



Genetics

& Cell biology

☒ Sheet

☐ Slides

Number

1

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Doctor

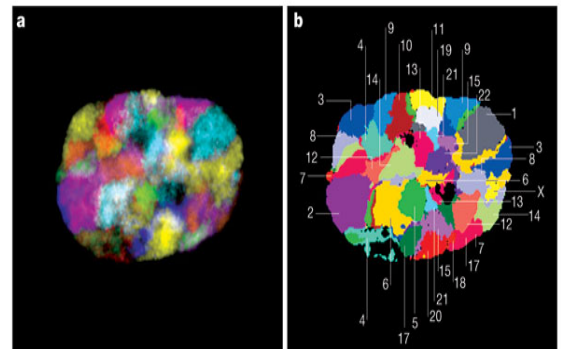
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Cytogenetics

Chromosomes

- We have in our cells 46 chromosomes
- Nucleosome is made up from DNA and proteins (histones)
- Multiple nucleosomes will make chromatin
- Condensation of Chromatin on a scaffold will make chromosome.
- in the normal situation (rest state) each chromosome is composed from single chromatid. Even though, during metaphase; each chromosome will be composed up of two sisters' chromatids, that contain the same genetic material.

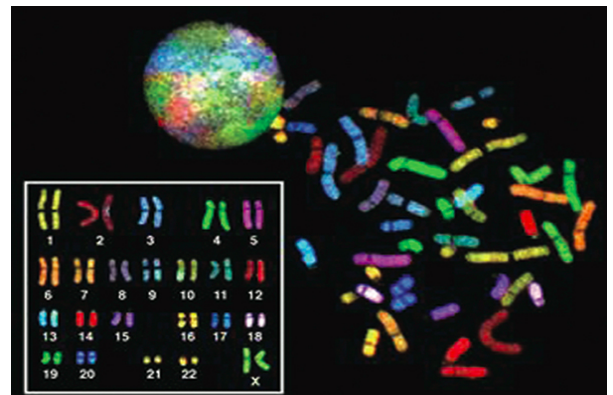
- if you stain the chromosomes in the nucleus with different colors , this is how you will see it , and every chromosome has an area with number as you see in the picture . here you do not have an individual chromosomes . **when will you see the nucleus like this in the cell cycle ?**



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In the **INTERPHASE** , because the chromosomes are de-condensed , giving the chance for DNA polymerase to bind to DNA and start the replication .

-But in this picture you can identify the chromosomes as they are very condensed , you will see this appearance in the **METAPHASE** , because you do not want to replicate the DNA , just to separate the



chromosomes to have daughter cells . ** (the doctor said you should differentiate between these two states .)

Chromosome structure

-At the center of the chromosome we have an area called centromere which is composed of non coding DNA sequence with proteins .

-At the periphery of the chromosomes, they have telomeres

-The short arm is called **P arm**, as well as the long arm called **Q arm**

-We can classify chromosomes depending on the location of the centromeres:

*IF the centromeres located at the center, we will call chromosomes **Meta centric**.

*IF the centromeres located away from the center, we will call chromosomes **submeta centric**.

*IF the centromeres located very far from the center, we will call chromosomes **acrocentric**.

*IF we have abnormalities in the chromosomes, we will have **telocentric** chromosomes.

-Sex chromosomes are X and Y, otherwise any chromosome is called autosome.

-The chromosome could contain two sister chromatins (one from father and one from mother), and also it can contain one chromatid.

Cell cycle

-The replication of chromosomes happened during **S phase** (that is part of the interphase of the cell cycle)

-During the interphase, we will see the chromosomes diffuse in the nucleus; in order to the enzymes and materials that needed for replication to reach different regions on the chromosomes, otherwise the cell won't replicate any more.

-During M phase, the cell doesn't need DNA replication, the most important event in that phase is the separation of chromosomes into daughter cells; so the chromosomes will be condensed in the nucleus. (If you have a strings, and you want to unwrap it; this process will be easier once the strings are rolled around a roller, than in case they diffused and connected to each other. The same principle is applied to chromosomes during M phase).

-During cell cycle we will focus on Mitosis and meiosis.

-Mitosis phase will give two identical daughter cells, and this process will happen to all cells in our body, especially once we take about embryonic development , that have a single cell, and with huge mitotic activity it will make up the human body.

-Meiosis happened at two places only. Testis in males, and ovaries in females.

-The purpose of meiosis is to produce gametes, which have one set of chromosomes.

-Meiosis is sub divided into two stages:

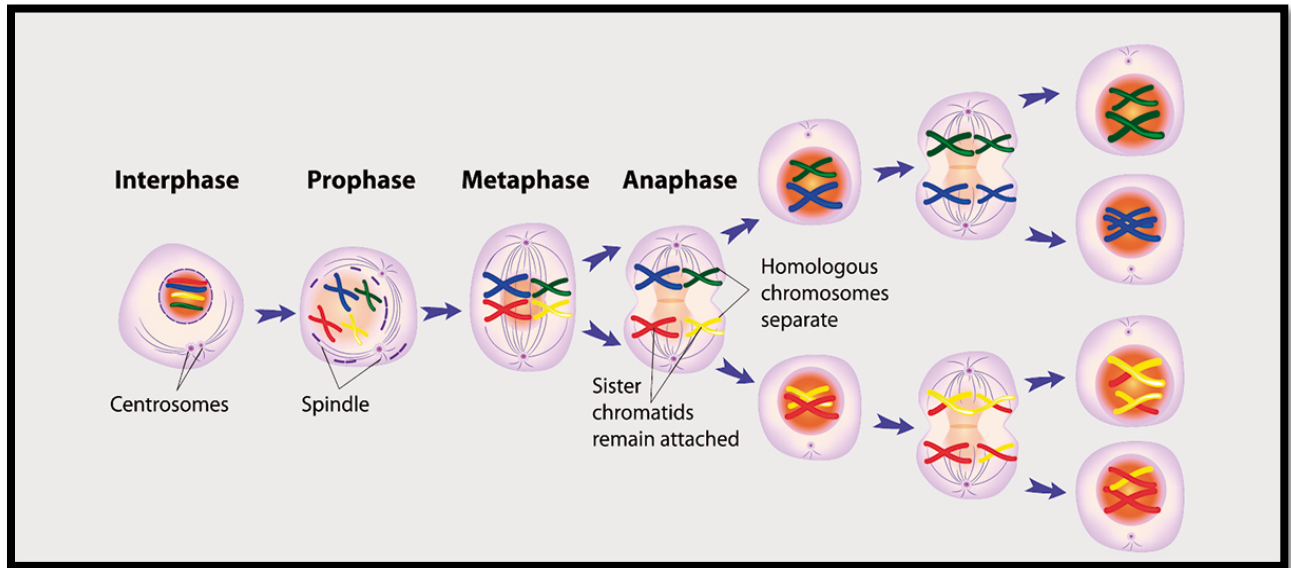
***Meiosis one:** 1) Interphase: chromosomes will condense into chromatin

2) Prophase: every chromosome will condense separately, and then spindle fibers will be formed from centrioles.

3) Metaphase: spindle fibers will attach to **one side** of the centromere .

4) Anaphase: Homologous chromosomes will be separated, but the sister chromatids won't be separated; and this is what's make a reduction in the number of chromosomes.

5) Telophase: division of the cell into two cells by a process called cytokinesis.



***Meiosis two:** it is identical to mitosis

The spindle fibers during metaphase 2 are attached to both sides of the centromeres, then when anaphase 2 hatching; separation of sister chromatids will be happened. So the number of chromosomes will be preserved.

-Any disorder during cell division will result in disaster case.

-At the end of meiosis we will have 4 daughter cells; each cell will contain 23 chromosomes (in the case of human cell)

-We will take about some phases in meiosis in details:

*Prophase I:

-It is long phase, and contains a special event that doesn't happen elsewhere in any type of cell division (mitosis and meiosis 2)

-This special event called **crossing over**.

-**Crossing over:** the exchange of genetic material between non-sister chromatids of homologous chromosomes.

-This process is very important for diversity and evolution .

-Prophase I is subdivided into: (there is a question in the exam about them)

1) **Leptotene:** in this stage homologous chromosomes will start to line behind next to each other.

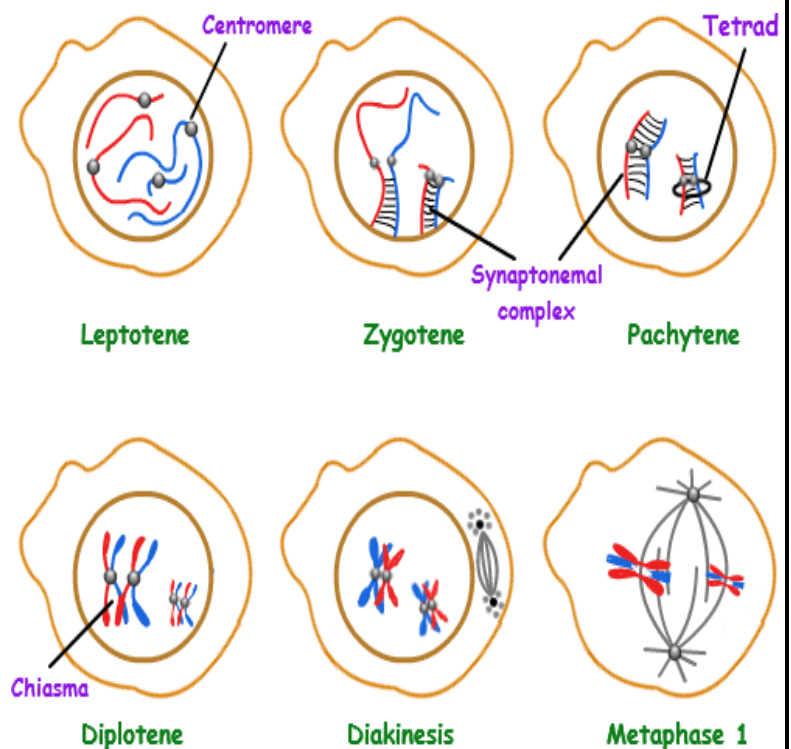
2) **Zygotene:** homologous chromosomes became very close to each other.

3) **Pachytene:** synapse will occur, that will lead to form tetrad, and then the crossing over will occur

4) **Diplotene:** The homologous chromosomes will separate from each other (but not complete separation; in order to facilitate the separation of chromosomes during the metaphase).

Chiasma: is the point where two homologous non-sister chromatids exchange genetic material. The chiasmata become visible during the diplotene stage of prophase I of meiosis, but the actual "crossing-over" of genetic material is thought to occur during the previous pachytene stage.

5) **Diakinesis:** chromosomes coil tightly (condense)



Law of segregation and law of Independent assortment

*law of segregation:

-Each gene has multiple copies, and each copy (version) is called allele. In our body, we have two alleles for each gene.

-After separation of homologous chromosomes in meiosis one will give two daughter cells, each cell will contain one allele for the same gene; because each homologous chromosome become at separated cell.

-At the level of chromosomes, there will separation between homologous chromosomes

-At the genetic level, there will separating between alleles for the same gene.

*Law of independent assortment:

-imagine that we have 6 chromosomes in each cell, three from each parent

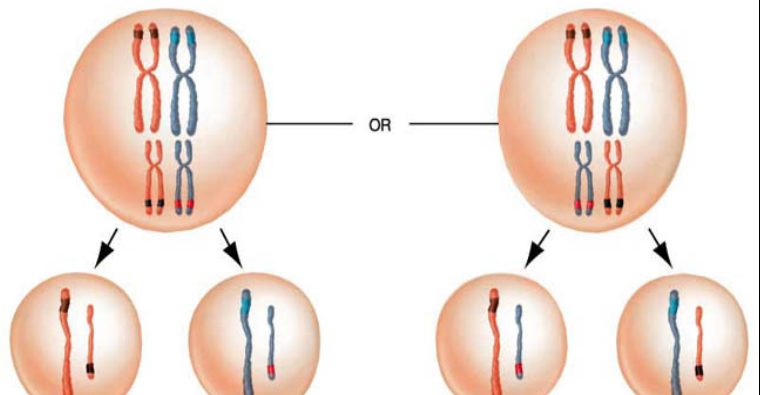
-In Metaphase I, there is no role the oblige chromosomes that taken from father to aligned in a side, and the chromosomes taken from the mother to aligned to another side.

-The assortment of chromosomes in the metaphase is a random process

-If we want to calculate the possibilities of that random alignment, as well as, the outcome chromosomes in each cell, we can use 2^n equation. And once we have 3 pairs, we will have $2^3=8$; so we have 8 possibilities of alignment during metaphase and 8 possibilities for the cell content of chromosomes.

-In human body, we will have $2^{23}= 8$ million possibilities!! , but wait, this possibilities applied for

During meiosis I, tetrads can line up two different ways before the homologs separate.



one gamete (sperm or egg), so for two gametes we will have a bigger number of possibilities. That is not the whole story; all these calculations are done without the consideration the possibilities that could be come from the crossing over. SO we can end up with a very huge number of possibilities.

-This random alignment of chromosomes during metaphase will make the possibility to have two identical DNA between two persons, is very minimal, but once we talk about twins, we will have another story.

-The twins will be created after fertilization. During mitosis of the zygote; one of the cells may separated, and continuo to form the other twin. So it makes a sense that they have the same DNA.

*“All human wisdom is summed up in
two words;
Wait and hope.”*

The End