FEMALE REPRODUCTIVE SYSTEM:
Part 1  Ovary and hormonal orchestration

Dr. Larry Johnson  Texas A&M University
Objectives: female reproductive system

Part 1 Ovary and hormonal orchestration
- Identify the tissues of the ovary, and distinguish between primordial, primary, secondary, tertiary, and atretic follicles.
- Hormonal orchestration

Part 2 Uterine tube and uterus
- Describe the three layers of the uterine tube and compare the structure in the different regions along its length.
- Describe the three layers of the uterus. Understand the morphological changes in the endometrium and myometrium during the normal menstrual cycle and during pregnancy.

Part 3 Cervix, mammary gland, and placenta
- Compare the structures and functions of the mammary glands at different stages.
- Identify the three layers of the cervix and the vagina.
- Identify the villi and intervillous space in the placenta. Relate these structures with placental function.
FUNCTIONS OF THE FEMALE REPRODUCTIVE SYSTEM

- OVA PRODUCTION
- OVA and SPERM TRANSPORTATION
- MICROENVIRONMENTS FOR FERTILIZATION
- IMPLANTATION AND FETAL-PLACENTAL GROWTH
- NOURISHMENT AND SUPPORT OF OFFSPRING
- POSTNATAL REPETITION
OVARY

GENERAL STRUCTURE

- GERMINAL EPITHELIUM
- TUNICA ALBUGINEA
- MEDULLA
- CORTEX

FUNCTIONAL OVERVIEW
Slide 79: Ovary

- Medullary blood vessels
- Tunica albuginea
- Germinal epithelium

- Cortex
- Medulla
- Cortex
Ovary, monkey

Ovarian Cortex:
1. Germinal epithelium
2. Tunica albuginea
3. Primordial and primary follicles
Follicle development and changes within ovary
FOLLCILE MATURATION

PRIMORDIAL FOLLICLES

- OOCYTE
- FOLLICULAR (GRANULOSA) CELLS
Ovary:
1. Primordial follicle
2. Granulosa cell

Ovarian Cortex:
1. Germinal epithelium
2. Tunica albuginea
3. Primary follicle
FOLLICLE MATURATION

PRIMARY FOLLICLE
- ZONA PELLUCIDA
- STRATUM GRANULOSUM
- THECAL FOLLICULI
- CALL-EXNER BODIES
FOLLICLE MATURATION

SECONDARY (ANTRAL) FOLLICLE

FOLLICULAR FLUID

MEMBRANA GRANULOSA

CUMULUS OOPHORUS

CORONA RADIATA

THECA INTERNA

THECA EXTERNA
FOLLICLES

FOLLICLE
MATURATION
GRAAFIAN
FOLLICLE
GRAAFIAN FOLLICLE

egg
Slide 79: Ovary

Primordial follicle

- Zona pellucida
- Granulosa cells

Primary follicle

- Theca externa & interna
- Antrum with liquor folliculi
- Corona radiata
- Cumulus oophorus
- Membrana granulosa

Secondary follicle
EM 50: Ovary

Primary Follicle

- Oocyte
- Zona pellucida
- Granulosa cells
EM 25: early primary follicle
1. Cytoplasm of primary oocyte
2. Zona pellucida
3. Follicular cell
Ovary
Ovary
Ovary, guinea pig
Ovary, guinea pig – primary and secondary follicles; follicle with atresia and its final form as a glassy membrane
OVULATION
Ovary, corpus luteum
1. Granulosa lutein
2. Theca lutein
3. Central clot
Corpus luteum of the ovary
Slide 80: Ovary with corpus luteum

- Corpus luteum
- Corpus hemorrhagicum remnants
- Theca lutein cells
- Granulosa lutein cells
Corpus luteum of Ovary, mouse (toluidine blue)
EM 24: corpus luteum

1. Capillary
2. Nucleus of granulosa lutein cell
3. erythrocyte
Corpus luteum and corpus albicans of ovary
Slide 81: Ovary

- Vasculature
- Corpus luteum
- Corpus albican
OOGENESIS - FORMATION AND DEVELOPMENT OF OVA

MITOSIS (OOCYTOGENESIS) – OOGONIA

- PRENATAL DEVELOPMENT (RUMINANTS, RODENT, SWINE, HUMAN)
- POSTNATAL DEVELOPMENT (CARNIVORES)
OOGENESIS - FORMATION AND DEVELOPMENT OF OVA

MEIOSIS – OOCYTES
EARLY DEVELOPMENT
MATURATION ARREST (DICTYATE STEP OF MEIOTIC PROPHASE)
LATER DEVELOPMENT SYNCHRONIZED WITH DEVELOPMENT AND MATURATION OF FOLLICLES
DIVISION

• FIRST MEIOTIC DIVISION – REDUCTION DIVISION – FIRST POLAR BODY
• SECOND MEIOTIC DIVISION –
• EQUATIONAL DIVISION – SECOND POLAR BODY
Oogenesis

**Before birth (embryonic and fetal period)**
- Oogonia are diploid cells (containing 23 pairs of chromosomes, or 46 total) that are the origin of oocytes. Mitotic divisions of oogonia produce primary oocytes, which are diploid cells.
- Primary oocytes start the process of meiosis but are arrested in prophase I.

**Oogenesis (development of oocytes)**
- 46 → Oogonium
- Mitosis
- 23 → Primary oocyte (arrested in prophase I)
- 23 → Primordial follicle

**Follicle development**
- 23 → Oocyte
- Follicle cells
- Primordial follicle

**Childhood**
- Ovary is inactive. It houses primordial follicles. Some atresia of primordial follicles occurs.

**Monthly, from puberty to menopause**
- Up to approximately 20 primordial follicles mature into primary follicles every month. Some primary follicles mature into secondary follicles. Primary follicles that do not mature undergo atresia.

- Typically only one secondary follicle matures into a vesicular follicle, where the primary oocyte completes the first meiotic division to produce a polar body and a secondary oocyte. The secondary oocyte is a haploid cell (containing 23 chromosomes only) that is arrested in the second meiotic metaphase.

- If the secondary oocyte is fertilized, it completes the second meiotic division and becomes an ovum. If the secondary oocyte is not fertilized, it degenerates.
The number of chromosomes are present in the human secondary oocyte is 23 chromosomes, the haploid number.
MEIOSIS (ONLY IN SPERMATOGENESIS AND OOGENESIS)

EXCHANGE OF GENETIC MATERIAL IN HOMOLOGOUS CHROMOSOMES (LEPTOTENE, ZYGOTENE, PACHYTENE, AND DIPLOTENE STEPS OF DEVELOPMENT)
MEIOSIS (ONLY IN SPERMATOGENESIS AND OOGENESIS)

PRODUCES HAPLOID CONDITION OF GAMETES
<table>
<thead>
<tr>
<th>POLAR BODY EXTRUSION</th>
<th>MANY MAMMALS</th>
<th>HORSE &amp; DOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST</td>
<td>Preovulation</td>
<td>Postovulation</td>
</tr>
<tr>
<td>SECOND</td>
<td>Zona penetration of sperm</td>
<td>Zona penetration of sperm</td>
</tr>
</tbody>
</table>
FIRST POLAR BODY
birth
# FOLLICULAR DEVELOPMENT - SYNCHRONIZED WITH GAMETE DEVELOPMENT

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DESCRIPTION</th>
<th>GERM CELL TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIMORDIAL</td>
<td>FLATTENED FOLLICULAR CELLS</td>
<td>PRIMARY OOCYTE</td>
</tr>
<tr>
<td>PRIMARY</td>
<td>LOW CUBOIDAL FOLLICULAR CELLS</td>
<td>PRIMARY OOCYTE</td>
</tr>
<tr>
<td>SECONDARY</td>
<td>YOLK FORMATION, ZONA PELLUCIDA, THECA INTERNA,</td>
<td>PRIMARY OOCYTE</td>
</tr>
<tr>
<td></td>
<td>THECA FOLLICULI EXTERNA</td>
<td></td>
</tr>
</tbody>
</table>
### Follicular Development - Synchronized with Gamete Development (cont’d)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Germ Cell Type</th>
</tr>
</thead>
</table>
| Vesicular Follicle - Call-Exner Bodies (Tertiary Follicle) (Precursors of Liquor FOLLICULI) | - Formation of Follicular Antrum  
- Cumulus Oophorus - Mound of Cells  
- Corona Radiata - Adjacent to Oocyte Nutrients  
- Stratum Granulosum | Primary Oocyte                 |
| Mature Follicle - Preovulatory (Graafian Follicle) Largest, Extend from Cortex to Surface of Ovary |                                                                             | Primary/Secondary Oocyte |
HORMONES ORCHESTRATE THE PROCESS

Figure 23–9. Diagram showing the relationships of the hypothalamus, hypophysis, and ovaries. This feedback mechanism regulates the secretion of hormones produced by the pituitary.
OVARIAN HORMONES

ANDROGENS
- LH STIMULATION CAUSES THECA INTERNA CELLS TO PRODUCE ANDROGENS (ANDOSTENEDIONE AND TESTOSTERONE)

ESTROGENS
- FSH STIMULATION CAUSES MEMBRANA GRANULOSA CELLS TO PRODUCE ESTROGENS (ESTRODIOL - 17B)
  - GRANULOSA CELLS AROMATIZE ANDROGENS FROM THECA INTERNA CELLS TO PRODUCE ESTROGENS
  - ESTROGENS - INDUCE FURTHER PROLIFERATION OF GRANULOSAL CELLS
OVARIAN HORMONES

INHIBITION OF FSH

- FOLLICULOSTATIN - INHIBITORY SUBSTANCE HAS NEGATIVE FEEDBACK ON FSH
- STEROIDSTHEMSELVES WORK THROUGH NEGATIVE FEEDBACK

PROGESTERONE - GRANULOSA LUTEIN CELLS OF CORPUS LUTEUM

- UTERINE GLAND DEVELOPMENT
- MAINTENANCE OF PREGNANCY

RELAXIN - PRODUCED BY CORPUS LUTEUM

- CAUSES RELAXATION OF LIGAMENTS ASSOCIATED WITH PUBIC SYMPHYSIS BEFORE PARTARITION
Hormonal regulation of ovarian function

**Most of follicular phase**

1. Hypothalamus secretes GnRH, which stimulates anterior pituitary.
2. FSH and LH stimulate follicular development.
3. Maturing ovarian follicles secrete inhibin (which inhibits FSH production) and low levels of estrogen (which initially inhibit both the hypothalamus and anterior pituitary).
4. Estrogen also assists with the development of the vesicular follicle.
5. Vesicular follicle produces a large threshold amount of estrogen, which stimulates the hypothalamus and anterior pituitary.

**Late follicular, ovulation, and luteal phases**

6. An LH surge from the anterior pituitary induces ovulation.
7. The corpus luteum forms under the influence of LH.
8. The corpus luteum secretes large amounts of progesterone, estrogen, and inhibin, which inhibit the hypothalamus and anterior pituitary.
Female reproductive system cycles
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End of Part 1  Ovary and hormonal orchestration

FEMALE REPRODUCTIVE SYSTEM:
Part 1  Ovary and hormonal orchestration

Dr. Larry Johnson  Texas A&M University
FEMALE REPRODUCTIVE SYSTEM:
Part 2  Uterine tube and uterus

Dr. Larry Johnson  Texas A&M University
Objectives: female reproductive system

Part 1 Ovary and hormonal orchestration

• Identify the tissues of the ovary, and distinguish between primordial, primary, secondary, tertiary, and atretic follicles.
• Hormonal orchestration

Part 2 Uterine tube and uterus

• Describe the three layers of the uterine tube and compare the structure in the different regions along its length.
• Describe the three layers of the uterus. Understand the morphological changes in the endometrium and myometrium during the normal menstrual cycle and during pregnancy.

Part 3 Cervix, mammary gland, and placenta

• Compare the structures and functions of the mammary glands at different stages.
• Identify the three layers of the cervix and the vagina.
• Identify the villi and intervillous space in the placenta. Relate these structures with placental function.
Uterine tubes and uterus
image 179

Fallopian tube = uterine tube
Uterine tube - infundibulum frimbriae

Lymphatic vessels help give rigidity to the projections.
Uterine tube: infundibulum frimbriae - ciliated epithelium
Slide 82: Oviduct (ampulla)

- **Serosa**
- **Muscularis externa**
- **Blood vessels**
- **Ciliated simple columnar epithelium**
- **Lamina propria**
Uterine tube: isthmus
Uterine tube
Uterine tube - ciliated epithelium
1. Endometrium
2. Myometrium
3. Perimetrium
Fig. 18-10  Uterus: Proliferative (Follicular) Phase.  Stain: hematoxylin-eosin.  Low magnification.
The stratum basalis remains relatively unchanged during the menstrual cycles.
ZONA FUNCTIONALIS
SPIRAL ARTERIES

Diagrammatic representation of the glands and vasculature of the human endometrium.
Fig. 18-10  Uterus: Proliferative (Follicular) Phase. Stain: hematoxylin-eosin. Low magnification.

Fig. 18-12  Uterus: Menstrual Phase. Stain: hematoxylin-eosin. Low magnification.
Uterus, early proliferative endometrium
Uterus, early proliferative endometrium
Slide 83: Uterus (early proliferative [follicular] stage)

- Perimetrium serosa lined by mesothelium
- Uterine lumen lined by simple columnar epithelium

Myometrium

Endometrium
Slide 83: Uterus (early proliferative [follicular] stage)

- Basal layer
- Functionalis layer

Arterial supply to endometrium:
- Uterine lumen epithelium
- Capillaries
- Lacunae
- Uterine gland
- Endometrium
- Spiral artery
- Straight artery
- Radial branch
- Arcuate artery
- Myometrium

Straight uterine glands
Uterus, late proliferative endometrium
Uterus, late proliferative endometrium
Uterus, early secretory endometrium
Uterus, early secretory endometrium
Uterus, early secretory endometrium
Uterus, early secretory endometrium and myometrium
Slide 84: Uterus (secretory [luteal] stage

- **Myometrium**
- **Endometrium**
  - **Functionalis layer**
  - **Basal layer**
- Hypertrophied and tortuous uterine glands
Uterus, late secretory endometrium

SPIRAL ARTERIES
Uterus, late secretory endometrium smooth muscle
Uterus, late secretory endometrium

The phase of the uterine cycle when the glands produce the most glycogen is secretory phase.
HORMONES ORCHESTRATE THE PROCESS
Uterus, late secretory
1. Decidual cells
2. Spiral arteries
~ 10-day implantation

10 day old implant human #272
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End of Part 2: Uterine tube and uterus

FEMALE REPRODUCTIVE SYSTEM:
Part 2  Uterine tube and uterus

Dr. Larry Johnson  Texas A&M University
FEMALE REPRODUCTIVE SYSTEM:
Part 3  Cervix, mammary gland, and placenta
Objectives: female reproductive system

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• Compare the structures and functions of the mammary glands at different stages.
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• Identify the villi and intervillous space in the placenta. Relate these structures with placental function.
Slide 184, cervix
1. Lumen
2. Cervical glands
3. Lamina propria
4. Smooth muscle
Cervix
Cervix
Cervix
Cervix,
1. junction of endocervix and ectocervix
2. Vagina cervix
ENDOCERVIX ends in the Vagina which has no MUCUS glands
Vagina

Vagina epithelium
1. Stem cells
2. Prickle cell layer
3. Nonkeratinized squamous epithelial cells

The wall of the vagina lacks glands. Any mucus in the vagina is produced by cervical glands and other liberation comes from blood plasma.
Vagina
Slide 85: Cervix / vagina

- Mucous glands
- Endocervix
- Simple columnar epithelium
- Nonkeratinized stratified squamous epithelium lining the portio vaginalis
Slide 86: Vagina

1. Lamina propria
2. Muscularis externa

Nonkeratinized stratified squamous epithelium
Slide 89: Mammary gland (inactive)

1. Mature, but inactive
2. Early pregnancy
3. Midpregnancy
4. Lactating
5. Regression after weaning

- Pectoralis major muscle
- Lactiferous duct
- Lobule
- 5th rib
- Fat

- Nipple
- Lactiferous sinus

- Alveolar duct
- Intralobular CT

- Adipocytes
- Lobule

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NOURISHMENT AND PROTECTION OF OFFSPRING
Mammal Mothers Have Milk

What’s so great about milk? It’s rich in nutrients, full of antibodies, and easy to digest. On top of that, it’s portable and convenient. Nursing mammal mothers have food available for their babies on demand.
Figure 33-10. Diagram of the transcellular pathways involved in milk secretion. Casein, lactate, calcium, and citrate are packaged in the Golgi and released by exocytosis. Lipid droplets, enveloped in portions of the cell membrane, are released in a unique form of apocrine secretion. Water and ions freely diffuse through the membrane. Immunoglobulins, taken up by receptor-mediated endocytosis at the basolateral region of the cell, are transported in small vesicles and released at the cell apex. (Redrawn and modified after Neville, M.C. et al. 1983. In Lactation: Physiology, Metabolism, and Breast-Feeding. New York, Plenum Press.)
OTHER GLANDS OF EPIDERMAL ORIGIN – mammary gland

Gland for which our class, Mammalia, was named. Mammals are characterized by hair on skin, special ear bones, and in females, milk-producing mammary glands for nourishment of young.
Nipple
Breast inactive
Breast, pregnancy
Breast, early pregnancy
Breast during late pregnancy
Slide 90: Mammary gland (early proliferative)

- Intralobular CT
- Interlobular CT
- Lobule
- Alveolar duct
- Adipocytes
Slide 91: Mammary gland (active)

- Lobule
- Interlobular CT
- Alveoli with colostrum
- Intralobular CT
- Large duct with colostrum
- Myoepithelial cell
In summary

Mammary gland

1. Mature, but inactive
2. Early pregnancy
3. Midpregnancy
4. Lactating
5. Regression after weaning

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Figure 32–33. Drawing depicting the morphological changes in the ovary menstrual cycle, and the hormones controlling these changes. (From Eastm Englewood Cliffs, NJ, Appleton-Century-Crofts, 1956.)
IMPLANTATION AND Fetal-Placental GROWTH
The umbilical vein carries oxygenated blood to the fetus.
Blood flow from the mother to the fetus. 
Maternal artery > placenta > umbilical vein > liver OR ductus venosus (bypasses liver) > R atrium of heart > foramen ovale OR R ventricle 
Foramen ovale (bypass lungs) > L atrium > L ventricle > aorta > brain and body 
R ventricle > pulmonary artery > ductus arteriosus (bypass lungs) > aorta > body 
Body > 2 umbilical arteries > placenta > maternal vein
Slide 88: Placenta

- Chorionic villi
- Intervillous space
- Cytotrophoblast cell
- Fetal capillaries
- Mesenchyme
- Synctiotrophoblast cells
- Decidua basalis
- Decidual cells
EM 26; trophoblast, 20,000x

1. Nucleus
2. Microvilli
3. Tubular cristae
hemochorial placenta = human placenta
A hemochorial placenta type has the maternal blood in direct contact with the chorionic trophoblast. However, there are three layers of cells:

- **Mesenchyme**
- **Cytotrophoblast cell**
- **Synctiotrophoblast cells**
- **Fetal capillaries**
CONNECTIVE TISSUE CLASSIFICATION

Connective tissue

Connective tissue proper

Connective tissue with special properties

Supporting connective tissues

Mucous tissue

Cartilage (Chapter 7)

Bone (Chapter 8)
Clinical Correlation

Stimulation of receptors in the nipple during breast-feeding results in release of oxytocin from the posterior pituitary.

Where are the cell bodies of the cells that release oxytocin located?
- The cell bodies of the cells that release oxytocin are located in the hypothalamus.

Oxytocin is responsible for the milk-ejection reflex.

Which cells in the breast are stimulated oxytocin?
- Oxytocin stimulates contraction of the myoepithelial cells around the alveoli, thereby ejecting milk.
Clinical Correlation

The structure of the endometrium changes dramatically during the menstrual cycle.
Reclining Pregnant Woman, 1999

The fetus can be seen in the opened uterus as can the placenta, which has been cut through at the front wall of the uterus. From head to tail, the fetus already measures 28 centimeters (11 inches) and is pushing the abdominal organs of the mother upwards. The liver can be seen under the right arch of her ribs; the opened stomach is under the left one. Below these are horizontal parts of the large intestine and loops of the small intestine.

FUNCTIONS

- OVA PRODUCTION
- SPERM reception and TRANSPORTATION
- MICROENVIRONMENTS FOR FERTILIZATION
- IMPLANTATION AND FETAL-PLACENTAL GROWTH
- NOURISHMENT AND SUPPORT OF OFFSPRING
- POSTNATAL REPERITITION
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End of Part 3  Cervix, mammary gland, and placenta
The End!