CHAPTER 6.1 – CELL DIVISION

Cell division

Cell division involves two stages,

I Karyokinesis (involves the division of nucleus)

II Cytokinesis (involves the division of the cytoplasm)

The organism's body cells are divided into

1) Somatic cells
2) Reproductive cells or gametes

SOMATIC CELLS

- ❑ Body cells apart from gametes
- ❑ Somatic cells are produced through the mitosis process
- ❑ It contains a diploid number of chromosomes which means each cell contains two sets of chromosomes or 2n
- ❑ In human somatic cells, 2n = 46

GAMETE

- ◊ Gametes are reproductive cells
- ◊ Gametes are produced through the meiosis process
- ◊ It contains a haploid number of chromosomes which means each cell contains one set of chromosomes or n
- ◊ In human gametes, n = 23

DIPLOID CELLS

- » One set of chromosomes originate from the male parent (paternal chromosomes) and female parent (maternal chromosomes)
- » Both paternal and maternal chromosomes have the same structural characteristics and are called homologous chromosomes
- » Chromatin is a chromosome that looks like a long thread

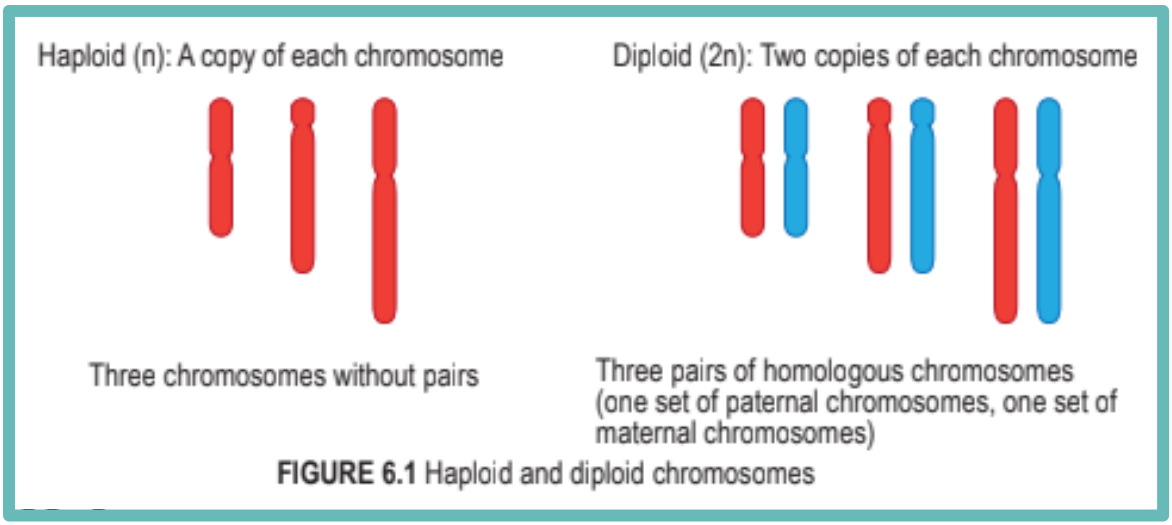


FIGURE 6.1 Haploid and diploid chromosomes

CHAPTER 6.2 – CELL CYCLE AND MITOSIS

Cell cycle

→ Cell cycle refers to the sequence of events that involves DNA multiplication and cell division to produce two daughter cells

→ Consists of interphase and M phase

→ Interphase is the longest phase in the cell cycle and is made up of the G_1, S and G_2 phase

G_1 PHASE

- Cells grow
- Cell components that are produced at this stage are
  - I Mitochondrion
  - II Endoplasmic reticulum
- Proteins used in the cell cycle are also synthesised during this time
- At this stage, the nucleus looks big and the chromosome is in the form of chromatin

S PHASE

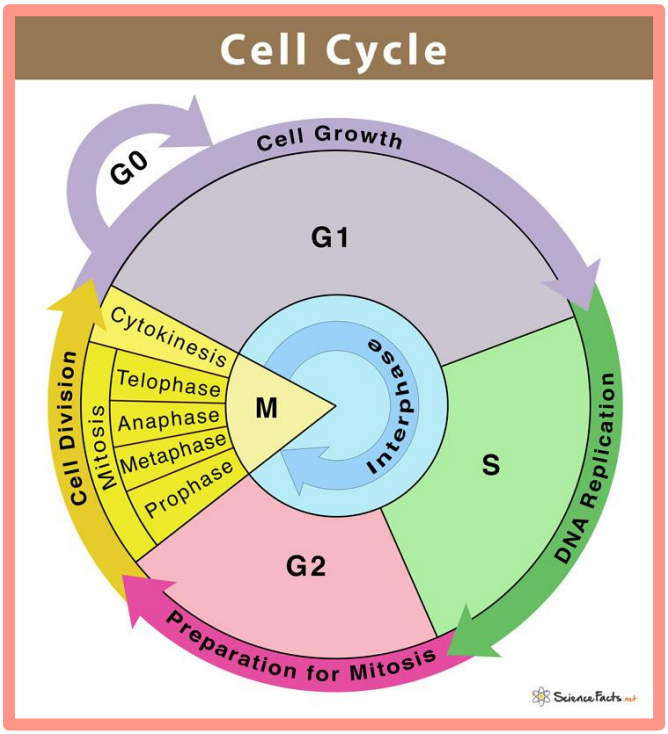
- DNA synthesis is occurring
- The DNA in the nucleus is replicated
- Each chromosome multiplies into two identical chromosomes known as sister chromatids
- Both chromatids contain the same copy of the DNA molecule and are joined at the centromeres

G_2 PHASE

- The cells will continue to grow and remain active metabolically
- Cells gather energy and make final arrangements to enter the next stage of cell division
- The cells will enter the M phase after the interphase stage

M PHASE

- M phase is made up of
  1. Mitosis
  2. Cytokinesis
- Mitosis involves
  A) Prophase
  B) Metaphase
  C) Anaphase
  D) Telophase

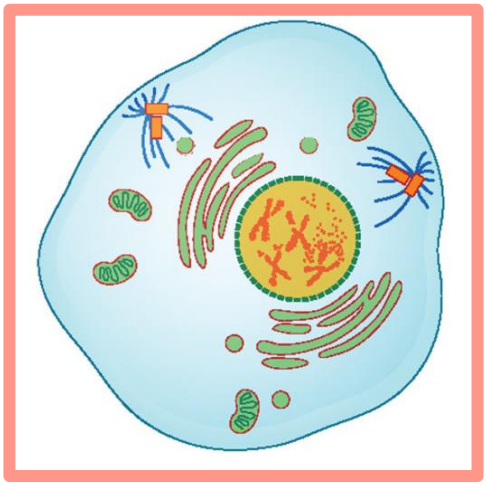


Mitosis

- Mitosis is defined as the division of the nucleus of parent cell into two nuclei
- Each nucleus contains the same number of chromosomes and genetic content with the nucleus of parent cell
- Consists of
  i. Prophase
  ii. Metaphase
  iii. Anaphase
  iv. Telophase

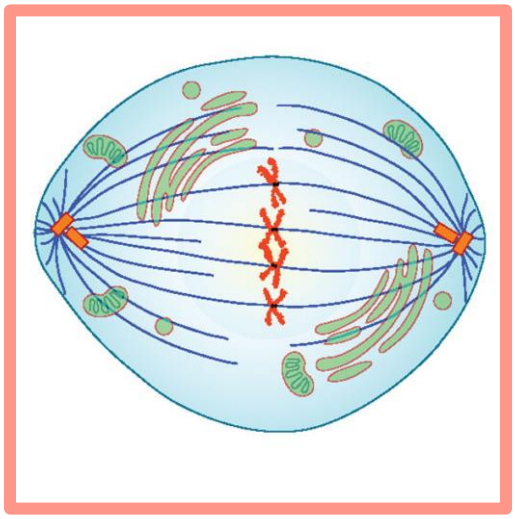
PROPHASE

- In the nucleus, chromatin start to shorten and thicken to form a chromosome that can be visible through a light microscope
- The chromosome is made up of two identical threads called sister chromatids
- Both sister chromatids are joined at the centromere
- The nucleus membrane disintegrates
- The nucleolus disappears
- The centriole moves to the opposite poles and spindle fibres start to form



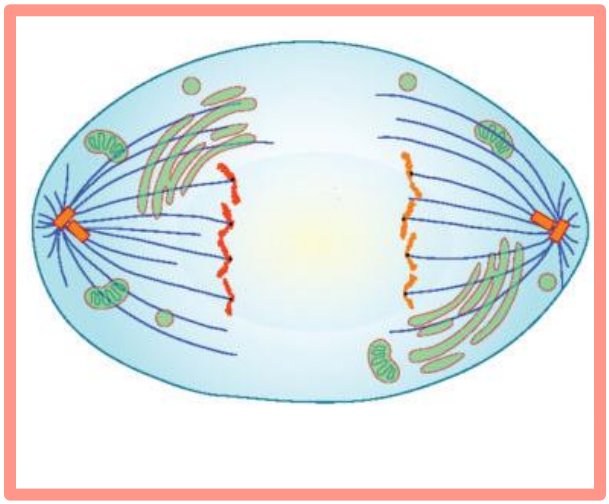
METAPHASE

- Centrioles are the opposite poles of the cell
- The spindle fibres maintain the chromosomes at the equatorial plane
- The chromosomes become aligned in a single row on the equatorial plane
- Metaphase ends when the centromere begins to divide



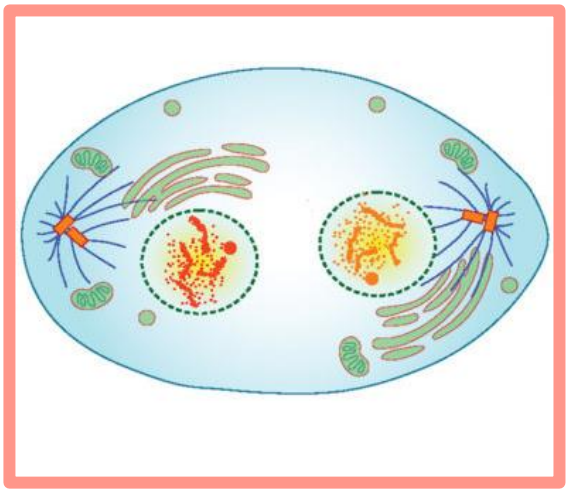
ANAPHASE

- The centromere divides into two and the sister chromatids separate
- Spindle fibres shorten, contract and the sister chromatids are pulled to the opposite poles of the cell
- Anaphase ends when the chromatid arrives at the pole of the cell



TELOPHASE

→ When the chromatids are at the opposite poles, they are now called the daughter chromosome
→ Each pole contains one set of complete and identical chromosomes
→ Chromosomes are re-formed as fine chromatin threads
→ Nucleoli are formed again
→ Spindle fibres disappear
→ A new nucleus membrane is formed
→ The telophase stage is followed by cytokinesis



The differences between mitosis and cytokinesis in animal cells and plant cells

- Cytokinesis is the division of cytoplasm that happens immediately after that nucleus is formed which is a the end of telophase

CYTOKINESIS IN ANIMAL CELLS

» Cytokinesis occurs in animal cells when the plasma membrane constricts in the middle of the cell between the two nuclei
» Microfilaments at the point of constriction will contract, causing the cell to constrict until it splits to form two daughter cells

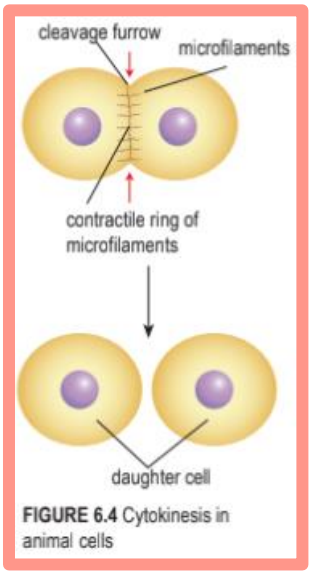


FIGURE 6.4 Cytokinesis in animal cells

CYTOKINESIS IN PLANT CELLS

↘ Plant cells does not contain centrioles
↘ However, plant cells can still form spindle fibres during mitosis
↘ Cytokinesis begins where the formed vesicles combine to form cell plates at the centre of the cell
↘ The cell plates are surrounded by a new plasma membrane and a new cell wall substance is formed among the spaces of the cell plates
↘ The cell plates expand outwards until they combine with the plasma membranes
↘ At the end of cytokinesis, cellulose fibres are produced by the cells to strengthen the new cell walls

- Two daughter cells are formed which has a diploid condition each

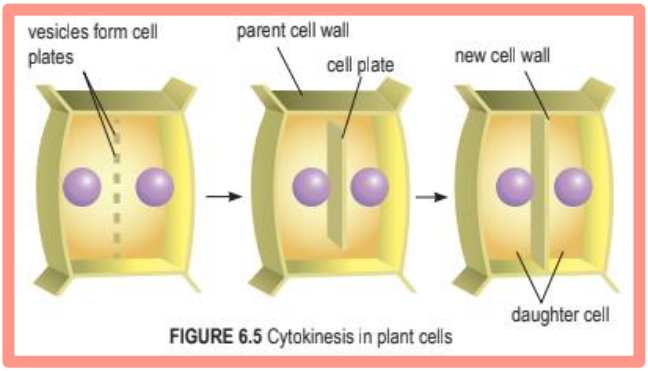


FIGURE 6.5 Cytokinesis in plant cells

The necessity of mitosis

- For embryo development and organism growth, mitosis ensures that rapid cell growth occurs
- When the body is injured, mitosis will produce new cells to replace cells that are dead or damaged
- Through the mitosis process, the lizard is able to grow a new tail (regeneration) if the tail breaks
- Mitosis aids organism (e.g., hydra) to produce new individuals through the formation of new buds
- The culturing technique uses stem cells from animals which are then cultured in laboratories to produce meat
- Stem cell therapy uses stem cells from bone marrows to treat damaged cartilage
- In agriculture, the technique of culturing plant tissues is used to produce young plants through the culturing of parent cells without going through the fertilization process

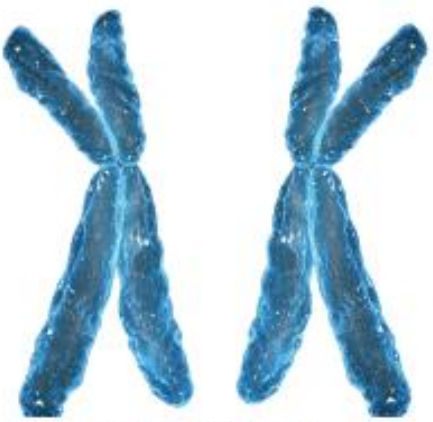
CHAPTER 6.3 – MEIOSIS

Meiosis

- Meiosis is the process of cell division that occurs in reproductive organs to produce gametes that contain half the number of chromosomes (haploid) of the parent cells (diploid)
- Meiosis occurs in
  - I Testis (male)
  - II Ovary (female)

The need for meiosis

- Meiosis forms gametes through the process of gametogenesis
- Meiosis ensures that the diploid chromosome number of organisms that carry out sex reproduction is always maintained from one generation to the next
- Meiosis also produces genetic variation in the same species
- Meiosis is divided into two stages of cell division
  1. Meiosis I comprises of
     a. Prophase I
     b. Metaphase I
     c. Anaphase I
     d. Telophase I
  2. Meiosis II comprises of
     a. Prophase II
     b. Metaphase II
     c. Anaphase II
     d. Telophase II



PHOTOGRAPH 6.4
Homologous chromosome

PROPHASE I

→ Chromatin shortens, thickens and forms visible chromosomes
→ The pairing of homologous chromosomes (synapsis) forms bivalent (aka a tetrad, that is four chromatids for each homologous chromosomes)
→ The crossing over process is an exchange of genetic material between non-identical chromatids takes place
→ Crossing over produces a combination of genes that are new in chromosomes
→ The point where the chromatids cross over is called chiasma
→ At the end, the nucleus membrane and nucleoli will start to disappear
→ Both centrioles will move towards the opposite of pole cells
→ Spindle fibres are formed among the centrioles

*aka → also known as

METAPHASE I

- The homologous chromosomes are arranged at the equatorial plane
- One chromosome from each pair of the homologous chromosome is tied to the spindle fibres from one pole cell and its homologous is tied to the spindle fibres from the opposite pole cell
- The sister chromatids are still tied together because the centromere has not separated

ANAPHASE I

- The spindle fibres contract and cause each homologous chromosome to separate form its homologous pair and be pulled to the opposite poles
- Each chromosome is still made up of a pair of sister chromatids tied to a centromere and move as one unit

TELOPHASE I

- The chromosomes arrive at the opposite pole cells
- Each polar cells contains a number of haploid chromosomes that are made up of one set of chromosomes only
- The spindle fibres will then disappear
- Nucleoli will reappear and the nuclear membrane is formed
- Telophase I is succeeded by the cytokinesis process that produces two daughter cells
- Both daughter cells produced are in the haploid condition
- The interphase for meiosis I is usually short and the DNA does not replicate

PROPHASE II

- The nucleoli and the nuclear membrane disappear
- Each chromosome is made up of sister chromatids that are joined at the centromere
- The spindle fibres start to form in both daughter cells

METAPHASE II

- Chromosomes are arranged at random on the equatorial plane for each daughter cell
- Each chromatid is tied to the spindle fibres at the centromere
- Metaphase II ends when the centromere separates

ANAPHASE II

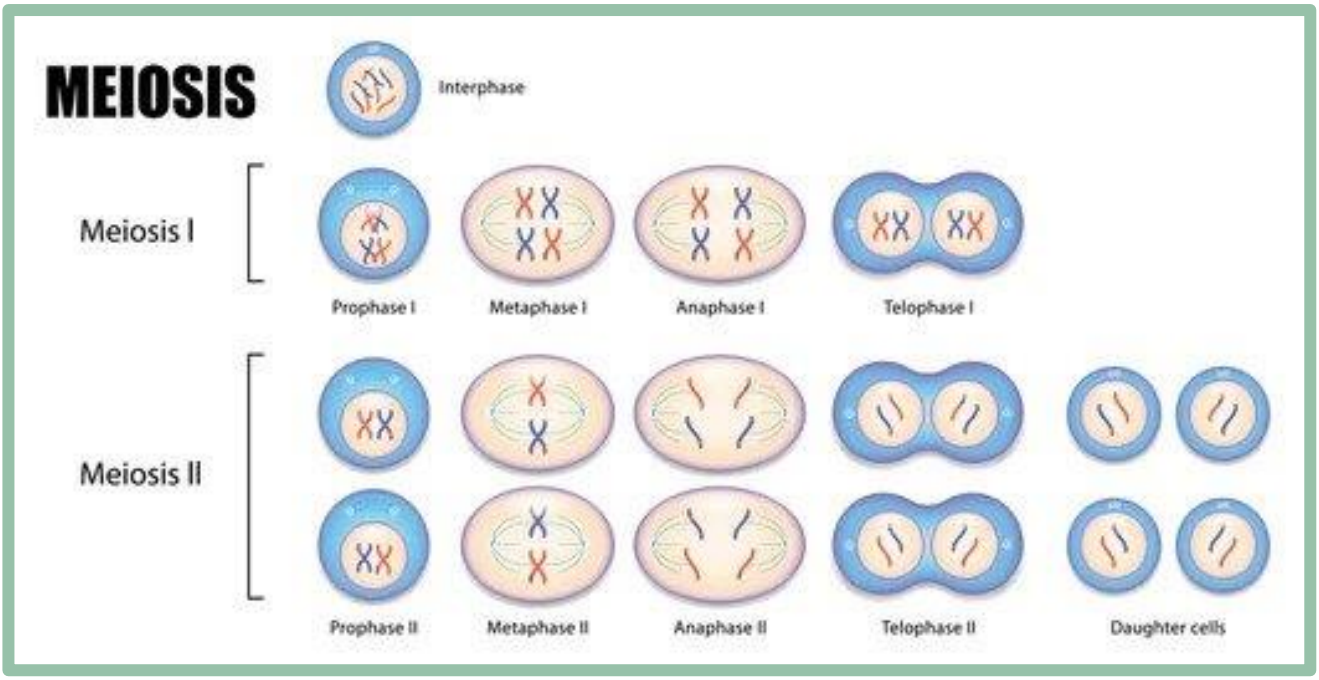
- The sister chromatid centromere starts to separate
- The sister chromatid pair separates and moves towards the opposite poles led by the centromere
- Each chromatid at this stage is ka a chromosome

TELOPHASE II

- Chromosomes arrive at the pole of the cell
- Spindle fibres disappear
- The nucleus membrane and the nucleoli are reconstructed
- The number of chromosome for each daughter cell is half the number of parent chromosomes
- Telophase II ends with the process of cytokinesis that produces four daughter cells that are haploid

*ka → known as

- Each haploid cell contains half the number of parent cell chromosomes
- The genetic content is also different from the diploid parent cell
- The haploid cells develop into gametes



Comparison and contrast between meiosis and mitosis

SIMILARITIES

SIMILARITIES
▪ Mitosis and meiosis must duplicate its DNA before going through the division process ▪ Mitosis and meiosis pull it apart into two sets, each of it move to opposite pole of cell and then divide down the middle of the cell ▪ Mitosis and meiosis produce fresh new cells based on their parent cells' genes

DIFFERENCES

MITOSIS	MEIOSIS
• Produces two new daughter cells	○ Produces four new daughter cells
• Going through one division process	○ Going through two division process
• Consists the same number of chromosomes (diploid number, 2n)	○ Consists half the number of chromosomes (haploid number, n)
• Occurs to all parts of body	○ Occurs in reproductive organs (testis, ovary)
• Produces somatic cells	○ Produces reproductive cells (gametes)

CHAPTER 6.4 – ISSUES OF CELL DIVISION ON HUMAN HEALTH

Issues of cell division on human health in mitosis

FORMATION OF TUMOURS

» Uncontrolled cell division can lead to the formation of tumours
» Tumour is divided into two types
  I. Benign tumour
  II. Malignant tumour

BENIGN TUMOUR

- Benign tumour is not dangerous
- Can be removed surgically

MALIGNANT TUMOUR

◊ Also called cancer
◊ Cancer is caused by several factors
  A) Radiation (x-ray, gamma rays, ultraviolet rays)
  B) Chemical substances (tar in tobacco)
  C) Carcinogens (formaldehyde, benzene)
  D) Genetic factors
  E) Bacteria or viruses
◊ These factors will cause the cells to divide continuously and develop into a tumour
◊ The cancer cells will spread and destroy normal cells around them
◊ This condition will affect the functions of the tissues around them
◊ Cancer that is not identified at the early stage can cause damage to the organs and finally death

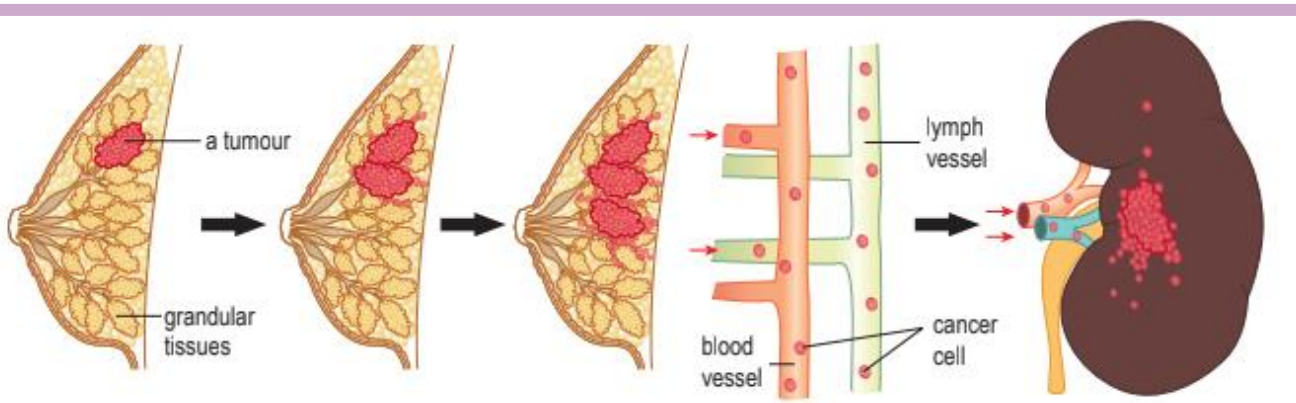


FIGURE 6.7 The development of breast cancer

Issues of cell division on human health in meiosis

- Any abnormality during the division of meiosis can also cause genetic diseases (Down syndrome)
- This happens because the spindle fibres fail to function during anaphase I or anaphase II
- As a result, the chromosome fails to separate (nondisjunction)
- Gametes will have an abnormal number of chromosomes (22 or 24 chromosomes)
- If fertilisation between a normal gamete (23 chromosomes) occurs, the zygote will carry 47 chromosomes which is an abnormal condition

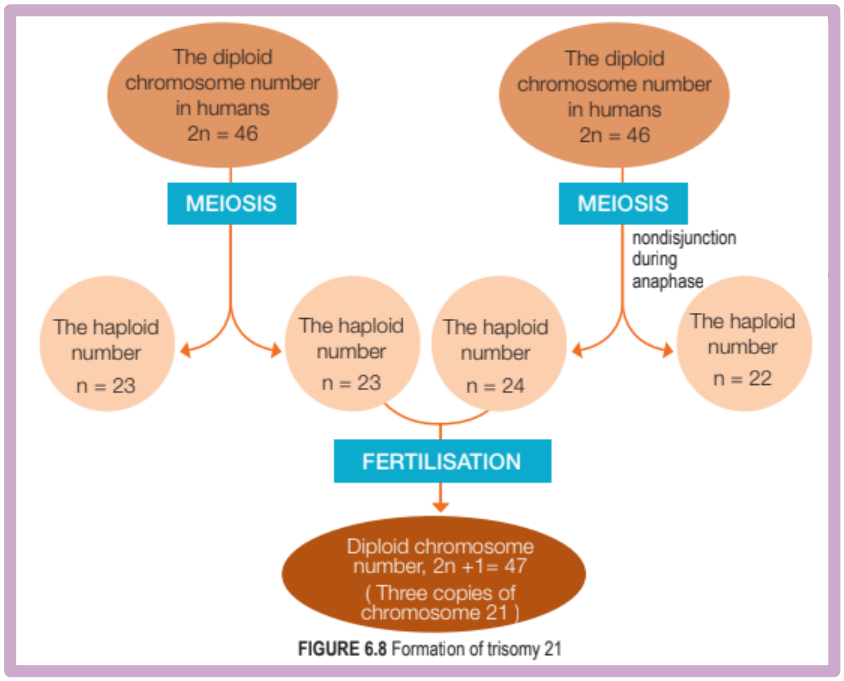


FIGURE 6.8 Formation of trisomy 21