Chromosomes, Structure and FUNCTIONS

LEARNING OUTCOMES

- STUDENTS WILL BE ABLE TO KNOW

- 1. THE STRUCTURE OF CHROMOSOME

- 2. DIFFERENT TYPES OF CHROMOSOME BASED ON
- a. Functions
- b. Location of centromere
- c. Number of Centromere

E. Strasburger in 1875 discovered thread-like structures which appeared during cell division

Waldeyer coined the term chromosome first time in 1888

Chromosome means: chroma - colour; some - body

A chromosome is a thread-like self-replicating genetic structure containing organized DNA molecule package found in the nucleus of the cell

A complex network of DNA and protein- coiled around each other and helps to fit DNA inside the nucleus is known as a chromosome

So the colored thread like bodies present in the nucleoplasm of the living cells, which helps in the inheritance (transmission) of characters in form of Genes from generation to generation are known as ***CHROMOSOMES.***

Chromosome shape is usually observed at anaphase, when the position of primary constriction (centromere) determines chromosome shape.

The somatic chromosome: Is any chromosome in the body that is not sex chromosome

DIPLOID CELL: *is a cell that contains two complete sets of chromosomes. This is double the haploid chromosome number. Each pair of chromosomes in a diploid cell is considered to be a homologous chromosome set. A homologous chromosome pair consists of one chromosome donated from the mother and one from the father*

The gametic chromosome number is half of the somatic chromosome numbers and represented by n (Haploid)

They are covered with a sheath made of proteins

Inside this sheath is present granular matter referred as matrix

Inside the matrix, there are two threads called _Chromonemata‘ which are the subunits of chromatids and are present during Prophase

Chromosomes are capable of duplication and maintaining their morphologic and physiologic properties through successive cell divisions

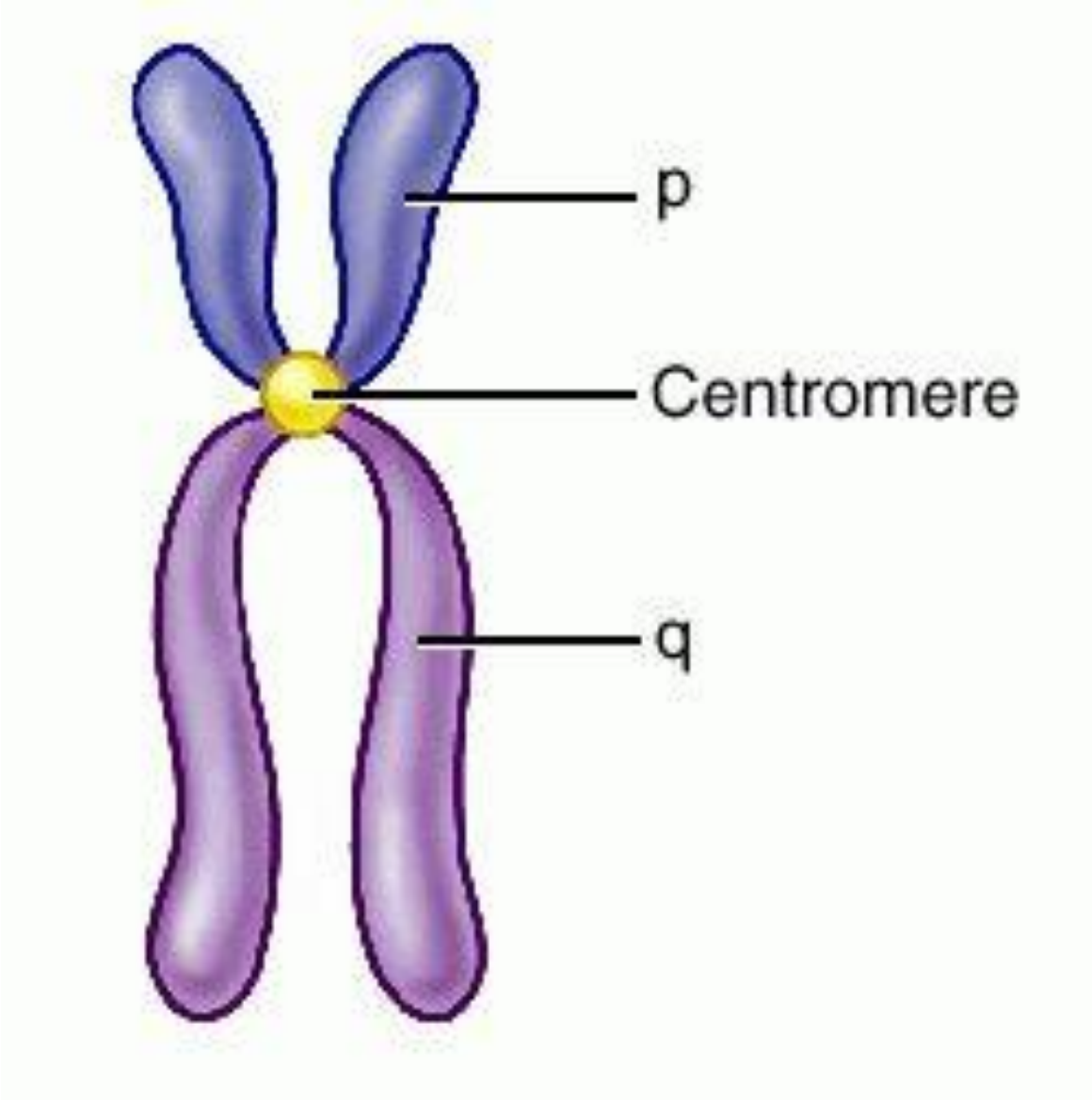
Chromosomes contributed to the division of cells and they are of prime importance as they carry the genes which are the hereditary material.

CHROMOSOME MORPHOLOGY

The chromosome morphology changes during cell division. Chromosomes are thin, coiled, elastic, thread-like structures during the interphase

As cells enter mitosis, their chromosomes become highly condensed so that they can be distributed to daughter cells.

Each chromosome has two arms - p (the shorter of the two) and q (the longer).


p
Centromere
q

Each metaphase chromosome appears to be longitudinally divided into two identical parts each of which is called chromatid.

Both the chromatids of a chromosome appear to be joined together at a point known as centromere.

The two chromatids making up a chromosome are produced through replication of a single chromatid during synthesis (S) phase of interphase, they are referred to as sister chromatids

CENTROMERE

Centromere is the landmark for identification of chromosome.

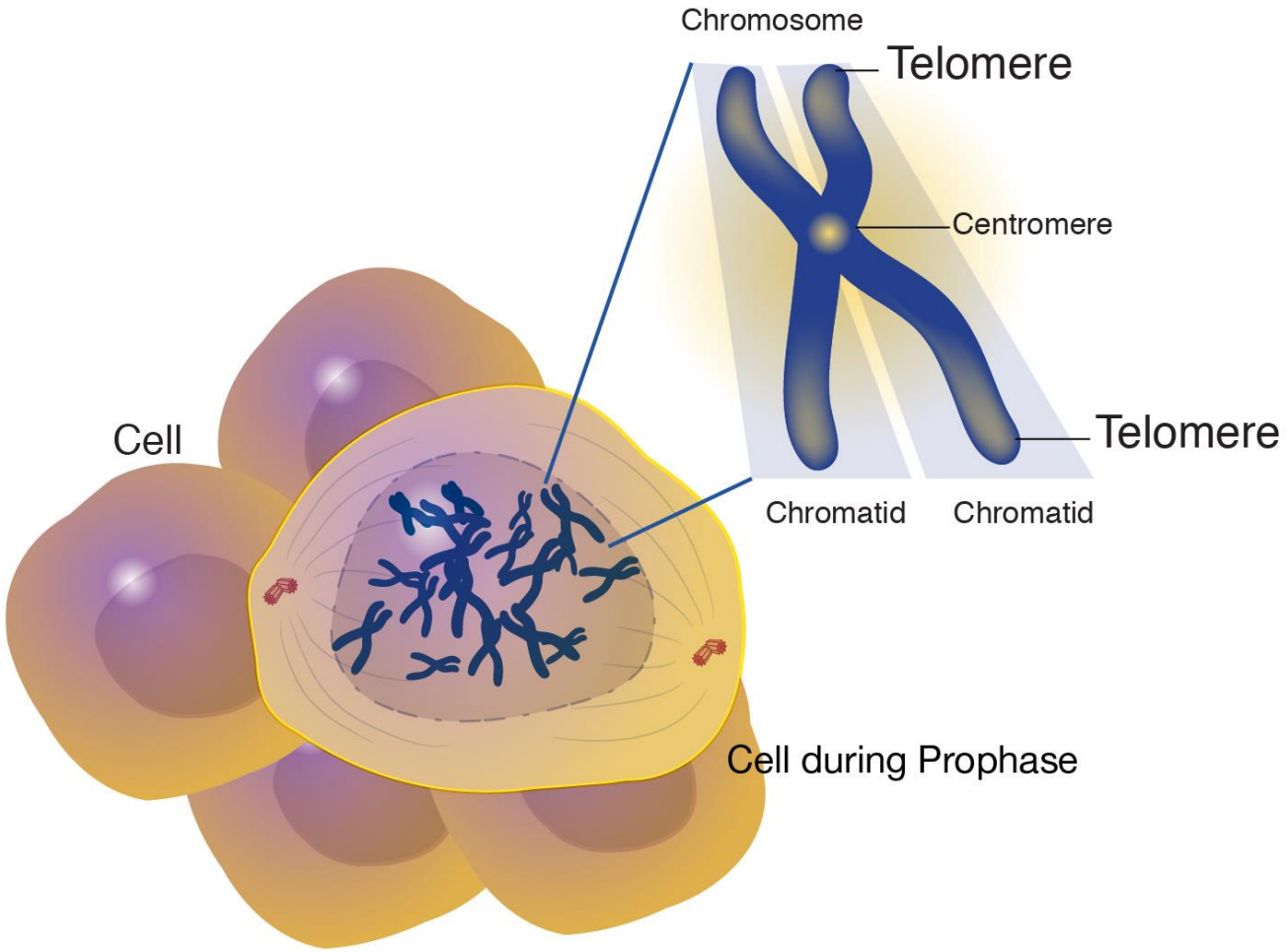
Each chromosome has a constriction point called the centromere (Synonym: Kinetochore), which divides the chromosome into two sections or arms.

The short arm of the chromosome is labeled the "p" arm. The long arm of the chromosome is labeled the "q" arm.

TELOMERE

The two ends of a chromosome are known as telomeres, they play critical roles in chromosome replication and maintenance of chromosomal length

The telomeres are highly stable and telomeres of different chromosomes do not fuse.


Chromosome
Telomere
Centromere
Telomere
Chromatid
Chromatid
Cell
Cell during Prophase

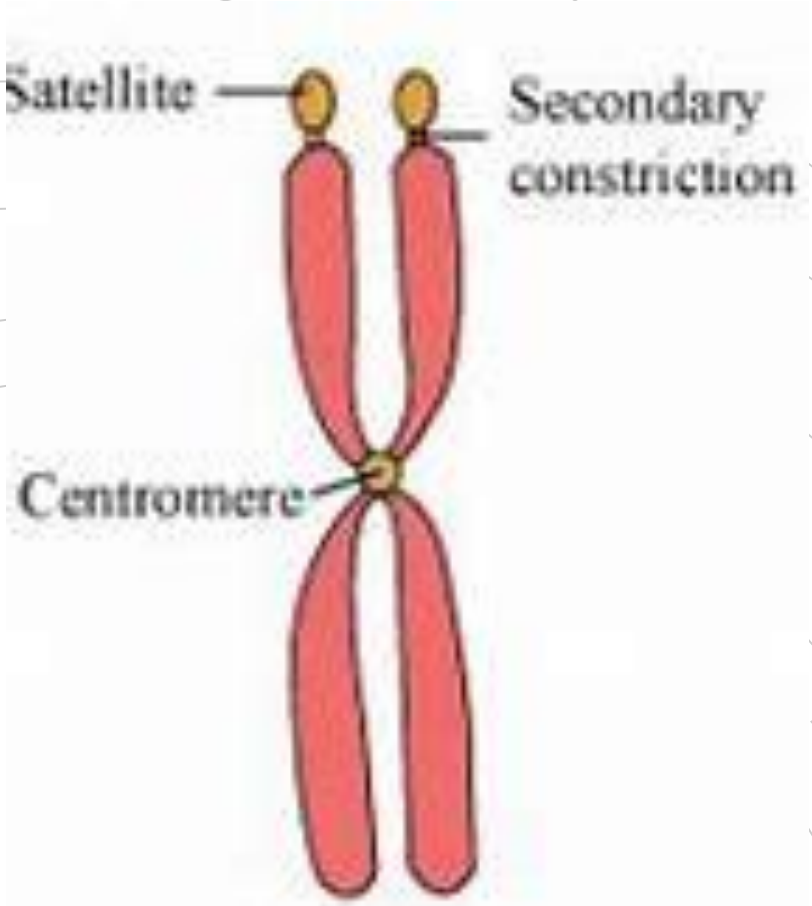
SECONDARY CONSTRICTION

In some chromosome addition to centromere / primary constriction, one or more constrictions in the chromosome are present termed secondary constrictions.

SATELLITE

The chromosomal region between the secondary constriction and nearest telomere is called as satellite and chromosomes that possess this region called as satellite chromosome or sat chromosome.

A small chromosomal segment separated from the main body of the chromosome by a secondary constriction is called Satellite



Chromosome showing satellite region

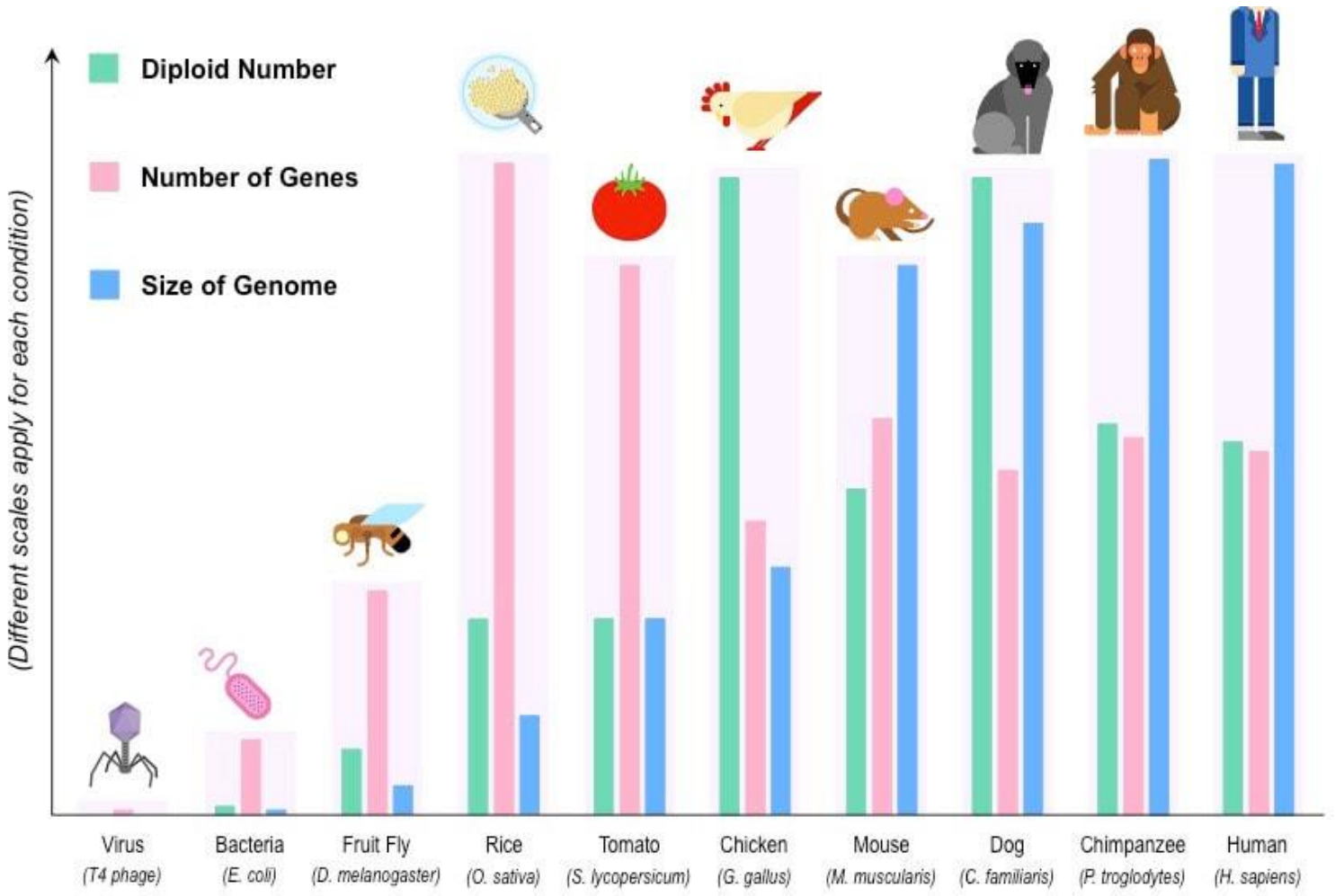
SIZE OF THE CHROMOSOME

The size of the chromosome varies from stage to stage of cell division.

The chromosomes are the longest and thinnest during interphase (resting stage) and hence not visible under light microscope.

Chromosomes are the smallest and thickest during mitotic metaphase.

Chromosome size is not proportional to the number of genes present on the chromosome.



The location of the centromere on each chromosome gives the chromosome its characteristic shape.


CHROMOSOMES ARE CLASSIFICATION BASED ON THE CENTROMERE POSITION

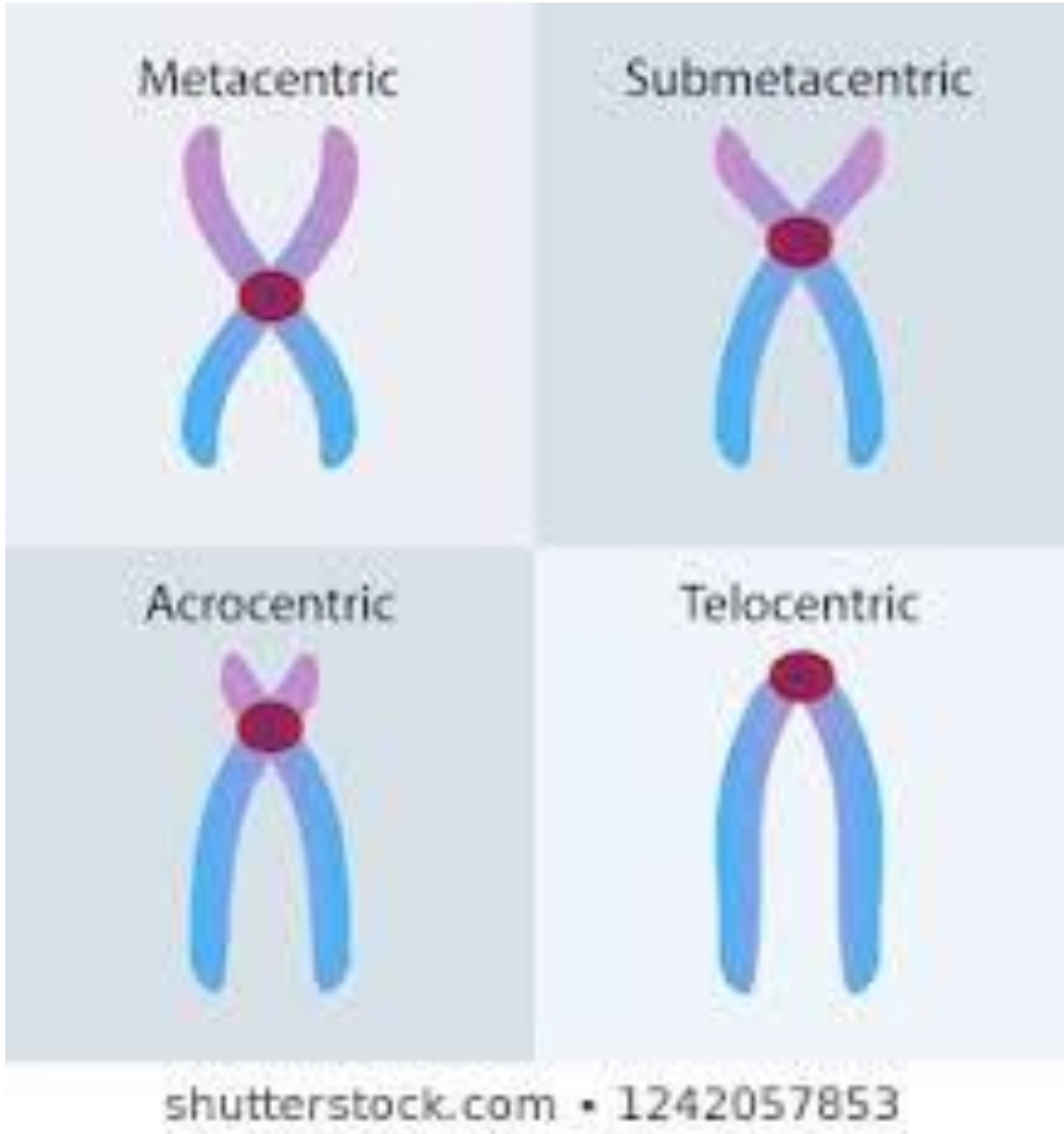
TELOCENTRIC CHROMOSOMES

Whose centromere is located at one end proximal end of the chromosome

Has only one chromosomal arm

Appeared as I shaped

Telocentric chromosomes are very rare


Metacentric
Submetacentric
Acrocentric
Telocentric
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METACENTRIC CHROMOSOME

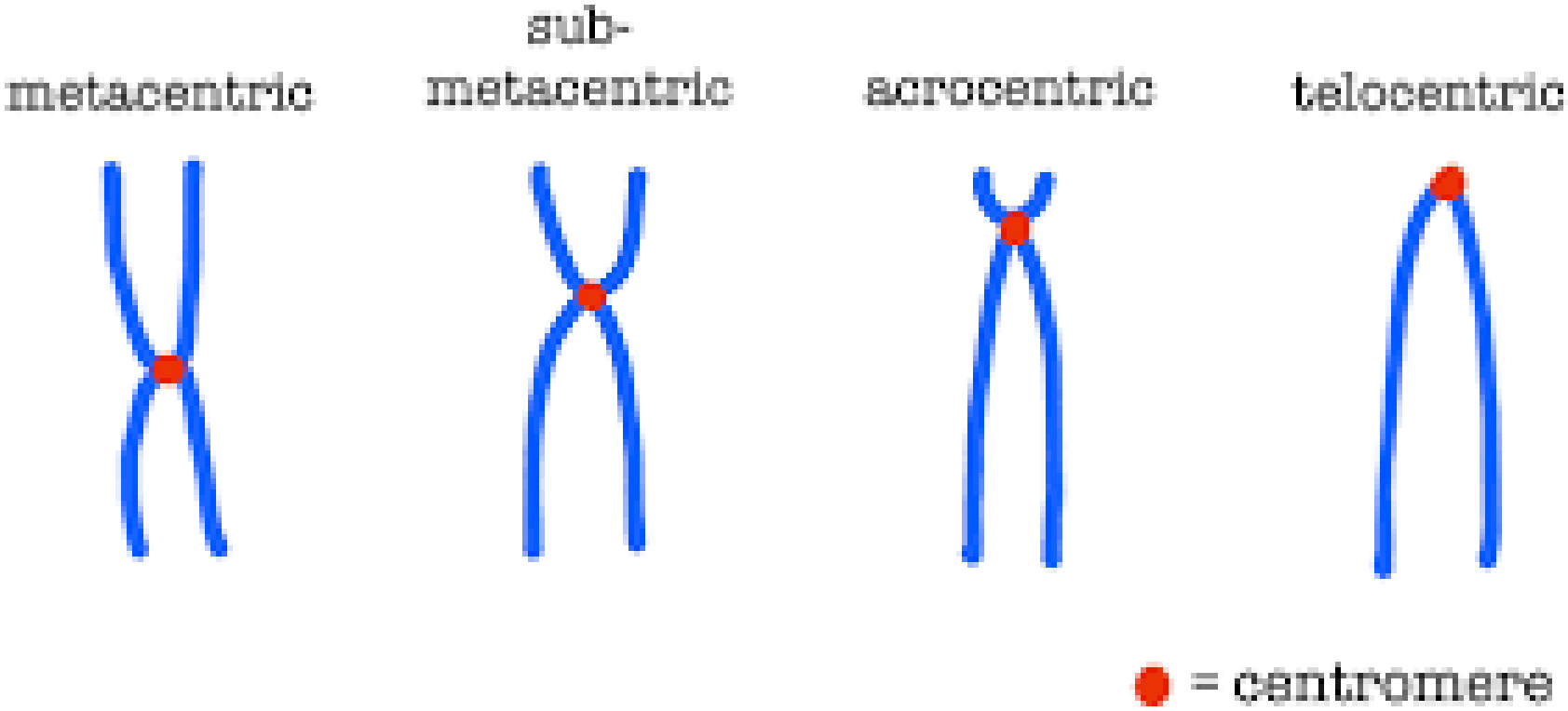
The metacentric chromosome has its centromere located centrally between the two arms.

This gives the chromosome a typical "V" shape seen during anaphase.

The arms of this chromosome are approximately equal in length.

In certain cells, the fusion of two acrocentric chromosomes leads to the formation of a metacentric chromosome

Centromere Localizations



SUBMETACENTRIC CHROMOSOME

It is said that the arms of the submetacentric chromosome are unequal in length.

This is because the kinetochore is present in the sub mediate position.

This gives rise to the 'L' form of the submetacentric chromosome.

ACROCENTRIC CHROMOSOME

The location of the centromere on the acrocentric chromosome is subterminal.

This causes the short arm of the chromosome to become very short, making it very difficult to observe

Holocentric Chromosome

In the holocentric chromosomes, the centromere travels the full length of the chromosome.

These chromosomes are very common in the cells that belong to organisms in the animal and vegetable kingdom.

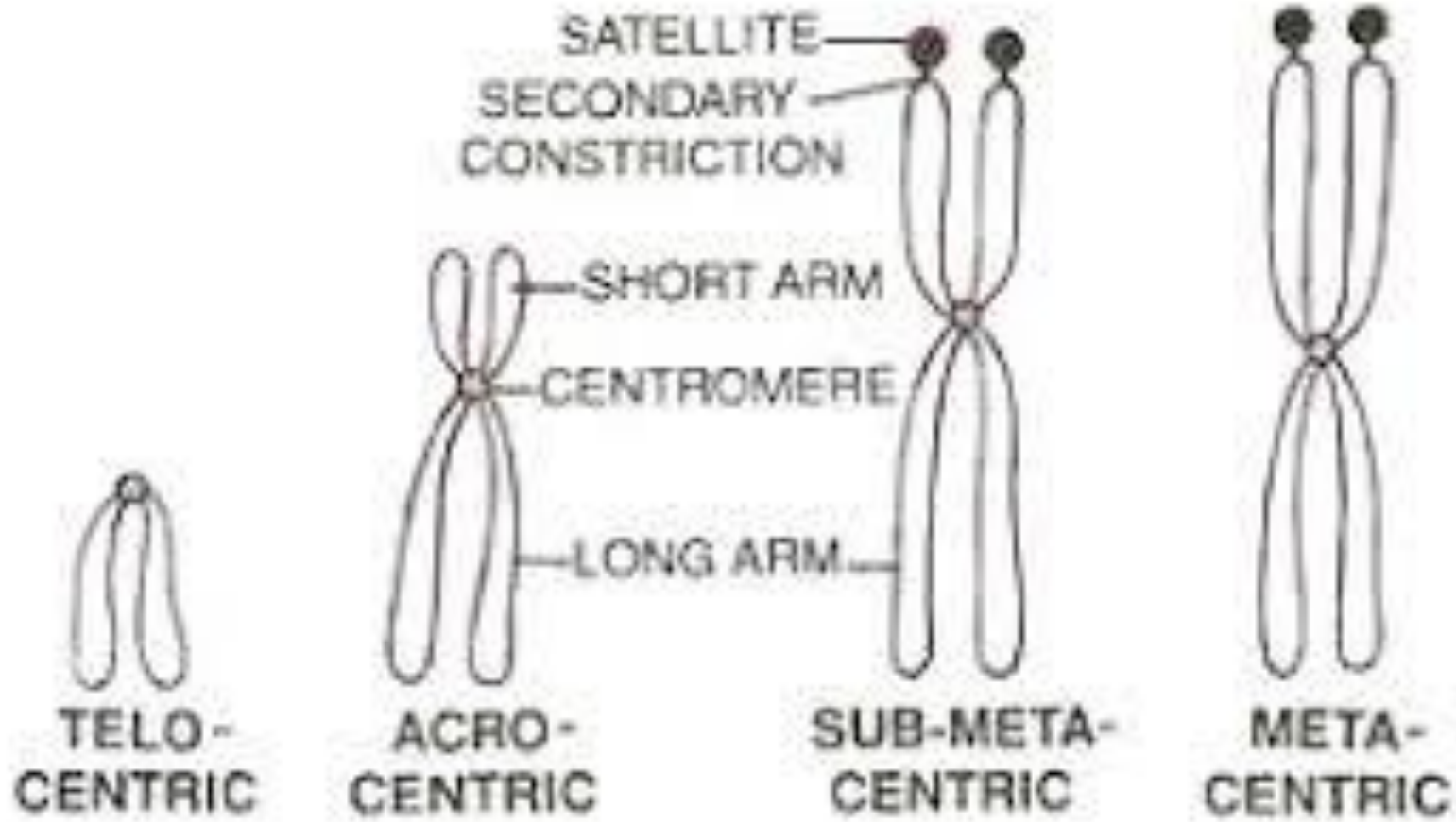


Fig. 8.55. Types of chromosomes on the basis of position of centromere.

According to the number of centromeres

The amount of centromeres present in the chromosome helps determine the type of chromosome.

These different types of chromosomes based on the number of centromeres are the following:

Acromic chromosome

• *The acentric chromosomes are those that lack centromeres, that is, the centromere is totally absent in the chromosome.*

Monocentric chromosome

Monocentric chromosomes are those that contain a single centromere.

This type of chromosome is present in most organisms.

CHROMOSOME DICENTRICO

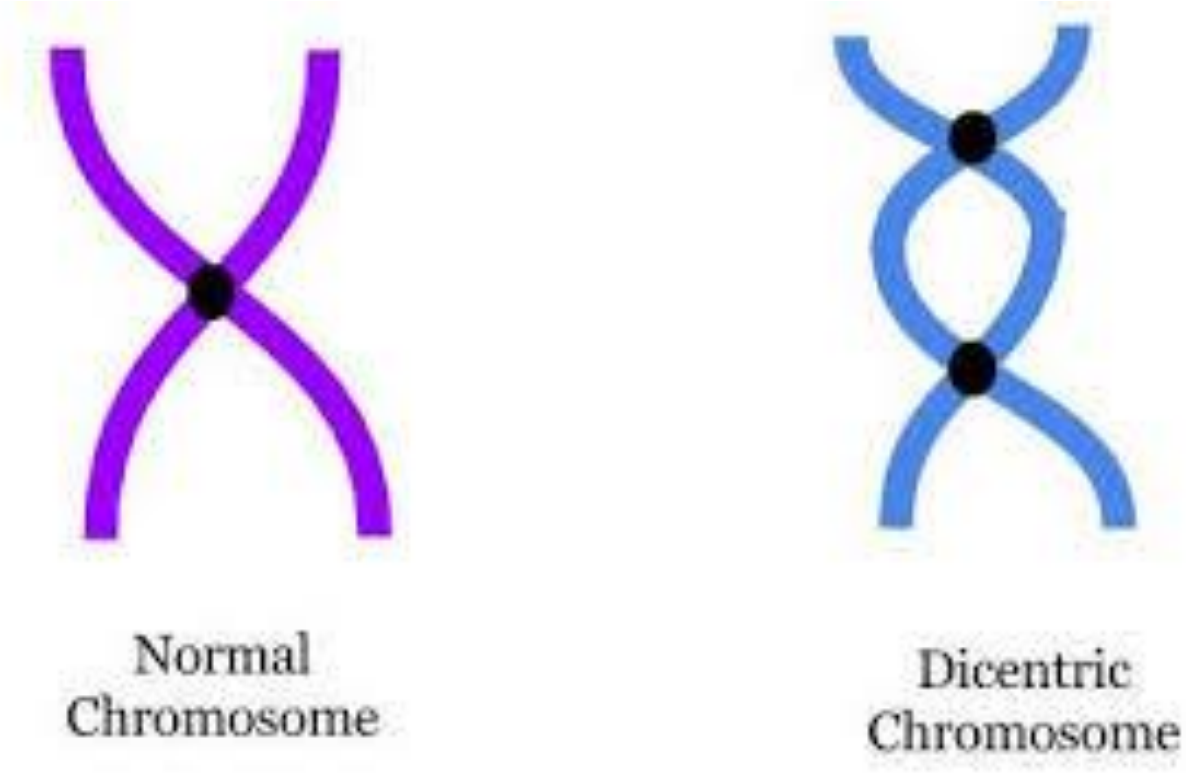
The dicentric chromosomes are those that have two centromeres that are present.

These chromosomes are formed after two chromosomal segments with a centromere each, are fused from end to end.

This causes them to lose their acentric fragments, which leads to the formation of the dicentric chromosome.

A dicentric chromosome is an abnormal chromosome .

It is formed through the fusion of two ***chromosome*** *segments, each with a centromere, resulting in the loss of acentric fragments (lacking a centromere) and the formation of* ***dicentric*** *fragments*



CROMOSOMA POLICENTRICO

Polycentric chromosomes are those that contain more than two centromeres.

These chromosomes are very common in plants, for example, the Adder tongue fern has 1262 chromosomes.

Chromosomes are very important for each and every organism, since the future of their offspring depends on the normal division and separation of the chromosomes.

	Species names of some Plant & Animals	Number of chromosomes
1	Homo sapiens (Man)	46
2	Zea mays (Corn or maize)	20
3	Triticum vulgare (common wheat)	42
4	Ascaris lumbricoides (Giant roundworm)	48
5	Musca domestica (Housefly)	12
6	Drosophila melanogaster (fruit fly)	8

CHROMOSOME SHAPE

The shape of the chromosomes is changeable from phase to phase in the continuous process of the cell growth and cell division.

During cell division chromosomes may appear in different shapes, they can be rod shaped, twisted or spiral curved or filamentous.

In the resting phase or interphase stage of the cell, the chromosomes occur in the form of thin, coiled, elastic and contractile, thread-like stainable structures, the chromatin threads.

In the metaphase and the anaphase, the chromosomes become thick and filamentous

According to the information they contain

Autosomes

Autosomes are structures that contain hereditary information.

They do not contain information related to sexual reproduction and determination.

They are identical in both sexes, that is, species of male and female humans, being of the same size and shape, form an identical mating.

There are 44 pairs of autosomes and they contain information related to phenotypic characters.

Alosomes

Alosomes are sex chromosomes that are different from autosomes in shape, behavior and size, X and Y chromosomes also have different structures.

There are a couple of allosomes in humans. The X chromosomes are present in the ovule and the X or Y chromosome may be present in the sperm. These chromosomes help in determining the sex of the progeny.

If the offspring receives the X chromosome of the mother and father, it results in a girl (XX).

If the offspring receives an X chromosome and a Y chromosome from the parents, it results in a male child (XY).

The donation of the X or Y chromosome by the father helps determine the sex of the child.

Functions of chromosome

1. The most important function of chromosomes is to provide the genetic information for various cellular functions essential for growth, survival, development, reproduction, etc., of organisms.

2. To protect the genetic material (DNA) from being damaged during cell division. Chromosomes are coated with histones and other proteins which protect it from both chemical (e.g., enzymes) and physical forces.

3. The chromosomes are capable of self-duplication. During duplication process the DNA strands unwind.

As unwinding starts, each template of DNA forms its complementary strand in double-helix nature. The conversion of the old DNA molecule into two new molecules helps in duplicating the chromosomes.

3. *The properties of chromosomes ensure a precise distribution of DNA (genetic material) to the daughter nuclei during cell division.*

4. Centromeres of chromosomes perform an important function in chromosome movements during cell division which is due to the contraction of spindle fibres attached to the centromeric regions of chromosomes.

5. Gene action in eukaryotes is believed to be regulated through histone and non-histone proteins associated with chromosomes.

They help in expression of different characters in an organism by synthesizing proteins in cells. A definite protein is accumulated to produce a definite character

6. As carrier of genes they transmit characters from generation to generation, i.e. parents to offspring. Chromosomes form a link between the offspring and the parents.

7. The chromosomes control the physiological and biochemical processes in the body of the organism

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