Genetics & molecular biology

◉ Sheet ○ Slide

Number: - 16

Done by: - Hala Al Suqi

Corrected by: - Faisal

Doctor: - Dr. Belal Azab

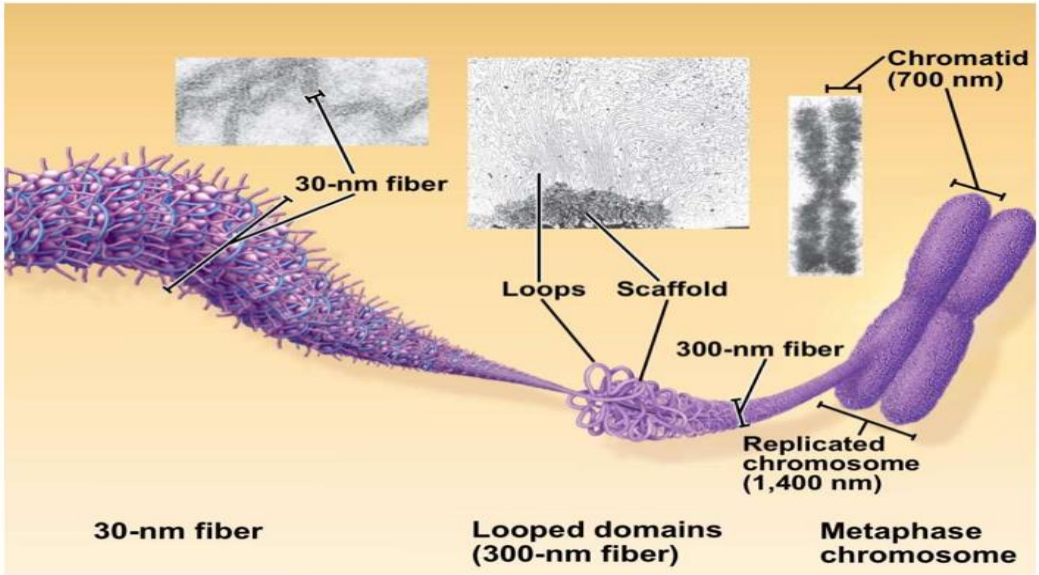
Genetics Lecture #1

Before 1956, the human chromosome number was unknown. It was established through **cytogenetics**, the study of chromosomes.

DNA structure:

A DNA molecule, which generally refers to double stranded DNA, is wrapped around proteins called **histones**, forming a DNA-protein complex known as a **nucleosome**.

Nucleosomes are packed together forming coils of **chromatin**. Chromatin is anchored onto what is called a **scaffold**, forming a **chromosome.**

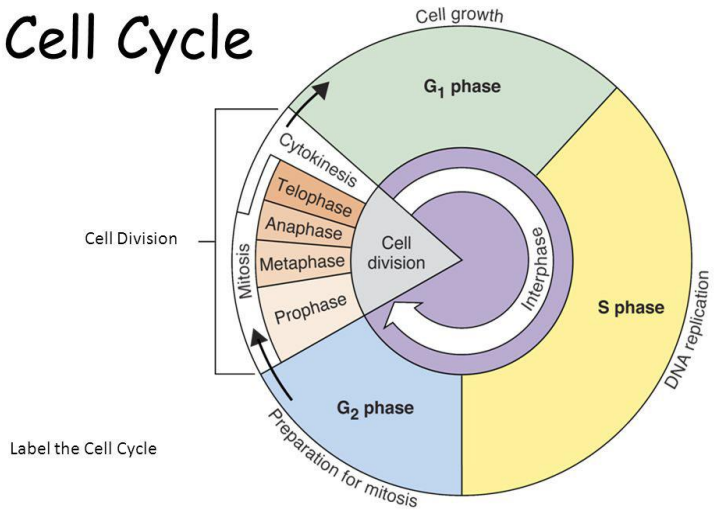


To define a chromosome, we can refer to it as **condensed chromatin**.

The Cell Cycle:

Before S phase (i.e. DNA replication): a chromosome consists of one double stranded DNA molecule (one chromatid), and it's STILL called a chromosome!

At the end of S phase: a chromosome consists of two sister chromatids (the chromatid itself is one long double stranded DNA molecule).



G1 phase: Cell growth (enlargement of size, contents, like proteins which requires transcription)

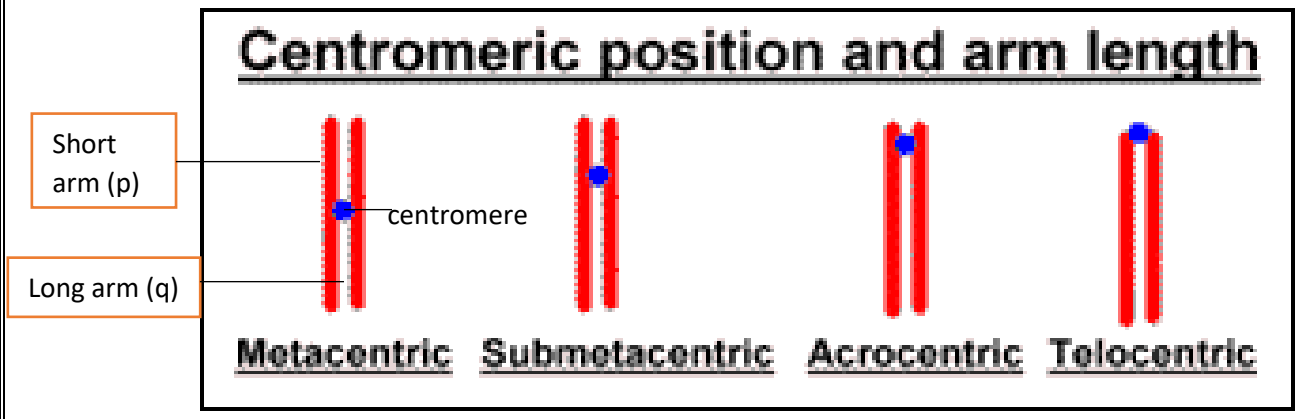
The *G1-S-G2 phase* is collectively known as **interphase**, the stage preceding cell division. In interphase, the DNA is loosely packed (diffuse chromatin) in order to be accessible to DNA polymerase during S phase and G1 phase.

However, in M phase (or mitosis, cell division, etc.) DNA is tightly packed for easier separation of chromosomes.

This explains why **chromosomes are only seen in M phase**, particularly *metaphase*, which is when chromosomes are most condensed.

So theoretically, one can say that there are no chromosomes in interphase, and that they only exist in M phase.

Nomenclature of chromosomes:



Normal centromere positions are:

- Metacentric (centromere located in the middle)
- Submetacentric (displaced from the center)
- Acrocentric (placed near the end)

EXAM QSN ON CENTROMERIC POSITIONS!!

Telocentric is considered an **abnormal** centromere position.

Human chromosomes:

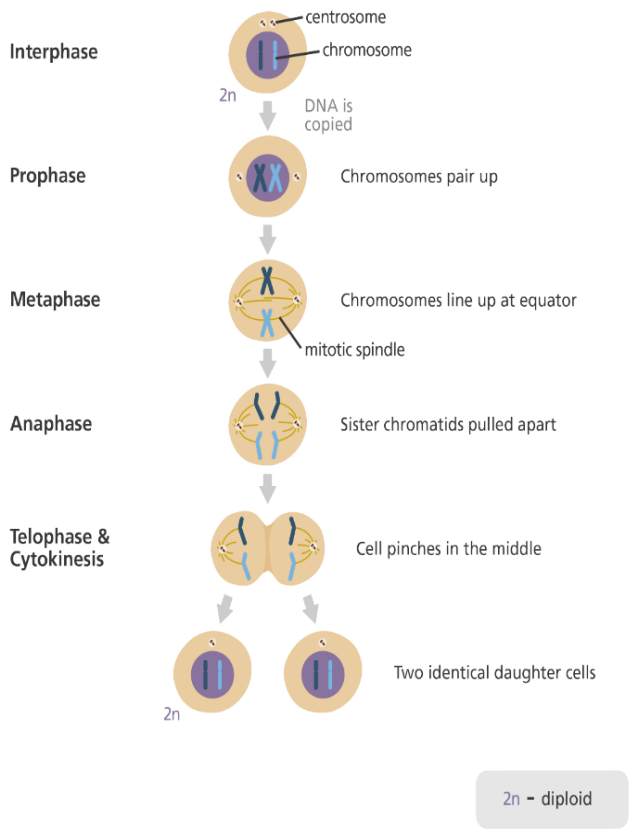
We have 46 chromosomes in total. 23 pairs: one set from the mother and the other from the father. 22 pairs are autosomes, and the 23rd pair are the sex chromosomes. All the cells in our bodies have 46 chromosomes, except the sex/germ cells which are haploid and have only 23.

Mitosis:

The division of cells to produce identical daughter cells (identical in the terms of the nucleus and DNA sequence, but not cytoplasm).

Mitosis occurs in the zygote, the developmental process, repair, etc.

Like we said before, prior to S phase a chromosome is one DNA molecule and after it is 2 DNA molecules ⇒ at M phase, the chromosome consists of 2 DNA molecules.



- Phases (PMAT):
  - Prophase: chromosomes begin to condense, nuclear envelope collapses, a pair of centrioles (centrosome) appears at opposite poles. Note: each chromosome is

attached to spindle fibers at the centromere from both poles of centrioles

- Metaphase: each chromosome is aligned **individually** along metaphase plate
- Anaphase: separation of **sister chromatids** (each chromatid is now called a chromosome**⇒ so if we had 2 chromosomes to start with, we have 4 in this stage)
- Telophase: coincides with cytokinesis; nuclear envelope reforms, cleavage furrow forms producing identical daughter cells (each with two chromosomes).

Meiosis:

Unlike mitosis, meiosis does not produce identical daughter cells. It gives daughter cells with half the number of chromosomes with varying DNA sequences.

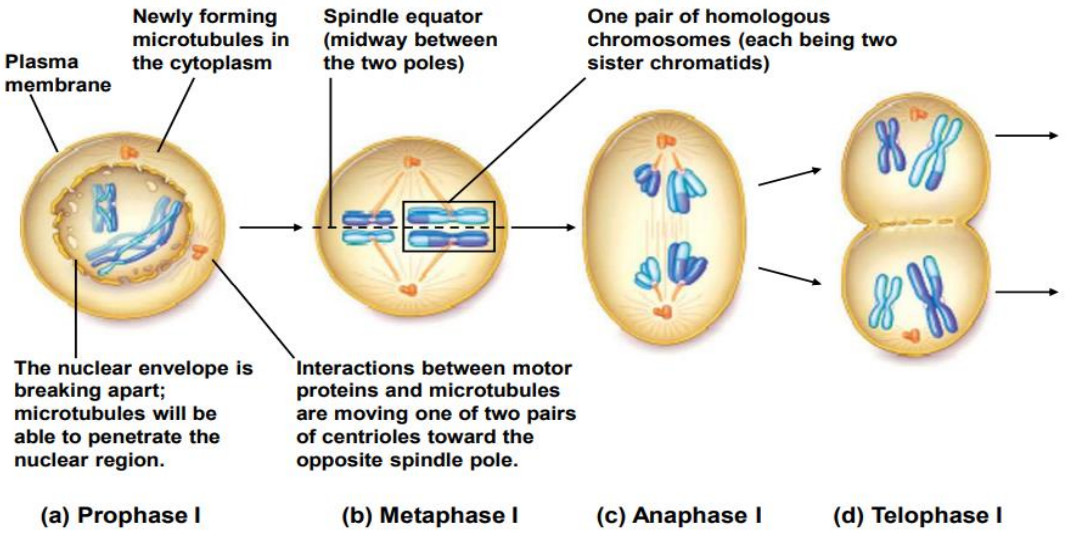
- Meiosis I (reductional): the most important details to know are
  1. prophase I: condensation of chromosomes, the nuclear envelope disappears, spindle fibers appear from centrioles and centrioles migrate to the opposite poles… (prophase I is when *recombination* happens, *Prophase I takes the most time out of all stages).*
  2. in metaphase I, the chromosomes are aligned **in pairs (homologues)** and each chromosome is attached to spindle fibers of only **one** centriole on one pole of the cell.

  3. anaphase I consists of the disjunction of *homologous chromosomes* (and not sister chromatids), **reducing the chromosome number to half.**

  4. Telophase I: the 2 haploid cells separate

  The end of meiosis I is when haploid chromosome number is first seen.

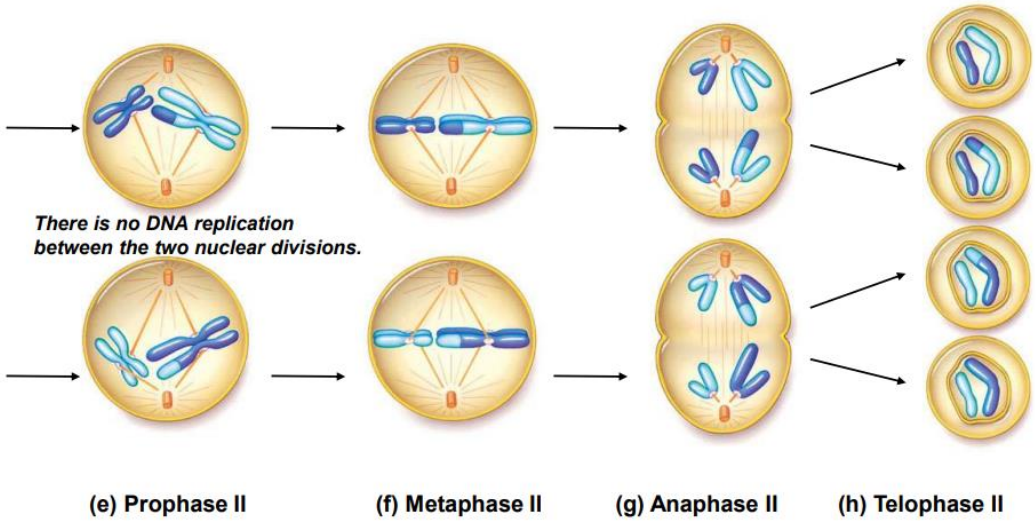
Meiosis I



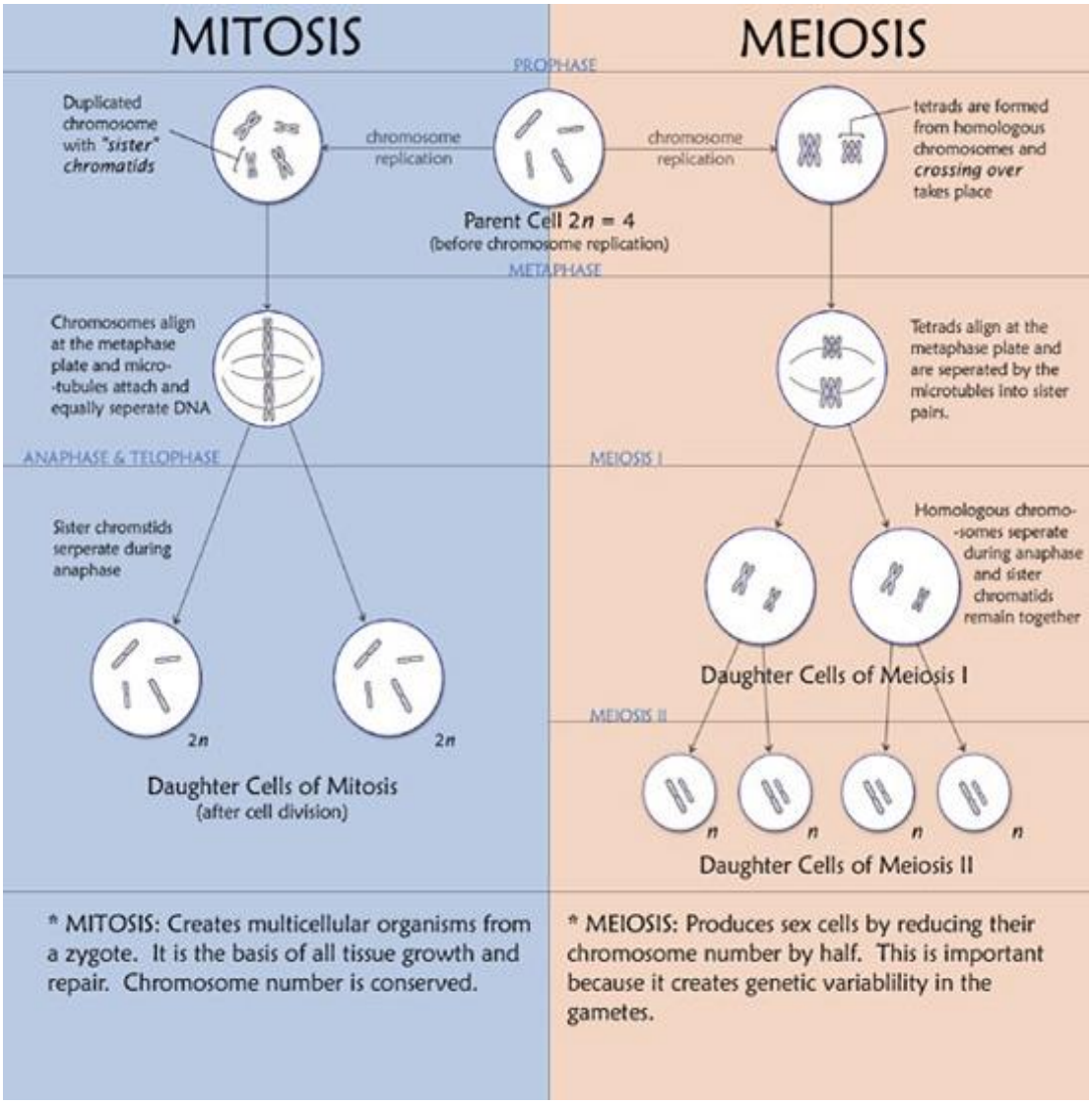
*Prophase I is subdivided into even more stages: **Leptotene**, **Zygotene** (synapsis & tetrad formation), **Pachytene** (crossing over), **Diplotene** (chromosomes separate but remain bound at chiasmata) and **Diakinesis** (further condensation)

- <u>Meiosis II:</u> happens immediately after meiosis I (no interphase)
  1. Anaphase II: separation of sister chromatids
  2. Product: 4 non-identical daughter cells

Meiosis II



Compare mitosis to meiosis I and II: (Notice how mitosis is identical to meiosis II)



<u>Gregor Mendel's Laws</u>:

1. *Law of Segregation*: each homologous chromosome will separate and appear in different daughter cells, such that each gamete receives one allele for a given trait

2. *Law of Independent Assortment*: chromosomes are aligned at the metaphase plate independently of each other, meaning that traits are inherited independently of each other

NOTE: Number of possible chromosomal combinations= 2^n (n is the haploid number or # of chromosomal pairs)

Where in humans n=23 so there are 8,388,608 possible different combinations.