



EDO UNIVERSITY IYAMHO
Department of Anatomy
ANA 213: General Embryology

Instructor: *Dr. Odetola Amos A.*, email: odetola.amos@edouniversity.edu.ng
Lectures: Friday, 8am to 10 am, LT1, phone: (+234) 8032072958
Office hours: Thursday, 1.30 to 2.30 PM, Office:

General overview of lecture: This course aims at giving the students a thorough knowledge of general embryology. It covers the following topics: Gametogenesis: Spermatogenesis and Oogenesis; Fertilization; Implantation, Cleavage, Morula, Blastocysts, Primitive Streak, Bilaminar and Trilaminar Germ Disc, Development of tissues, organs and systems of the embryo, the chorionic and amniotic cavities, Foetal Membranes, Placenta formation and functions, molecular regulation in differentiation, Patterning of body axis, and Birth defects, Twins and Twin defects, embryonic environment and foetal periods.

Topic: Gametogenesis: Mitosis & Meiosis

Learning outcomes: At the completion of this lecture, students should be able to:

- " describe the cell division
- " mention the source of the primordial germ cells
- " differentiate between mitotic and meiotic cell division
- " understand the meaning of haploid number of chromosome

Assignments: students are going to have three (3) individual and one (1) group assignments throughout the course in addition to a Mid-Term Test and a Final Exam. Assignments are organized and structured as preparation for the midterm and final exam, and are meant to be a studying material for both exams.

Grading: We will assign 10% of this class grade to homeworks, 10% for the programming projects, 10% for the mid-term test and 70% for the final exam. The Final exam is comprehensive.

Textbook: The recommended textbook for this class are as stated:

Title: Langman's Medical Embryology

Author: T.W. Sadler

Publisher: Wolters Kluwer Health

ISBN: 978-1-4511-9164-6

Title: Larsen's Human Embryology

Authors: Gary C.S., Steven B.B., Philip R.B., and Philippa H.F.

Publisher: Churchill Livingstone

ISBN: 978-1-4557-0684-6

Title: The Developing Human, Clinically Oriented Embryology 8th Ed.
Author: K.L. Moore and T.V.N.Persaud
Publisher: Saunders

Main Lecture: Below is a description of the contents. We may change the order to accommodate the materials you need for the projects.

Introduction

- ❖ Gametogenesis is the process of formation and development of specialized generative cells, gametes.
- ❖ This process, involving the chromosomes and cytoplasm of the gametes, prepares these sex cells for fertilization.
- ❖ During gametogenesis, the chromosome number is reduced by half and the shape of the cells is altered.
- ❖ Primordial germ cells: give rise to the gametes

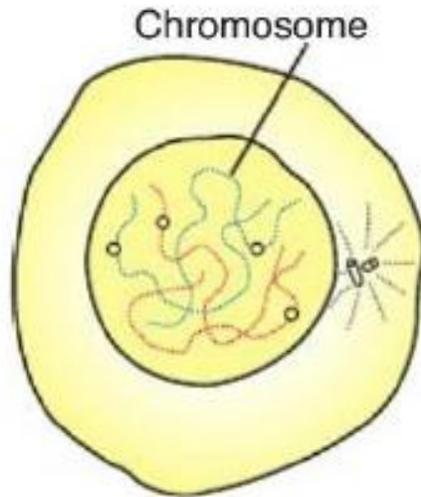
Chromosome Theory of Inheritance

- ❖ Traits of a new individual are determined by specific genes on chromosomes inherited from the parents
- ❖ Humans have \approx 23,000 genes on 46 chromosomes
- ❖ Genes on the same chromosome tend to be inherited together and called linked genes
- ❖ In somatic cells \approx 23 homologous pairs = 46 Diploid number
- ❖ Autosomes \approx 22 pairs matching chromosomes (XX)
- ❖ Sex chromosomes \approx one pair. XX or XY
- ❖ One chromosome of each pair is from the maternal, Oocyte and the other from the paternal, Sperm.
- ❖ Each gamete contains haploid number of chromosomes

Mitosis Cell Division

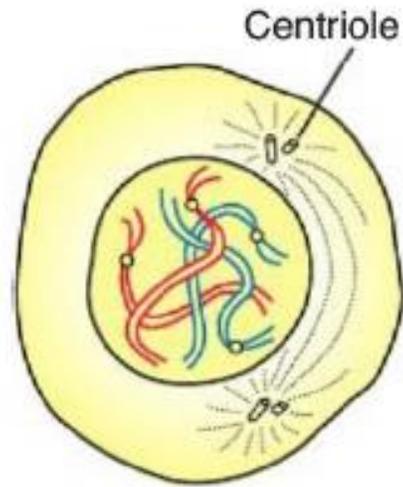
- ❖ Process by which one cell divides and gives rise to two daughter cells that are genetically identical to the daughter cells.
- ❖ Before mitosis, chromosome replicates its DNA
- ❖ Chromosomes become extremely long and spread diffusely within the nucleus
- ❖ At this stage, chromosome cannot be visualised with light microscope
- ❖ Consists of six phases
 - Interphase
 - Prophase
 - Prometaphase
 - Metaphase
 - Anaphase
 - Telophase

- **Prophase**
 - “ Chromosome continues to condense, shorten and thicken
- **Prometaphase**
 - “ Chromosome becomes visible under light microscope



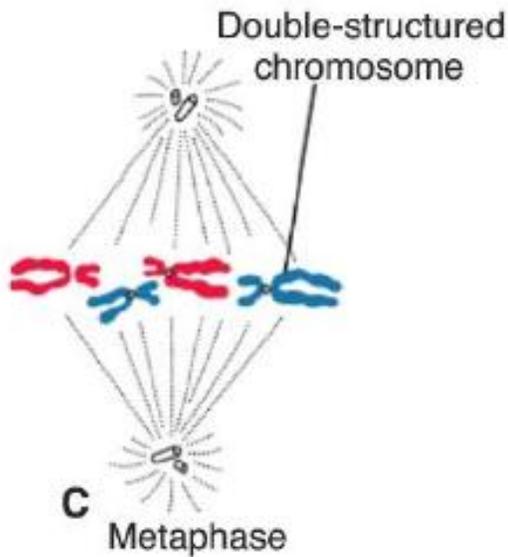
A
Prophase

Sadler et al 2015

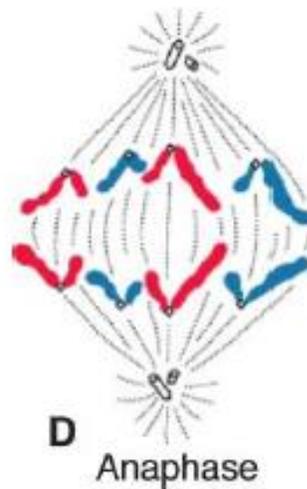


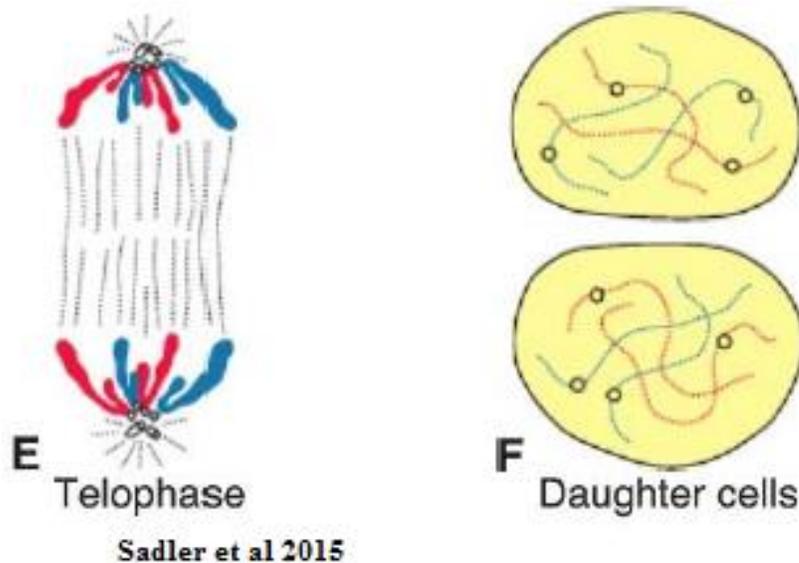
B
Prometaphase

- **Metaphase**
 - ~ Xsome line up in the equator
 - ~ Each xsome is attached by microtubules extending from the centromere to the centriole
- **Anaphase**
 - ~ Centromere of each xsome divides
 - ~ Migration of chromatids to the opposite pole of the spindle
- Telophase
- Cytokinesis



Sadler et al 2015





Meiotic Cell Division

- ❖ Cell division that takes place in the germ cells in which diploid number of chromosome is reduced to haploid
- ❖ It requires two cell divisions ó Meiosis I & II

First Meiotic Cell Division

- ❖ Germ cells replicate their DNA so that each of the 46 chromosomes is duplicated into sister chromatids
- ❖ Synapsis ó homologous chromosomes align themselves in pairs
- ❖ Points of interchange are temporarily united and form an X-like structure, Chiasma
- ❖ Homologous pairs then separate into two daughter cells
- ❖ Thus reducing chromosome numbers from diploids to haploid
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- ❖ Homologous pairs then separate into two daughter cells
- ❖ Thus reducing chromosome numbers from diploids to haploid

2nd Meiotic Cell Division

- ❖ The cell divisions of meiosis are equal and yield four identical spermatozoa in male
- “ In females, it yields a single, massive, haploid definitive oocyte and three-minute, non-functional, haploid polar bodies.
- ❖ Meiotic cell divisions brings about:
 - Genetic variability through
 - Crossover which re-distributes genetic materials
 - Random distribution of homologous chromosomes to the daughter cells
 - Germ cells with haploid number of chromosome

Morphological Changes During Maturation of the Gametes

- ❖ Oogenesis
- ❖ Spermatogenesis

Oogenesis

- ❖ The process whereby oogonia differentiate into mature oocyte
- ❖ Maturation of oocytes begins before birth
- ❖ Complete after puberty

Prenatal Maturation of Oocytes

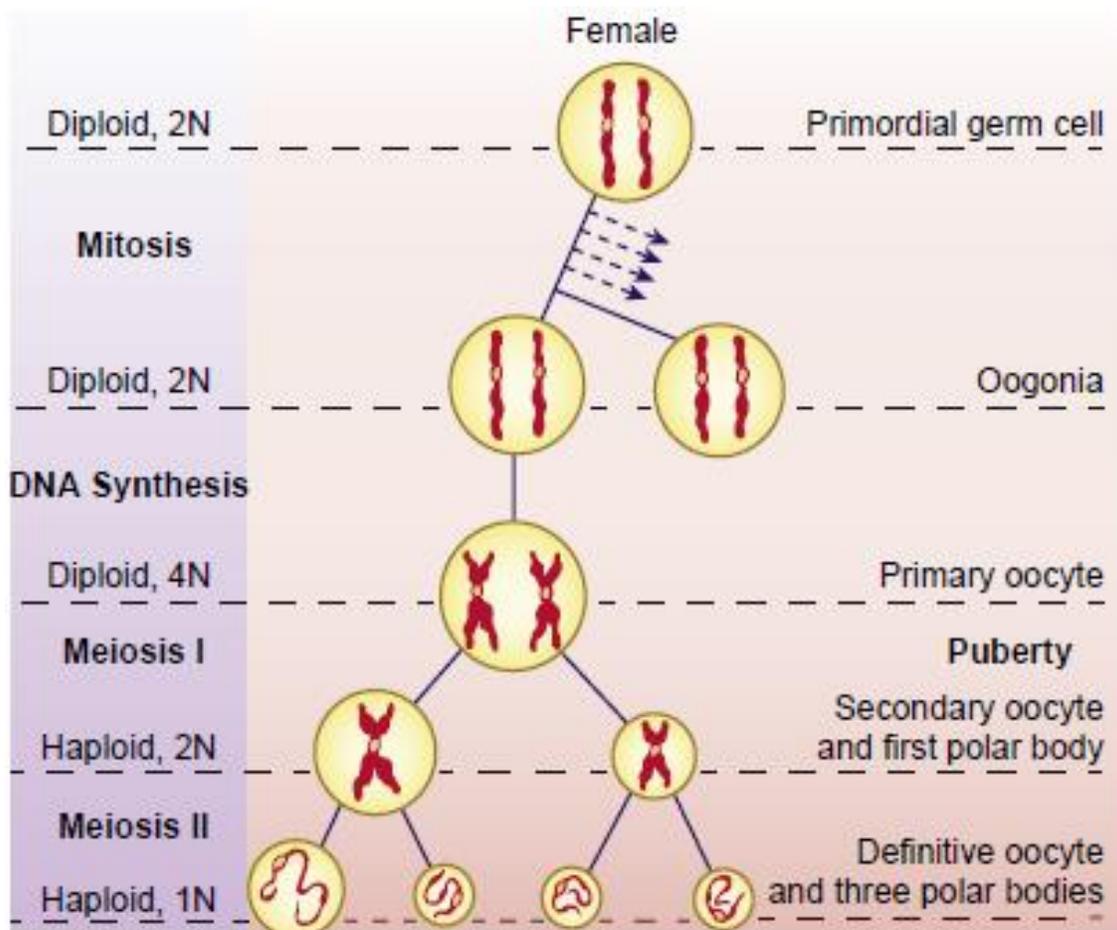
- ❖ Once primordial germ cells arrived in the gonad of a genetic female they differentiate into oogonia
- ❖ Oogonia then undergo a number of mitotic divisions
- ❖ By the end of the third month, they are arranged in clusters surrounded by a layer of flat epithelial cells
- ❖ The flattened epithelial cells are called follicular cells
- ❖ They are derived from the surface (Germinal) epithelium of the ovary
- ❖ Many oogonia continue mitotic division
- ❖ some are arrested in the prophase of meiosis I and become primary oocytes
- ❖ Oogonia proliferate and increase rapidly in number
- ❖ By 5th month of development, the total number of germ cells in the ovary reaches its maximum of 7 millions
- ❖ Many oogonia and primary oocytes degenerate and become atretic.
- ❖ By 7th month majority of oogonia have degenerated
 - At birth, only seven hundred thousand to two million remain
 - During childhood, most oocytes become atretics.
 - Only about 40,000 oocytes are present at the beginning of puberty
 - All surviving primary oocytes have entered prophase of meiosis I
 - Each primary oocyte becomes surrounded by a layer of flat follicular epithelial cells
 - Primary oocyte with its surrounding flat epithelial cells is called primordial follicle
 - the primary oocyte enlarges, the follicular epithelial cells become cuboidal in shape and then columnar, forming a **Primary follicle**.
 - The primary oocyte soon becomes surrounded by a covering of amorphous acellular glycoprotein material, the **zonapellucida**
 - Near the time of birth, all the primary oocytes have started prophase of meiosis I and become arrested at diplotene stage.
 - Completion of prophase does not occur until puberty.
 - The follicular cells surrounding the primary oocyte secrete a substance, oocyte maturation inhibitor (OMI), which keeps the meiotic process of the oocyte arrested.

Postnatal Maturation of Oocytes

- ❖ As primordial follicles begin to grow, the surrounding follicular cells change from flat to cuboidal and proliferate to produce a stratified epithelium of **granulosa cells** and the unit is called a **primary follicle**
- ❖ **Granulosa cells** rest on a basement membrane which separates it from the ovarian connective tissue called theca folliculi
- ❖ Granulosa cells and the oocytes secrete a layer of glycoprotein called Zonapellucida on the surface of the oocytes
- ❖ Theca folliculi organise into two layers:
 - Theca interna of an inner secretory cells
 - Theca externa of an outer fibrous capsule
- ❖ As the development continues, fluid-filled spaces appear between granulosa cells

- ❖ These spaces coalesce to form antrum and the follicle is now called Antral or vesicular follicle
 - ❖ Granulosa cells surrounding the oocyte remain intact and form the cumulus oophorus
 - ❖ Mature vesicular follicle is called Graafian follicle
 - ❖ At maturity, Meiosis I is completed resulting in the formation of two daughter cells of unequal size
 - ❖ Each with 23-double stranded chromosomes
 - ❖ One cell, secondary oocyte, receives most of the cytoplasm while the first polar body receives little or none
 - ❖ The 1st polar body lies in the perivitelline space (space between zona pellucida and the cell membrane of the secondary oocyte)
 - ❖ Secondary oocyte then enters meiosis II but arrests in metaphase 3hrs before ovulation
 - ❖ Meiosis II is completed only if fertilization occurs.
 - ❖ If no fertilization, the egg degenerates about 24hrs after ovulation
- ~ First polar body may undergo second division

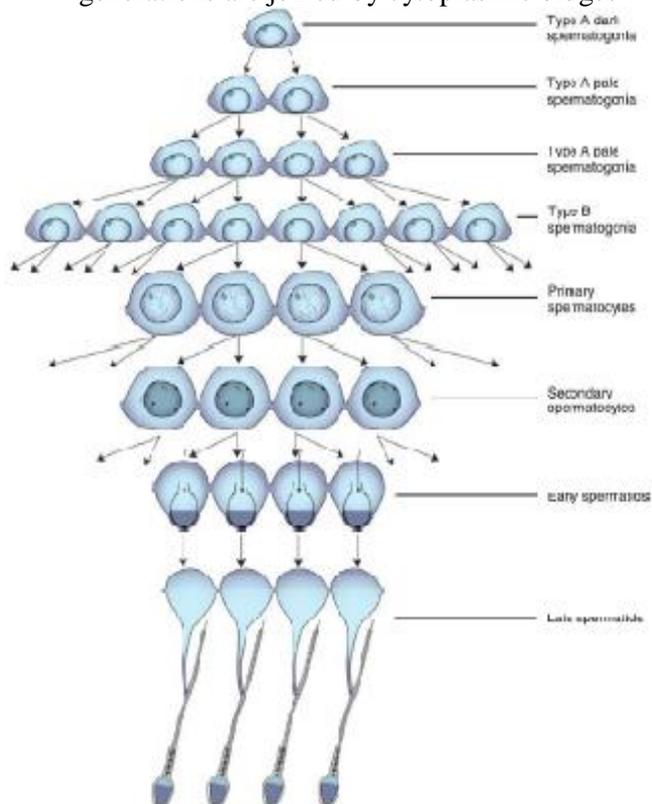
Nuclear Maturation of Germ Cell in Meiosis



Francis et al 2014

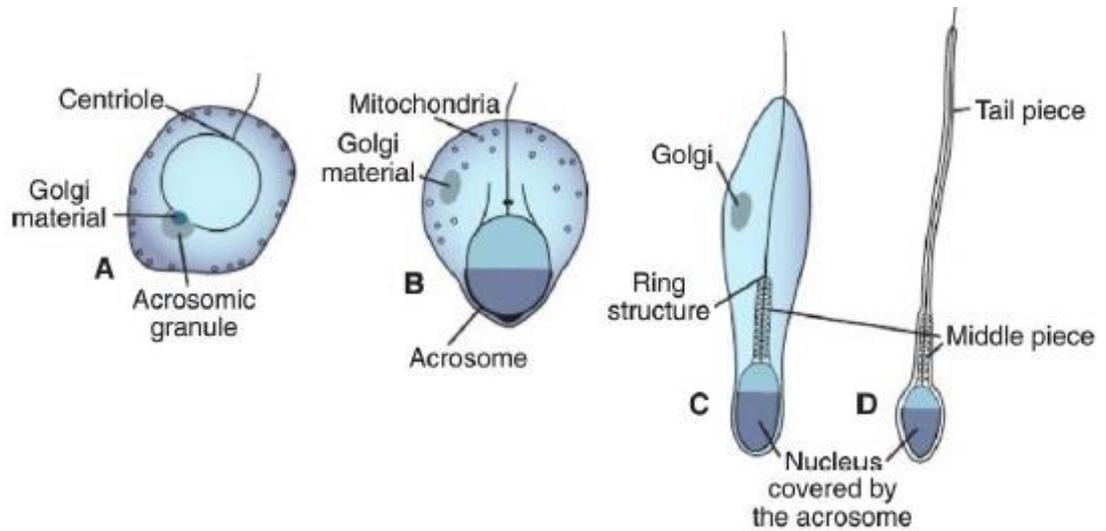
Spermatogenesis

- ❖ Def: is the sequence of events by which spermatogonia are transformed into **mature sperms**.
- ❖ This maturation process begins at puberty.
- ❖ Primordial germ cells give rise to spermatogonia stem cell
- ❖ Cells emerge from the stem cell to form type A spermatogonia
- ❖ Type A cells undergo limited number of mitotic divisions to form clones of cells
- ❖ The last cell division produces type B spermatogonia which then divide to form primary spermatocytes
- ❖ Primary spermatocytes enter a prolonged prophase (22days)
- ❖ Followed by rapid completion of meiosis I and formation of secondary spermatocytes
- ❖ Second meiotic division immediately begin to form haploid spermatids
- ❖ Throughout this series of events cytokinesis is incomplete so that successive cell generations are joined by cytoplasmic bridges



Spermiogenesis

- ❖ Def: The series of changes resulting in the transformation of spermatids into spermatozoa
- ❖ These changes include
 - Formation of acrosome which covers half of the nuclear surface and contains enzyme
 - Condensation of the nucleus
 - Formation of neck, middle piece and tail
 - Shedding of most of cytoplasm as residual bodies that are phagocytized by sertoli cells



Important stages in transformation of the human spermatid into the spermatozoon.
 Sadler et al 2015

- ❖ In human, it takes about 74 days for spermatogonium to develop into mature spermatozoa
- ❖ Spermatozoa attain full motility in the epididymis

Conclusion

- ❖ The first meiotic division produces haploid double stranded chromosome while the second produces haploid single stranded chromosome
- ❖ Male and female gametes are haploid cells which are produced after second meiotic division

References

- " Sadler TW. Langman's Medical Embryology. 13th Ed. Philadelphia: Wolters Kluwer, 2015.
- " Gary CS, Steven BB, Philip RB, Philipa HF, Larsen's Human Embryology. 5th Ed. Philadelphia: Churchill Livingstone. 2015.
- " Keith LM, Persaud TVN. The developing human clinically oriented embryology. 8th Ed.