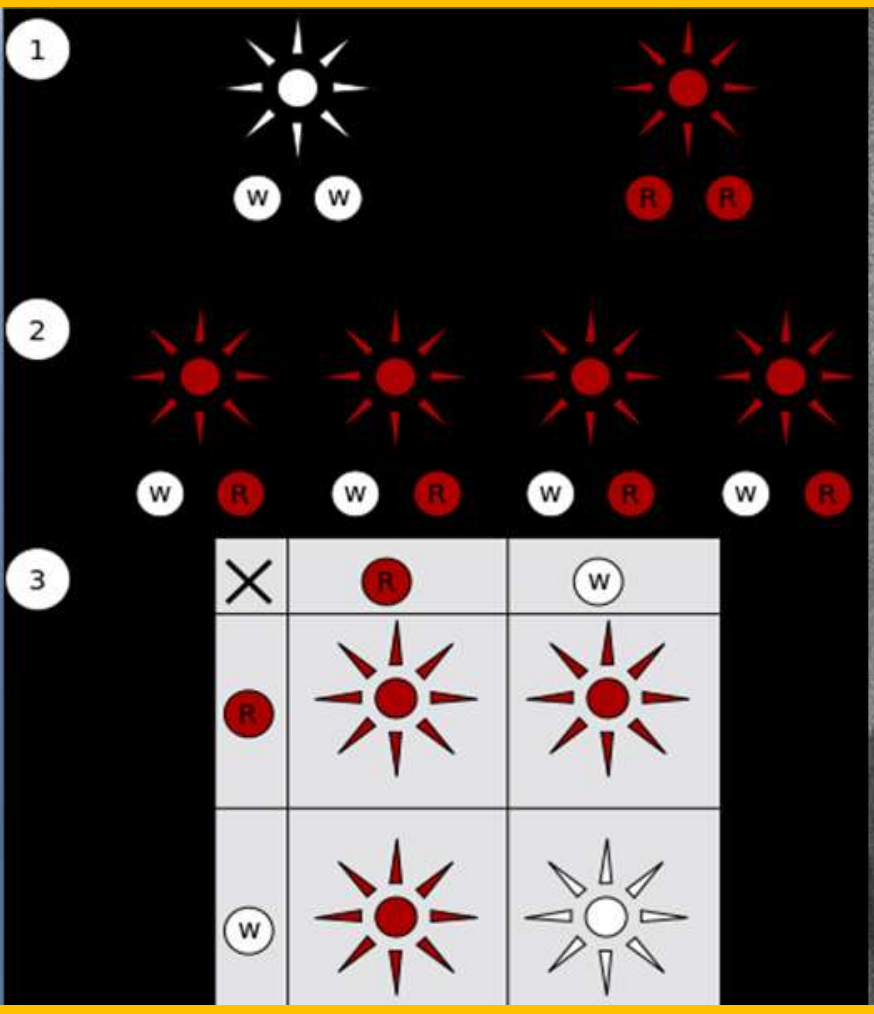
HEREDITY





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UNIT 2

HEREDITY

Introduction

- **Heredity** refers to the passing of traits from parents to offspring through genetic information encoded in DNA.
- Inside the nucleus of every cell there are thread-like structures called **chromosomes**.
    - Chromosomes play a fundamental role in heredity.
- During reproduction, chromosomes are passed from parent to offspring.
    - Each different type of organism has a different number of chromosomes.
    - Humans have 46 chromosomes.
        - ✓ Chromosomes come in pairs known as **homologous pairs**.
- Each individual inherits half of their chromosomes from one parent and the other half from the other parent.
- A visual representation of the chromosomes within a cell is called a **karyotype**.
    - Karyotype provides a snapshot of an individual's chromosomal makeup.
    - Chromosomes are arranged according to size, shape, and other characteristics.
    - Karyotyping involves staining and imaging chromosomes during cell division.
- Chromosomes are categorized into two main types: autosomes and sex chromosomes.
    - Humans have 22 pairs of autosomes.
    - Sex chromosomes are denoted as X and Y.
        - ✓ Females (XX) and Males (XY).
- The chromosomes are made up of DNA (deoxyribonucleic acid).
- DNA carries the instructions needed to make all the proteins in cells.
- DNA is a long molecule made up of two strands twisted together to make a spiral known as a **double helix**.
    - Watson, Crick, and Maurice Wilkins are credited with unraveling the structure of DNA.

- DNA molecule is made up of nucleotides joined together.
  - DNA is a polynucleotide chain.
  - A nucleotide consists of a phosphate group, a sugar and a base.
  - In DNA there are four different bases.
    - ✓ The bases that make up DNA are called adenine, thymine, guanine and cytosine.
    - ✓ Adenine (A) always pairs with thymine (T) and Cytosine (C) always pairs with guanine (G).
  - Each sequence of bases along a DNA molecule is unique to an individual.
- A gene is a unit of hereditary material located on the chromosomes.
  - Each gene is a small section of DNA.
  - Genes are made up of repeating patterns of bases in the DNA.
- Cell division is crucial for heredity as it ensures the accurate transfer of genetic material from parent cells to daughter cells.
- There are two primary types of cell division involved in heredity: Mitosis and Meiosis.

Cell Division

- It is the process by which a parent cell divides into two or more daughter cells.
  - Each cell can only produce identical copies of itself.
- It is essential for growth, development, repair, and reproduction in living organisms.

a) Mitosis

- It is a type of cell division that produces two genetically identical daughter cells from a single parent cell.
  - It is division of the somatic cells to make identical daughter cells.
- It is involved in growth, tissue repair, and asexual reproduction in unicellular organisms.
- Mitosis consists of several stages, including prophase, metaphase, anaphase, and telophase.

How does mitosis work?

- Before cell division occurs, the parent cell undergoes a series of preparatory steps (Interphase).
  - The cell prepares for division by growing, replicating its DNA, and synthesizing proteins.

- The chromosomes duplicate to form identical sister chromatids held together at a region called the **centromere**.
- Once interphase is complete, mitosis progresses through several stages.
- Interphase is the longest phase of the cell cycle (90% of the total cycle time).

1. Prophase

- The chromatin condenses into visible chromosomes.
  - When a cell is dividing, the chromosomes become much shorter and denser.
- The nuclear membrane disintegrates.
  - It allows the spindle fibers to access the chromosomes.
- The disappearance of the nucleolus.
  - It is a structure within the nucleus responsible for the production of ribosomes.
- Centrosomes move far enough apart from each other.
- Spindle fibers form and extend across the cell.

2. Metaphase

- The chromosomes align along the center of the cell.
- Spindle fibers attach to the centromere of each chromosome.

3. Anaphase

- The sister chromatids separate and are pulled apart toward opposite poles
- Each chromatid is now considered a separate chromosome.

4. Telophase

- The separated chromosomes reach the poles of the cell.
- Nuclear envelopes form around the chromosomes, creating two distinct nuclei.
- Meanwhile, the cytoplasm begins to divide through a process called **cytokinesis**.

The Cell Cycle

- The cell cycle is a sequence of events that cells undergo to divide and duplicate.
- It involves a period of active cell division and a long period of non-division.
- The key phases within the process of the cell cycle are resting, interphase, and cell division.
- The length of the cell cycle varies considerably.

b) Meiosis

- Meiosis is essential for sexual reproduction in organisms.
- The reproductive organs in humans are the ovaries and the testes.
  - Ova are made in ovaries and sperm cells are made in the testes.
  - In plants, the sex cells are the pollen and the ovules.
- The cell division that takes place in the reproductive organ cells and produces gametes is known as **meiosis**.
  - The cells in the reproductive organs (germ cells) divide to make sex cells.
- Meiosis is a specialized type of cell division that occurs in germ cells.
  - Germ cells are cells that develop into reproductive cells (egg and sperm cells).
- It is essential for sexual reproduction.
- Unlike mitosis, meiosis involves two rounds of division.
- It results in the formation of four haploid daughter cells.
  - Each daughter cell has half the number of chromosomes as the parent cell.
- It introduces genetic variation through crossing over and random assortment of chromosomes.

The key steps involved in meiosis

1. Meiosis I

a. Prophase I

- Chromosomes condense and become visible.
- Homologous chromosomes pair up and undergo crossing over.
- The nuclear envelope breaks down and spindle fibers form.

b. Metaphase I

- Homologous chromosome pairs line up along the metaphase plate.
- Spindle fibers from opposite poles attach to each pair of homologous chromosomes.

c. Anaphase I

- Homologous chromosomes are pulled apart toward opposite poles of the cell.
- Sister chromatids remain attached at their centromeres.

d. Telophase I

- Chromosomes reach the poles and decondense.
- Nuclear envelopes may re-form, and cytokinesis may occur.

- Two haploid daughter cells are made.

2. Meiosis II

a. Prophase II

- Chromosomes condense again if they decondensed during telophase I.
- Spindle fibers form, and nuclear envelopes may break down.

b. Metaphase II

- Chromosomes line up along the metaphase plate of each daughter cell.

c. Anaphase II

- Sister chromatids are separated and pulled toward opposite poles of the cell.

d. Telophase II

- Chromosomes reach the poles, and nuclear envelopes may reform around them.
- The formation of four haploid daughter cells, each with a unique genetic material.

Gametogenesis

- Meiosis occurs as part of a process known as gametogenesis, or gamete formation.

Oogenesis

- In females, the process of gamete formation is called **oogenesis**.
- In a baby girl, the first stage of meiosis is completed before she is even born.
    - The tiny ovaries of a baby girl contain all the ova she will ever have.
- The second meiotic division begins as the eggs mature in the ovaries during the monthly cycle.

Spermatogenesis

- In males, the process of gamete formation is called **spermatogenesis**.
    - Spermatogenesis carries on throughout a man's life.
- In males, meiosis doesn't start until puberty, when the testes start to produce sperm.
- Each gamete you produce is slightly different from all the others.

Comparison of Mitosis and Meiosis

Aspect	Mitosis	Meiosis
Purpose	Growth, tissue repair, asexual reproduction	Production of gametes (sperm and egg cells) for sexual reproduction
Number of Divisions	One division: Mitosis	Two divisions: Meiosis I and Meiosis II
Number of Daughter Cells	Two daughter cells produced	Four daughter cells produced
Genetic Content	Daughter cells are genetically identical to parent cell	Daughter cells are genetically unique due to crossing over and random assortment
Chromosome Number	Diploid (2n)	Haploid (n)
Homologous Chromosome Interaction	No pairing or crossing over between homologous chromosomes	Homologous chromosomes pair up and undergo crossing over in Prophase I
Number of Chromosomes in Daughter Cells	Same as parent cell	Half the number of chromosomes as parent cell
Occurrence in Organisms	Occurs in somatic cells	Occurs in germ cells (reproductive cells)
Occurrence in Life Cycle	Throughout the life cycle	Specific to the formation of gametes
Role in Evolution	Maintains genetic stability	Introduces genetic variation and contributes to evolution

Test Yourself

1. What does heredity refer to?
   A. A change in the DNA of an organism due to environmental factors
   B. The transfer of sperm from the male to the female reproductive tract.
   C. Passing of traits from parents to offspring through genetic information
   D. It is a medical condition caused by abnormalities in an individual's DNA.
2. What are the thread-like structures inside the nucleus of every cell called?
   A. Genes
   B. Ribosomes
   C. Nucleotides
   D. Chromosomes
3. What is a visual representation of chromosomes within a cell called?
   A. Genotype
   B. Karyotype
   C. Phenotype
   D. Chromatography
4. What is DNA made up of?
   A. Fatty acids
   B. Amino acids
   C. Nucleotides
   D. Deoxyribose
5. What are chromosomes categorized into?
   A. DNA and Histone proteins
   B. Autosomes and Sex chromosomes
   C. Ribosomes and Nucleosome
   D. Autosomes and Centrosomes
6. How many pairs of autosomes do humans have?
   A. 22
   B. 23
   C. 24
   D. 46
7. In humans, what are sex chromosomes denoted as?
   A. A and B
   B. Z and W
   C. X and Y
   D. Y and Z
8. What are males' sex chromosomes?
   A. YY
   B. XY
   C. XX
   D. XZ
9. Who are credited with unraveling the structure of DNA?
   A. Mendel, Franklin and Watson
   B. Watson, Crick, and Franklin
   C. Crick, Franklin and Wilkins
   D. Watson, Crick, and Wilkins

10. What process involves staining and imaging chromosomes during cell division?

A. PCR
C. Karyotyping
B. Cloning
D. Transcription

11. How many different bases are there in DNA?

A. Two
C. Four
B. Three
D. Five

12. Which of the following is **NOT** one of the bases found in DNA?

A. Adenine
C. Thymine
B. Uracil
D. Guanine

13. Which bases always pair together in DNA?

A. Adenine with uracil, cytosine with guanine
B. Adenine with thymine, cytosine with guanine
C. Adenine with cytosine, thymine with guanine
D. Adenine with guanine, thymine with cytosine

14. What are the two primary types of cell division involved in heredity?

A. Mitosis and Meiosis
C. Mitosis and Cytokinesis
B. Oogenesis and Spermatogenesis
D. Meiosis and Gametogenesis

15. What is the longest phase of the cell cycle?

A. Prophase
C. Metaphase
B. Interphase
D. Telophase

16. What is the correct sequence of stages in mitosis?

A. Interphase, Prophase, Metaphase, Anaphase, Telophase
B. Telophase, Anaphase, Metaphase, Prophase, Interphase
C. Prophase, Telophase, Anaphase, Metaphase, Interphase
D. Interphase, Prophase, Anaphase, Metaphase, Telophase

17. What happens during prophase of mitosis?

A. Chromosomes pair up and recombination occurs
B. Chromosomes align along the center of the cell
C. Chromosomes condense into visible structures
D. Nuclear envelopes form around the chromosomes

18. What happens during metaphase of mitosis?
    A. Chromosomes align along the center of the cell
    B. The chromosomes move toward the spindle poles
    C. Nuclear envelopes form around the chromosomes
    D. Sister chromatids separate and move to opposite poles
19. What happens during anaphase of mitosis?
    A. Chromosomes condense into visible structures
    B. Chromosomes align along the center of the cell
    C. Nuclear envelopes form around the chromosomes
    D. Sister chromatids separate and move to opposite poles
20. What happens during telophase of mitosis?
    A. Chromosomes align along the center of the cell
    B. Nuclear envelopes form around the chromosomes
    C. Chromosomes line up at the equator of the spindle
    D. Sister chromatids separate and move to opposite poles
21. How many rounds of division does meiosis involve?
    A. One
    B. Two
    C. Three
    D. Four
22. What is the outcome of meiosis?
    A. Four diploid daughter cells
    B. Two diploid daughter cells
    C. Four haploid daughter cells
    D. Two haploid daughter cells
23. What occurs during prophase I of meiosis?
    A. Homologous chromosomes are pulled apart
    B. Chromosomes reach the poles and decondense
    C. Chromosomes line up along the metaphase plate
    D. Chromosomes condense and undergo crossing over
24. In which phase of meiosis do sister chromatids separate and are pulled toward opposite poles of the cell?
    A. Anaphase I
    B. Anaphase II
    C. Prophase I
    D. Prophase II

25. What is the process of gamete formation called in females?

A. Ovulation
C. Fertilization
B. Oogenesis
D. Spermatogenesis

26. When does the second meiotic division begin in females?

A. At birth
C. During puberty
B. After menopause
D. During pregnancy

27. What is the purpose of meiosis?

A. To repair damaged tissues in organisms
B. To produce somatic cells from germ cells
C. To produce gametes with genetic variation
D. To produce genetically identical daughter cells

28. What is the ploidy level of daughter cells produced by mitosis and meiosis, respectively?

A. Haploid, haploid
C. Diploid, diploid
B. Haploid, diploid
D. Diploid, haploid

29. How many daughter cells are produced at the end of mitosis and meiosis, respectively?

A. Two, four
C. Four, two
B. Two, two
D. Four, four

30. Which of the following accurately describes the genetic variation introduced during mitosis and meiosis?

A. Both mitosis and meiosis introduce genetic variation through random assortment.
B. Mitosis introduces genetic variation through crossing over, while meiosis does not.
C. Both mitosis and meiosis introduce genetic variation due to chromosomal mutation.
D. Meiosis introduces genetic variation through crossing over, while mitosis does not.

Answers for the Checkpoint

1. C
2. D
3. B
4. C
5. B
6. A
7. C
8. B
9. D
10. C
11. C
12. B
13. B
14. A
15. B
16. A
17. C
18. A
19. D
20. B
21. B
22. C
23. D
24. B
25. B
26. C
27. C
28. D
29. A
30. D