HATAHET ANATOMY

Cell cycle & Gametogenesis

Lecture: 22

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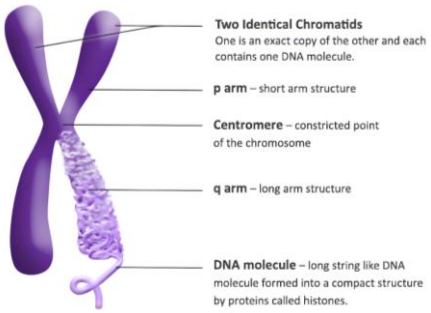
Lecture 22: Cell Cycle & Gametogenesis

- **Chromosome** is the long thread of DNA that contains all the human genes, each chromosome

1) **Chromatid**, one of the two identical copies of the human chromosome; one from each parent:

A. Paternal → from the father
B. Maternal → from the mother

2) **Centromere**, the region where two sister chromatids come in contact



- Types of Chromosomes:

1) **Autosomes** (**22 Pairs**): Chromosomes not involved in sex determination
2) **Sex chromosomes** (**1 Pair**): Responsible for sex determination

Cell cycle

Mitosis

▪ **Mitosis**: the division of a cell to give rise to two daughter cells (2n), identical to the parent cell, has 2 phases:

❶ **Replication phase**, somatic cell replicates its DNA before entering mitotic division
❷ **Mitotic phase**, consists of 5 consecutive phases:

- **Prophase**: coiling & condensing of replicated DNA to form chromosomes
- **Metaphase**: arrangement of chromosomes in metaphase plane "Equatorial"
- **Anaphase**: splitting of centromeres & movement of chromosome to the poles
- **Telophase**: uncoiling of chromosomes to chromatin
- **Cytokinesis**: formation of cleavage furrow and cytoplasmic division

Meiosis

▪ **Meiosis**: the division of reproductive cells to produce gametes; a total of 4 haploid cells (1n), composed of 2 phases:

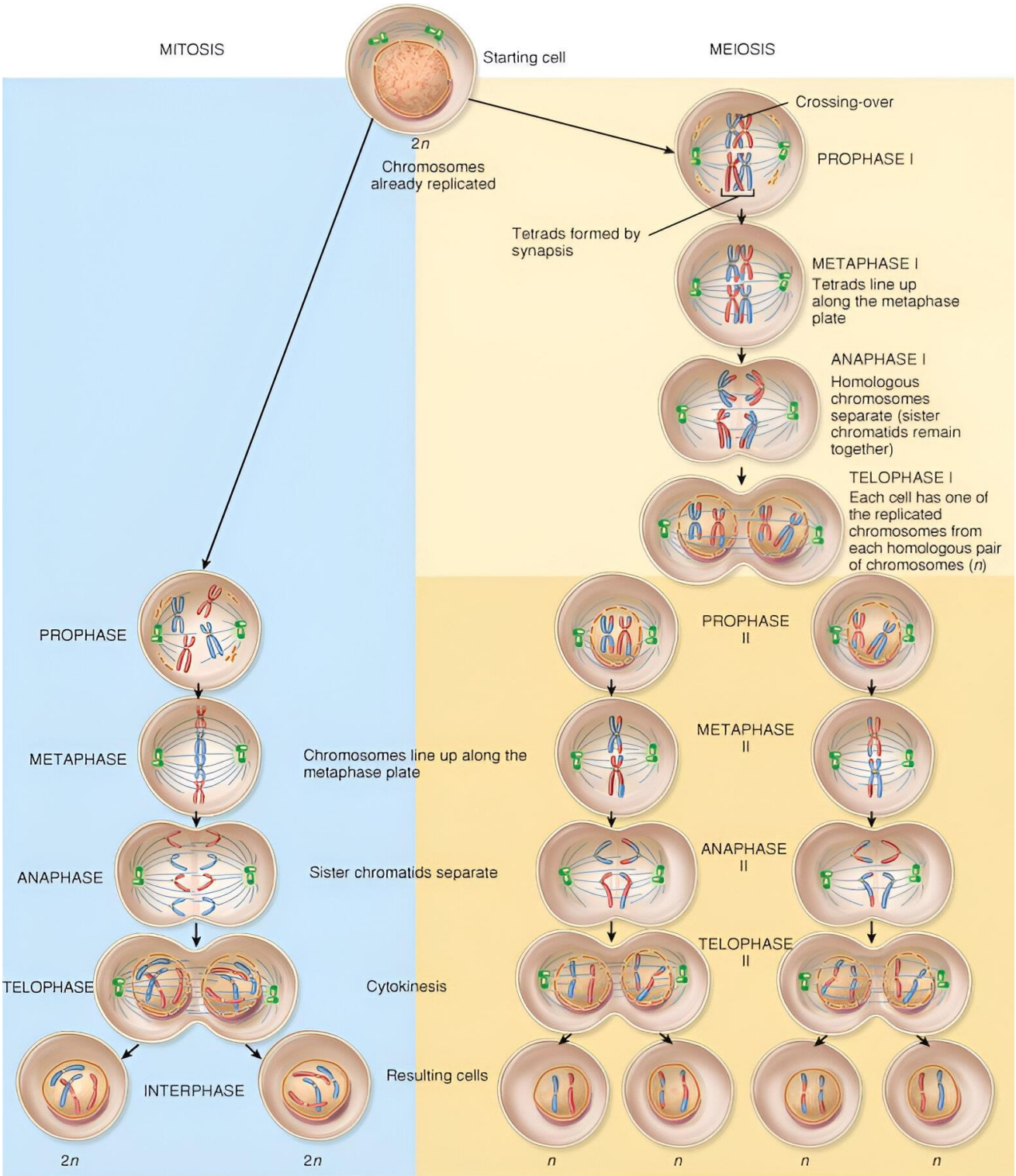
❶ **Reduction division**, starts right after the chromosomes have replicated (2n)

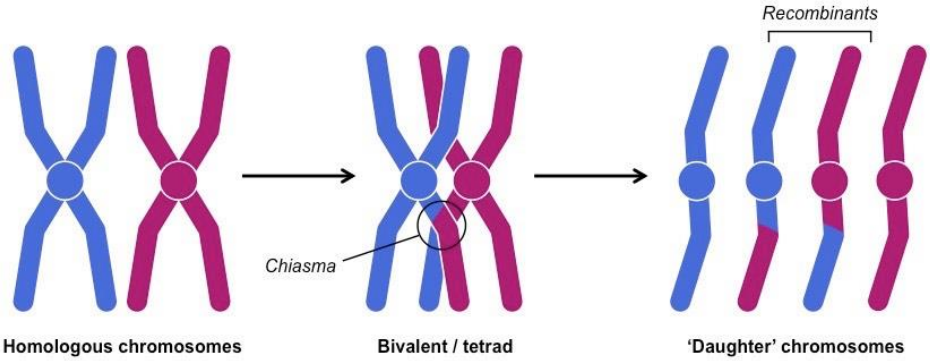
- **Interphase I** → pairing of homologous chromosomes
- **Prophase I** → crossing over between homologous chromosomes at the (chiasma) to form (Tetrads)
- **Metaphase I** → arrangement of the chromosomes in metaphase plane
- **Anaphase I** → chromosomes separate, sister chromatids stay together; because the centromere stays intact
- **Telophase I** → cleavage, resulting in 2 cells each contains 23 double-structured chromosomes (1n)

❷ **Chromosomal division**, begins shortly after the reduction division

- has the same 5 phases of a normal mitosis, but we add the number (II) for differentiation
- results in the formation of 4 cells with 23 double-structured chromosomes (1n) called Gametes (الأمشاج)

▪ **Double-structured chromosome**: a chromosome that contains parts from different homologous chromosomes


MITOSIS
Starting cell
MEIOSIS
2n
Chromosomes already replicated
Crossing-over
PROPHASE I
Tetrads formed by synapsis
METAPHASE I
Tetrads line up along the metaphase plate
ANAPHASE I
Homologous chromosomes separate (sister chromatids remain together)
TELOPHASE I
Each cell has one of the replicated chromosomes from each homologous pair of chromosomes (n)
PROPHASE
METAPHASE
Chromosomes line up along the metaphase plate
ANAPHASE
Sister chromatids separate
TELOPHASE
Cytokinesis
INTERPHASE
Resulting cells
2n
2n
PROPHASE II
METAPHASE II
ANAPHASE II
TELOPHASE II
n
n
n
n
Somatic cells with diploid number of chromosomes (not replicated)
Gametes with haploid number of chromosomes (not replicated)


Recombinants
Chiasma
Homologous chromosomes
Bivalent / tetrad
'Daughter' chromosomes

Gametogenesis

▪ **Gametogenesis**: the process of producing fully mature gametes, divided into Spermatogenesis in testes of males or Oogenesis in ovaries of females

Spermatogenesis

- Spermatogenesis is the production of fully mature and functional sperms
- takes place in the (Seminiferous tubules) of the testicles
- starts at puberty at the age of (13-16 years)
- the Stem cell (found in the born males) of the sperms is (Spermatogonium)
- the Germ cell (found in the embryo) of the sperms is (Primordial spermatic germ cell)

❖ Spermatogenesis process❖

➢ Spermatocytogenesis

- **Primary Spermatogonium** undergoes Mitosis to give 2 Diploid (2n) Secondary Spermatogonia:

A. Type A Spermatogonium, returns to the basal lamina and becomes a new primary spermatogonium in reservoir
B. Type B Spermatogonium, continues differentiation & division to produce sperms, called (**Primary Spermatocyte**)

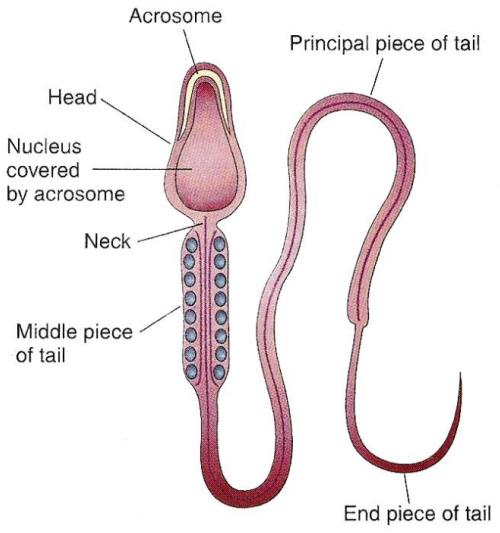
➢ Meiosis I & II

- Primary spermatocyte undergoes **Meiosis I** to give 2 Haploid cells (1n) called (**Secondary spermatocytes**)
- each 1 Secondary spermatocyte has ½ the size of the primary spermatocyte, and it will undergo **Meiosis II** to give 2 Haploid (1n) cells called (**Spermatids**)

➢ Spermiogenesis

- Spermatids differentiate into actively motile and functional sperms called (**Spermatozoa**), this is accompanied by several changes in shape (**Metamorphosis**):

① condensation of Nucleus
② formation of Acrosome
③ loss of 90% of Cytoplasm
④ arrangement of Mitochondria
⑤ development of the Tail



❖ Anatomy of mature sperm ❖

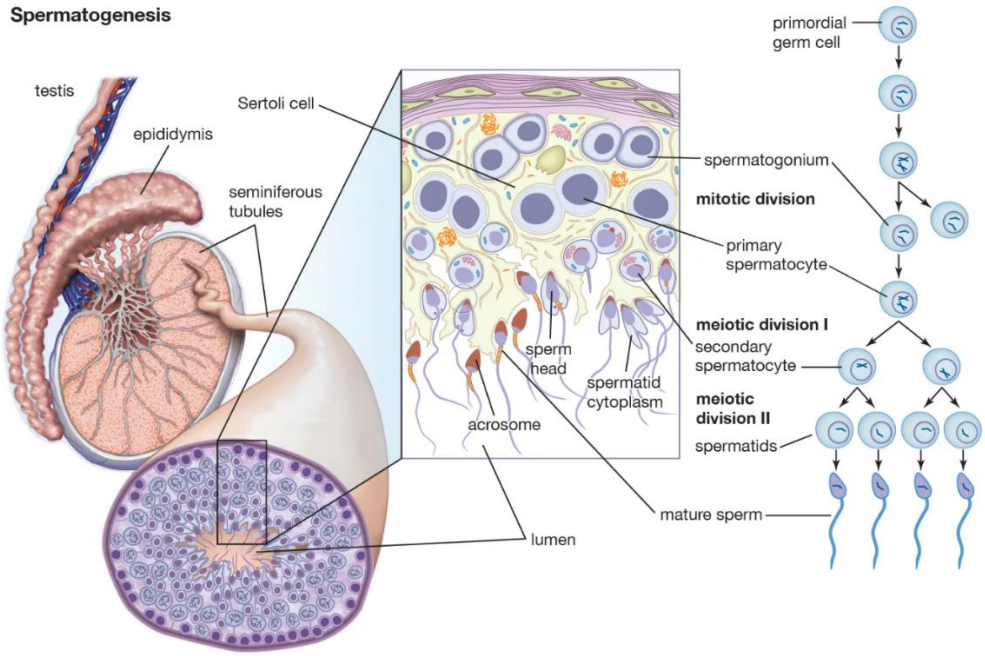
❶ **Head**, contains:

A. **Nucleus** (23 chromosomes - 1n)
B. **Acrosome**, contains hydrolytic enzymes

❷ **Neck**

❸ **Tail (Flagellum)**, composed of 3 parts:

A. **Middle piece**, which contains the mitochondria
B. **Principal piece**
C. **End piece**, the tapered termination



***Notes:**

- Spermatogenesis process requires 2 months (64 days)
- After spermatogenesis, sperms move to epididymis where they are stored and mature
- Normal human male usually ejaculates 2-5 mL of semen
- Normal sperm count is (50 - 100 million) sperms/mL, according to that:
  - (20 - 50 million) sperm/mL → **Adequate**
  - (10 million) sperm/mL → **Poor/Infertile**

Oogenesis

- Oogenesis is the production of fully mature and functional eggs
- occurs inside either the right or the left ovary each month
- the Stem cell for oocytes is (Oogonium)
- the Germ cell for oocytes is (Primordial germ cell)

❖ Oogenesis process ❖

➢ Fetal life (week 10)

- all the (**Primordial germ cells**) will have undergone Mitosis to give all the (**Oogonia**) the female will ever have, no primordial germ cells will return as a reservoir
- Oogonia undergo Meiosis I to give (**Primary oocytes**), but it is arrested in **Prophase I**
- the primary oocyte starts having a layer of follicular granulosa surrounding it, this layer is called (**Primordial follicle**)
- granulosa of the primordial follicle layer will undergo Mitosis to give (**Primary follicle**)

✪ **Primordial Oocyte = Primary oocyte + Primary follicle**

➢ Childhood (birth - 16 "puberty age")

- all the primary oocytes will have completed **Prophase I** and pause there until puberty, during this whole period, around 90% of the 400,000 primary oocytes are degraded and only 40,000 will remain

➢ Puberty (16 and during each menstrual cycle - menopause)

❶ Changes in primary oocyte

- each one of the remaining 40,000 primary oocytes will resume **Prophase I** and complete Meiosis I, unequally divides into 2 haploid cells (1n):

  A. **Secondary oocyte**
  B. **1st Polar body**, which will either degrade OR undergo Meiosis II and give **3rd and 4th Polar bodies**

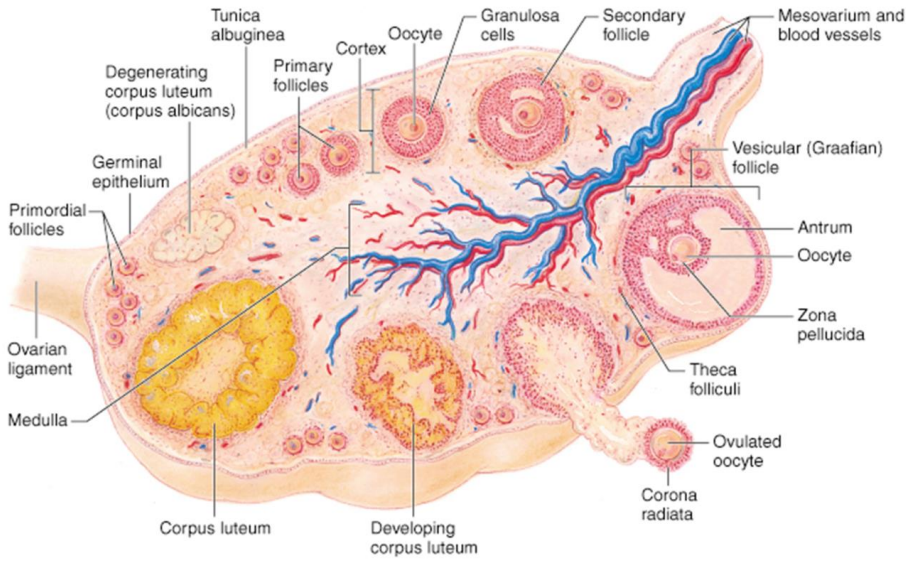
- ovulation of secondary oocyte occurs, it sheds leaving the secondary follicle behind
- inside fallopian tube, Meiosis II of secondary oocyte takes place, but it is paused in **Metaphase II** until fertilization
- secondary oocyte will divide into 2 haploid cells:

  A. **Ovum (Mature egg)**
  B. **2nd Polar body**, which will have the same fate as the 3rd & 4th polar bodies; apoptosis

- once fertilized, ovum will resume **Metaphase II** and complete Meiosis II and unite with the sperm to give the Diploid (2n) **Zygote**

❷ Changes in primary follicle:

- **Primary follicle** undergo Mitosis to give **Early secondary follicle**, and later give **Late secondary follicle**
- late secondary follicle will produce follicular fluid inside the secondary follicle, and this extra fluid will cause some lake-like pockets to form, and when these pockets get bigger, they merge together into a larger sac called (**Antrum**)
- the secondary follicle that has formed antrum is now called (**Graafian follicle** / **Antral follicle**) and it contains secondary oocyte that was arrested at **Metaphase II**
- after ovulation, the remaining cells of Graafian follicle will start differentiation into the **Corpus luteum** (الجسم الأصفر)



- **the female is born with a fixed number of oocytes, this number changes during the female's lifetime:**

① during fetal life, female have **1 million** primordial germ cells, and ALL will undergo mitosis to give **2 million** oogonia
② only **400,000** oocytes will remain when the female is born, the rest are degraded and undergo apoptosis
③ during childhood, 90% of **400,000** oocytes will degrade and undergo apoptosis; due to lack of female hormones, and only **40,000** oocytes will remain when the female hits puberty
④ each menstrual cycle during puberty, about **50** primary follicles undergo oogenesis; to ensure that at least **1** ovum will differentiate into fully mature ovum

∴ **400 - 500 is the total average of fully matured ova the woman will ever ovulate during puberty until Menopause**