Human genetics

Lecture III

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chromosomes

Originated from the Greek word (chroma, colour) and (soma, body)

A chromosome is an organized structure of DNA and protein found in cells

Structure of DNA and RNA

- Genetic information in bacteria is stored as a sequence of **DNA bases.**
- In bacteriophages and viruses, genetic information can be stored as a sequences of **ribonucleic acid** (RNA).
- Most DNA molecules are double stranded, with complementary bases (A-T; G-C) paired by hydrogen bonding in the center of the molecule. The orientation of the two DNA strands is antiparallel: One strand is chemically oriented in a $5' \longrightarrow 3'$ direction, and its complementary strand runs $3' \longrightarrow 5'$.

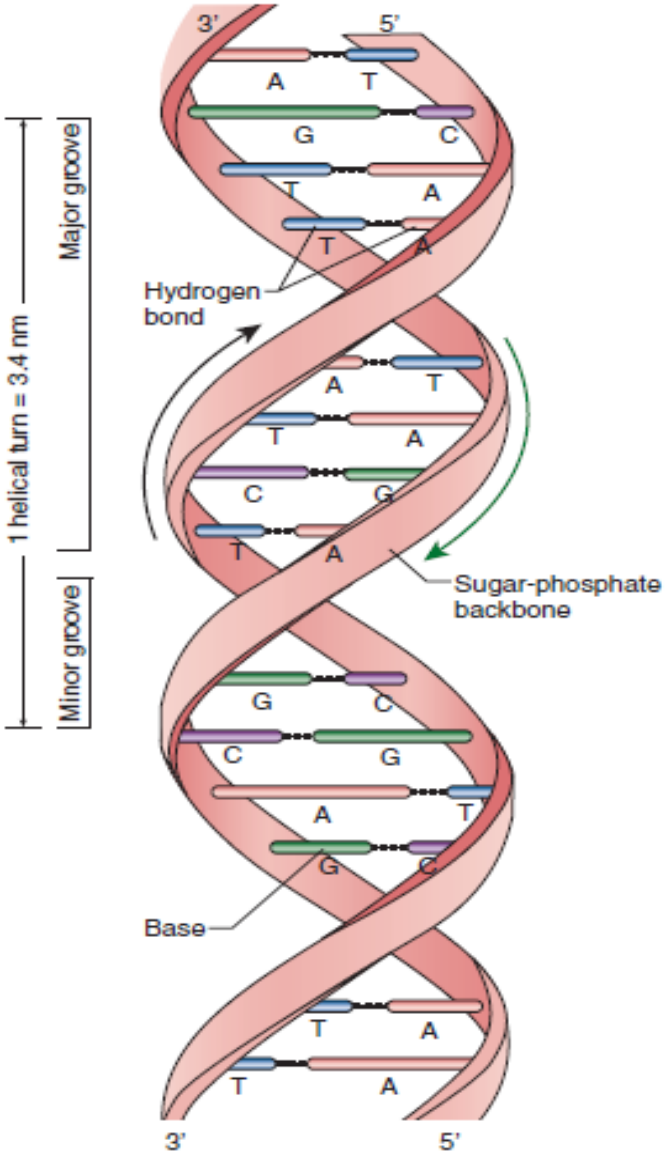
- The complementarity of the bases enables one strand (template strand) to provide the information for copying or expression of information in the other strand (coding strand)

- The base pairs are stacked within the center of the DNA double helix , and they determine its genetic information. Each turn of the helix has one major groove and one minor groove.

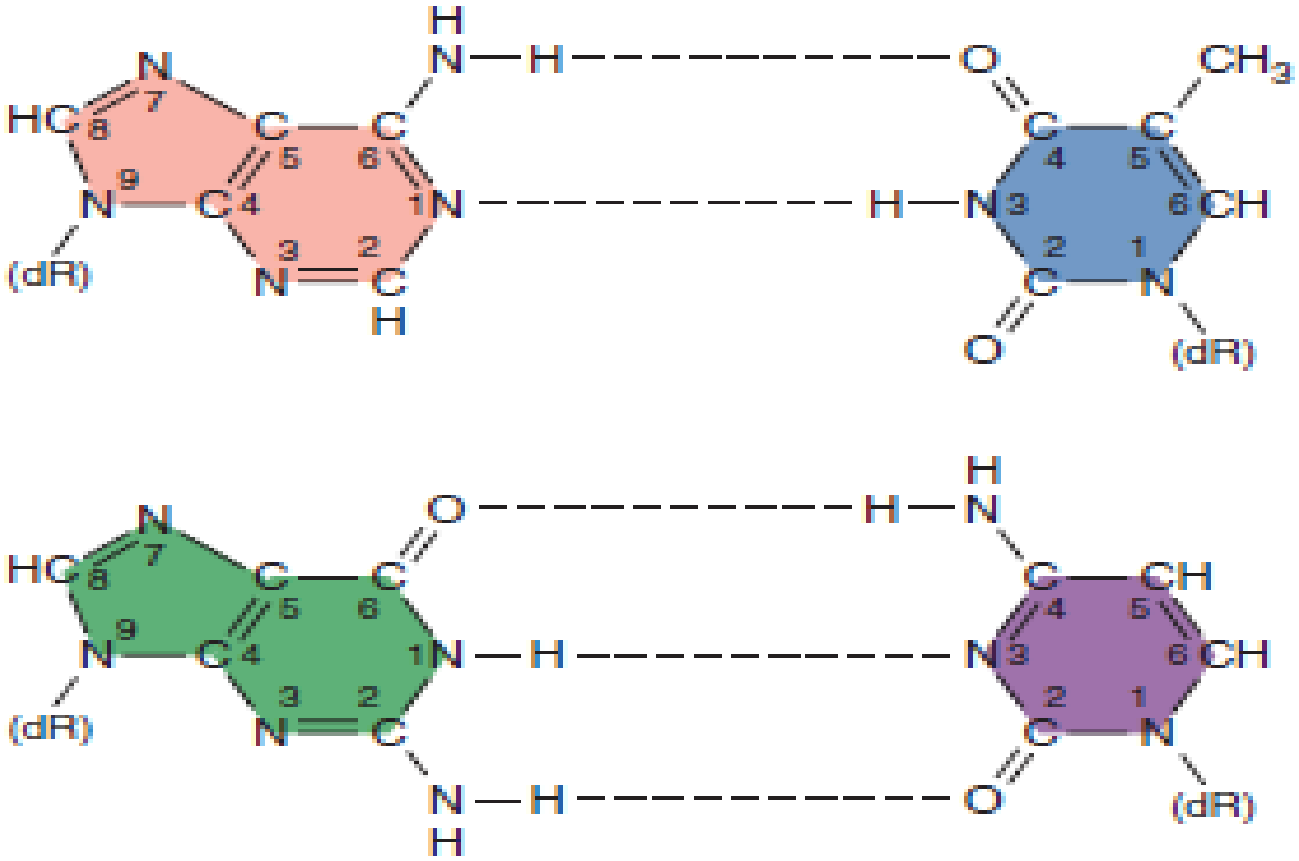
Certain proteins have the capacity to bind DNA and regulate gene expression by interacting predominately with the major groove, where atoms comprising the bases are more exposed. Each of the four bases is bonded to phospho-2′-deoxyribose to form a nucleotide.

The length of a DNA molecule is usually expressed in thousands of base pairs, or kilobase pairs (kbp) . Whereas a small virus may contain a single DNA molecule of less than 0.5 kbp, the single DNA genome that encodes *Escherichia coli* is greater than 4000 Kbp. each base pair is separated from the next by about 0.34 nm, or 3.4×10^{-7}mm

RNA most frequently occurs in single-stranded form. The base uracil (U) replaces thymine (T) in DNA, so the complementary bases that determine the structure of RNA are A-U and C-G. The overall structure of single-stranded RNA molecules is determined by pairing between bases within the strand-forming loops, with the result that single-stranded RNA molecules assume a compact structure capable of expressing genetic information contained in DNA.



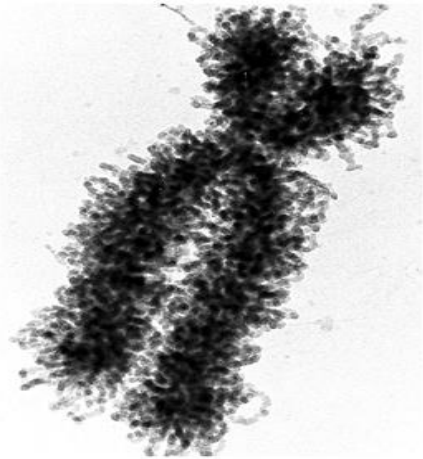
A schematic drawing of the Watson-Crick structure of DNA, showing helical sugar-phosphate backbones of the two strands held together by hydrogen bonding between the bases.



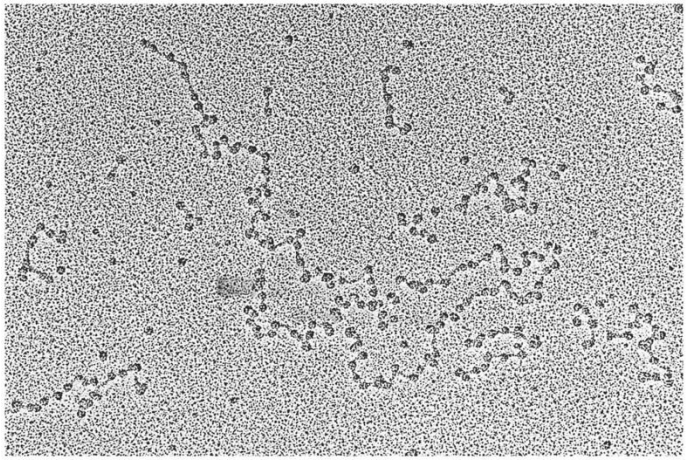
Normal base-pairing in DNA. **Top:** Adeninethymidine (A-T) pairing; **bottom:** guanine-cytosine (G-C) pair. Hydrogen bonds are indicated by *dotted lines*. Note that the G-C pairing shares three sets of hydrogen bonds, but the A-T pairing has only two. Consequently, a G-C interaction is stronger than an A-T interaction. dR, deoxyribose of the sugar-phosphate DNA backbone.

A human nucleus is only about 5–8 µm long, yet it holds all the chromatin that condenses to form the chromosomes when cells divide

Q/ Are all cells contain nucleus?

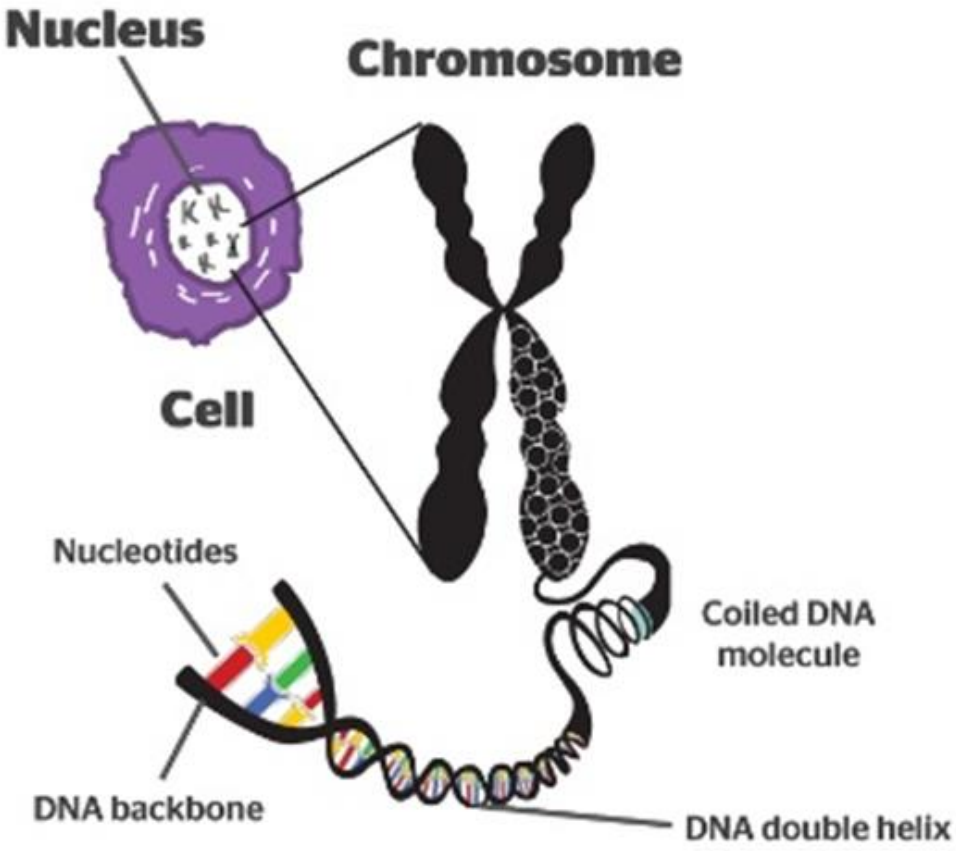


During division of cells

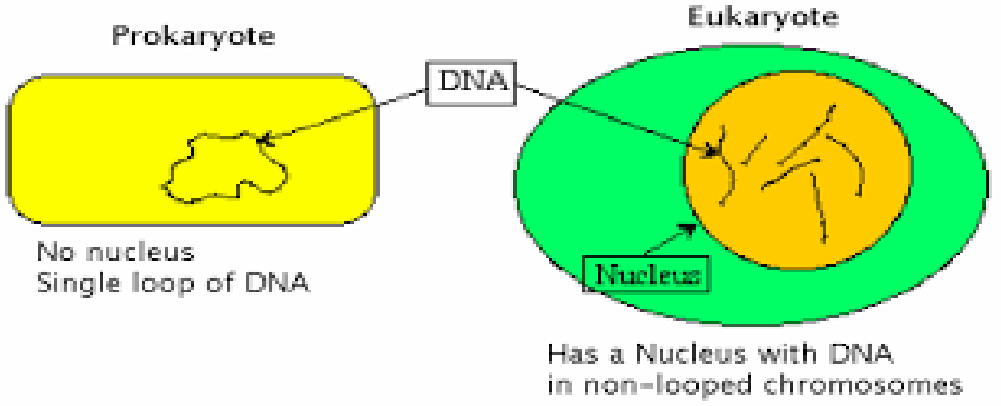


Before division of cells

Relative position of chromosome in cell



Prokaryotic chromosomes	Eukaryotic chromosomes
Genomes are simple and the organization of DNA is also different.	Genomes are composed of multiple chromosomes,
Genomes are contained in single chromosomes, which are usually circular DNA molecules	Contain a linear molecule of DNA
DNA is associated with proteins but no histones present.	Histones are unique feature of eukaryotic cells.



Humans have 46 chromosomes that occur in 23 pairs.

One pair of chromosomes is called the sex chromosomes because this pair contains the genes that control gender.

Males have the sex chromosomes X and Y, and females have two X chromosomes.

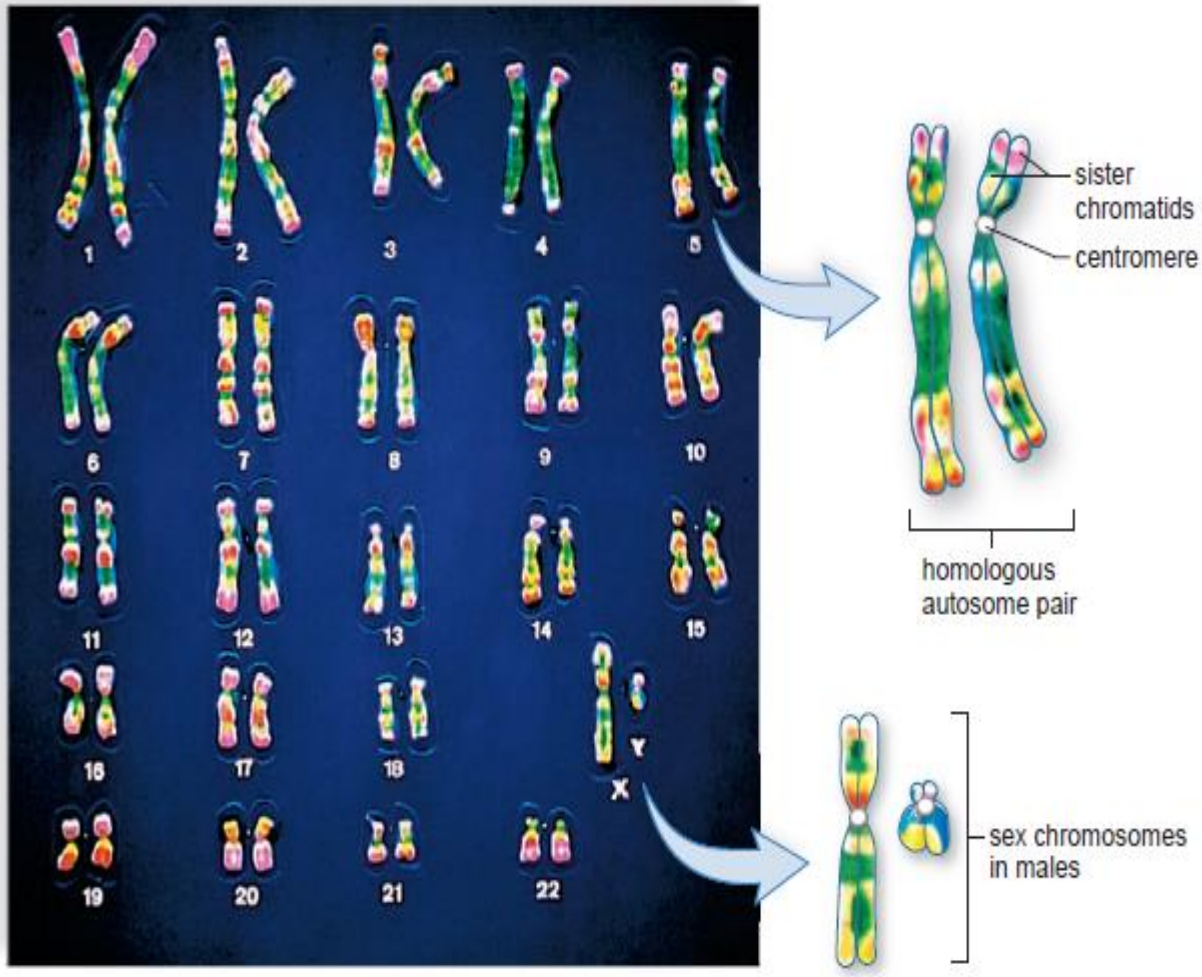
Twenty-two of these pairs are called autosomes. All of these chromosomes are found in both males and females

Somatic chromosome number of some common plants and animals

Sr. no	Scientific name	Common name	Chromosome number	
			Somatic	Gametic
1	*Homo sapiens*	Human	46	23
2	*Oryza sativa*	Rice	24	12
3	*Rattus norvegicus*	rat	42	21
4	*Pisum sativum*	Pea	14	7
5	*Daucus carota*	Carrot	20	10
6	*Allium cepa*	Onion	16	8
7	*Zea mays*	Maize	20	10
8	*Apis mellifera*	Honey bee	32	16
9	*Musca domestica*	House fly	12	6
10	*Felis domesticum*	Cat	38	19
11	*Drosophila melanogaster*	Fruit fly	8	4
12	*Neurospora Crassa*	Bread mold	14	7

Karyotype

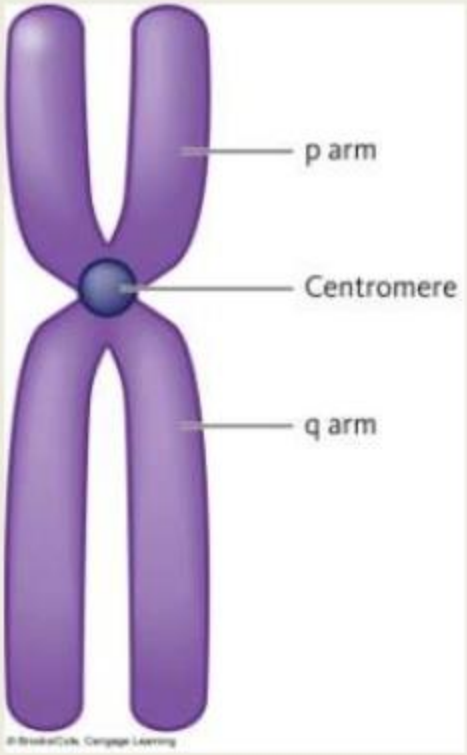
A karyotype is simply a picture of a person's chromosomes. In order to get this picture, the chromosomes are isolated, stained, and examined under the microscope. Most often, this is done using the chromosomes in the **white blood cells**. A picture of the chromosomes is taken through the microscope. Then, the picture of the chromosomes is cut up and rearranged by the chromosome's size. The chromosomes are lined up from **largest to smallest**. A trained cytogeneticist can look for missing or extra pieces of chromosome

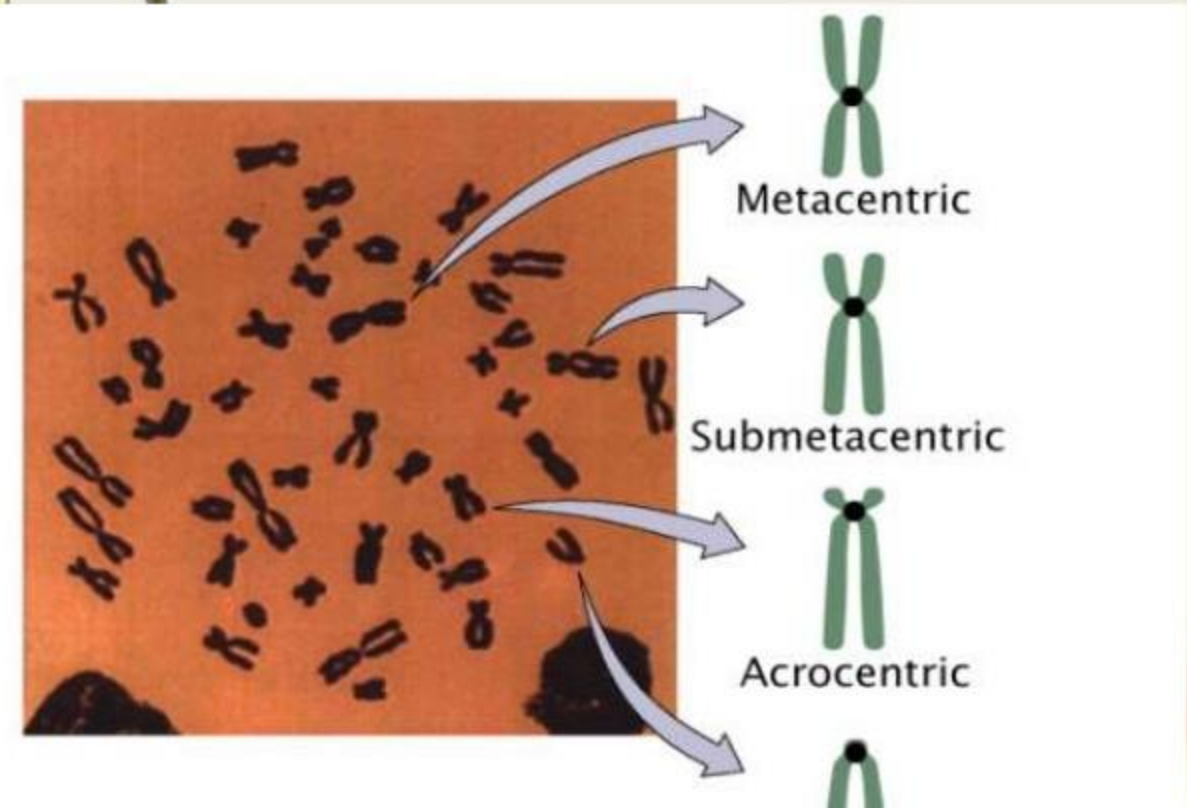


A karyotype of human chromosomes . In body cells, the chromosomes occur in pairs. In a karyotype, the pairs have been numbered and arranged by size from largest to smallest. These chromosomes are duplicated, and each one is composed of two sister chromatids.

Chromosomes Structure

- Centromere
- p arm **(petit)**
- q arm **(queue)**
- Telomeres





TYPES OF CHROMOSOMES

There are four basic types of chromosomes seen during anaphase.

These are:

1.TELOCENTRIC:

–No P arm, centromere is on the end

2. ACROCENTRIC:

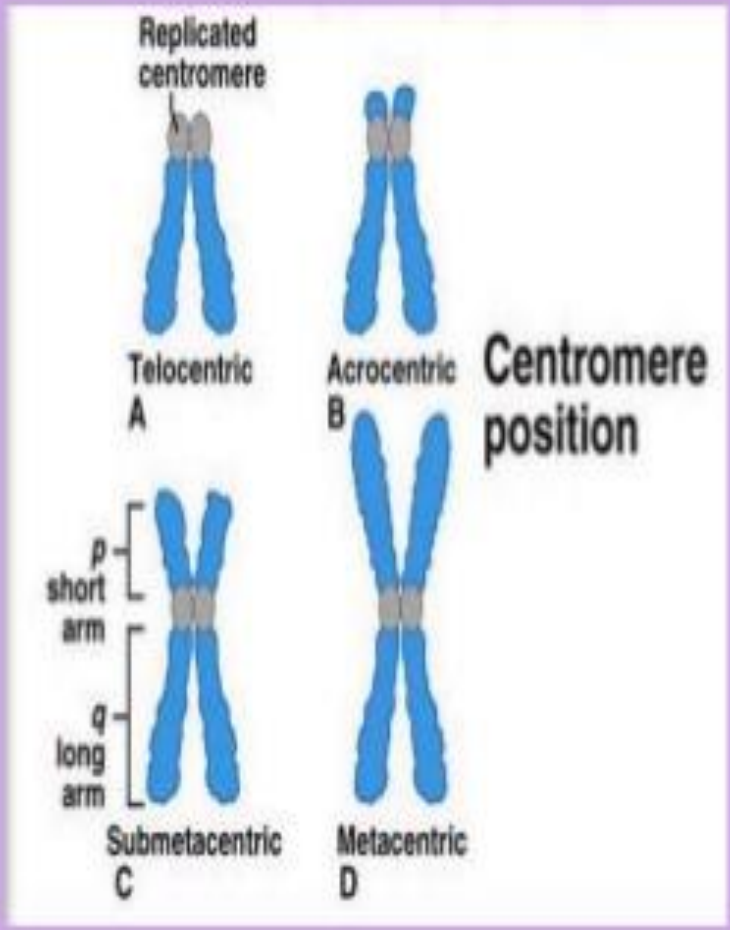
–very small P arm, centromere is very near to the end

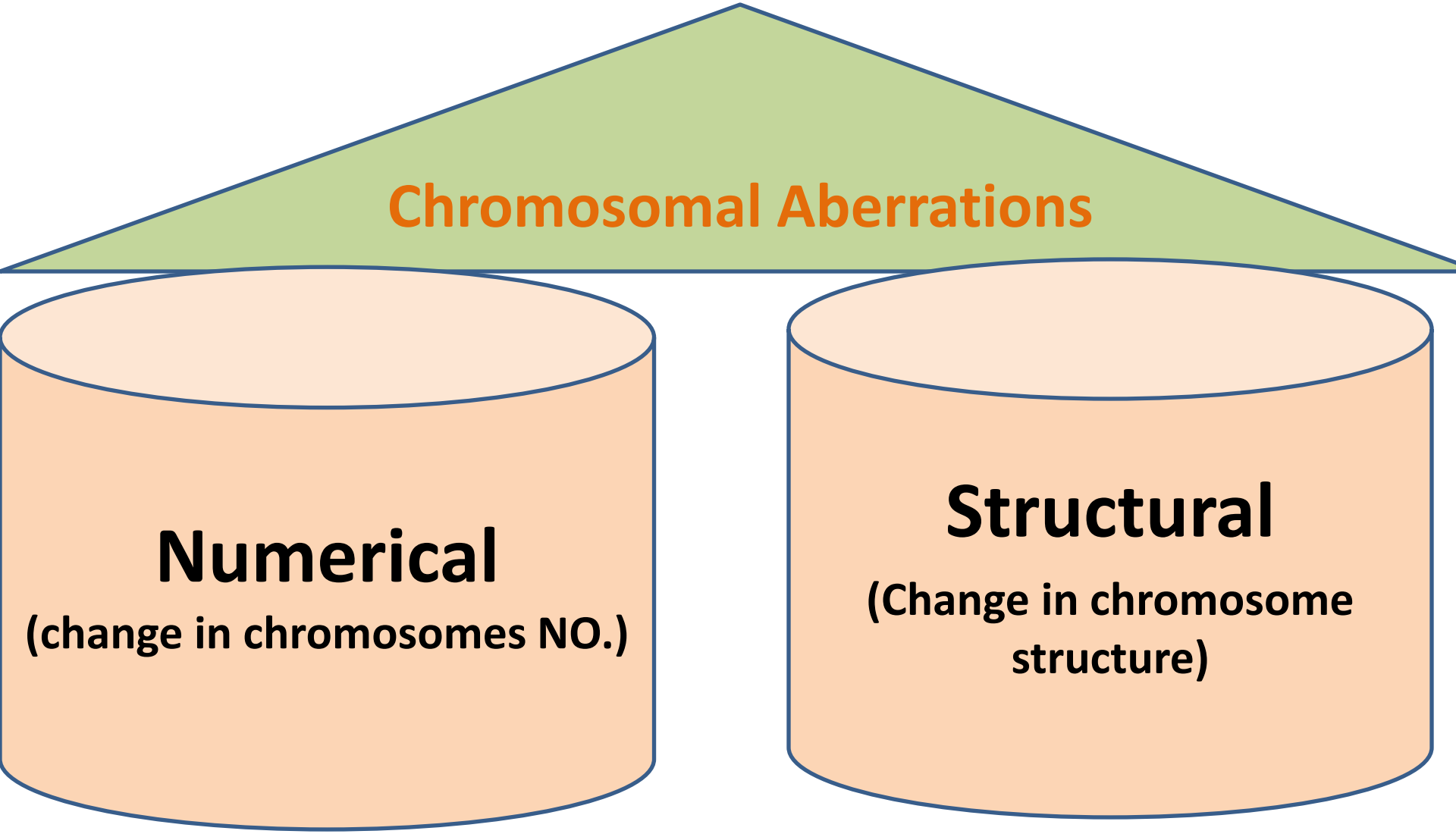
3. SUB-METACENTRIC:

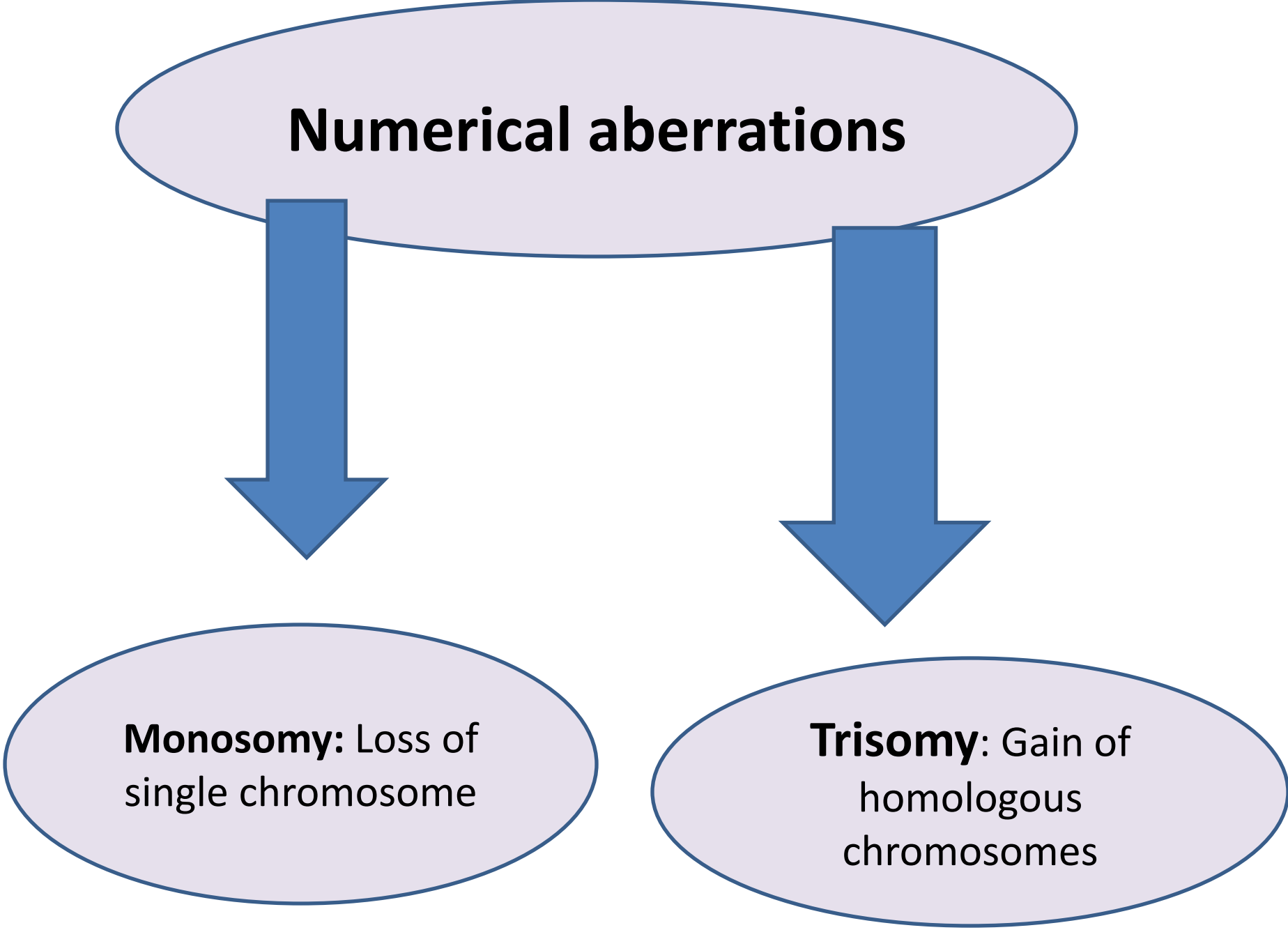
–P arm just a little smaller than Q arm; centromere is in the middle

4. METACENTRIC:

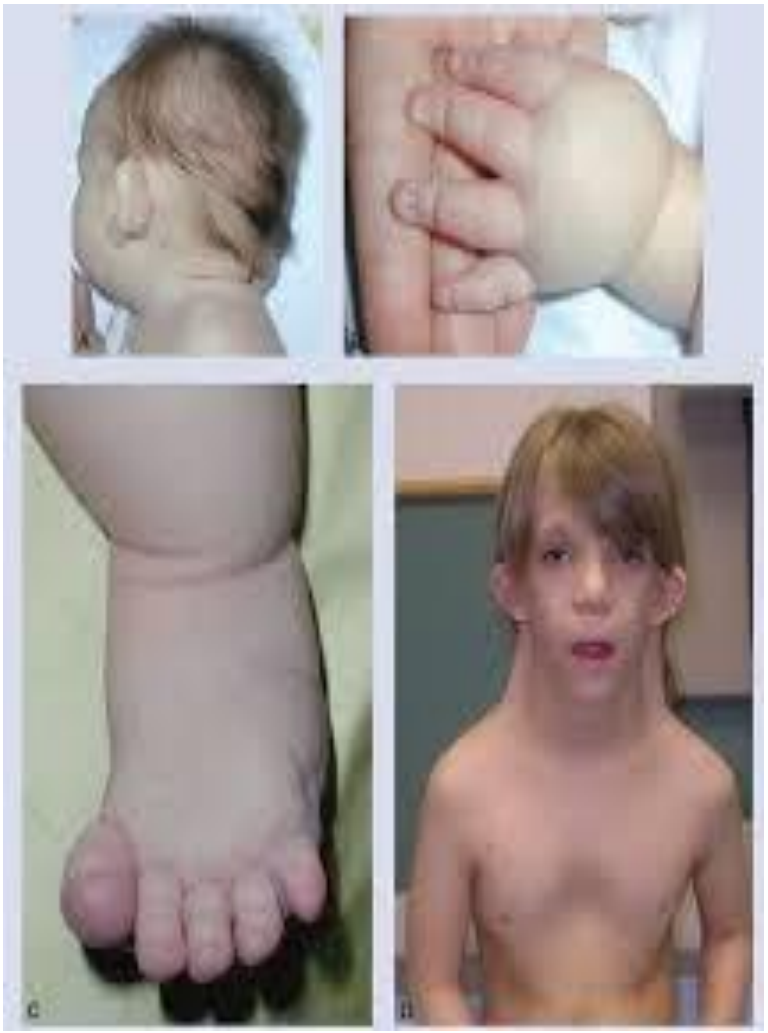
P and q arms are exactly the same length, centromere is in exact middle of chromosome




Chromosomal Aberrations
Numerical
(change in chromosomes NO.)
Structural
(Change in chromosome structure)


Numerical aberrations
Monosomy: Loss of single chromosome
Trisomy: Gain of homologous chromosomes

Down's syndrome: Trisomy 21



Turner syndrom: Loss of sex chromosome.

Glossary

- **Allele:** Alternative form of a gene;alleles occur at the same locus on homologous chromosomes.

- **Gene:** Unit of heredity existing as alleles on the chromosomes; in diploid organisms, typically two alleles are inherited—one from each parent.

- **Apoptosis** : Programmed cell death involving a cascade of specific cellular events leading to death and destruction of the cell.

- **DNA (deoxyribonucleic acid)** Nucleic acid polymer produced from covalent bonding of nucleotide monomers that contain the sugar deoxyribose; the genetic material of nearly all organisms.

- **chromatin** (kroh-muh-tin) Network of fine threads in the nucleus composed of DNA and proteins.

- **chromosome** (kroh-muh-som) Chromatin condensed into a compact structure.

Lethal genes

- Genes which result in the reduction of viability of an individual or become a cause for death of individuals carrying them are called as lethal genes.

- Certain genes are absolutely essential for survival. Mutation in these genes creates lethal allele

TYPES OF LETHAL ALLELES

Lethal alleles fall into four categories.

1. **Early onset-** lethal alleles which result in death of an organism at early stage of life, for example, during embryogenesis.

2. **Late onset-** lethal allele which kills organism at their final stage of life are known as late onset allele.

3. **Conditional** - lethal allele which kill an organism under certain environmental conditions only. e.g., some temperature sensitive alleles kill organisms only at high temperature.

4. **Semi lethal** – Lethal allele which kill only some individuals of the population but not all are know as semi lethal

Sickle Cell Disease

What is sickle cell disease?

- Sickle cell disease (SCD) is a group of inherited red blood cell disorder.
- Healthy red blood cells are round and they move through small blood vessels carrying oxygen to all parts of the body.
- In sickle cell disease ,the red blood cells become hard and sticky and look like a C-shaped farm tool called a sickle.

Phenotype----------eye color in human, antibiotic resistance

in bacteria.

Genotype---------- alteration in the DNA sequence, within a gene or within the organization of genes.