MahaScience9

CLASS 9 SCIENCE · MAHARASHTRA STATE BOARD

CHAPTER 16

Heredity and Variation

Chapter Notes

1. Heredity and variation

- **Heredity:** the passing of characters (traits) from parents to their offspring. Children look like their parents because of heredity.
- **Variation:** the differences between individuals of the same species, even among brothers and sisters.
- **Asexual reproduction** gives very little variation, because the offspring get the genes of only one parent. **Sexual reproduction** gives more variation, because genes from two parents combine in new ways.
- **Inherited traits** (eye colour, blood group, shape of earlobes) come from parents through genes. **Acquired traits** (learning to swim, a scar) develop during life and are not passed on.

Genes are the **units of heredity**. A gene is a part of DNA that controls a particular trait. Genes are present on **chromosomes** in the **nucleus** of the cell, so the nucleus carries hereditary traits.

2. Chromosomes

Chromosomes are thread-like structures in the nucleus, made of **DNA and proteins** (histones). They become clearly visible during cell division. Each chromosome has two identical **chromatids** joined at a point called the **centromere**.

Human body cells have **46 chromosomes (23 pairs)**:

- **22 pairs of autosomes**, which control body characters.
- **1 pair of sex chromosomes**: **XX in females** and **XY in males**. They decide the sex of the child.

The chromosome formula is written as **44 + XX** (female) and **44 + XY** (male).

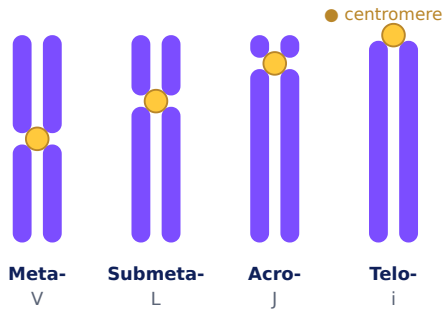


Fig. 16.1 Types of chromosomes by position of the centromere

Type	Position of centromere	Shape
Metacentric	In the middle; two equal arms	V-shaped
Submetacentric	Slightly away from the middle; unequal arms	L-shaped
Acrocentric	Near one end; one very short arm	J-shaped
Telocentric	At the very end; only one arm	i-shaped (not found in humans)

3. DNA and RNA

DNA (deoxyribonucleic acid)

In 1953, **James Watson and Francis Crick** showed that DNA has a **double helix** structure, like a twisted ladder.

- DNA is made of units called **nucleotides**. Each nucleotide has a **deoxyribose sugar**, a **phosphate** group and a **nitrogenous base**.
- There are four bases: **adenine (A), thymine (T), guanine (G)** and **cytosine (C)**.
- Sugar and phosphate form the two sides (backbone) of the ladder, and pairs of bases form the steps. **A always pairs with T**, and **G always pairs with C**.
- DNA stores all the genetic information of an organism and passes it to the next generation.

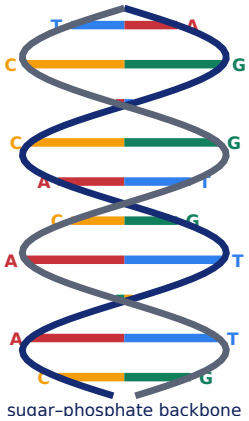


Fig. 16.2 DNA double helix and base pairing

RNA (RIBONUCLEIC ACID)

- Usually a **single strand**, with **ribose** sugar.
- Bases: A, G, C and **uracil (U)** instead of thymine.
- **Function:** helps make proteins using the information in DNA.

Types:

- **mRNA** (messenger): carries the message from DNA to the ribosomes.
- **tRNA** (transfer): brings amino acids to the ribosome.
- **rRNA** (ribosomal): forms the ribosomes where proteins are made.

DNA FINGERPRINTING

Except identical twins, every person's DNA pattern is **unique**, like a fingerprint. DNA from blood, hair, skin or saliva can be compared. It is used to **identify criminals**, settle **disputes about parents**, identify victims of accidents and disasters, and study family histories. It was developed by **Alec Jeffreys** (1984). In India, **Dr Lalji Singh** developed it at the CCMB, Hyderabad. It is very useful, but it must be used carefully to protect people's privacy.

4. Mendel's experiments

Gregor Johann Mendel (1822–1884), an Austrian monk, is called the **father of genetics**. He studied inheritance in the **garden pea** (*Pisum sativum*), because it grows quickly, is self-pollinating, produces many seeds, and has clearly **contrasting characters**.

Character	Dominant	Recessive	Character	Dominant	Recessive
Height of stem	Tall	Dwarf	Pod shape	Inflated	Constricted
Seed shape	Round	Wrinkled	Pod colour	Green	Yellow
Seed colour	Yellow	Green	Flower position	Axial	Terminal
Flower colour	Violet	White			

KEY TERMS

Dominant: the trait that appears in the F1 generation (T = tall). **Recessive:** the trait that stays hidden in F1 (t = dwarf). **Alleles:** two forms of a gene (T and t). **Homozygous:** both alleles the same (TT, tt). **Heterozygous:** different alleles (Tt). **Genotype:** the genetic make-up (TT, Tt). **Phenotype:** the visible trait (tall, dwarf). **F1, F2:** first and second filial (offspring) generations.

4.1 Monohybrid cross (one pair of contrasting characters)

Mendel crossed a pure **tall** plant (TT) with a pure **dwarf** plant (tt).

- **F1:** all plants were **tall (Tt)**. Tall is dominant over dwarf.
- When F1 plants were self-pollinated (Tt × Tt), the **F2** generation gave:

Phenotype ratio 3 tall : 1 dwarf
Genotype ratio 1 TT : 2 Tt : 1 tt

This shows that the factor for dwarfness was not lost in F1; it was only hidden.

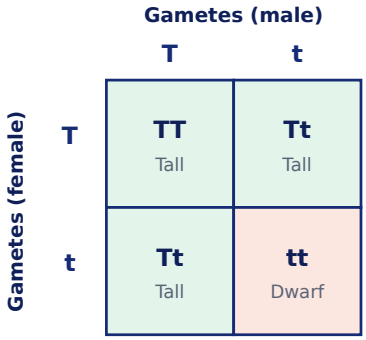


Fig. 16.3 F2 of a monohybrid cross (Tt × Tt)

4.2 Dihybrid cross (two pairs of contrasting characters)

Mendel crossed a plant with **round, yellow** seeds (RRYY) with one having **wrinkled, green** seeds (rryy). All **F1** plants had **round, yellow** seeds (RrYy). F1 plants were self-pollinated (RrYy × RrYy). Each F1 plant forms 4 types of gametes: RY, Ry, rY and ry.

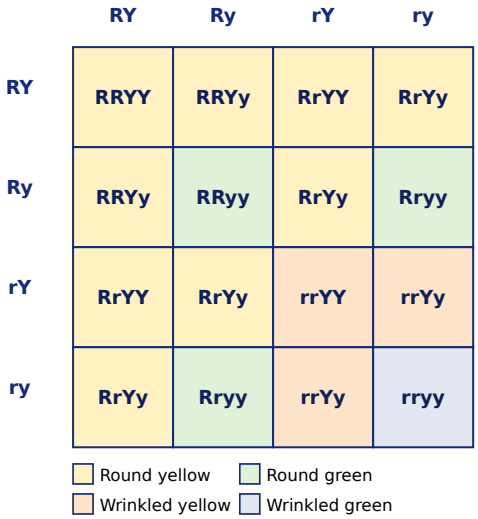


Fig. 16.4 F2 of a dihybrid cross (16 combinations)

F2 phenotype ratio = 9 : 3 : 3 : 1

Seeds	Number
Round, yellow	9
Round, green	3
Wrinkled, yellow	3
Wrinkled, green	1

Two new combinations (round green, wrinkled yellow) appear, which shows that the two characters are inherited **independently** of each other.

Point	Monohybrid cross	Dihybrid cross
Characters studied	One pair (e.g. tall/dwarf)	Two pairs (e.g. seed shape and colour)
F2 phenotype ratio	3 : 1	9 : 3 : 3 : 1
F2 genotype ratio	1 : 2 : 1	1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1 (9 genotypes)
Gametes of F1	2 types (T, t)	4 types (RY, Ry, rY, ry)

5. Genetic (hereditary) disorders

Disorders caused by abnormalities in **chromosomes** or **genes** are called genetic disorders. They can be passed from parents to children. They are **not infectious**.

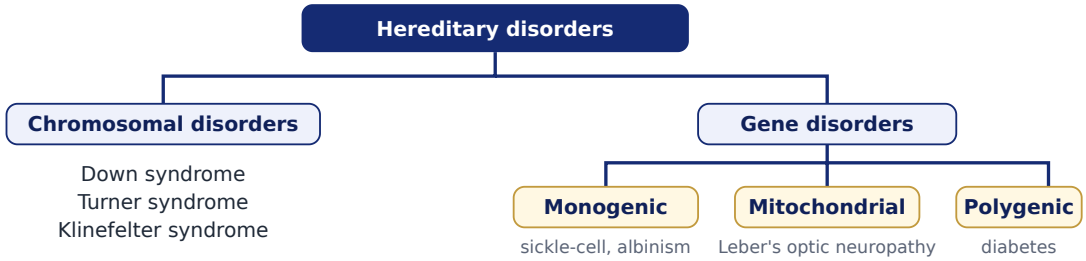


Fig. 16.5 Classification of hereditary disorders

5.1 Chromosomal disorders

Disorder	Chromosomes	Effects
Down syndrome	47 (an extra 21st chromosome: trisomy 21), 45 + XX or 45 + XY	Slow mental growth, short height, flat face, slanting eyes, short neck, weak muscles, sometimes heart defects. Named after Dr John Langdon Down.
Turner syndrome	45 (44 + X); females	Short height, underdeveloped ovaries, **sterile** (cannot have children)
Klinefelter syndrome	47 (44 + XXY); males	Tall, underdeveloped testes, some breast development, **sterile**

5.2 Monogenic (single-gene) disorders

Caused by a change (**mutation**) in just **one gene**. Examples: **sickle-cell anaemia, albinism** (no melanin pigment: very white skin and hair, eyes sensitive to light), **haemophilia** (blood does not clot), **colour blindness** and **thalassaemia**.

Sickle-cell anaemia: red blood cells become **sickle (crescent) shaped** instead of round. They carry less oxygen, break easily and block small blood vessels. It is common in parts of Maharashtra, including Vidarbha.

- **Symptoms:** anaemia, tiredness, pain and swelling in joints, hands and feet, frequent infections, jaundice and slow growth.
- **Treatment:** there is no complete cure. Regular check-ups, folic acid, plenty of water, medicines to reduce pain, blood transfusions, and in some cases a bone-marrow transplant help patients. Blood tests and genetic counselling before marriage can prevent it in children.

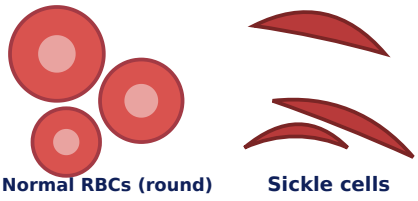


Fig. 16.6 Normal and sickle-shaped red blood cells

5.3 Mitochondrial and polygenic disorders

- **Mitochondrial disorders:** caused by defects in the DNA of **mitochondria**, which children inherit **only from the mother**. Example: **Leber's hereditary optic neuropathy** (gradual loss of eyesight).
- **Polygenic (multi-gene) disorders:** caused by **many genes** together with lifestyle and environment. Examples: **diabetes**, high blood pressure, heart disease, obesity and some cancers.

BLOOD TESTS BEFORE MARRIAGE

Testing blood before marriage helps find whether both partners carry genes for disorders such as **sickle-cell anaemia** or **thalassaemia**, and checks blood group (Rh factor) and infections. With **genetic counselling**, couples can make informed decisions and prevent serious disorders in their children.

SHOULD WE AVOID PEOPLE WITH GENETIC DISORDERS?

No. Genetic disorders are not infectious; they do not spread by touch, living together or eating together. People with these disorders need love, care, treatment and equal opportunities, not discrimination.

6. Important questions for the exam

1. Fill in the blanks: **Genes** are the units of heredity. Variation is less in **asexual** and more in **sexual** reproduction. The **nucleus (chromosomes)** carries hereditary traits. Chromosomes are mainly made of **DNA and proteins**.
2. Explain Mendel's monohybrid and dihybrid crosses with Punnett squares. Write the differences between them.
3. What is a chromosome? Explain its types. Describe the structure of DNA. Write the structure, function and types of RNA.
4. Write short notes on: Down syndrome, monogenic disorders, sickle-cell anaemia.
5. Match: Leber's optic neuropathy – mitochondrial – loss of vision; diabetes – polygenic – high blood sugar; albinism – monogenic – no skin pigment; Turner – 44 + X – sterile female; Klinefelter – 44 + XXY – sterile male.
6. Complete the analogy: Down syndrome : 47 (45 + XX/XY) :: Turner syndrome : 45 (44 + X). Monohybrid : 3 : 1 :: Dihybrid : 9 : 3 : 3 : 1.
7. Why are blood tests before marriage necessary? What is your opinion on using DNA fingerprinting?