The primary organs of reproduction

- **Ovaries**
  - All potential gametes are present at birth
  - Remain in the body cavity

- **Testes**
  - Not all potential gametes are present at birth
  - Do not remain in the body cavity
Features of reproductive system

Gonads

• produce gametes and hormones
• ducts to transport the gametes
• accessory glands and organs
• (secrete fluids)
• external genitalia
EXTERNAL GENTILIA

- The vulva refers to those parts that are outwardly visible
- The vulva includes:
  - Mons pubis
  - Labia majora
  - Labia minora
  - Clitoris
  - Urethral opening
  - Vaginal opening
  - Perineum

**Individual differences in:**
- Size
- Coloration
- Shape
- Of external genitalia are common

Female reproductive system

- Ovaries
- Accessory organs
  - uterus
  - uterine (Fallopian) tubes
  - vagina
  - external genitalia
The Female External Genitalia

External genitalia

- Vulva
  - Vestibule
  - Labia minora and majora
  - Paraurethral glands
  - Clitoris
  - Lesser and greater vestibular glands
The triangular mound of fatty tissue that covers the pubic bone.

- It protects the pubic symphysis.
- During adolescence, sex hormones trigger the growth of pubic hair on the mons pubis.
- Hair varies in coarseness, curliness, amount, color, and thickness.
LABIA MAJORA

- Referred to as the outer lips
- They have a darker pigmentation
- The **Labia Majora**:
  - Protect the introitus and urethral openings
  - Are covered with hair and sebaceous glands
  - Tend to be smooth, moist, and hairless
  - Become flaccid with age and after childbirth
The distinction between the labia majora and minora is lost and the clitoris becomes buried under the fused prepuce. Reproduced with permission from Ridley, CM, Neill, SM (Eds), The Vulva, 2nd ed, Blackwell Science, Oxford 1999. Copyright © 1999 Blackwell Science.

1. Labia majora
2. Labia minora
3. Clitoral hood (foreskin)
4. Clitoral glans (under the clitoral hood)
5. Vagina
RECONSTRUCTION OF THE LABIA MAJORA

1. Labia majora
2. Labia minora
LABIA MINORA

- Referred to as the “inner lips”
- Made up of erectile, connective tissue that darkens and swells during sexual arousal
- Located inside the labia majora
- They are more sensitive and responsive to touch than the labia majora
- The labia minora tightens during intercourse
CLITORIS

- Highly sensitive organ composed of nerves, blood vessels, and erectile tissue
- Located under the prepuce
- It is made up of a **shaft** and a **glans**
- Becomes engorged with blood during sexual stimulation
- Key to sexual pleasure for most women
- **Urethral opening** is located directly below clitoris
The clitoral glans is highly sensitive, containing 8,000 nerve endings, double the nerve endings as the analogous organ in males, the glans penis, making it particularly well-suited for sexual stimulation.
Development of Male and Female External Genitalia

Common Genital Anlagen

Goto, JCI 116: 954-60, 2006
Vagina and cervix
VAGINAL OPENING
INTROITUS

- Opening may be covered by a thin sheath called the **hymen**
- Using the presence of an intact hymen for determining virginity is erroneous
- Some women are born without hymens
- The hymen can be perforated by many different events
VAGINA

- The vagina connects the cervix to the external genitals
- It is located between the bladder and rectum
- It functions:
  - As a passageway for the menstrual flow
  - For uterine secretions to pass down through the introitus
  - As the birth canal during labor
  - With the help of two **Bartholin's glands**, becomes lubricated during SI[INTERCOURSE]
Bartholin glands or greater vestibular glands are two glands located slightly below and to the left and right of the opening of the vagina in women. Bartholin’s glands are homologous to bulbourethral glands in males.

However, while Bartholin’s glands are located in the superficial perineal pouch, bulbourethral glands are located in the deep perineal pouch.
Function and purpose

- They secrete mucus to provide vaginal lubrication.
- Bartholin's glands secrete relatively minute amounts (one or two drops) of fluid just before a woman orgasms.
- The fluid may slightly moisten the labial opening of the vagina, serving to make contact with this sensitive area more comfortable for the woman.
PERINEUM

- The muscle and tissue located between the vaginal opening and anal canal
- It supports and surrounds the lower parts of the urinary and digestive tracts
- The perinium contains an abundance of nerve endings that make it sensitive to touch
- An episiotomy is an incision of the perinium used during childbirth for widening the vaginal opening
Dr. Nedal Matar, Aleppo University Hospital, Syria.
Perineal laceration following blunt trauma. No associated pelvic fracture and did not involve the anal sphincter mechanism.
This is normal cervical non-keratinizing squamous epithelium.

- The squamous cells show maturation from basal layer to surface.
CERVIX

- The cervix connects the uterus to the vagina
- The cervical opening to the vagina is small
- This acts as a safety precaution against foreign bodies entering the uterus
- During childbirth, the cervix dilates to accommodate the passage of the fetus
- This dilation is a sign that labor has begun

UNIT 3: FEMALE REPRODUCTIVE SYSTEM

Cervix

- **Squamocolumnar junction (SCJ)**
  - Junction between columnar and squamous epithelium
  - Dynamic: puberty, pregnancy, menopausal, original vs active SCJ
  - **Neonate – exocervical, menopausal – endocervical**
- **Transformation zone**
  - Metaplasia advances from the original SCJ inward, toward the external os, over the columnar villi
  - This process creates the transformation zone
- **Nabothian Cysts**
  - Endocervical glands covered during the metaplastic process
Uterus

Ovaries
UTERUS

- Commonly referred to as the womb
- A pear shaped organ about the size of a clenched fist
- It is made up of the endometrium, myometrium and perimetrium
- Consists of blood-enriched tissue that sloughs off each month during menstrual cycle
- The powerful muscles of the uterus expand to accommodate a growing fetus and push it through the birth canal
The uterus

- **Muscular organ**
  - Mechanical protection
  - Nutritional support
  - Waste removal for the developing embryo and fetus
- Supported by the broad ligament and 3 pairs of suspensory ligaments

Uterine wall consists of three layers:

- **Myometrium** – outer muscular layer
- **Endometrium** – a thin, inner, glandular mucosa
- **Perimetrium** – an incomplete serosa continuous with the peritoneum
The uterus

- Muscular organ
  - Mechanical protection
  - Nutritional support
  - Waste removal for the developing embryo and fetus
- Supported by the broad ligament and 3 pairs of suspensory ligaments
The uterus is a muscular sac, lined with epithelium that undergoes cyclic changes. The wall is made up of thick smooth muscle, organized in interlacing bundles that run randomly. It is called the myometrium.
Arterial/Venous Supply
- Uterine, ovarian, and vaginal artery

**Lymphatic Drainage**
- Fundus = aortic/lumbar/pelvic lymph nodes
- Body = within broad ligament to external iliac nodes
- Cervix = internal iliac and sacral lymph nodes

**Innervation**
- Sympathetic and parasympathetics run through the uterovaginal plexus (which travels with the uterine artery) from the inferior hypogastric plexus and lumbar splanchnic nerves
The Uterus

**Figure 28.18a, b**

The Wall
- Perimetrium, myometrium, endometrium

**The Endometrium**
- **Stratum basale** – premordial glands and densely cellular stroma
- **Stratum functionale** – responds to fluctuating hormone levels, includes Stratum compactum and spongiosum,

**Stratum Compactum**
- Consists of the necks of the glands and densely populated stromal cells

**Stratum Spongiosum**
- Consists primarily of glands with less densely populated stroma and large amounts of interstitial tissue
Figure 28.18  The Uterus

(c) Posterior view

28.18.jpg
The Uterine Wall

Uterus (Secretory)
During the secretory phase, the endometrium thickens and the tubular glands become extremely convoluted (arrow), as shown in this low power micrograph.
The Uterine Wall

Figure 28.19b

- Spiral artery
- Endometrium
- Radial artery
- Straight artery
- Myometrium
- Uterine artery
- Uterine glands
- Arcuate arteries
The Uterine Tubes

Figure 28.17a-c

(a) Posterior view

Smooth muscle

Columnar epithelium (b) Lamina propria

Cilia Microvilli of mucin-secreting cells

(c)

Cilia of ciliated columnar epithelial cell

Secretory cell with microvilli

Cilia and secretory cells lining the uterine (Fallopian) tube

Portion of endometrium and myometrium

SEM 4000x

LM 25x
This is the microscopic appearance of normal proliferative endometrium in the menstrual cycle.

The proliferative phase is the variable part of the cycle. In this phase, tubular glands with columnar cells and surrounding dense stroma are proliferating to build up the endometrium following shedding with previous menstruation.

Here is early secretory endometrium.

The appearance with prominent subnuclear vacuoles in cells forming the glands is consistent with post-ovulatory day 2.

The histologic changes following ovulation are quite constant over the 14 days to menstruation and can be utilized to date the endometrium.
Uterine cycle

- Repeating series of changes in the endometrium
- Continues from menarche to menopause

  - Menses
    - Degeneration of the endometrium
    - Menstruation
  
  - Proliferative phase
    - Restoration of the endometrium
  
  - Secretory phase
    - Endometrial glands enlarge and accelerate their rates of secretion
MENSTRUATION

- Menarch, the onset of menstruation signals the bodily changes that transform a female body
- Average age is 12.8
- Amount of bleeding varies from woman to woman
- Expulsion of blood clots

- Blood color can vary from bright red to dark maroon
- Usually occurs every 25 to 32 days
- Women can experience fluid retention, cramping, mood swings, weight gain, breast tenderness, diarrhea, and constipation
UNIT 3: FEMALE REPRODUCTIVE SYSTEM
UNIT 3: FEMALE REPRODUCTIVE SYSTEM

Figure 28.20  The Uterine Cycle

Figure 28.20
A menstrual cycle is defined as that period of time from the beginning of one menstrual flow to the beginning of the next menstrual flow. The menstrual cycles includes:

**Follicular Phase** - approximately 14 days but highly variable and ending with ovulation.

*After menstruation, low levels of estradiol and progesterone stimulate the hypothalamic release of GnRH with in turn increases the pituitary’s release of FSH and LH.*

*FSH stimulates the maturation of ovarian follicles and LH stimulates theca cells of the ovary to produce androgens, which are then converted to estrogens in the granulosa cells of the ovary.*

*Estrogen stimulates proliferation of the endometrial lining (proliferative phase).*
Ovulation
• A preovulatory estradiol surge leads to a midcycle LH surge, which initiates ovulation.
• A mature follicle releases an oocyte and becomes a functioning corpus luteum.

Luteal Phase
• The luteal phase begins with ovulation and ends with the menstrual flow and usually lasts 14 ± 2 days.
• Large amounts of progesterone are produced by the corpus luteum as well as estrogen.
• Rising levels of estrogen and progesterone lead to falling levels of FSH and LH.
• Progesterone stops the growth of the endometrium and stimulates differentiation of the endometrium into a secretory endometrium.
• Without fertilization and human chorionic gonadotropin production, the corpus luteum involutes after about 10 - 12 days and sloughing of the endometrium.
• Local prostaglandin release leads to vasoconstriction and uterine contractions.
Uterus, Menstrual Phase

Exfoliating tissue

Breakdown of the corpus luteum in the absence of LH causes loss of estrogen and progesterone to maintain the endometrium.

Stratum functionalis

Stratum basalis

OVARIAN HORMONES

(D)

UNIT 3: FEMALE REPRODUCTIVE SYSTEM
SEX HORMONES

- Follicle stimulating hormone (FHS)
- Luteinizing hormone (LH)
- Estrogen
- Progesterone

Both FHS and LH are produced in the pituitary gland.

Both estrogen and progesterone are produced by the follicles in the ovaries.

UNIT 3: FEMALE REPRODUCTIVE SYSTEM

DYSMENORRHEA

- Painful menstrual cramps
- Painful menses without evidence of a physical abnormality
- Believed to be normal body response to uterine contractions

Other symptoms:
- Nausea, vomiting, gastrointestinal disturbances, and fainting
- Prostaglandins cause forceful, frequent uterine contractions called cramps
- Fibroids, polyps, IUD, PID, or endometriosis

UNIT 3: FEMALE REPRODUCTIVE SYSTEM
ENDOMETRIOSIS

- Common cause of dysmenorrhea, dyspareunia, and infertility
- Endometrium fragments and lodges in other parts of the pelvic cavity
- Causes inflammation, bleeding, scarring, and adhesions
- Causes are still being studied
- Treated through hormonal therapy, laparoscopic surgery, or major surgical management

UNIT 3: FEMALE REPRODUCTIVE SYSTEM

OVIDUCTS

- Oviducts, uterine tubes, salpinges (singular salpinx)
- Are two very fine tubes lined with ciliated epithelia, leading from the ovaries of female mammals into the uterus
FALLOPIAN TUBES

- Serve as a pathway for the ovum to the uterus
- **Are the site of fertilization by the male sperm**
- Fertilized egg takes approximately 6 to 10 days to travel through the fallopian tube to implant in the uterine lining
There are two Fallopian tubes attached to either side of the cornual end of the uterus at the axilla of Welch.

Each terminates at or near one ovary forming a structure called the fimbria.

The Fallopian tubes are not directly attached to the ovaries, but open into the peritoneal cavity (essentially the inside of the abdomen); they thus form a direct communication between the peritoneal cavity and the outside via the vagina.

In humans, the Fallopian tubes are about 7–14 cm long.

If a Fallopian Tube is missing from the pair, then the other fallopian tube that is functional could still be a way of carrying an egg down to the uterus.

---

**Regions**

There are four regions of the fallopian tube from the ovary to the uterus:

- **Infundibulum** - contains fimbria
- **Ampulla** - usual site of fertilization
- **Isthmus**
- **Intramural oviduct** - inside wall of uterus
Histology

Layers of the wall of the fallopian tube.

- There are three layers of the fallopian tube:
  1. **Mucosa** - the distinctive folds of the mucosa are the most unusual feature. The folds contain ciliated cells and "peg cells". The region of the fallopian tube can be approximated by looking at the mucosa, because the folds are most elaborate at the ampulla and almost nonexistent at the intramural portion.
  2. **Muscularis externa**
  3. **Serosa**

**Motility**

- The Fallopian tubes are mobile, and have been observed on time-lapse videography moving about the pelvis.
- Although anatomical illustrations have them proceeding from the uterine horns to the ovary, this is not the case for most of the menstrual cycle, and a tube may cross to the other side or lie on top of the uterus.
Fallopian Tube, ls

- **Mucosa:** consists of longitudinal folds lined with ciliated and non-ciliated columnar epithelium.

- **Muscularis:** consists of a circular and a longitudinal layer.
Fallopian Tube, cs

- Muscularis
- Mucosal folds
- Ovarian artery and vein

Anatomy of the Ovary and Follicle

- Ovary
- Uterus
- Vagina
- Oviduct
- Vesicular (Graafian) follicle
- Primary follicles
- Secondary follicles
- Oocyte
- Corpus luteum
The Fallopian Tubes

- **Arterial/Venous Supply**
  - Terminal branches of the uterine and ovarian arteries found in the mesosalpinx

- **Lymphatic Drainage**
  - Separate and distinct from the uterus
  - Drains to the internal iliac nodes and the aortic nodes at the level of the renal vessels

- **Innervation**
  - Sympathetic and parasympathetic from the uterine and ovarian plexus.
  - Sensory nerves come from T11, T12, and L1

- **Four segments**
  - Intramural, isthmic (narrowest internal diameter), ampullary, infundibulum

- **Fimbriae**
  - The largest attached to the ovary is called *fimbria ovarica*

- **Layers**
  - Serosa, Adventia (vessels), muscle, mucosa (plica, cilia)
OVARIES

The ureter runs close to the ovarian fossa
- Germinal epithelium is cuboidal
- Ligaments – ovarian and infundibular pelvic (vessels)
- Ovarian fossa
  - A depression in the peritoneum where the ovary rests in nulliparous women
Ovaries
The Ovaries

**Two functions** –
- production and ovulation of oocytes
- the production and secretion of hormones.

The ovary is attached to the **broad ligament** by a short fold of peritoneum, called the **mesovarium** (or ligament of the ovary), through which vessels and nerves pass to the ovary and enter it at the hilus of the ovary.

**The surface of the ovary is covered by a single layer of cuboidal epithelium**, also called germinal epithelium.

It is continuous with the peritoneal mesothelium.

Fibrous connective tissue forms a thin capsule, the **tunica albuginea**, immediately beneath the epithelium.

Like so many other organs the ovary is divided into an **outer cortex** and an **inner medulla**.

The cortex consists of a very cellular connective tissue stroma in which the ovarian follicles are embedded.

The medulla is composed of loose connective tissue, which contains blood vessels and nerves.
Ovarian Follicles

consist of one oocyte and surrounding follicular cells.

Follicular development can be divided into a number of stages.

Development represents a morphological continuum, and it may not be possible to assign all follicles to a specific stage.
Graafian follicle expels ovum.
Corpus luteum produces progesterone, estrogen, relaxin and inhibin.
**Graafian Follicle**

The Graafian follicle is identified by the large antrum (A) and the corona radiata (arrow) that surrounds the actual oocyte and projects into the antrum.

---

**Mature (Vesicular) Follicle**

- Theca interna
- Theca externa
- Antrum
- Secondary oocyte
- Corona radiata
- Granulosa cells
- Cumulus oophorus
- Zona pellucida
**Primordial Follicle**
The primordial follicle can be identified by its single layer of follicular cells (red arrow). To the right are two atretic follicles (blue arrows). Notice the wavy stroma.

---

**Corpus Luteum**
Progesterone from the corpus luteum maintains the uterus for implantation. Notice the fullness of the granulosa luteal cells (GL) and positioning of the theca luteal cells (TL).
Stages of follicle maturation

a). Primordial follicle  Only 1 layer of cells
b). Primary follicle  2 or more layers of cells.
c). Secondary follicle: fluid filled space
d). Vesicular (Graafian) follicle: Bulges
e). Corpus luteum: The ruptured follicle

Primordial follicles

- are located in the cortex just beneath tunica albuginea.
- One layer of flattened follicular cells surround the oocyte (about 30 µm in diameter).
- The nucleus of the oocyte is positioned eccentric in the cell.
- It appears very light and contains a prominent nucleolus.

- Most organelles of the oocyte aggregate in the centre of the cell, where they form the vitelline body (probably not visible in any of the available preparations).
During fetal development, meiosis I begins.

After puberty, primary oocytes complete meiosis I, which produces a secondary oocyte and a first polar body that may or may not divide again.

The secondary oocyte begins meiosis II.

A secondary oocyte (and first polar body) is ovulated.

After fertilization, meiosis II resumes. The oocyte splits into an ovum and a second polar body.

The nuclei of the sperm cell and the ovum unite, forming a diploid (2n) zygote.

(a) Ovarian cortex

28.17.jpg
(a) Fluctuation of gonadotropin levels

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<table>
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<tr>
<th>Age</th>
<th>Oogenesis</th>
<th>Follicular development</th>
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<tbody>
<tr>
<td>Fetal period</td>
<td>2n Oogonium</td>
<td>Primordial follicle</td>
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<td>Mitosis</td>
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<td></td>
<td>2n Primary oocyte</td>
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<td>Meiosis in progress</td>
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<td>Childhood (incomplete development of follicles)</td>
<td>2n Primary oocyte (still in prophase I)</td>
<td>Primary follicle</td>
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<td>Puberty to menopause each month</td>
<td>2n Primary oocyte</td>
<td>Secondary follicle</td>
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<td>Mitosis</td>
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<td></td>
<td>2n Secondary oocyte (in metaphase II)</td>
<td>Mature (Graafian) follicle</td>
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<td>First polar body</td>
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<td>Meiosis II by one primary oocyte each month</td>
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<td>Meiosis II of first polar body may or may not occur</td>
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<td>All polar bodies degenerate</td>
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<td>Sperm cell</td>
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<td>Meiosis II completed if fertilization occurs</td>
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Ovarian teratoma

Large leiomyoma in the lower uterine segment in a 28-year-old woman