Reproduction & Development:
Reproductive Technologies
Embryonic Differentiation & Development

Booklet 4

Name: ________________________________
Male Reproductive System

- The male gonad is the TESTES
- Testes produce SPERM and the hormones TESTOSTERONE and INHIBIN
- The testes are located in the scrotum. The temperature in scrotum is about 1.5°C cooler than that of the body. This is necessary so that sperm will develop properly.

The path of the sperm from the inside to the outside of the male:

TESTES (Seminiferous tubules) → EPIDIDYMIS → VAS DEFERENS → URETHRA → PENIS → OUTSIDE

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penis</td>
<td></td>
</tr>
<tr>
<td>Testes</td>
<td></td>
</tr>
<tr>
<td>Scrotum</td>
<td></td>
</tr>
<tr>
<td>Urethra</td>
<td></td>
</tr>
<tr>
<td>Cowper’s Gland</td>
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<tr>
<td>Prostate Gland</td>
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<tr>
<td>Seminal vesicles</td>
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<tr>
<td>Epididymis</td>
<td></td>
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<tr>
<td>Vas Deferens</td>
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</tbody>
</table>
What are the male sex hormones?

1. **Follicle Stimulating Hormone (FSH)** - stimulates the testes to produce sperm and the hormone inhibin. It is produced by the anterior pituitary gland.

2. **Luteinizing Hormone (LH)** - stimulates the testes to produce male sex hormones (ex: Testosterone). It is produced by the anterior pituitary gland

* FSH and LH are called gonadotropic hormones - which means they stimulate the gonads (testes)

3. **Testosterone** – causes the development of secondary sex characteristics (hair growth, deepening of voice, etc). Testosterone is produced in the testes.

4. **Inhibin** - This hormone causes a negative feedback signal for the hypothalamus to regulate sperm production. When the testes are full of sperm, inhibin is released into the blood to tell the pituitary gland to stop releasing FSH. Inhibin is produced by the seminiferous tubules of the testes.
Female Reproductive System

- The female gonads are the **OVARIES**
- Ovaries produce eggs (ova) and the hormones **ESTROGEN** and **PROGESTERONE**

The path of eggs from the inside of the female to the outside of the female:

OVARY → OVIDUCT → UTERUS → CERVIX → VAGINA → OUTSIDE

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovaries</td>
<td></td>
</tr>
<tr>
<td>Follicle</td>
<td></td>
</tr>
<tr>
<td>Oviduct (Fallopian Tubes)</td>
<td></td>
</tr>
<tr>
<td>Fimbriae</td>
<td></td>
</tr>
<tr>
<td>Uterus (womb)</td>
<td></td>
</tr>
<tr>
<td>Endometrium</td>
<td></td>
</tr>
<tr>
<td>Cervix</td>
<td></td>
</tr>
<tr>
<td>Vagina</td>
<td></td>
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</tbody>
</table>
**What are the female sex hormones?**

1. **Estrogen** – stimulates the development of secondary sex characteristics (breasts growth, etc). Estrogen is produced in the ovaries.

2. **Progesterone** – important in the menstrual cycle and in maintaining the early stages of pregnancy. It maintains the thickness of the endometrium. It is secreted by the corpus luteum in the ovary. It is called the “hormone of pregnancy”

3. **Luteinizing hormone (LH)** – causes ovulation (release of the egg). It is produced by the anterior pituitary gland.

4. **Follicle Stimulating Hormone (FSH)** – stimulates the follicle, which contains the egg, to grow. It is produced by the anterior pituitary gland.
What is the Menstrual Cycle?

1. The maturation of an egg
2. The preparation of the uterus (womb) for pregnancy (temporarily) and menopause (permanently)

What are the stages of the Menstrual Cycle?

1. Menstruation (lasts about 5 days)
   - Also called the Flow Stage (Menses) is the beginning of new menstrual cycle
   - FSH levels start to increase

2. Follicle Stage (Day 5-13)
   - FSH stimulates the growth of the follicle in the ovary.
   - The growing follicle produces ESTROGEN. This causes the wall of the uterus to grow and thicken.

3. Ovulation (Day 14)
   - As ESTROGEN levels increase, FSH decreases. The hypothalamus detects this and increases LH
   - This sudden increase of LH causes ovulation. This causes the follicle to burst and an egg is released

4. Corpus Luteum (Day 15-28)
   - LH causes the ruptured follicle to turn into the corpus luteum or “yellow body”.
   - The corpus luteum begins to produce the hormone PROGESTERONE, which helps to maintain the thick wall of the uterus.

If fertilization does NOT occur the uterine lining breaks down, blood and tissue pass out of the uterus through the vagina. This is called the woman’s PERIOD or MENSTRUATION
Draw what happens during the Menstrual Cycle. Include hormone levels (FSH, LH, Estrogen and Progesterone), the endometrial lining and the follicle developing in the ovary.

| Stage of cycle | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Hormone Levels|   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Thickness of Endometrial Lining |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Follicle developing in the Ovary |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

What is hormone replacement therapy?

As a woman ages, her reproductive hormone levels decrease and the menstrual cycle no longer occurs. This is called menopause. During and after menopause, the female’s body goes through many changes:

1. A rise in cholesterol level
2. A decrease in bone mass
3. Constricting and dilating of blood vessels to produce what we call hot flashes
4. Mood changes

Doctors may prescribe low levels of estrogen and progesterone to lessen the effect of these changes. (Pages 492-493)
What are some benefits and side effects to hormone replacement therapy?

<table>
<thead>
<tr>
<th>Benefits include:</th>
<th>Side-effects include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Relief of menopausal symptoms such as hot flashes, night sweats and sleep disturbance</td>
<td>- Irregular vaginal bleeding</td>
</tr>
<tr>
<td>- Prevention of bone loss</td>
<td>- Stomach upset</td>
</tr>
<tr>
<td>- Improved memory</td>
<td>- Severe headaches</td>
</tr>
<tr>
<td>- Decrease in urinary infections</td>
<td>- Formation of blood clots</td>
</tr>
<tr>
<td></td>
<td>- Increased risk of breast and uterine cancer</td>
</tr>
<tr>
<td></td>
<td>- Increased risk of heart attack</td>
</tr>
</tbody>
</table>

Potential health risks of Sexually Transmitted Infections: *(Page 496)*

**HIV & AIDS** – caused by a virus that destroys the **immune system**; No cure

**Chlamydia** – caused by a bacterium, usually no symptoms, but can cause infertility problems, such as **Pelvic Inflammatory Disease** (PID) in women. If caught early it can be treated with antibiotics.

**Hepatitis B** – caused by a virus, it starts with flu like symptoms, but can cause **liver failure** if left untreated. A vaccination for Hepatitis B is available to prevent infection.

**Genital herpes** – caused by a virus, it results in **sores or blisters** on the genitals. No cure, but medications are available to help with outbreaks.

**Syphilis** – caused by a bacterium, the first stage is sores on the genitals, followed by a rash and eventually the infection can affect the **heart and nervous system**.

**Gonorrhea** – caused by a bacterium, it causes in painful urination and may lead to **Pelvic Inflammatory Disease** (PID). It can be treated with antibiotics.
Causes of Human Infertility: (Page 500)

<table>
<thead>
<tr>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Blocked oviducts – often caused by PID</td>
<td>1. Obstructions in the vas deferens or epididymis – from STI’s</td>
</tr>
<tr>
<td>2. Failure to ovulate – caused by hormonal imbalances</td>
<td>2. Low sperm count – many reasons, such as overheated testicles, overweight, smoking, etc…</td>
</tr>
<tr>
<td>3. Endometriosis – when the endometrium grows outside the uterus</td>
<td>3. Abnormal Sperm – many factors, such as overheated sperm, exposure to toxins, etc…</td>
</tr>
<tr>
<td>4. Damaged egg – may be caused by environmental factors (ex: exposure to chemicals)</td>
<td></td>
</tr>
</tbody>
</table>

Technological Solutions to Human Infertility: (Page 501)

1. Artificial insemination (AI) – when a doctor places sperm in the vagina
2. In vitro fertilization (IVF) – fertilization takes place in a lab and then the fertilized zygote is implanted in the uterus
3. In vitro maturation (IVM) – follicles are removed from the uterus and matured in a lab to get eggs ready for IVF
4. Surrogate mother – another person carries the baby to term
5. Superovulation using fertility drugs – used to produce multiple eggs for in vitro
6. Embryo Storage (Cryopreservation) – eggs, sperm or embryos are preserved by freezing

Birth Control Technologies:

<table>
<thead>
<tr>
<th>Barrier method</th>
<th>Hormonal Method</th>
<th>Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Prevents the sperm from reaching the egg</td>
<td>- Hormones (Progesterone &amp; estrogen) are used to make the body think it’s pregnant. No ovulation</td>
<td>- Permanent sterilization</td>
</tr>
<tr>
<td>- Helps prevent STIs</td>
<td>- No protection from STIs</td>
<td>- No protection from STIs</td>
</tr>
<tr>
<td>Ex: Condom, diaphragm, jellies, foams, IUD</td>
<td>Ex: Birth control pills, Norplant™, Morning after pill, Depo-Provera™ needle</td>
<td>Ex: Tubal Ligation, vasectomy</td>
</tr>
</tbody>
</table>

Other: Abstinence (100% effective at preventing pregnancy) and Rhythm Method (know your cycle)
Fertilization, Development and Birth

- Fertilization occurs in the oviduct, when the egg and sperm join together
- Pregnancy occurs 6-7 days after fertilization. The fertilized egg (zygote) divides by mitosis and moves into the uterus, where it is implanted in the endometrium (inner lining of the uterus)

How do twins form?

<table>
<thead>
<tr>
<th>Fraternal Twins</th>
<th>Identical Twins</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Develop from separate fertilizations (2 eggs &amp; 2 sperm)</td>
<td>- Develop from a single fertilized egg</td>
</tr>
<tr>
<td>- Two different placentas develop</td>
<td>- Early embryo splits into two (or more) babies</td>
</tr>
<tr>
<td>- Twins are NOT genetically identical</td>
<td>- Usually share one placenta</td>
</tr>
<tr>
<td></td>
<td>- Genetically identical (clones)</td>
</tr>
</tbody>
</table>

The Stages of Embryonic Development

1. **Cleavage** – a series of mitotic cell divisions in which zygote becomes a mass of cells called the **morula**.

2. **Implantation of Blastocyst (or blastula)** - A hollow fluid-filled cavity develops inside the morula. Implantation occurs at this stage

   **Draw a Blastocyst (Label the Trophoblast & Inner cell mass)**

   Trophoblast – forms part of the placenta
   Inner cell mass – becomes the embryo

3. **Gastrulation** – the stage where cells of the trophoblast get reorganized to form 3 cell layers (germ layers). This is called differentiation of cells. The 3 germ layers are:

   (i) Ectoderm – becomes skin and nervous system
   (ii) Mesoderm – becomes the kidneys, skeleton, muscles, blood vessels and gonads
   (iii) Endoderm – becomes lungs and lining of the digestive tract
4. **Neural development** – when the nervous system develops. Cells of the ectoderm form neural ridges, which fold together to form a hollow neural tube, which becomes the spinal cord and brain.
**Embryonic Membranes**

These membranes are NOT part of the embryo, but support, nourish, and protect it.

1. **Amnion (amniotic sac)** - a fluid-filled sac that surrounds and protects the embryo, it acts as a shock absorber. During birth, when the amniotic sac ruptures, the fluid passes out of the vagina. This is known as the “water breaking.” The amniotic sac develops from the trophoblast.

2. **Chorion** - has finger-like projections called chorionic villi that connect with the endometrium of the uterus. The villi and endometrium form the **placenta**. The chorion develops from the trophoblast.

3. **Yolk** - a membrane containing the food supply (as in the yolk of a chicken egg). The yolk forms part of the umbilical cord.

4. **Allantois** - a membrane that collects wastes from the embryo. The allantois also becomes part of the umbilical cord.

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**Draw the Embryonic Membranes (Page 509)**

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**What is the role of the umbilical cord during pregnancy? (Page 510)**

- It is a cord of tissue and blood vessels, which connects the embryo to the placenta.
- It contains umbilical arteries carrying blood from the embryo to the placenta, and veins returning blood to the embryo.
What is the role of the placenta during pregnancy? *(Page 510)*

- It is tissue through which exchange takes place between mother and embryo.
- The mother and embryo’s blood capillaries are very close, but not directly connected, in the placenta. Materials (O₂, food, wastes) pass from mother to embryo, and vice versa, by diffusion.
- The placenta produces estrogen and progesterone to inhibit the release of FSH and LH. This means NO ovulation or menstruation occurs during pregnancy.

**Practice Question:**

Identify the wall of the uterus, amniotic fluid, fetus, placenta, and umbilical cord in the following diagram.

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**What are Teratogens? *(Page 511)***

Teratogens are any substance that negatively affects the developing embryo and may cause defects, such as physical abnormalities.

1) Alcohol (ex: Fetal Alcohol Syndrome – babies have decreased weight, height & head size, and have cognitive delays)

2) Chemicals in cigarette smoke (ex: babies born with low birth weight – due to having less oxygen during development)

3) Prescription drugs (ex: thalidomide – prescribed by doctors in 1950s to treat morning sickness. It caused babies to be born with deformed or missing limbs)
What happens during implantation?

Implantation occurs about 7 days after ovulation. The blastocyst attaches itself to endometrium in the uterus. Next the trophoblast begins to secrete **Human Chorionic Gonadotropin (HCG)**. This hormone prevents corpus luteum from breaking down. A pregnancy test will detect HCG levels in the urine of females.

Over a period of 38 weeks, a tiny clump of identical cells develops into a human being with fully formed tissues and organs. Then its time to be born!

**The stages of childbirth:**

1. **Dilation Stage**– The cervix dilates (opens up) to allow baby to pass through. Muscles of the uterus begin to contract (labor). This is caused by oxytocin – *released by pituitary gland in positive feedback loop*. During this stage the amniotic sac breaks and fluid flows from the vagina.

2. **Expulsion Stage**- Powerful contractions push the baby into the birth canal (vagina). The baby comes out head first, through the vagina, and then the umbilical cord is clamped and cut.

3. **Placental Stage** – occurs when contractions of the uterus push out the placenta. This is known as the “afterbirth”

An alternative to natural birth is a Caesarean Section. This occurs when there is a problem with delivering the baby naturally. An Incision is made in mother’s abdomen and uterus to remove the baby.

**Lactation** - the formation and secretion of breast milk from the new mother. Prolactin is released after woman has given birth if the baby nurses. Initially, the breasts secrete a thin, yellowish fluid called **colostrum**, but eventually they secrete milk for the baby.  
*See Figure 15.22 on Page 514 for the positive feedback loop*
**Fetal diagnostic techniques:** *Ways to check on the health of your baby*

1. **Amniocentesis** - sample of amniotic fluid is taken to produce a karyotype, which is a photograph of the fetal chromosomes. This technique is used to identify chromosomal disorders, such as Down’s syndrome.

2. **Chorionic Villi Sampling (CVS)** – sample of cells is taken from the chorion of the embryo to produce a Karyotype. It is similar to an amniocentesis, but it can be performed earlier in pregnancy.

3. **Fetoscopy** – a special camera called an endoscope is used to see the fetus in the womb. The camera is inserted into the woman’s abdomen.

4. **Ultrasound** - high frequency sound waves are directed at the womb to produce an image of the fetus. This technique can be used to study external features of the fetus (ex: Determining sex of fetus)

**Practice Public Exam Questions:**

1. A physician suspects that a developing fetus has Down syndrome. Describe two diagnostic techniques that would aid the physician in confirming her suspicion.

2. Give two reasons why underdeveloped countries have high birth rates.
3. Graph 1 below shows the hormone levels present in a female over 28 days.

Graph 1

i) Explain two ways to cause the changes in hormone levels observed below in Graph 2.

Graph 2

ii) Compare the roles of follicle stimulating hormone (FSH) in men and women.
4. A woman is suffering from irregular and painful menstrual periods. Her doctor prescribes birth control pills for this condition.
   i) Explain how and why this treatment would be effective.

ii) What is a possible unwanted side effect of this treatment?

5. A couple has been trying to have a baby for over a year. Tests have shown that the male’s sperm are healthy and numerous.

   (a) What are two possible causes of the couple’s inability to conceive?

   (b) What is one way to correct this problem without using reproductive technologies?

   (c) What are two ways to correct this problem using reproductive technologies?
6. Describe two ways in which the human population would most likely change if the only form of human reproduction was asexual?

7. Give two reasons why birth control pills can be used to treat menopause.

8. Give two biological situations that could stop the menstrual cycle. Explain.

9. The rhythm method is a method of birth control in which a couple does not have sexual intercourse while they believe ovulation is occurring. Give three biological reasons why this is an ineffective method of birth control.