6.1 CELL DIVISION

- Cells in our body always grow, divide and die
- As such, the dead cells must be replaced with new cells
- Cells in the body produce new cells through the cell division process.

- Karyokinesis involves the division of the nucleus.
- Cytokinesis involves the division of the cytoplasm

ORGANISM CELL

SOMATIC CELL

- Body cells apart from gametes.
- Somatic cells are produced through the mitosis process.
- It contains a diploid number of chromosomes, that is, 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, that is, each cell contains one set of chromosomes or n. In human gametes, n = 23.

- In diploid cells, one set of chromosomes originate from the male parent or paternal chromosomes and another set is from the female parent or maternal chromosomes..
- Both paternal and maternal chromosomes have the same structural characteristics
- This pair of chromosomes are called homologous chromosomes.
- Chromatin is a chromosome that looks like a long thread.

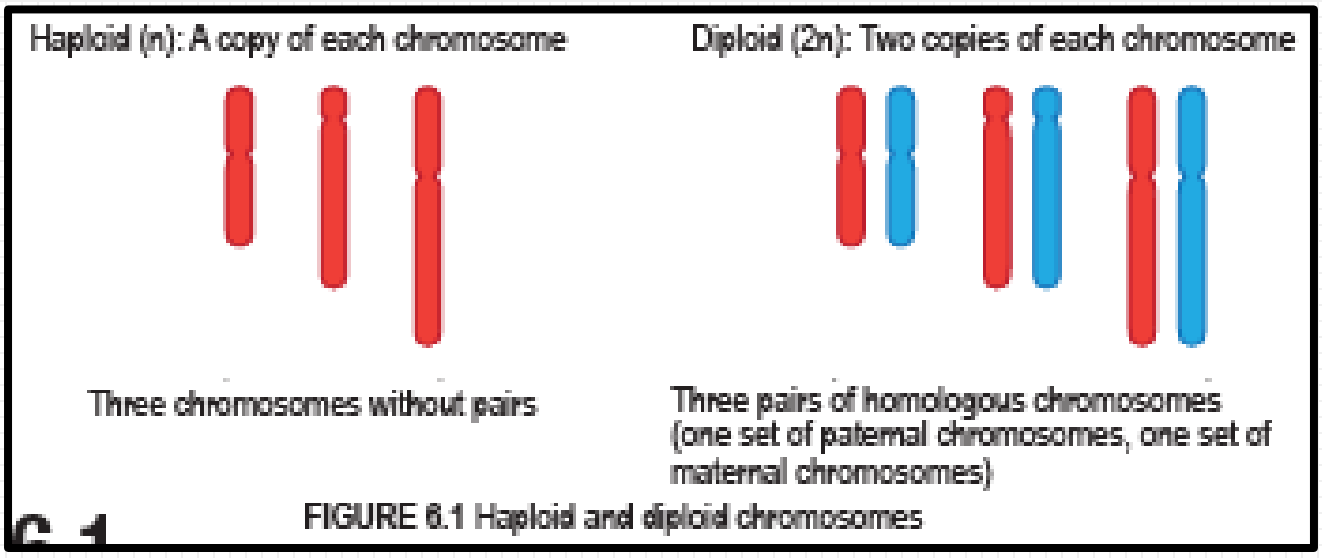

FIGURE 6.1 Haploid and diploid chromosomes

charcoal grey.

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6.2 CELL CYCLE AND MITOSIS

CYCLE CELL

- The cell cycle refers to the sequence of events that involves DNA multiplication and cell division to produce two daughter cells
- The cell cycle consists of interphase and M phase. Interphase is the longest phase in the cell cycle.
- This phase is made up of the G1, S and G2 phase.

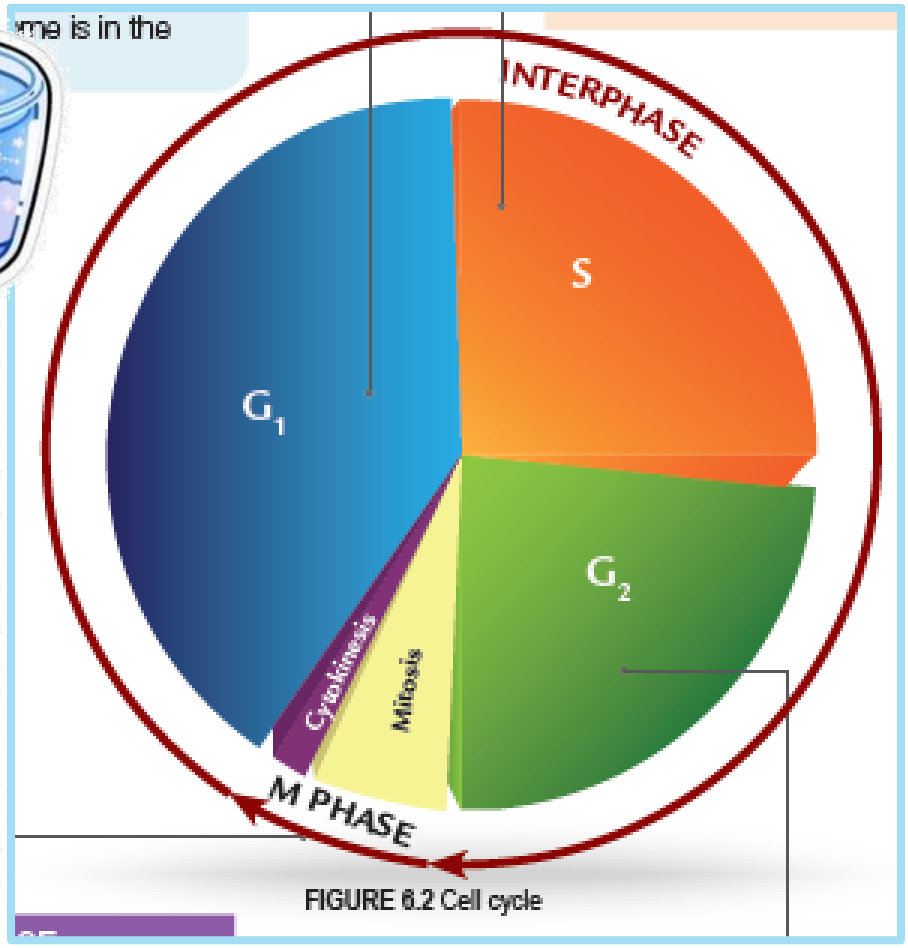

FIGURE 6.2 Cell cycle

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G1 PHASE

- Cells grow.
- Cell components such as mitochondrion and endoplasmic reticulum are produced at this stage
- 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 occurs in the S phase.
- 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.
- Both chromatids are joined at the centromeres

G2 PHASE

- The cells will continue to grow and remain active metabolically during the G2 phase.
- Cells gather energy and make final arrangements to enter the next stage of cell division.
- After the interphase stage, the cell will enter the M phase

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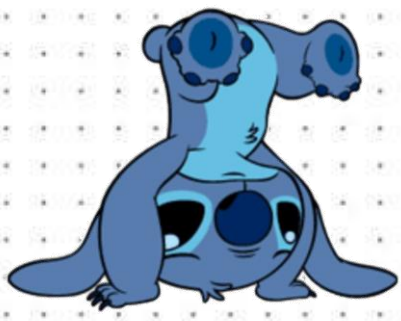
M PHASE

- M phase is made up of mitosis and cytokinesis.
- Mitosis involves prophase, metaphase, anaphase and 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

PROPHASE

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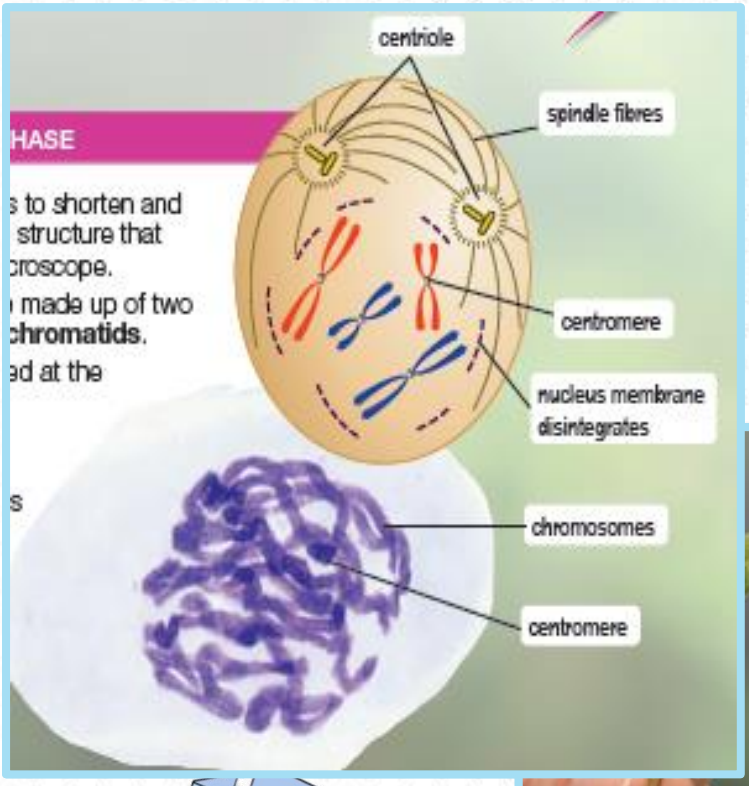
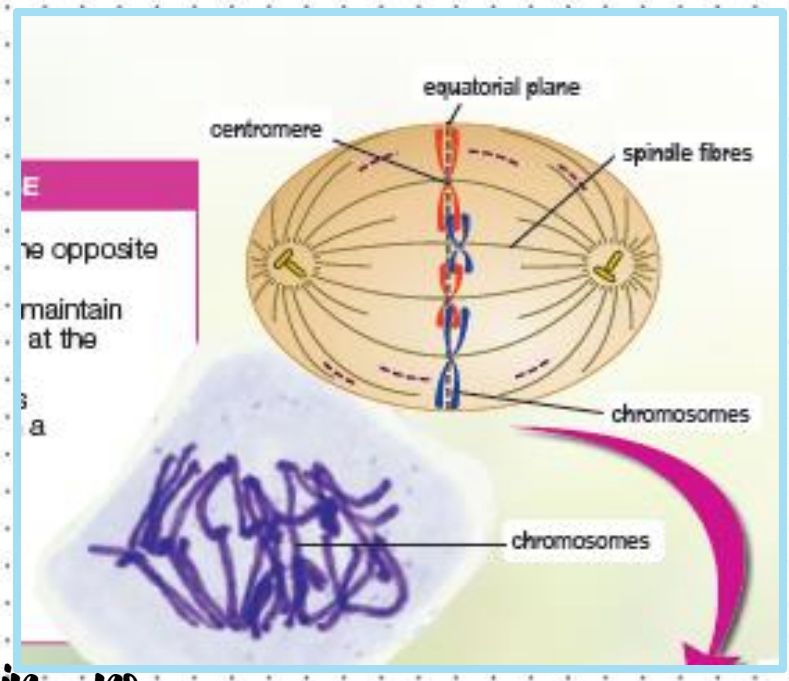
- In the nucleus, chromatin starts to shorten and thicken to form a chromosome structure that can be seen through a light microscope.
- The chromosome is seen to be made up of two identical threads called sister chromatids.
- Both sister chromatids are joined at the centromere.
- The nucleus membrane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



METAPHASE

- Centrioles are at 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.



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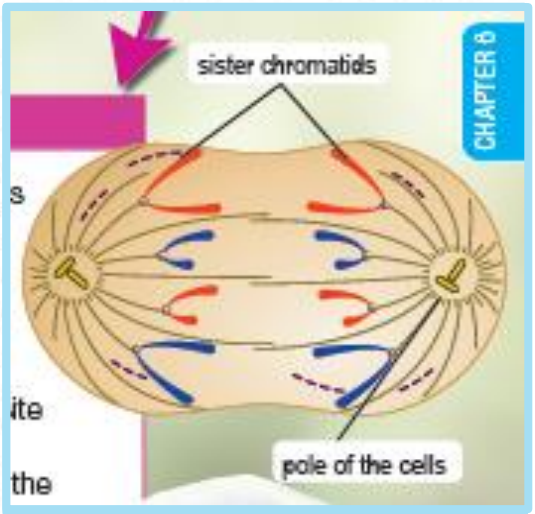
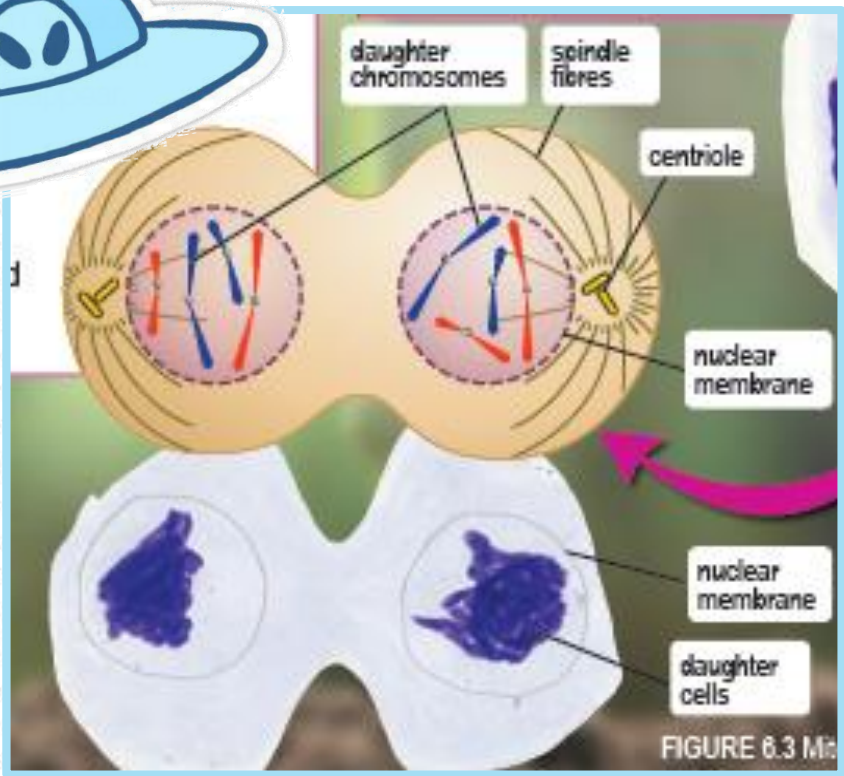
ANAPHASE

- The centromere divides into two and the sister chromatids separate.
- Spindle fibres shorten, contract and the sister chromatids are attracted to the opposite pole cells.
- 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 shaped again 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

- Plant cells do not contain centrioles.
- However, plant cells can still form spindle fibres during mitosis

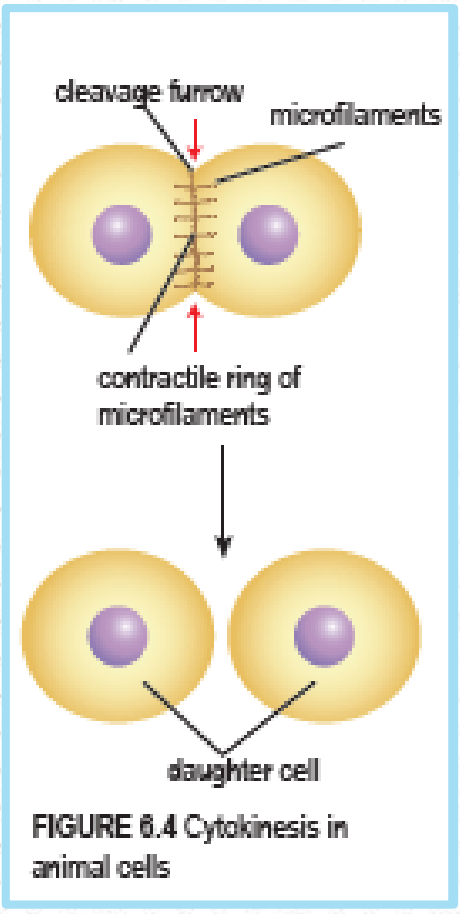


FIGURE 6.4 Cytokinesis in animal cells

- Cytokinesis is different between animal cells and plant cells.
- Cytokinesis is the division of cytoplasm that happens immediately after the nucleus is formed, that is, at the end of telophase.
- 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.

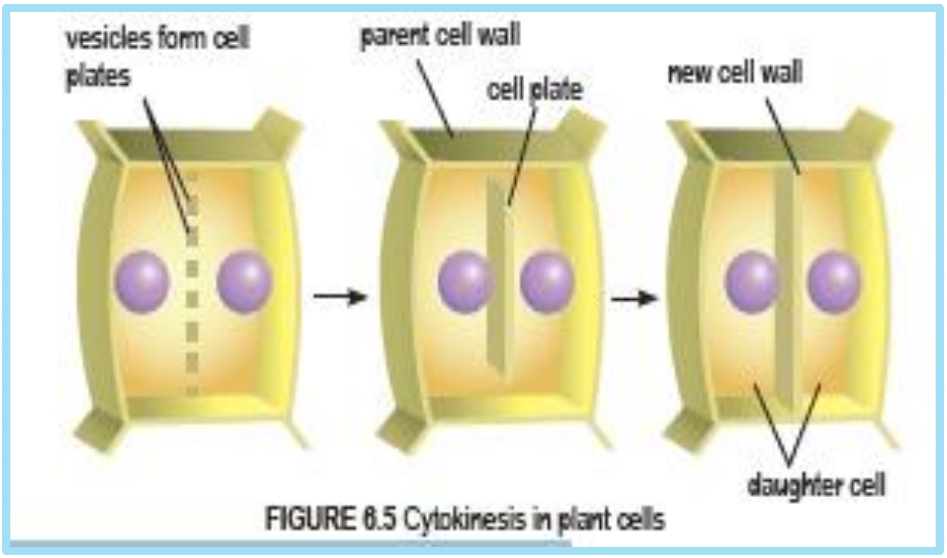


FIGURE 6.5 Cytokinesis in plant cells

- Cytokinesis in plant cells also begins when 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. Each cell has a diploidncondition

The necessity of mitosis

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- Through the mitosis process, the lizard is able to grow a new tail (regeneration) if the tail breaks
- 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
- Mitosis aids organisms such as hydra to produce new individuals through the formation of new buds
- 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 fertilisation process.
- The culturing technique uses stem cells from animals which are then cultured in laboratories to produce meat.

6.3 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 the testis (male) and ovary (female) for animals and humans.

The need for meiosis

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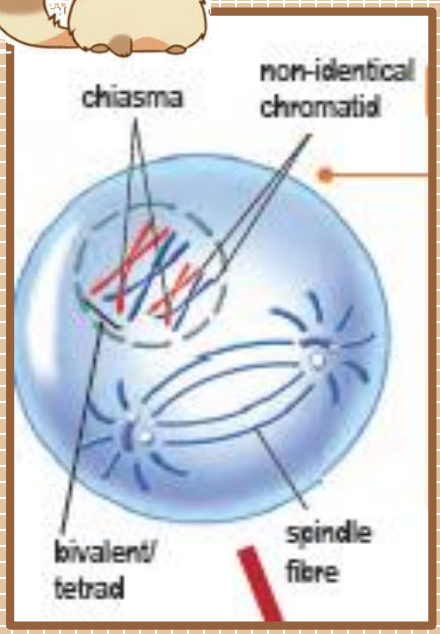
- Meiosis forms gametes through the process of gametogenesis and ensure that the diploid chromosome number of organisms that carry out sex reproduction is always maintained from one generation to the next.
- Meiosis also produces genetic variation in the same species. Meiosis is divided into two stages of cell division, that is meiosis I and meiosis II

MEIOSIS

- Meiosis I comprises of prophase I, metaphase I, anaphase I and telophase I.
- Meiosis II comprises of prophase II, metaphase II, anaphase II and telophase II.

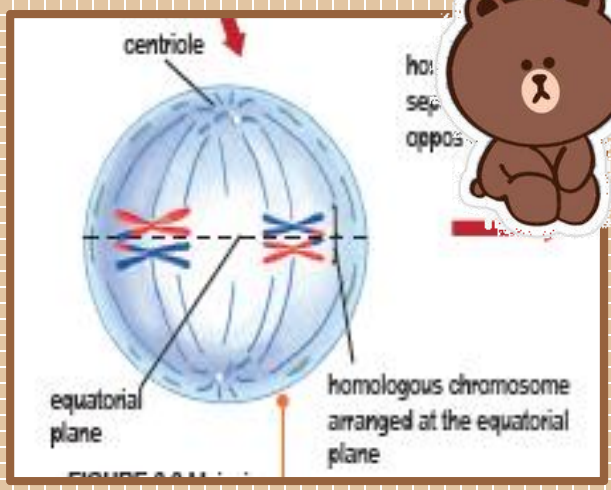


PROPHASE I

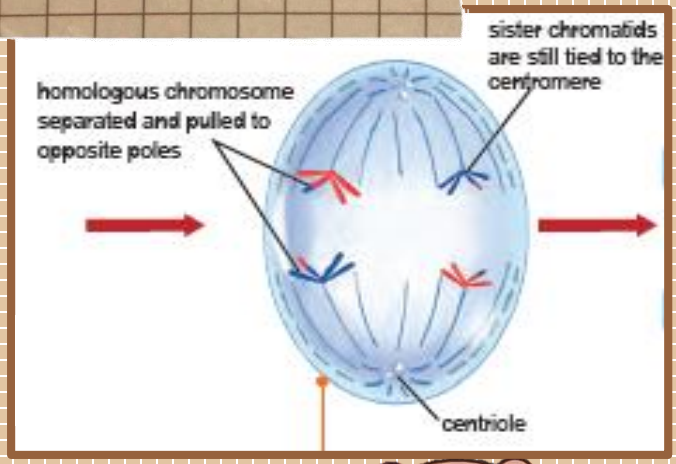
- Chromatin shortens, thickens and forms visible chromosomes.
- The pairing of homologous chromosomes (synapsis) forms bivalent (or known as a tetrad, that is four chromatids for each homologous chromosome).
- The crossing over process that is an exchange of genetic material between non-identical chromatids 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 of prophase I, the nucleus membrane and nucleoli will start to disappear.
- Both centrioles will move towards the opposite pole cells.
- Spindle fibres are formed among the centrioles.

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.



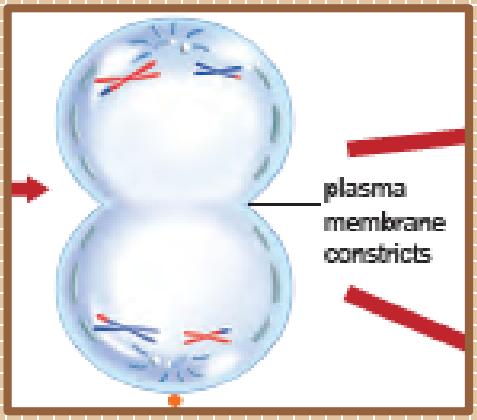
ANAPHASE I



- The spindle fibres contract and cause each homologous chromosome to separate from 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 cell 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.

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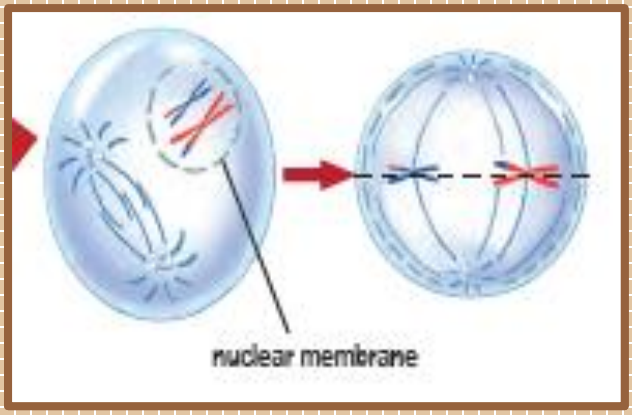
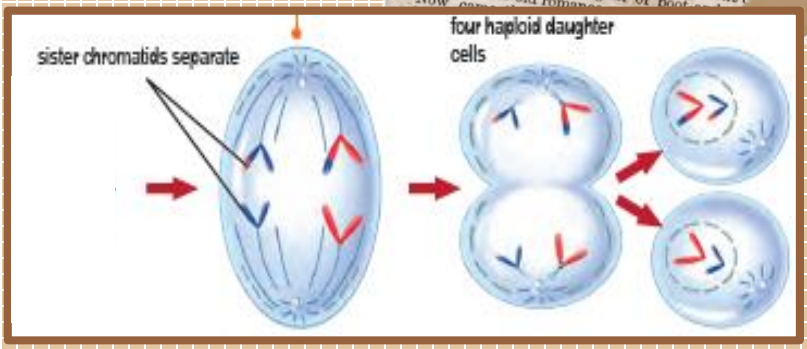


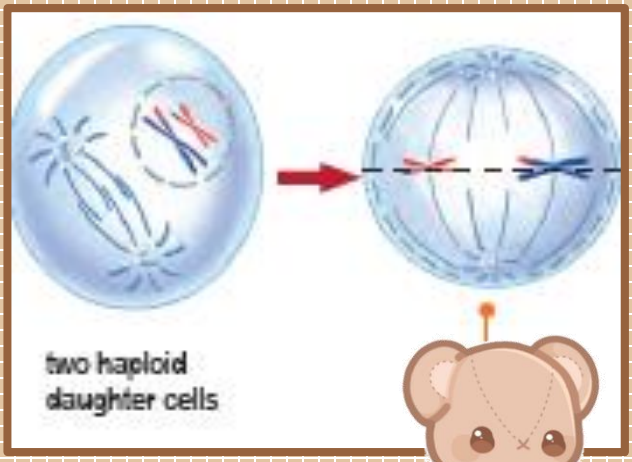
PROPHASE II

- 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

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 known as a chromosome.





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.

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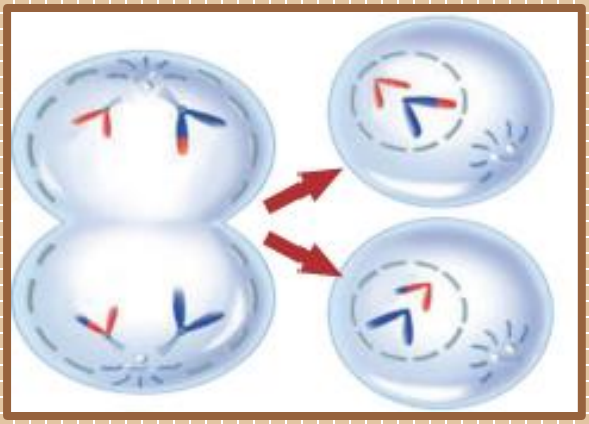
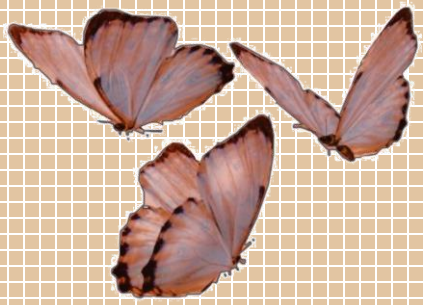
TELOPHASE II

- Chromosomes arrive at the pole of the cell.
- Spindle fibres disappear. The nuclea 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.
- 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



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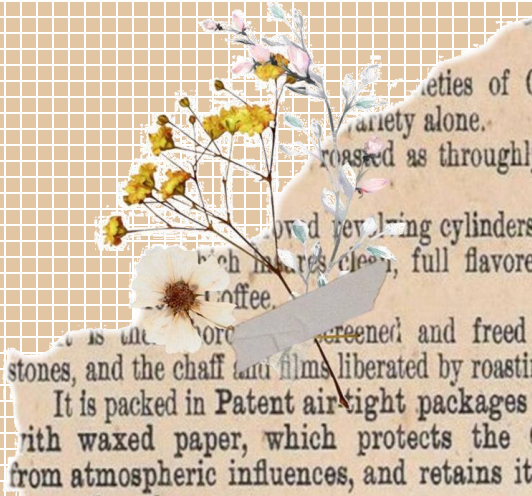

6.4 issues of cell division on human health

- The cell cycle is controlled by a special control system at each G1, S, G2 and M phase to ensure proper division of the cells.
- However, uncontrolled cell division sometimes can lead to the formation of tumours.
- Tumour is divided into two types which are benign tumour and malignant tumour.
- A benign tumour is not dangerous and can be removed surgically. A malignant tumour is also called cancer.
- Cancer is caused by several factors such as radiation (x-ray, gamma rays and ultraviolet rays), chemical substances (such as tar in tobacco), carcinogens (such as formaldehyde and benzene), genetic factors, and also bacteria and viruses.
- This 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

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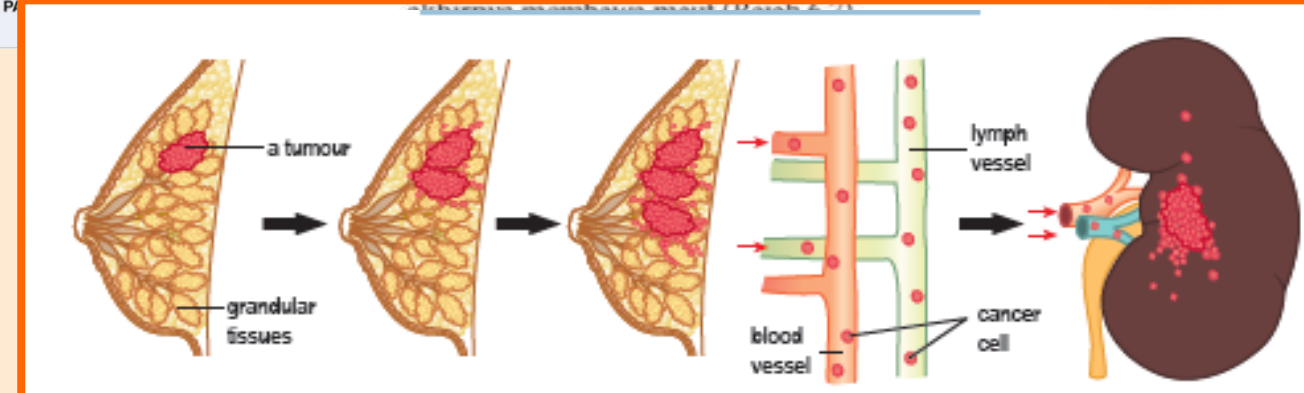

FIGURE 6.7 The development of breast cancer

- Any abnormality during the division of meiosis can also cause genetic diseases such as 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) and an abnormal chromosome (24 chromosomes) occurs, the zygote will carry 47 chromosomes which is an abnormal condition

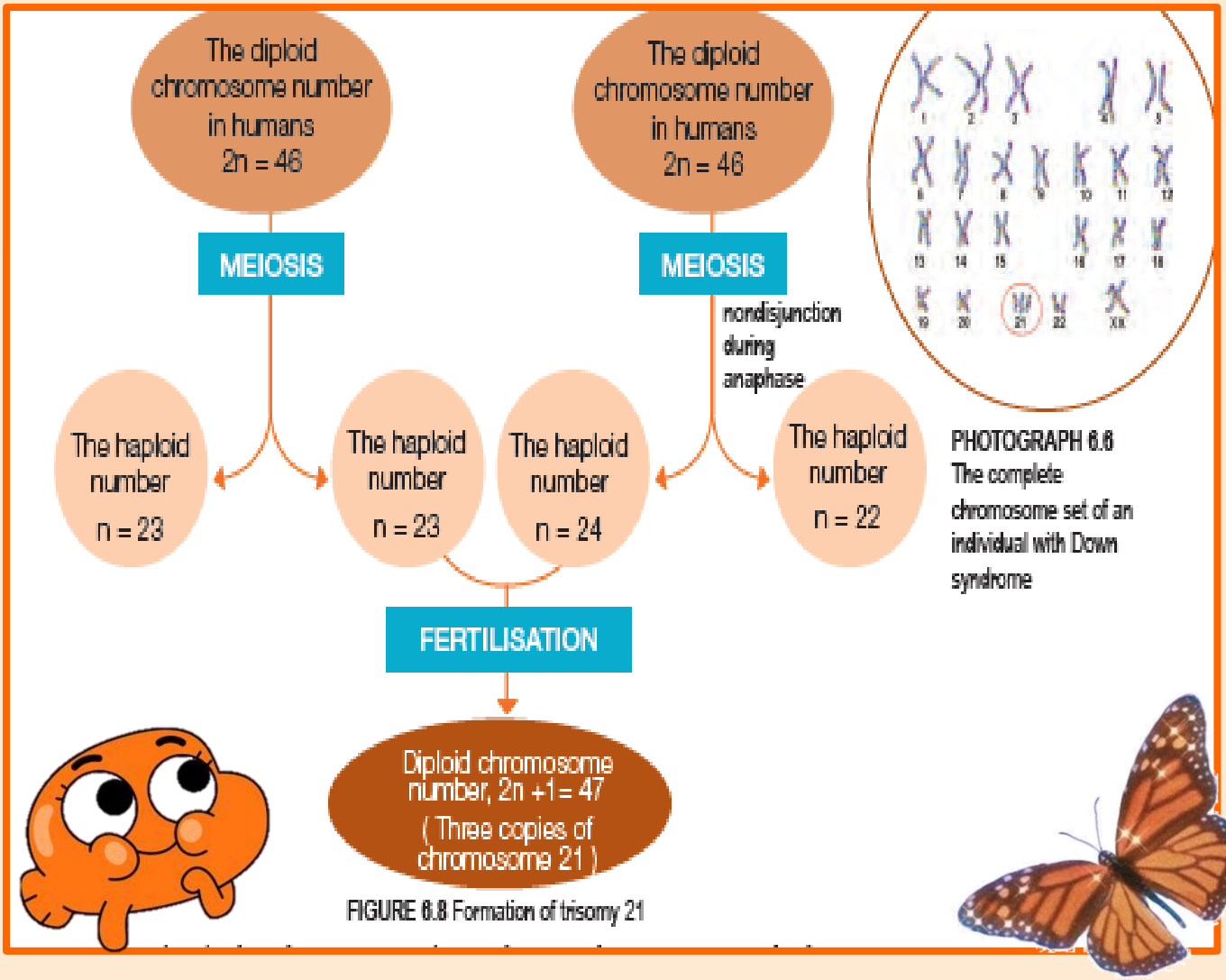

FIGURE 6.8 Formation of trisomy 21

PHOTOGRAPH 6.6 The complete chromosome set of an individual with Down syndrome

- In a normal meiosis division, the chromosomes are divided evenly among the gametes
- If the homologous chromosome or sister chromatids fail to separate, the distribution of parent chromosomes during meiosis will be uneven
- An individual with Down syndrome has 47 chromosomes, which is an extra chromosome at the 21st set. This condition is known as trisomy 21.
- This syndrome can cause mental retardation, slanted eyes and a slightly protruding tongue.

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