

IJSO Training: How Life Begins – Human Reproduction

Notes

SECTION 2: HUMAN REPRODUCTION

2.1 DETERMINATION OF SEX

A. CHROMOSOMES

The characteristics of organisms are determined by the genetic materials inside their cells.

Genetic information is carried by DNA which is present in the nucleus of a cell.

DNA is a molecule consists of 2 chains twisted around each other forming a **double helix**.

DNA coils many times around some **proteins** to form a chromosome.

The sex of human is determined by a pair of **sex chromosomes**.

Sex chromosomes are the **X chromosome** and **Y chromosome** which differ greatly in size and shape.

The other chromosomes that are not sex chromosomes are known as **autosomes**.

Autosomes exist as homologous pairs (similar in size and length).

Human has **23 pairs** of chromosomes (46 chromosomes):

For female, the pair of sex chromosomes is **XX**. For male, the pair of sex chromosomes is **XY**.

In a female, during meiosis the pair of X chromosomes separates and get into the eggs.

All the eggs from the female contain **X** chromosome.

In a male, the XY chromosomes separate during meiosis.

Sperms have $\frac{1}{2}$ the chance to carry a **X** chromosome
and $\frac{1}{2}$ the chance to carry a **Y** chromosome.

If a sperm carrying a Y chromosome fertilizes an egg,
a **boy** will be resulted.

- If a sperm carrying a X chromosome fertilizes an egg,
a **girl** will be resulted.

2.2 MALE REPRODUCTIVE SYSTEM

A. STRUCTURES OF THE MALE REPRODUCTIVE SYSTEM

1. Testis (*pl. testes*)

Each male has a pair of testes in the scrotum.

The testis consists of numerous seminiferous tubules which are the sites of sperm production.

Functions of testis:

- ① production of **sperms** (male gametes) from **seminiferous tubules**
- ② production of **male hormone** (testosterone) from **interstitial cells**

2. Epididymis

It is a elongated sac-like structure joining
to the testis for the **storage of sperms**.

3. Sperm duct / Vas deferens (*pl. vasa deferentia*)

It **transfers sperms** from epididymis to urethra.

4. Accessory glands: **seminal vesicle, prostate gland and Bulbourethral gland** (Cowper's gland)

- 1 pair of seminal vesicles connected to sperm ducts
- 1 pair of bulbourethral glands connected to urethra
- 1 prostate gland below the urinary bladder and surrounding part of the urethra

These glands secrete **seminal fluid** which provides a nutritive medium for sperms and a fluid medium for sperms to move.

Prostate gland can also provide propulsive force during ejaculation of semen.

Seminal vesicles are NOT used for the storage of sperms.

Semen = sperms + seminal fluid

About **100 million sperms** are present in **1 mL of semen**.

The volume of semen in each ejaculation is about 2 – 4 mL.

5. Penis

It is a tubular structure for transferring sperms into the female's vagina.

It consists of spongy / erectile tissue. Vasodilation of arterioles of the penis causes the spongy tissue filled with blood causing the erection of penis.

B. PROCESSES OF SPERM PRODUCTION (SPERMATOGENESIS) AND SPERM MATURATION (SPERMIOGENESIS)

Sperms are produced at the rate of about **120 million per day**.

1. Spermatogenesis – production of spermatids

Spermatogonia are diploid cells (i.e. $2n$ or 46 chromosomes) on the seminiferous tubule.

At puberty (adolescence), the spermatogonia undergo mitosis to increase their number.

Then the matured spermatogonia carry mitosis to produce primary spermatocytes ($2n$).

The primary spermatocytes undergo the 1st division of meiosis to give rise to secondary spermatocytes.

The secondary spermatocytes then undergo the 2nd division of meiosis to give rise to spermatids.

Spermatids are haploid cells (n) with 23 chromosomes.

2. Spermiogenesis - differentiation and maturation of spermatids into sperms (spermatozoa)

The **Golgi body** of spermatid becomes a flattened sac called **acrosome** containing **hydrolytic enzymes** for entering the ovum during fertilization.

The **centrioles** of spermatid elongates and forming a **flagellum** which will become the tail of the sperm.

Numerous mitochondria are aggregated around the flagellum.

The spermatid becomes a tadpole-shaped cell, it is known as sperm / spermatozoon.

The heads of spermatozoa are then embedded in Sertoli cells (nutritive cells) which provides nutrients for the maturation of the spermatozoa.

Maturation of sperms requires a temperature at about 32°C , the testes are therefore located outside the abdominal cavity but in the scrotum.

Normal body temperature (37°C) can kill sperms or cause the sperms abnormal.

2.3 FEMALE REPRODUCTIVE SYSTEM

A. STRUCTURES OF THE FEMALE REPRODUCTIVE SYSTEM

1. Ovary

There are 2 ovaries in the abdominal cavity of a female.

Ovary **produces ova** and **female hormones**.

2. Oviduct / Fallopian tube

Oviducts are the **site of fertilization**.

The released ovum or fertilized egg is transferred through oviduct down to the uterus.

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3. Uterus

It is divided into 2 layers, namely endometrium and myometrium.

a) Endometrium

- ~ the inner layer of the uterus
- ~ with numerous mucus gland and blood vessels
- ~ thickness changes during menstrual cycle
- ~ for **implantation of embryo**

b) Myometrium

- ~ the outer layer of the uterus
- ~ made up of **muscle**
- ~ contracts during menstruation to shed the thicken endometrium and during giving birth to push the baby out

4. Cervix

It is the entrance to the uterus from vagina.

5. Vagina

Vagina is a tubular structure for reception of penis and the place where sperms are deposited.

B. PRODUCTION OF FEMALE GAMETES

1. Before birth / Fetal stage

Oogonia in the ovaries undergo mitosis to increase their number.

The oogonia develop into primary oocytes.

The primary oocytes are surrounded by follicular cells to form primary follicles.

2. After birth

About **200,000 primary oocytes** are found in each ovary at birth.

The primary follicles remain dormant after birth until puberty.

3. From Puberty to Menopause

Between puberty and menopause, several primary follicles develop each month under the influence of the hormone. (Menopause: menstruation stops)

The primary oocytes have entered the first meiotic division.

But the division of cytoplasm in the 1st meiotic division is unequal. A secondary oocyte and a first **polar body** (a very small daughter cell from the meiosis I which will not undergo division anymore) are formed.

The secondary oocyte will continue the meiosis only after fertilization.

After ovulation, if there is sperm to fertilize the secondary oocyte, it will enter the 2nd meiotic division.

The division of cytoplasm in the 2nd meiotic division is also unequal. An ovum and a 2nd polar body are formed.

C. MENSTRUATION / MENSTRUAL CYCLE

Menstruation is the periodic changes in the lining of the uterus with shedding of the uterine epithelium.

The changes in the uterine lining and ovaries are under the influences of hormones.

The length of the cycle in women is about 28 days.

Follicles under the influence of hormone from the pituitary gland develop.

During the cycle, only one follicle can mature and burst to release the ovum (secondary oocyte).

Ovulation is the process of **releasing an ovum** from the ovary. It happens around the middle of the cycle. The ovum will then be collected by the oviduct and transferred to the uterus.

The lining of the uterus getting thicker and thicker to prepare for the implantation of embryo. If there is no fertilization, the lining will shed off at the end of the cycle and causes bleeding (menstrual flow).

2.4 FERTILIZATION AND DEVELOPMENT OF EMBRYO

A. FERTILIZATION

After ejaculated into the vagina of the female, sperms remain alive for a few days. The ovum only remains alive for about 24 hours after ovulation.

For a regular 28-day menstrual cycle, sexual intercourse on days 12 to 16 will have the greatest chance having fertilization.

Sperms swim up to the oviduct and meet the ovum there.

The released ovum is surrounded by corona radiata (several layers of follicular cells) and a layer of zona pellucida (a layer of glycoprotein).

The acrosome in the head of the sperm releases its hydrolytic enzymes when the sperm touches the cells of the **corona radiata**. The enzymes break down the cells of corona radiata and make a hole on the **zona pellucida**.

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The cell membrane of ovum is then broken and the sperm head penetrates into the ovum with the tail left outside.

Then the zona pellucida becomes thickened and with the formation of the fertilization membrane which prevents the entry of another sperm. (**Polyspermy**: fertilization of an egg by more than one sperm.)

The nucleus of the ovum enters the 2nd meiotic division.

The nuclei of the ovum and the sperm fuse together to give the diploid zygote.

Prevention of Polyspermy:

- Fast block: The egg plasma membrane becomes depolarized (change in the potential of the cell membrane), therefore no other sperms can fuse with it.
- Slow block: the formation of the fertilization membrane

B. DEVELOPMENT OF EMBRYO

The duration of pregnancy on average is 266 days (38 weeks) from the day of fertilization and 280 days (40 weeks) from the 1st day of last menstrual period.

The zygote undergoes cleavage as it passes down the oviduct.

(**Cleavage**: a series of rapid mitotic divisions with no period of growth of the cells, the cell number increases but the embryo does not increase in size)

The cells formed are called **blastomeres**.

Morula: 32-cell stage, a solid ball of blastomeres

Blastocyst: 64 cells to hundreds of blastomeres, a hollow ball with a fluid-filled cavity (blastocoel).

Gastrula: the blastula becomes a three-layered embryo

Zygote → early cleavage stages → morula → blastula (blastocyst) → gastrula

When the blastocyst reaches the uterus, it embeds among the cells of the endometrium of the uterus.

This process is called **implantation**.

A placenta will be developed for the exchange of gases, nutrients and wastes between the foetus and the mother.

The foetus is linked to the placenta via the umbilical cord.

The foetus is surrounded by chorion and amnion.

The amnion secretes amniotic fluid which supports the foetus and protects it from mechanical shock, desiccation.

Functions of placenta:

- ① site of exchange of metabolites such as gases, nutrients and wastes between the mother and the foetus
- ② secretes hormones to inhibit contraction of myometrium for maintaining pregnancy

C. PARTURITION / GIVING BIRTH

Myometrium of the uterus contracts rigorously (labour) to expel the foetus from the uterus.

The amnion and chorion are ruptured and amniotic fluid is released to the vagina as lubricant for the passage of the foetus.

The cervix dilates.

The foetus is then expelled out and the umbilical cord is tied up and cut.

The placenta will later also be expelled out forming the afterbirth.

2.5 CHANGES DURING PUBERTY (secondary sexual characteristics)

Boys	Girls
The penis and testes become larger.	Development of breasts.
Growth of pubic, axillary and facial hair.	Growth of pubic and axillary hair.
The body becomes more muscular and shoulders broaden.	The hips broaden.
Voice deepens.	More fat is deposited under the skin.
	Starts to have periods (menstruation)