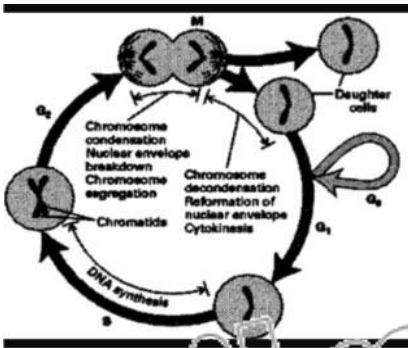

Chapter 21
Cell Cycle

21.0 INTRODUCTION

Definition

Sequence of changes by which cell undergoes growth, replication of DNA and cell division is called cell cycle.

Phases

There are two phases of cell cycle i.e.

1) Interphase (Period of non apparent division)

2) Mitotic phase (Period of division)

21.1 INTERPHASE

Definition

The period of cell cycle between two consecutive divisions is called interphase.

It is misleadingly called resting phase. It is the period of great biochemical activity and further be divided into G_1-phase, S-phase and G_2-phase. Chromosomes are not visible during this stage even with electron microscopy. They can be seen as fine network of threads by histological stains for DNA. This network is called chromatin.

Phases of Interphase

It is subdivided into three phases.

G_1-Phase

It is first growth phase (Gap 1). It starts after cell division, so may be called post-mitotic phase. During this phase, following events occur;

i) There is extensive metabolic activity.

ii) Cell grows in size.

iii) Specific enzymes are synthesized.

iv) DNA base units are accumulated for DNA synthesis.

Post-mitotic cell can exit the cell cycle during G_1 enering a phase called G_0 and remain for days, weeks or in some cases life time of organism without proliferating further (e.g. nerve cells, cells of eye lens).

S-Phase

It is called synthesis phase. Various events occurring during this phase are as follows:

i) DNA is synthesized.

ii) Chromosome number is doubled.

G_2-Phase

It is second growth phase and also called as pre-mitotic phase. It prepares the cell for division. Various events occurring during this phase are as follows

i) Cell prepares energy stores for chromosomes.

ii) Mitosis specific proteins are synthesized.

iii) RNA and microtubule subunits for spindle fibers are also synthesized.

After this phase cell enters into phase of cell division.

Check Points & Duration of Cell Cycle

During cell cycle, there are specific check points, which determine the fate of new phase according to cell's internal make up.

Length of each phase is variable. e.g.

(i) In human cell average time period of:

- Cell cycle is 24 hours
- Mitosis is 30 minutes
- G1 is 9 hours
- S is 10 hours
- G2 is 4.5 hours

(ii) In yeast cells full cell cycle occurs in 90 minutes.

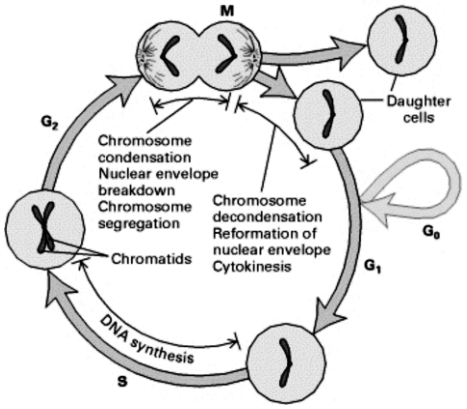

Fig 21.1 The fate of a single parental chromosome throughout the eukaryotic cell cycle

QUESTIONS RELATED TO ABOVE ARTICLE

Describe about the interphase of cell cycle.

21.2 MITOSIS

Definition

Such type of cell division in which number of chromosomes in daughter cells remains same as in parental cell is called mitosis.

Features

i) Major steps of mitosis in plants and animal cells are same with slight differences.

ii) It takes place in haploid as well as diploid cells.

iii) It occurs in nearly all parts of the body if and when required.

Cell division described here explains division in animal cell.

Difference between Mitosis in Plant & Animal Cell

Difference	Animal cell	Plant cell
Centrioles	Present	Absent
Mitotic apparatus	It is made by centrioles, asters and spindles.	It is made only by spindles.
Spindle formation	Spindles are formed from centrioles.	They have region analogous to centriole from which spindles radiate.
Cytokinesis	It occurs by contractile ring.	It occurs by phragmoplast which develops from vesicles of Golgi bodies. It is also responsible for cell wall formation.
Shape of cell	Shape of cell does not remain same.	Shape of cell remains same due to rigid cell wall.

Phases

Mitosis is a continuous process but conventionally it is divided into two phases.

1) Karyokinesis

2) Cytokinesis

21.2.1 Karyokinesis

Definition

Division of nucleus is called karyokinesis.

Initial Events

In an animal cell following initial steps occur:

i) Centrioles, which have been duplicated during interphase and are in same centrosome, are partitioned.

ii) Early in the mitosis the two pairs of centrioles separate and migrate to opposite sides of the nucleus, establishing bipolarity of dividing cells.

iii) Three sets of microtubules (fibers) originating from each pair of centrioles. These microtubules are formed by protein tubulin and traces of RNA. Mitotic apparatus is larger than nucleus and is designed to attach, capture chromosomes, align and finally separating them.

iv) Three sets of microtubules are:

- Astral microtubules, which radiate outward and form asters.
- Kinetochore microtubules will be attached to chromosomes at kinetochore.
- Polar microtubules do not interact the chromosomes but instead interdigitate with polar microtubules from the opposite pole.

Both kinetochore and polar microtubules constitute spindles.

Phases of Karyokinesis

Karyokinesis can further be divided into four phases:

I) Prophase

II) Metaphase

III) Anaphase

IV) Telophase

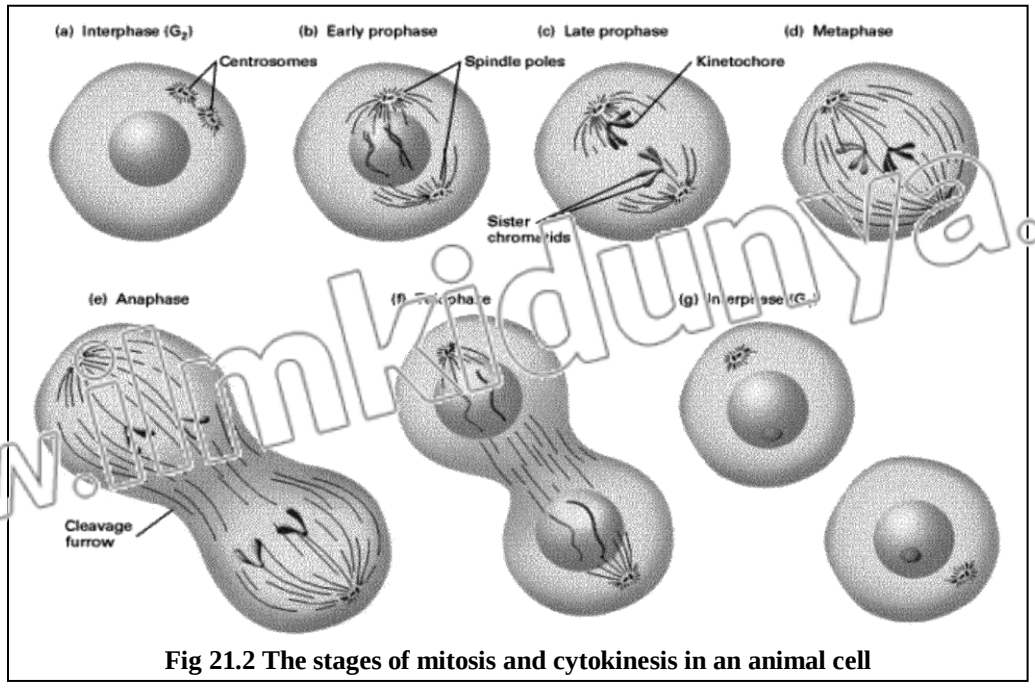

Fig 21.2 The stages of mitosis and cytokinesis in an animal cell

I) Prophase

Various steps occurring during this phase are:

i) Chromatin material gets condensed by folding and chromosomes appear as thin threads (0.25µm-50µm in length) at the beginning of prophase

ii) Chromosomes start thickening, become visible having two sister chromatids attached at centromere.

iii) Nucleoli and nuclear membrane are disappeared.

iv) Nuclear material is released in cytoplasm.

v) Cytoplasm becomes viscous.

vi) Mitotic apparatus is organized.

II) Metaphase

Each metaphase chromosome is a duplicated structure, which consists of two sister chromatids, attached at a point called centromere or primary constriction.

Various steps occurring during this phase are:

i) The kinetochore fibers of spindle attach to the kinetochore region. Kinetochore is a special area of centromere with specific base arrangement and special proteins. Each kinetochore gets two fibers each from opposite poles.

ii) These fibers align chromosomes at the equator of the spindle forming equatorial plate or metaphase plate.

III) Anaphase

It is the most critical phase of mitosis which ensures equal distribution of chromatids in the daughter cells. Various steps occurring during this phase are;

i) The kinetochore fibers of spindle contract towards their respective poles, at the same time polar microtubules elongates exert force and sister chromatids are separated from centromere.

ii) As a result, half sister chromatids travel towards each pole.

IV) Telophase

Various steps occurring during this phase are

i) Chromosomes reach at opposite poles terminate anaphase and start telophase.

ii) These chromosomes decondense due to unfolding and ultimately disappear as chromatin.

iii) Mitotic apparatus is disorganized.

iv) Nuclear membrane and nucleoli are reorganized.

v) At the end two nuclei appear at two poles of cell.

21.2.2 Cytokinesis

Definition

Division of whole cell is called cytokinesis.

Events in Animal Cell

Cytokinesis starts during late telophase. Various events occurring during this phase are as follows;

i) During late telophase astral microtubules send signals to equatorial region of the cell.

ii) Actin and myosin at equatorial region are activated and form contractile ring, followed by cleavage furrow.

iii) This cleavage furrow deepens towards the centre of the cell dividing the parent cell into two daughter cells.

MITOSIS IN PLANT CELLS

Mitotic events in plant cells are generally similar to the events observed in animal cells but there are some major differences.

i) Most higher plants lack visible centrioles, instead they have its analogous region from which the spindle microtubules radiate.

ii) Moreover, shape of the plant cell does not change greatly compared with an animal cell because it is surrounded by rigid cell wall.

iii) At cytokinesis, in place of contractile ring a membrane structure, phragmoplast is formed from vesicle which originate from Golgi complex. These vesicles originate actually during metaphase, line up in the centre of the dividing cell, where they fuse to form ***phragmoplast*** at the end of telophase.

iv) The membrane of vesicle becomes the plasma membrane of daughter cells. These vesicles also contain materials for future cell wall such as precursors of cellulose and pectin.

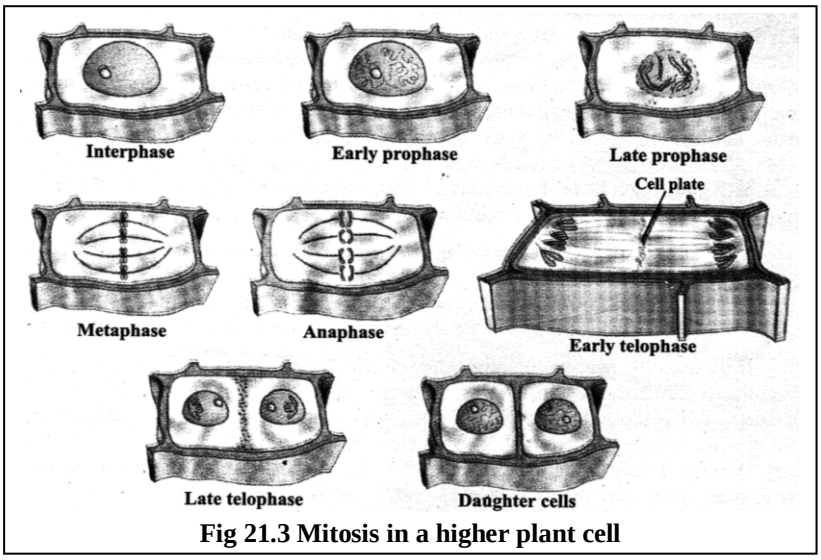

Fig 21.3 Mitosis in a higher plant cell

21.2.3 Importance of Mitosis

Following is the importance of mitosis.

1) Unchanged Genetic Information

In mitosis the hereditary material is equally distributed in the daughter cell. As there is no crossing over or recombination, the genetic information remains unchanged generation after generation, thus continuity of similar information is ensured from parent to daughter cell.

2) Asexual Reproduction

Some organisms, both plants and animals undergo asexual reproduction by mitosis.

3) Regeneration

Regeneration is also due to mitosis.

4) Healing of Wounds

Healing of wounds and replacement of older cells etc. are by mitosis.

5) Development and Growth

Development and growth of multicellular organism depends upon orderly controlled mitosis. For all this an organism requires managed, controlled and properly organized process of mitosis. If mitosis is uncontrolled then malfunction, unwanted tumors and lethal diseases like cancer may result.

6) Tissue Culture and Cloning

Tissue culture and cloning is carried out through mitosis.

QUESTIONS RELATED TO ABOVE ARTICLE

Write an essay on Mitosis.

How cytokinesis occurs in animal cells? In which way does it differ from that in plant cell? (Exercise Question i)

Why and how do the chromosomes get separated during anaphase of mitosis? (Exercise Question ii)

What is role of centriole in an animal cell? How is this function carried out in plant cell? (Exercise Question iii)

21.2.4 Cancer (Uncontrolled Cell Division)

Definition

Uncontrolled division of cells is called cancer.

Relation of Cancer with Normal Mechanism

- Normally multiplication of cells is carefully regulated and responsive to specific needs of body. Due to this control, process of cell death and birth are balanced to produce a steady state.
- In cancer, sometime the control regulates the cell multiplication breaks down and cell begins to grow and divide in unregulated fashion without body's need. This continuous division leads to unwanted clone of cells.

Tumor

Unwanted clone of cells produced by proliferation of cells due to uncontrolled multiplication is called tumor.

Types of Tumors

Tumors are of two basic types.

1) Benign tumors

2) Malignant tumors

1) Benign Tumors

- These are of small size and localized (not transferred to other parts) called benign.
- Benign cells usually behave like normal cells and have little deleterious effects.
- They only interfere with functioning of normal cells or produce hormone like secretions.

2) Malignant Tumors

They are also called cancer.

- They divide more rapidly and mostly invade surrounding tissues.
- They get into body circulatory system and set up areas of proliferation away from their site of original appearance.

The spread of tumor cells and establishment of secondary areas of growth is called metastasis.

Identification of Cancer Cells

Presence of invading cells in normal tissue is an indication of malignancy. Cancer cells can be distinguished from normal cells due to presence of following features;

i) They are less differentiated than normal cells.

ii) They exhibit characteristics of rapidly growing cells.

iii) They have high nucleus to cytoplasm ratio.

iv) They have prominent nucleoli.

v) They show many mitosis.

Causes of Cancer

i) Cancers frequently develop in old persons with age.

ii) Major cause is mutation in somatic cells.

iii) It may be due to accumulation of 3-20 mutations in genes regulating cell division.

Mechanism of Metastasis

Two basic changes are caused by mutations to produce cancer cells and their metastasis. These are following;

i) Metastatic cells break their contact with other cells and overcome the restrictions on cell movement provided by basal lamina and other barriers. After this metastatic cells can invade other parts of the body

ii) Their proliferation becomes unlimited against the normal programming of body without any control or check.

QUESTIONS RELATED TO ABOVE ARTICLE

Write a note on cancer.

21.3 MEIOSIS

Definition

It is a type of cell division by which chromosome number in daughter cells is reduced to half as compared to parent cell.

Features

i) It takes place in diploid cells only.

ii) It takes place in animals during gamete formation and in plants during spore formation.

iii) It results in formation of four haploid daughter cells.

Divisions

Meiosis is divided into two divisions.

1) Meiosis I

2) Meiosis II

1) MEIOSIS I

It is also called reduction division. It is further divided into four phases.

(A) Prophase I (B) Metaphase I

(C) Anaphase I (D) Telophase I

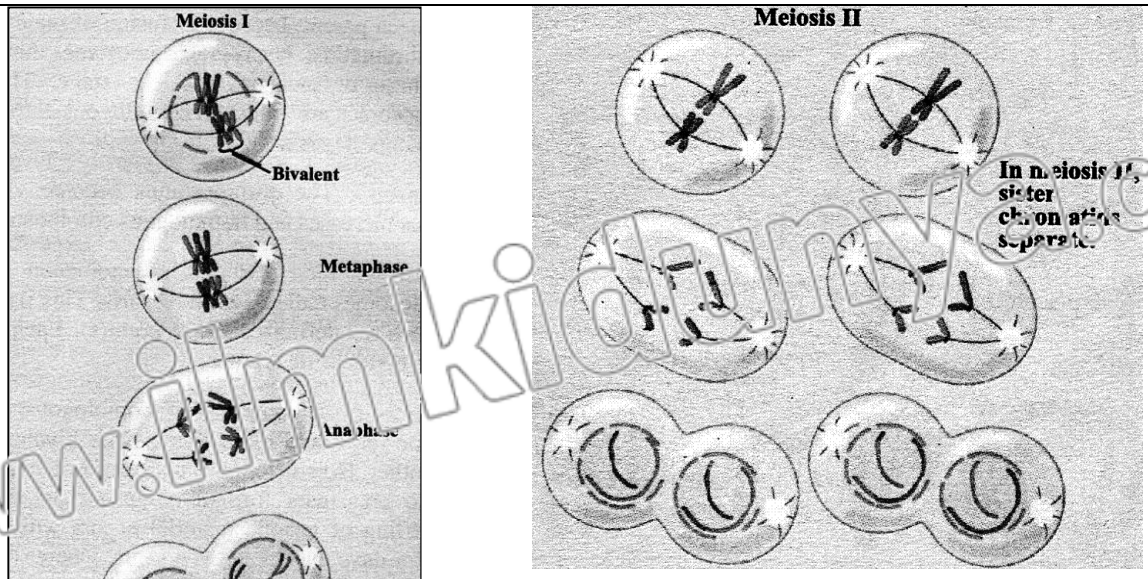

Fig 21.4 Result of meiosis, four haploid cells, each with half as many chromosomes as the original cells

(A) Prophase I

It is very lengthy phase. It is different from prophase of mitosis due to homologous pair of chromosomes.

Interphase of meiosis lacks G_2 stage. So, there is no duplication instead already similar chromosomes called homologous chromosomes join to form homologous pair of chromosomes.

Prophase I is further subdivided into five stages.

a) Leptotene

Various events occurring during this stage are following.

i) Chromosomes become visible, shorten and thick.

ii) Size of nucleus increases.

iii) Homologous chromosomes start getting closer to each other.

Leptotene can last only for few hours.

b) Zygotene

Various events occurring during this stage are following.

i) Pairing of homologous chromosomes called synapsis starts.

ii) Synapsis is highly specific and exactly pointed but there is no definite starting point.

iii) Each paired but not fused complex structure is called as bivalent or tetrad.

Zygotene can last only for few hours.

c) Pachytene

Various events occurring during this stage are following.

i) Pairing of homologous chromosomes is completed.

ii) Chromosomes become more and more thick and each bivalent has for chromatids.

iii) Chromatids wrap around each other.

iv) Non-sister chromatids of homologous chromosomes exchange their segments due to chiasmata formation. This exchange is called crossing over.

v) Due to crossing over, reshuffling of genetic material occurs, which produces recombination.

Pachytene may last for days, weeks or even years.

d) Diplotene

Various events occurring during this stage are following.

i) Paired chromosomes repel each other and begin to separate.

ii) Separation is not complete because homologous chromosomes remain united by their point of interchange (chiasmata).

iii) At the end, each bivalent has at least one such point, and the chromatids otherwise are separated.

e) Diakinesis

Various events occurring during this stage are following.

i) Condensation of chromosomes reaches to its maximum.

ii) Separation of homologous chromosomes is completed but still they are united at one point, more often at ends.

iii) Nucleoli disappear.

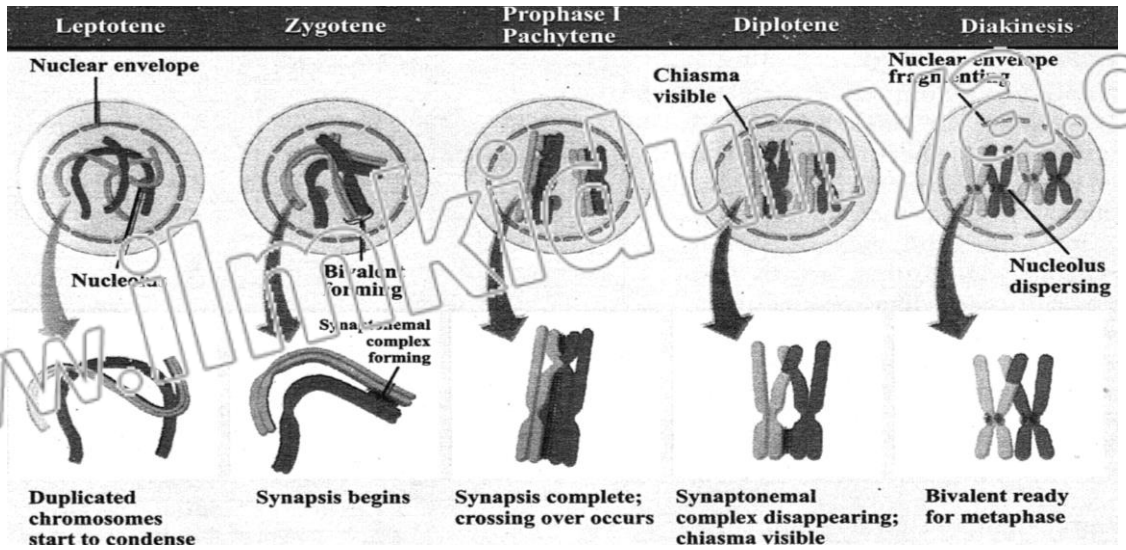

Fig 21.5 Chiasmata formation

(B) Metaphase I

Various events occurring during this phase are as follows.

i) Nuclear membrane disorganizes at the beginning of this phase.

ii) Spindle fibers originate.

iii) Kinetochore fibers are attached to the kinetochore of homologous chromosome from each pole.

iv) Bivalents are arranged at the equator. Sister chromatids of individual chromosome in bivalent behave as a unit.

(C) Anaphase I

Various events occurring during this phase are following.

i) Kinetochore fibers contract and the spindle or pole fibers elongate.

ii) Contraction of fibers pulls the individual chromosome towards their respective poles.

iii) In contrast to mitosis anaphase, sister chromatids are not separated.

This is in actual reduction phase because each pole receives half of the total number of chromosomes.

(D) Telophase I

Various events occurring during this phase are following.

i) Nuclear membrane reorganizes around each set of chromosomes at two poles.

ii) Nucleoli reappear.

iii) Two nuclei each with half number of chromosomes are formed.

Cytoplasm then divides cell into two, terminating first mitotic division. Chromosomes may decondense during this state.

2) MEIOSIS II

After telophase I, two daughter cells experience small interphase but in contrast to mitosis there is no replication of chromosome.

Meiosis II is further divided into

(A) Prophase II

(B) Metaphase II

(C) Anaphase II

(D) Telophase II

These phases are just like the phases of mitosis. Meiosis II receives two daughter cells from meiosis I and ends in production of four daughter cells with half number of chromosomes.

21.3.1 Importance of Meiosis

Crossing over and random assortment of chromosomes are two significant happenings of meiosis. Following is the importance of meiosis.

(i) Greater Recombinations

During crossing over, parental chromosomes exchange segments with each other which results in a large number of recombinations.

(ii) Wide Variety of Gametes

During anaphase, the separation of homologous chromosomes is random which gives very wide range of variety of gametes.

(iii) Evolution and Uniqueness

These variations are not only the bases of evolution, but also make every individual specific, particular and unique in his characteristics. Even the progeny of very same parents, i.e., brothers and sisters are not identical to each other.

(iv) Constancy in Chromosome number

Meiosis usually takes place at the time of sexual cells formation i.e. gamete formation in animals and spores' formation in plants. In this way chromosome number is halved (n number). However, the 2n number is restored after fertilization. Thus, the constant chromosome number is maintained generation after generation.

QUESTIONS RELATED TO ABOVE ARTICLE

What is meiosis? Elaborate the events of prophase-I.

Compare mitosis and meiosis and describe their importance. (Exercise Question v)

Describe meiosis and explain significance. (Exercise Question vii)

21.3.2 Meiotic Errors (Non-Disjunction)

Meiosis is an orderly occurring phenomenon, which ensures every phase with appropriate finish, but sometimes, at any point the result may be unexpected, causing abnormalities. One of such abnormalities is chromosome non-disjunctions, in which chromosomes fail to segregate during anaphase and telophase and do not finish with equal distribution of chromosome among all the daughter nuclei. This result either increase or decrease in the number of chromosomes, causing serious physical, social and mental disorders.

This non-disjunction may occur at

- Autosomes level.
- Sex chromosomes level.

Example

Some examples of each type may discuss below in some detail.

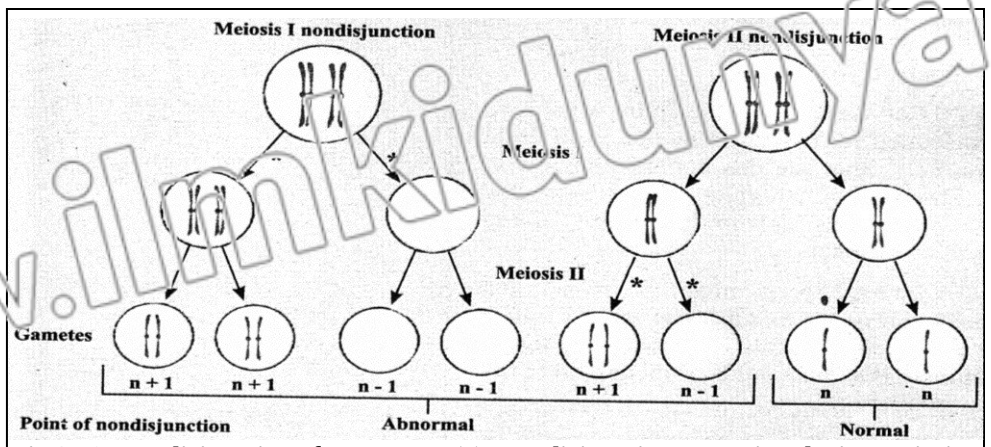

Fig 24.6 Non-disjunction of autosomes (a) Non disjunction occurring during meiosis I and meiosis II, gametes (asterisks mark points of non-disjunction).

Syndrome	Sex	Chromosomes	Frequency of Abortions	Frequency of births
Down	M or F	Trisomy 21	1/40	1/700
Patau	M or F	Trisomy 13	1/33	1/15,000
Edward	M or F	Trisomy 18	1/200	1/6,000
Turner	F	XO	1/18	1/6,000
Metafemale	F	XXX or XXXX	0	1/1,500
Klinefelter	M	XXY or XXXY	0	1/1,500
Jacobs	M	XYY	?	1/1,000

Fig 21.6 (b) Frequency of syndromes

A) Down's Syndrome (Mongolism)

Features

i) It is result of autosomal non-disjunctions in man during which 21st pair of chromosomes fail to segregate.

ii) Resulting in gametes with 24 chromosomes

iii) Individual resulting from fusion of this gamete with normal gamete has 47 (2n+1) instead of normal 46 chromosomes.

iv) Non-disjunction usually occurs in formation of ova.

Autosomal non-disjunction may occur in other than 21st chromosome, which usually results in abortion or death in very early age.

Frequency

It is related with age of mother.

- Frequency by teenage mother having down's syndrome child is one in many thousands.
- Frequency by forty-year-old mother is one in hundred chances.
- Frequency by forty five year old mother is three times greater than forty.

Abnormalities

The affected individuals have flat, broad face, squint eyes with skin folded in the inner corner, protruding tongue, mental retardation and defective development of central nervous system.

B) Turner's Syndrome

Features

i) These affected individuals have one missing X chromosome with only 45 chromosomes (44 autosomes + X).

ii) They have 45 chromosomes (2n-1) instead normal 46.

iii) There are 44 autosomes with one X chromosome.

Abnormalities

Individuals with this condition often do not survive pregnancy and are aborted. Those who survive have female appearance with short stature, webbed neck, without ovaries and complete absence of germ cells.

C) Klinefelter's Syndrome

Features

i) These individuals have additional sex chromosomes i.e. 47 chromosomes.

ii) Extra chromosomes may be X or Y.

iii) Individuals with 47 chromosomes (44 Autosomes + XXY) are phenotypically male but have enlarged breasts, tendency to tallness, obesity, small testes with no sperm ejaculation and under development of secondary sex characters.

iv) Male with 47 chromosomes i.e. 44 autosomes and XYY are also observed.

v) Male with 48 chromosomes have 44 autosomes with XXXY chromosomes.

vi) Male with 49 chromosomes have 44 autosomes with XXXXY chromosomes.

QUESTIONS RELATED TO ABOVE ARTICLE

Write note on Klinefelter 's syndrome.

Write note on Turner 's syndrome.

Define non-disjunction and discuss its effects with one example

(Exercise Question)

21.4 NECROSIS AND APOPTOSIS

All the activities of cells i.e. cell division, pattern formation, differentiation, morphogenesis and motility are controlled and depend upon extracellular and intracellular signals.

Death of a cell is also programmed and predestined.

Cell Death in Multicellular Organisms

Cell death in multicellular organisms is controlled by two fundamentally different ways;

1) Cell commits suicide in absence of survival signals (Trophic factors)

2) Murder of cells by killing signals from other cells (necrosis)

1) Apoptosis

It is Greek word meaning dropping off or falling off.

It can be defined as follows

"Internal program of events and sequence of morphological changes by which cell commits suicide is collectively called as apoptosis."

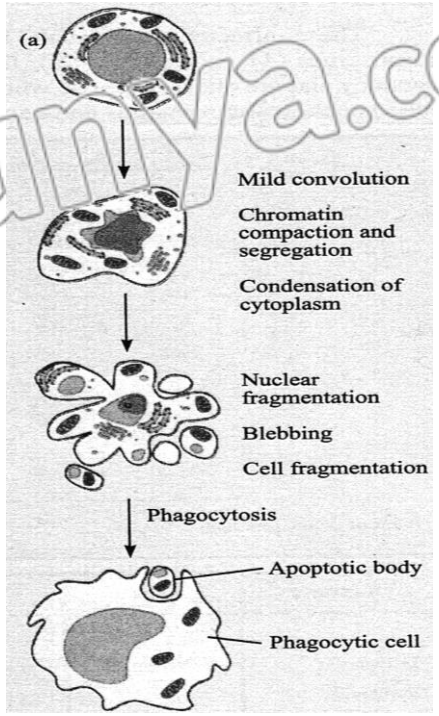

Fig. 21.7 Ultrastructural features of cell death by apoptosis

Changes in Cell during Apoptosis

Various events occurring during apoptosis are described below

i) Cell shrinks.

ii) Chromatin material first becomes compact and then segregates.

iii) Cytoplasm is condensed.

iv) Nuclear fragmentation occurs.

v) Blebbing of cell membrane occurs with its loss later on.

vi) Ultimately cell fragmentation occurs, and membrane bounded apoptotic bodies are released and phagocytosed by other cells.

vii) Intracellular constituents are not released freely in extracellular atmosphere which otherwise might have deleterious effects.

Importance

i) Programmed cell dearth helps in proper control of multicellular development.

ii) It may lead to deletion of entire structure e.g. tail of developing human embryo or part of structure e.g. tissue between developing digits.

iii) Cell death even controls the number of neurons because most of neurons in the human body die during development.

2) Necrosis

Cell death due to tissue damage is called necrosis.

Changes in Cell During Necrosis

i) Typical cell swells and bursts.

ii) Intracellular contents are released in extracellular environment.

iii) These contents damage neighbouring cells and cause inflammation.

QUESTIONS RELATED TO ABOVE ARTICLE

Write about necrosis and apoptosis.

In what respect cell death is regarded beneficial? (Exercise Question iv)

KEY POINTS

Genetic recombination

The reshuffling of genetic material (DNA) and formation of new combination is called genetic recombination.

Equatorial plate

The chromosomes in metaphase are arranged in the middle of spindle fibers in such a way that they form equatorial plates.

Random assortment of chromosomes

The phenomenon in which homologous chromosome has a chance to form combination with any other non – homologous chromosome. Humans have 46 chromosome, except its non-homologous chromosome.

Edward's Syndrome

Genetic disorder caused by the presence of all or part of an extra 18^{th} chromosome. The majority of people with the syndrome die during the fetal stage; in fact who survive experience serious defects and commonly live for short time period.

Jacob's Syndrome

Genetic condition in which a male has an extra Y-chromosome. Symptoms include being taller than average, acne and an increased risk of learning problems.

Patau Syndrome

In this syndrome all cells of the body contain extra genetic material from chromosome-13. This disrupts normal development causing multiple and complex organ defects.

Synaptonemal Complex

A protein structure that forms between homologous chromosomes during meiosis. It mediates chromosome pairing, synapsis and recombination.

EXERCISE

Q 1 Fill in the blanks.

i) Mongolism is also known as _____.

ii) During _____ homologous chromosomes get close to each other

iii) _____ Phase precedes G_2 phase.

iv) Polar microtubules _____ during anaphase.

v) Mitotic apparatus is formed during _____ of cell division.

vi) The chromosome number (44 + 1) denotes _____ syndrome.

vii) Intracellular contents are released during the type of cell death called _____.

Ans i) Down's syndrome
ii) Leptotene
iii) S
iv) Elongate
v) Prophase
vi) Turner's syndrome vii) Necrosis

Q 2 Encircle the correct answer from the multiple choices.

i) In Klinefelter's syndrome:
(a) One X chromosome is missing
(b) Additional sex chromosome present
(c) Sex chromosome fail to segregate
(d) None of these

ii) Mitosis is divided into:
(a) Karyokinesis (b) Cytokinesis
(c) Interphase (d) Both a and b

iii) Separation of homologous chromosomes occur during:
(a) Prophase (b) Metaphase
(c) Telophase (d) Anaphase

i	b
ii	d
iii	d

Q 3 Write whether the statement is true or false and write the correct statement if false.

i) Meiosis occurs in haploid cells only. **(False)**
Meiosis occurs in diploid cells only.

ii) Cell cycle is comprised of two phases i.e. karyokinesis and cytokinesis. **(False)**
Cell cycle is comprised of two phases i.e. interphase and cell division.

iii) A point where non-sister chromatids cross each other is called kinetochore. **(False)**
A point where non-sister chromatids cross each other is called chiasma.

iv) G_0 stands for no gap. **(True)**

v) Full life cycle of yeast cells requires 90 seconds to be completed. **(False)**
Full cell cycle of yeast cells requires 90 minutes to be completed.

vi) Crossing over takes place during metaphase I. **(False)**
Crossing over takes place during prophase I.

vii) Autosomal non-disjunction may occur in other than 21st chromosome. **(True)**

viii) Benign tumors are always non-localized. **(False)**
Benign tumors are always localized.

ix) Cancer is caused mainly by mutations in germ cells. **(False)**
Cancer is caused mainly by mutations in somatic cells.

x) Genetic information remains unchanged during mitosis. **(True)**

xi) Homologous chromosomes are necessarily identical. **(True)**

xii) The cells are kept alive due to trophic factors. **(True)**

xiii) Cytokinesis involves the division of cytochromes. **(False)**
Cytokinesis involves the division of whole cell.

xiv) Phragmoplast is a type of fragmentation **(True)**

Q 4 Short Questions.

i) Differentiate between "Necrosis" and "Apoptosis".

Ans:

Necrosis	Apoptosis
Cell death due to tissue damage.	It is programmed cell death.
Also known as murder of the cell	It is called as suicide of the cells.
Cell bursts after swelling	Cell shrinks, cytoplasm condenses
Intracellular contents are released outside.	Intracellular contents are not released instead apoptotic bodies are formed.
May causes inflammation.	Does not cause inflammation.
Harmful for tissues.	It is beneficial, as some unwanted cells during development or metamorphosis are removed.

ii) What are the functions of mitotic apparatus?

Ans: It is designed to attach and capture chromosomes, align them and finally separating them so that equal distribution of chromosomes is ensured.

iii) How can you identify the cancer cells?

Ans: Cancer cells can be indicated by;

- Higher nucleus to cytoplasm ratio
- Prominent nuclei
- Many mitosis
- Less differentiated than normal cells
- Rapidly growing cells

iv) Give importance and significance of meiosis.

Ans:

- Crossing over results in a large number of recombination.
- It results in wide range of variety of gametes.
- These variations provide raw material for evolution.
- Constancy in chromosome number.

v) Define chromosomal non-disjunction.

Ans: Inability of chromosomes to segregate during anaphase and telophase is called non-disjunction and do not finish equal distribution of chromosomes among all the daughter nuclei.

vi) What are symptoms of Turner's syndrome?

Ans: These affected individuals have one missing X chromosome with only 45 chromosomes (44 autosomes + X).

Individuals with condition often do not survive pregnancy and are aborted.

Those who survive have female appearance with;

- Short stature,
- Webbed neck,
- Without ovaries
- And complete absence of germ cells.

vii) Define cell cycle. Highlight its importance and significance

Ans: Sequence of changes, which involve period of growth, replication of DNA, followed by cell division is called cell cycle. At each stage of cell cycle, there are specific check points, which determine the fate of new phase according to cell's internal make up.

viii) Is interphase resting phase? Why?

Ans: No, interphase is the period of life cycle of cell between two consecutive divisions is termed as the interphase or misleadingly called resting phase. It is the period of great biochemical activity and can further be divided into G_1-phase, S-phase and G_2-phase

ix) In what respect mitosis in plant cells differ from that of in animal cells?

Ans:

Animal Mitosis	Plant Mitosis
Spindle fibers originate from centrioles.	As centrioles are absent so spindle fibers originate from analogous region of centriole.
Mitotic apparatus is formed.	Only spindle is present.
During cytokinesis cell shape is changed.	Cell shape does not change during cytokinesis.
Cytokinesis occurs by means of contractile ring.	Cytokinesis occurs by means of phragmoplast.
Centrioles are present	Centrioles are absent

Q 5 Extensive Questions.

i) How cytokinesis occurs in animal cells? In which way does it differ from that in plant cell?

Ans (see article 21.2)

ii) Why and how do the chromosomes get separated during anaphase of mitosis?

Ans (see article 21.2)

iii) What is role of centriole in an animal cell? How this function is carried out in plant cell?

Ans (see article 21.2)

iv) In what respect can cell death be regarded beneficial?

Ans (see article 21.4)

v) Compare mitosis and meiosis and describe their importance.

Ans (see article 21.2 & 21.2.3 & 21.3.1)

vi) Define non-disjunction and discuss its effect.

Ans (see article 21.3.2)

vii) Describe meiosis and explain significance.

Ans (see article 21.3)