitary gland
   - Stimulates uterine contractions during birth and compress uterine blood vessels and control bleeding
   - Stimulates let-down or milk-ejection reflex during breastfeeding.

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8. Prostaglandins
   - Produced by many organs of the body, including the endometrium
   - Affects menstrual cycle
   - Influences the onset and maintenance of labour.

PHYSIOLOGY OF PUBERTY

Puberty in girls is the period which links childhood to adulthood. It is defined as the period of gradual development of secondary sexual characteristics when the endocrine and gametogenic functions of the gonads have first developed to the point where reproduction is possible. There are profound biological, morphological and psychological changes which lead to full sexual maturity and eventually fertility.

Morphological Changes

As described by Tanner and Marshall, five important physical changes are evident during puberty. These are development of breast, pubic and axillary hair growth, growth in height and menstruation. The most common order is beginning of growth spurt→ breast budding (thelarche) → pubic and axillary hair growth (adrenarche)→ peak growth in height→ menstruation (menarche). All these changes are usually completed between the ages of 10 and 16 years.

Endocrinology in Puberty

The levels of gonadal steroids and gonadotrophins are low until the age of 6–8 years. This is mainly due to negative feedback effect of oestrogen to the hypothalamic-pituitary system (gonadostat). The gonadostat remain very sensitive (6–15 times) to the negative feedback effect, even though the level of oestradiol is very low (10pg/ml) at that time. As puberty approaches this negative feedback effect of oestrogen is gradually lost. This results in some significant changes in the endocrine function of the girl.

Rising levels of GnRH stimulate the anterior lobe of pituitary to secrete FSH and LH. FSH helps development of the ovarian follicles, which in turn secretes oestrogen, progesterone, inhibin and a small amount of androgen. These hormone levels rise gradually from ages 8–12 and more sharply in early teens. Oestrogens (oestradiol, oestriol and oestrone) are feminising hormones with widespread effect on the body. Oestradiol results in the most visible changes.

Endocrine control of puberty

The first demonstrable biological change of puberty is the appearance of pulsatile LH release during sleep. As puberty progresses the frequency and amplitude of LH peak increases. At the end of puberty, the difference between sleep and wake LH pattern disappear. The LH surge is triggered

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by the increasing activity of neurons that releases GnRH. GnRH cause the anterior pituitary to release gonadotrophins, LH and FSH. The factor that causes the hypothalamus to start secreting GnRH is uncertain. The precise trigger for the GnRH surge during puberty is not known. The influence of adequate nutrition has long been known. When adequate body fat distribution has been attained (17% body fat for female), a signal is sent to hypothalamus to trigger release of GnRH. Leptin is probable hormone that trigger GnRH surges during early puberty. GPR54 gene appears to be critical for the normal development of puberty. It encodes a protein that appears to have an effect on the secretion of GnRH by the hypothalamus. Multiple factors are probably involved.

Timing of onset of puberty

The onset of puberty varies among individuals. Puberty usually occurs around 10–14 years in girls. Adolescent girls reach puberty at earlier ages than were ever recorded previously. Nutritional and other environmental influences may be responsible for this change.

Five phases of puberty

1. **Adrenarche**: It refers to a stage of maturation of the cortex of the human adrenal glands. There is increase in the secretion of adrenal androgens. It typically occurs between ages 6–10 and involves both structural and functional changes. Adrenarche is a process related to puberty but distinct from hypothalamic-pituitary-ovarian maturation and function.
2. **Gonadarche**: It refers to the earliest gonadal changes of puberty. In response to pituitary gonadotrophins, the ovaries begin to grow and increase the production of sex steroids, especially oestradiol and testosterone. Ovarian growth cannot be directly seen, so thelarche and growth are usually the first evidence of gonadarche.
3. **Thelarche**: It is the first stage of secondary (postnatal) breast development, usually occurring at the beginning of puberty in girls. It is usually noticed as a firm tender lump directly under the centre of the nipple (papilla and areola). It is also referred to as the "breast bud" or more formally as Tanner stage II development. It may occur in one side first, or both side simultaneously.
4. **Pubarche**: It refers to the first appearance of pubic hair. It is one of the physical changes of puberty but should not be equated with it since it may occur independently of complete puberty. It usually results from rising levels of androgens from the adrenal glands but may also results from exposure of a child to anabolic steroids.
5. **Menarche**: It is the first menstrual period or first menstrual bleeding in girls. It is considered as the central event of female puberty, as it signals the possibility of fertility. Timing of menarche is influenced by both genetic and environmental factors, especially nutritional status.

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There is endometrial proliferation due to ovarian oestrogen but when the level drops temporarily, the endometrium sheds and bleeding is visible. It denotes an intact HPO axis, functioning ovaries, presence of responsive endometrium to the endogenous ovarian steroids and the presence of a patent uterovaginal canal. The first period is usually anovular. The ovulation may be irregular for a variable period following menarche and may take about 2 years for regular ovulation to occur. The menses may be irregular to start with. The average age of menarche has declined over the last century.

Effects of Gonadotrophins

1. **FSH**: It stimulates follicle maturation and is required for follicular progression to 2nd stage and begin to secrete oestradiol.
2. **LH**: A surge of LH causes the mature graafian follicle to ovulate and transform into a corpus luteum.
3. **Oestrogen**:
   - Establishes female pattern of body fat deposition
   - Bone growth (increased width of pelvis and hips) and body hairs
   - Stimulates growth of external genitalia, internal accessory sexual organs and maintain them in functional state
   - Stimulate growth of breast, particularly the ductal system
   - Stimulate growth of uterine endometrium during follicular phase of female cycle.
4. **Prolactin**: In girls prolactin level increases by 14–15 years of age, most likely due to concomitant increase in plasma oestrogen.
5. **Growth hormone**: GH increases during puberty, particularly at night. Puberty is delayed in patients with GH deficiency. GH plays a role in pubertal development. IGF-1 is an important modulator of growth during childhood and adolescence. It increases at the time of pubertal growth acceleration.

Genital Organ Changes

1. Ovaries change their shape, the elongated shape become bulky and oval. The ovarian bulk is due to follicular enlargement at various stages of development and proliferation of stromal cells.
2. The uterine body and the cervix ratio at birth is about 1:2, the ratio becomes 1:1 when menarche occurs. Thereafter the enlargement of the body occurs rapidly, so that the ratio soon becomes 2:1.
3. The vaginal changes are more pronounced. A few layers of thin epithelium in a child become stratified epithelium of many layers. The cells are rich in glycogen due to oestrogen. Doderlein's bacilli appear which convert glycogen into lactic acid; the vaginal pH becomes acidic ranging between 4–5.
4. The vulva is more reactive to steroid hormones.
5. The mons pubis and labia minora increase in size.

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Table 2.3: Tanner stages of pubertal development in girls

Stage	*Breast*	*Pubic hair*
Stage 1	Prepubertal stage, elevation of papilla only	No pubic hair present
Stage 2	Breast buds and papilla slightly elevated, and areola begins to enlarge (median age 9.8 years)	Sparse, long hair on either side of labia minora (median age 10.5 years)
Stage 3	Further enlargement of entire breast tissue	Darker, coarser and curly hair over the mons pubis
Stage 4	Secondary mound of areola and papilla projecting above the breast tissue (median age 12.1 years)	Adult type hair covering the mons only (median age 12.0 years)
Stage 5	Areola recessed to general contour of breast(median age 14.6 years)	Adult hair with an inverse triangular distribution (female escutcheon) covering the medial thighs (median age 13.7 years)

6. Breast changes are pronounced. Under the influence of oestrogen, there is marked proliferation of duct system and deposition of fat. The breast becomes prominent and round. Under the influence of progesterone, the development of acne increases considerably (Table 2.3).

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Banasree Bhadra MBBS MD (O & G) is at present working as Assistant Professor, Department of Obstetrics and Gynaecology, College of Medicine and JNM Hospital, Kalyani, West Bengal, India. She has participated in various national and international Obstetrics and Gynaecology conferences as faculty and has multiple paper presentations. She has publications in esteemed journals such as JIMA (Journal of the Indian Medical Association), Al Ameen Journal of Medical Sciences, Your Health, etc. She has contributed many chapters in various books on obstetrics and gynaecology published by Federation of Obstetric and Gynaecological Societies of India (FOGSI). Some of the books in which she contributed are:

- Recent Advances in High Risk Pregnancy (2010)
- Recent Advances in Gyne Oncology (2011)
- Osteoporosis: How we can Overcome (2011)
- Recent Advances in Obstetrics and Gynaecology: Threatened Miscarriage (2012)
- Teenage Pregnancy (2013).

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