

CLASS – 11

BIOLOGY

Chapter – 10

Cell Cycle and Cell Division

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Cell cycle and cell division

- The continuity of life depends on the cell division in which undergoes two type of division that is **mitosis** and **meiosis**.
- There are two major events which occurs both in mitosis and meiosis i.e. **karyokinesis** (nuclear division) and **cytokinesis** (cytoplasm division).
- **Mitosis** retains the same number of chromosomes in daughter cells .
- **Meiosis** retain halves the number of chromosomes in the daughter cells and results in the formation of gametes.
- **Amitosis** is another type of direct division that occurs in **unicellular organisms** (i.e. lower algae, fungi, and some protozoan's).

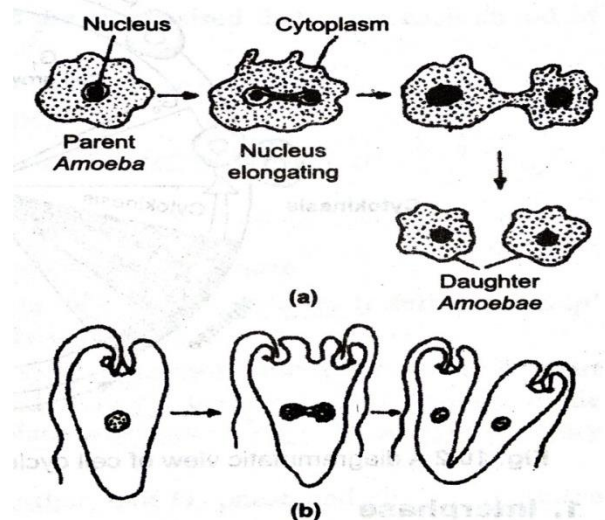


Fig. 10.1 Amitosis

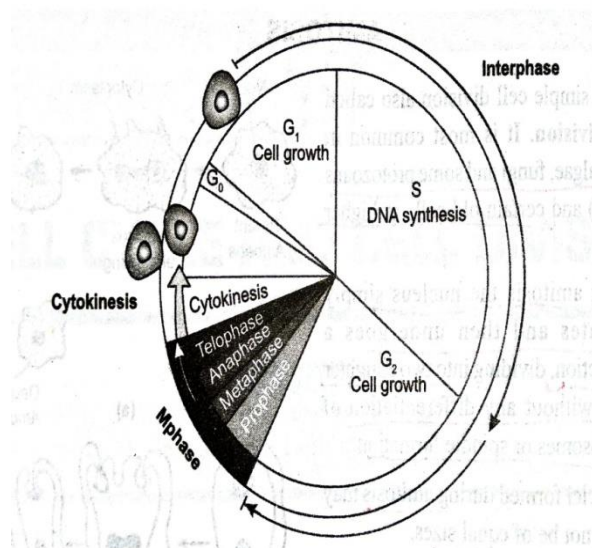
- During a mitosis the nucleus simple elongated and then undergoes constriction and divide into

two daughter nuclei without any differentiation of chromosomes or spindle formation.

- **The nuclei is formed during amitosis** may or may not be equal size and division of cytoplasm may lead to formation of two daughter cells.

Cell cycle

- It is the sequence of events by which a cell duplicates its genome, synthesis the other constituents of the cell and divides into two daughter cells.
- The duration of cell cycle differs from organism to organism and also from cell type to cell type and the amount of time they spend in different stage which is called phase of cell cycle.
- There are three main phases in cell cycle:



1. **Interphase**
2. **M phase**
3. **Cytokinesis**

Interphase

- It is **physiologically very active phase** in the cell cycle in which DNA is duplicated.
- It is the time during which the cell prepare for division by undergoing both cell growth and DNA replication in an orderly manner.

1. **G-1 phase** (i.e. enzyme and substrate are made)
2. **S phase** (i.e. DNA synthesis or replication takes place)
3. **G-2 phase** (i.e. spindle and aster protein are formed)

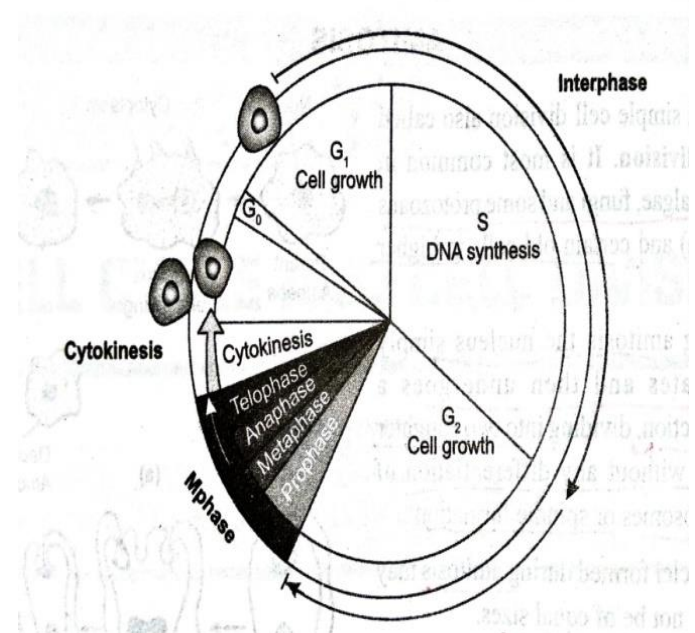
there is no DNA synthesis during G-1, and G-2 phase.

G₁ Phase:

- It **corresponds to the interval between mitosis and initiation of DNA replication.**
- Cell growth occurs and cell organelles are produced.
- Structural and functional protein are formed.
- Nucleolus produces rRNA, mRNA and tRNA and ribosome are synthesized.
- **Metabolic rate of cell is very high.**

Synthesis phase:

- It is period when **synthesis or replication occurs and no increase in the chromosome numbers occurs.**
- **Histone protein is synthesis** and each chromosome is in the form of two chromatids.
- **Centriole replicate in animal cells.**



G₂ Phase:

- Proteins are synthesized in preparation for M phase.
- Mitotic spindle begins to form and increase metabolic rate and cell growth continues.

During the cycle growth occurs throughout the G₁ and G₂ as well as during the S phase.

G₀ Phase:

- Some cells (*i.e. heart cells, muscle cells and nerve cells*) in adult animals do not exhibit division and some cells do not divide only occasionally.
- The cells which do not divide further enter an inactive phase called G₀ or quiescent phase.
- In this stage cells are metabolically active but do not divide unless required.

M phase (mitotic phase):

- This phase represent the phase of the division of nuclear material takes place through separation of daughter chromosomes called karyokinesis.
- In this nuclear division occurs in four main stage – *prophase, metaphase, anaphase and telophase.*

Cytokinesis:

- In this ***cytoplasm of the cell is dividing*** and referred as ***cytoplasmic division or cytokinesis.***
- In the equal distribution of cytoplasm and organelles into each daughter cell.

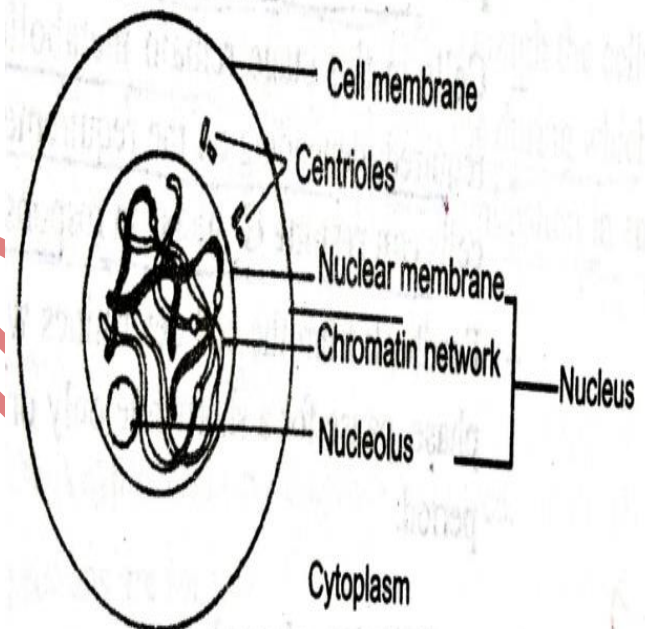
Mitosis

- Cell divide and produce two identical daughter cell which having the same genetic constitution.
- It occur in somatic cell in where the nucleus divide and produce two daughter nuclei that contain identical sets of chromosome.

- Nuclear division followed by cytoplasmic division by equal division of two cytoplasm and results an increase the number of cells.
- Help in growth, replacement and repair of cells.

Interphase

- It comprise with G₁, S and G₂ phase.
- Cell grow in size, nuclear membrane is intact and nucleoli prominent and synthesis ribosomal material.

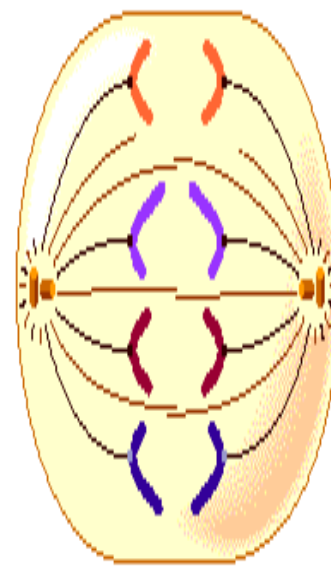
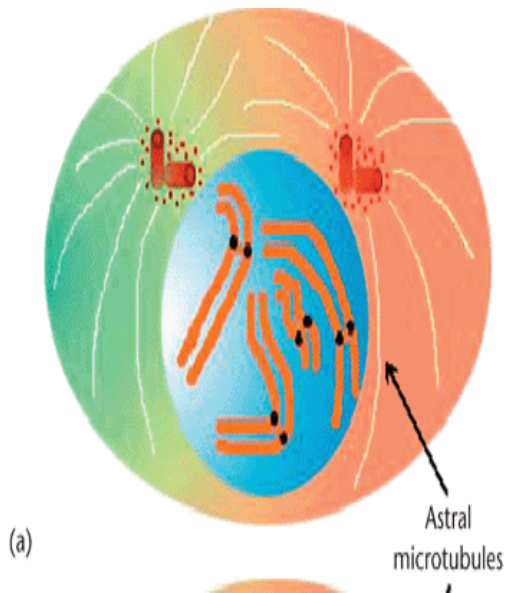


- DNA of chromosome undergoes replication and chromosome are in the form of a pair of chromatids through they appear as chromatin network.
- Centriole begins to divide.

A. Mitosis

1. Prophase-

- **In early prophase** –chromosome appear thin, filamentous and uncoiled.
- **In late prophase-** nuclear membrane and nucleolus are disappear.

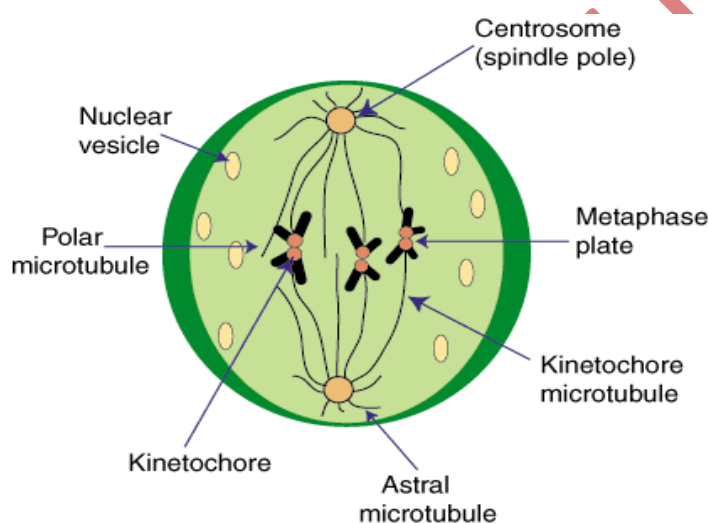


Anaphase

The chromosomes have separated and are moving toward the poles.

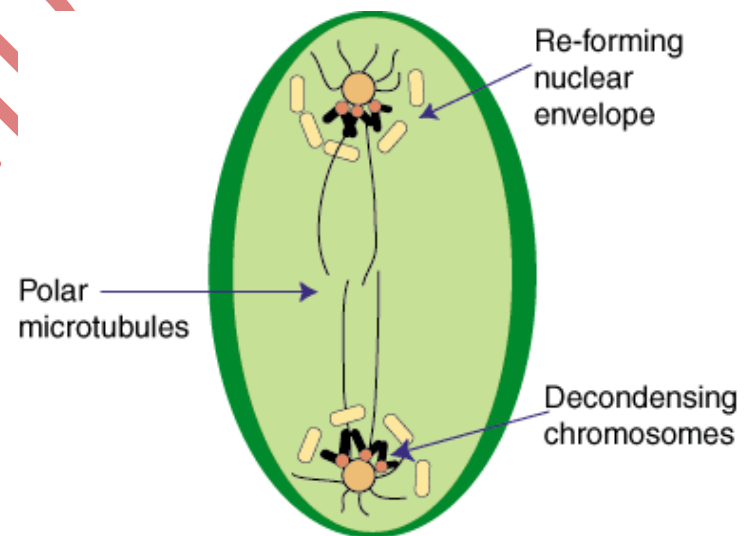
2. Metaphase –

- In metaphase- the spindle tubules start appearing and attached to the chromosome .
- Chromosome being active movement leading arrangement of chromosome at the plate.



4. Telophase –

- Nuclear membrane are reconstructed and nucleolus also reappear in this stage through the process of nucleogenesis .



3. Anaphase -

- In anaphase- chromosome split at centromere and move toward the pole of spindles.
- Mechanism of chromosome movement in anaphase stage due to repulsion between centrosome and contraction of spindle fibers.

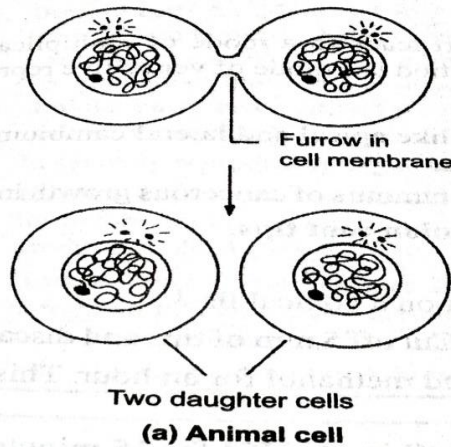
Cytokinesis

- It is a process by which the cytoplasm of the cell is dividing into two equal parts and it differ in animal and plant cell.

In animal cell

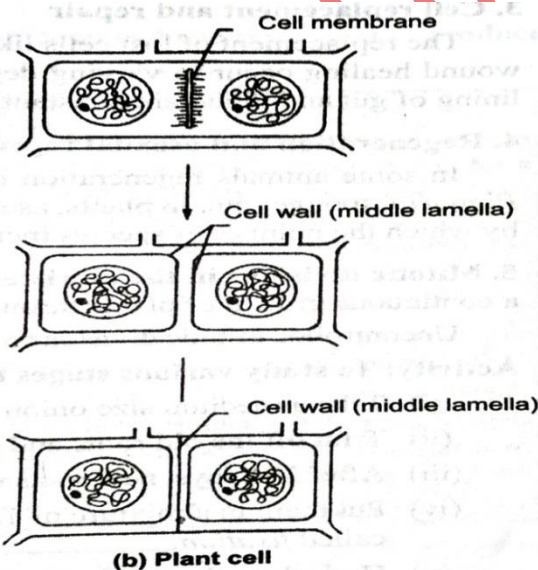
- The membrane begins to constrict and furrow is formed at the equator in telophase which deepens and eventually the cell membrane of

opposite sides meet at the center and results two daughters' cell.



In plant cell:

- Due to rigid cell wall constriction does not allow by cytokinesis and it start by the formation of the cell plate in the middle of the cell during the late anaphase.
- The spindle fiber do not disappear at the equatorial plane and form a cell plate that represent the middle lamella between the wall of two adjacent cells.



Significance of mitosis

- It produces identical gene composition.

- Involve in cell growth, cell replacement and repair.
- Regeneration and asexual reproduction.
- Mitotic division in the meristematic tissue.

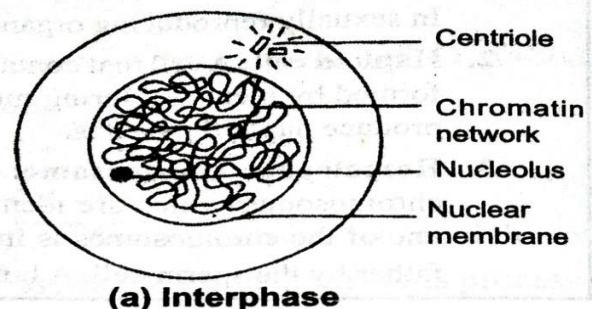
Meiosis

- Meiosis occurs in **male and female reproductive cell** during **gametogenesis** in plants and animals.
- During meiosis **diploid cell** undergo two successive divisions to give rise **four haploid daughter cells** (i.e. gamete).
- The **gamete** contains only **half number** of original chromosome so it is also called reduction division.
- Meiosis involves **single duplications of chromosome** that followed by **two successive divisions** i.e. Meiosis I and Meiosis II.
- **Meiosis I** is initiated **after the parental chromosome has replicated** to produce identical sister chromatids at the S phase of interphase.
- **Homologous chromosome**: in a diploid cell the **chromosome exist in pair** in which **two chromosomes** which are identical in appearance form a homologous pair.

Meiosis I

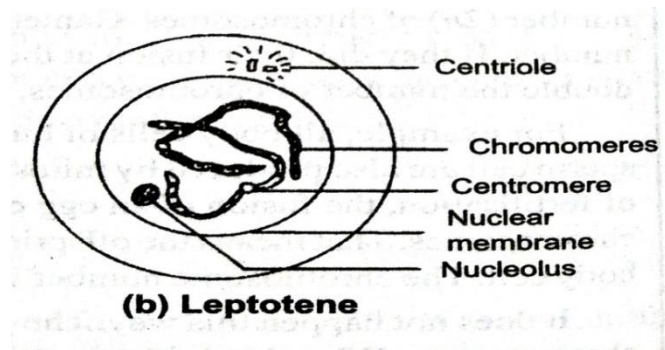
Interphase:

- It is **physiologically most active stage** in which most of DNA replicated and chromosome are in the form of a pair of chromatids.



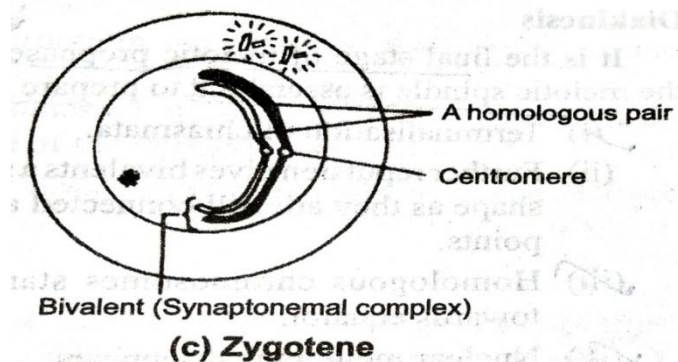
Leptotene:

- Chromosomes **shortened and are visible as single strands** with beaded appearance of chromosomes due to chromomeres.
- Nuclear membrane and nucleoli intact.



Zygotene:

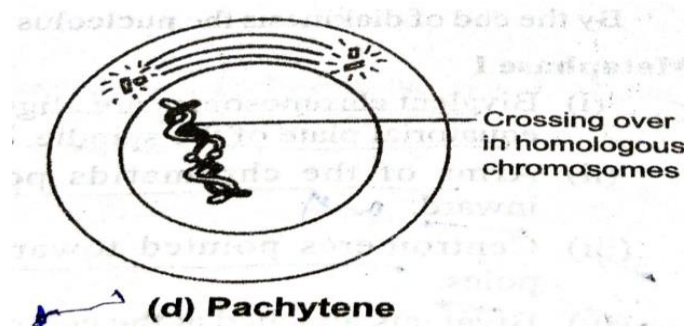
- Homologous chromosome pair up and seen as **bivalent or a tetrad**.
- Pairing process called **synapses** which accompanied by the **formation of synaptonemal complex**.
- Thickening and shortening of chromosomes and nucleoli tend to disappear.



Pachytene:

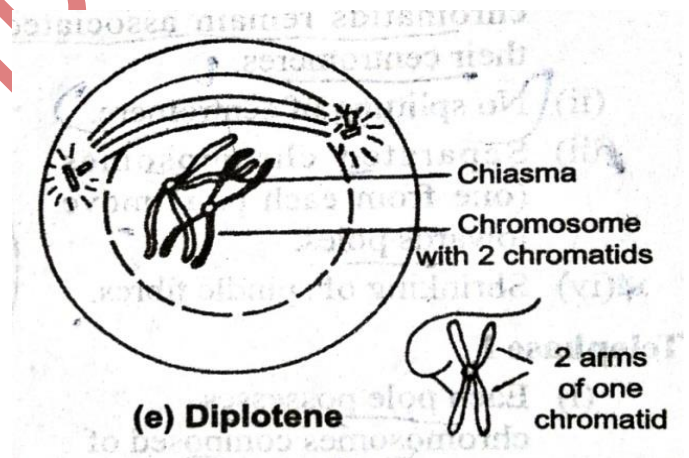
- This stage is characterized by the **appearance of recombination nodule** (i.e. sites at which crossing over occurs between the non-sister chromatids of the homologous pairs).
- Chromosome of a homologous pair (i.e. bivalent chromosome) become **twisted spirally around each other and appears as tetrads**.

- Crossing over results **exchange of genetic material or corresponding chromatid segments between two homologous chromosomes**.



Diplotene:

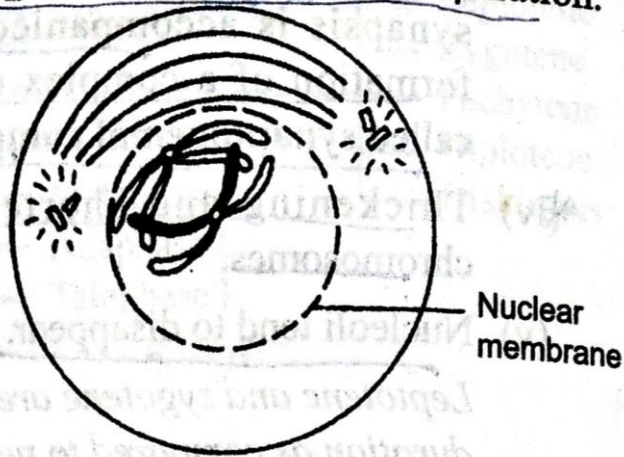
- Recognize by the **dissolution of the synaptonemal complex** and the tendency of the **recombined homologous chromosomes of the bivalents to separate from each other at the site of crossing over**.



Diakinesis :

- It is final stage of meiotic prophase I in which **chromosomes are fully condensed and meiotic spindle is assemble to prepare the homologous chromosomes for separation**
- Terminalization of chiasmata** takes place and homologues chromosome start moving towards equator.
- Nuclear membrane disappear, centriole migrate towards poles spindle fibers start to form.**

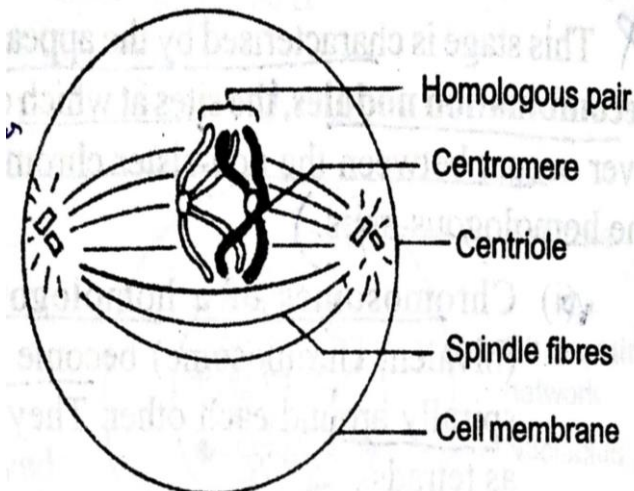
gous chromosomes for separation.



(f) Diakinesis

Metaphase I

- Bivalent chromosomes are *aligned at equator plate of the spindle* in which *arms of chromatids pointed towards inwards and centromere pointed towards the poles.*
- Bivalents attached to the centromeres to the spindle and microtubule from the opposite pole of the spindle attached to the pair of homologous chromosome.



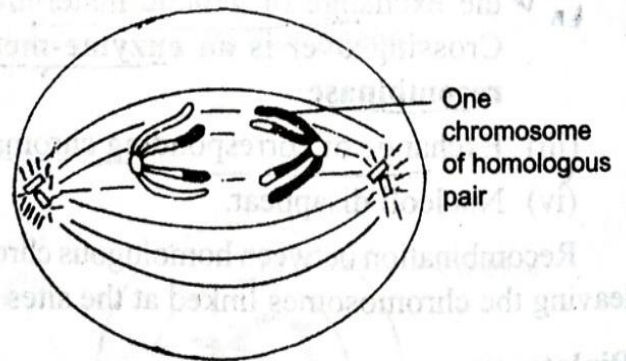
(g) Metaphase I

Anaphase I:

- *Spindle formation pull the whole chromosome* due to that *homologous chromosome separate*

but sister chromatids remain associated at their centromeres.

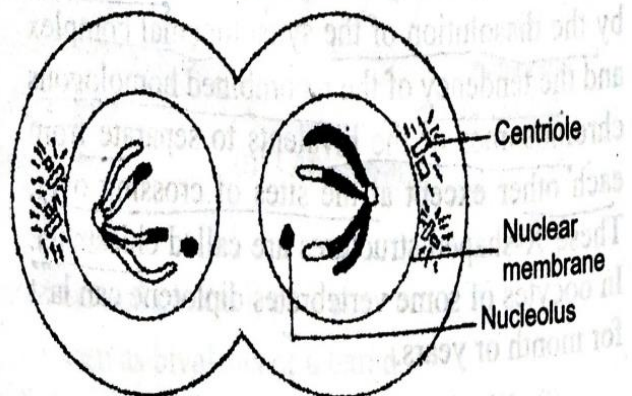
- *Separated chromosome move towards the pole* due to *shrinking of spindle fibers.*



(h) Anaphase I

Telophase I:

- Each pole possesses chromosomes composed of chromatids, spindle fibers usually disappear.
- *Chromatid uncoiled and formed chromatin network and nuclear membrane is formed.*
- *Nucleolus re appear*



(i) Telophase I

Interphase II (Interkinesis):

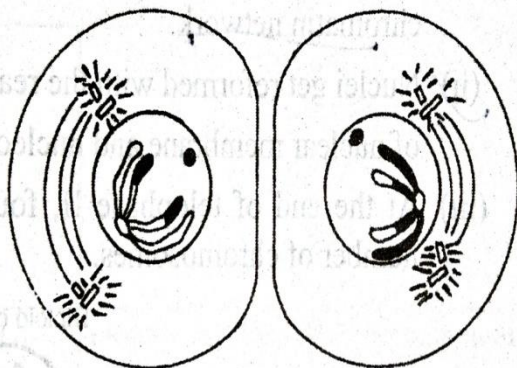
- It is stage of two mitotic division which followed by prophase II –
1. Generally present in animal cells only

- No S phase i.e. no DNA replication.

Meiosis II

Prophase II:

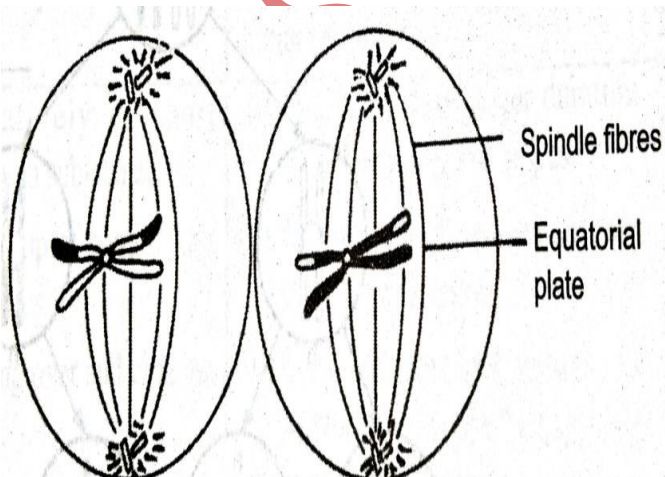
- Nuclear membrane breaks down and nucleoli disappear.
- Chromosome become shorten and thicken and are clearly visible
- Centriole start moving towards opposite poles and spindle fibbers appear.



(j) Prophase II

Metaphase II:

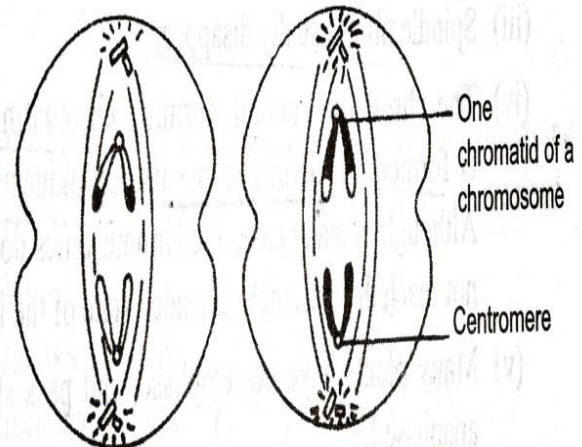
- Centrioles move to opposite poles and **chromosome aligned at the equatorial plate.**
- Nuclear membrane and nucleoli absent.



(k) Metaphase II

Anaphase II:

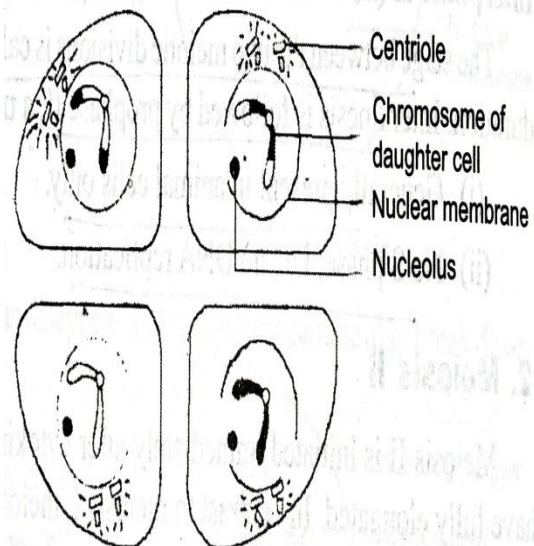
- It starts with simultaneous **splitting of centromere of each chromosome** and allows then to move towards opposite pole of cell.
- Separated chromatids are now called chromosomes.



(l) Anaphase II

Telophase II:

- Chromosome gets **uncoiled and gets elongated and form a chromatin network.**
- Nucleoli get reformed with the reappearance of nuclear membrane and nucleolus.



Cytokinesis:

- It is **division of cytoplasm** called cytokinesis and gives rise to tetrad of cell (i.e. four haploid daughter cells).

Significance of mitosis:

- Restoration of original number of chromosomes.
- Variation due to crossing over
- Appearance of some hidden characters.

The enigma of cancer

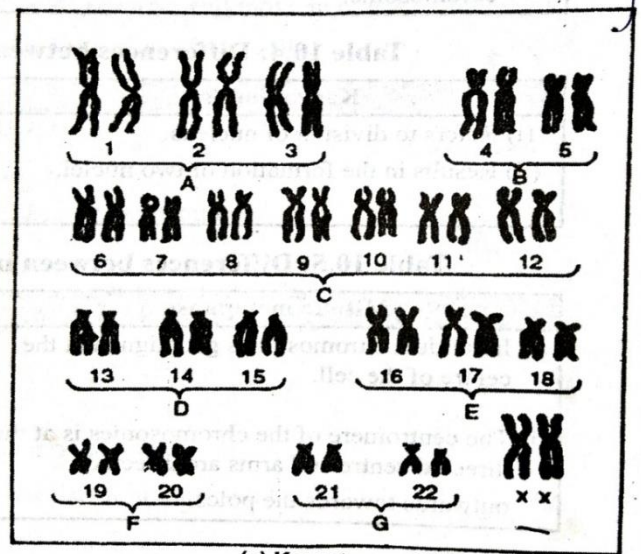
- All cell do not divide at the same rate and regulated from inside (i.e. DNA) or outside the cell (i.e. radiation, toxic substance, various chemical, viruses and change in cell DNA) can bring **uncontrolled cell division in certain tissue or organs** is known as cancer.

OR

Unusual rapid cell division results cancer.

Karyotyping:

- It is the **systematic arrangement of the chromosome according to their size and shape.**



- Karyotyping help to identify any defect or a gross morphological change in any chromosome.
- It also helps to correlate congenital malformations.

