Topic 6: Inheritance

Competency: The learner appreciates that transmission of characteristics is from parents to offspring through a process known as heredity.

SHORT NOTES ABOUT INHERITANCE

Inheritance: **How traits are passed from parents to offspring**

Have you ever been told you look like your father, or that you have your grandmother's nose? These resemblances are not just coincidences they are the result of **inheritance**, a biological process through which parents pass traits to their children/ offspring.

What Is Inheritance?
Inheritance is the process by which genetic information is passed from parents to offspring. This happens through structures called genes, which are made of DNA (deoxyribonucleic acid). Genes are located on thread-like structures called chromosomes found in the nucleus of cells. Humans typically have 46 chromosomes, arranged in 23 pairs. One chromosome from each pair is inherited from the mother and the other from the father.
The entire set of genes that an individual inherits is known as the genotype, and how those genes are expressed physically (like eye colour or blood type) is called the phenotype.

The role of genes
Each gene controls a specific trait. Some genes are dominant, meaning they will always be expressed when present, while others are recessive, meaning they only show up if an individual inherits the same gene from both parents.
For example:

- Tall/ long stems character is typically a dominant trait in garden pea plants
- Short/ short stem character is usually a recessive trait in garden pea plants.

Examples of inherited traits in humans

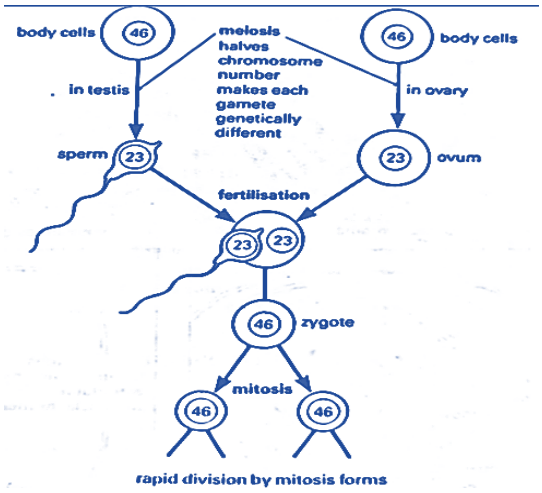
Trait/ character	**Inherited from**	**Type of inheritance**
Blood group	One allele from each parent	Co-dominance (A, B, O)
Tongue rolling ability	Often dominant	Mendelian trait
Earlobe attachment	Varies among individuals	Mendelian trait
Genetic diseases (e.g. sickle cell anaemia, haemophilia, albinism)	Both parents must carry the gene (Heterozygous)	Recessive condition

How traits are transmitted

During sexual reproduction, the father's sperm cell and the mother's egg cell each contribute 23 chromosomes. When these combine during fertilization, they form a zygote with 46 chromosomes. This zygote then grows into a baby, carrying traits from both parents.

If both parents carry a recessive gene for a condition (like sickle cell anaemia), their child has a chance of inheriting the condition. If only one parent has the gene, the child may become a carrier without showing symptoms.

How gametes are formed from meiosis



Why studying inheritance is important

Understanding inheritance:

- Helps families predict and prepare to mange genetic conditions.
- Enables farmers and breeders to improve crops and animals through selective breeding.
- Supports doctors and scientists in genetic research and disease prevention.
- Teaches students the value of biodiversity and biological uniqueness.

Activity 26.1:

In Lira, Mr. and Mrs. Ocen were shocked when their child, Abbo, was diagnosed with sickle cell anaemia. Both parents appeared healthy and had never shown any symptoms. At the local hospital, a genetic counsellor drew a diagram and explained how two people who are carriers of the sickle cell gene could still pass it on. The counsellor also explained how meiosis allows this gene to be inherited by chance.

Tasks and responses

a) Use a genetic illustration to show how two parents in the scenario can produce a child with sickle cell disease.

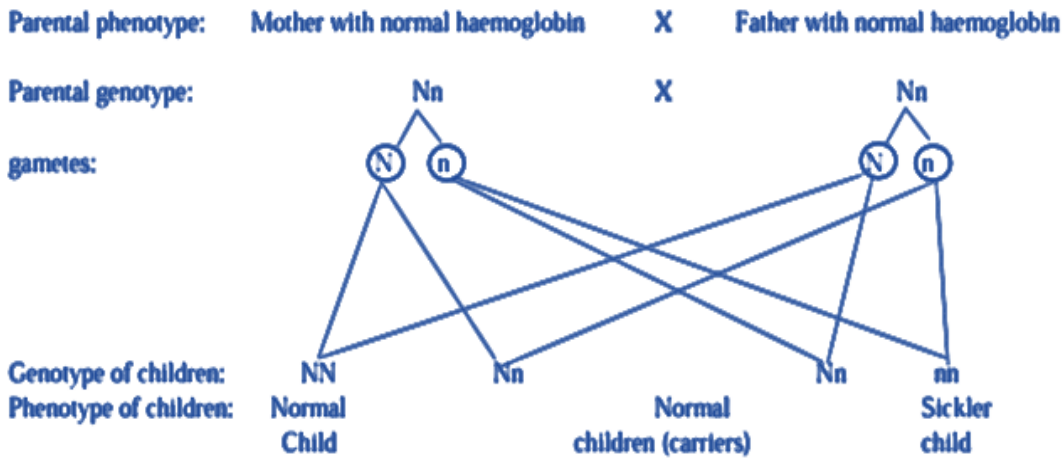
Genetic illustration showing inheritance of sickle cell disease

Let:

- ✓ N = allele for normal haemoglobin
- ✓ n = allele that causes sickle cell anaemia

Mr. and Mrs. Ocen are both carriers (Nn):

They are healthy but carry one sickle cell allele.



Offspring possibilities:

- **NN** (Normal): 1 out of 4 (25%)
- **Nn** (Normal but a carrier): 2 out of 4 (50%)
- **nn** (Sickle cell disease): 1 out of 4 (25%)

Therefore:

✓ A child like Abbo (**nn**) can result when both parents pass on the **n** allele
✓ Even though both parents are healthy carriers, their child can inherit two sickle cell genes and develop the disease

b) Explain the role of meiosis in passing on the sickle cell gene from carrier parents to their child.

Role of meiosis in passing on the sickle cell gene

Meiosis is the type of cell division that forms gametes (sperm and egg cells) during meiosis, each parent's pair of alleles (A and S) is separated so that each gamete carries only one allele when a sperm and an egg fuse during fertilisation, the child inherits one allele from each parent the combination is random, so there is a 1 in 4 chance of the child inheriting two S alleles (SS) and developing sickle cell anaemia

c) Discuss two reasons why genetic testing and counselling are important for couples in Uganda before having children.

Responses

Two reasons why genetic testing and counselling are important for couples in Uganda before having children

- ❖ Testing helps couples know their carrier status for conditions like sickle cell early before they risk of passing on genetic disorders, helps couples to plan accordingly
- ❖ Enables genetic counselling which prepares families for early monitoring, care, or treatment if a child is born with a condition
- ❖ It helps reduce emotional stress and stigma through education and support

Activity 26.2:

At a school in Mukono, a boy named Brian often fails to distinguish red and green during science activities. The same condition is also affecting his maternal uncle. The science teacher uses this opportunity to explain how the disorder is linked to the X Chromosome and passed from carrier mothers to their sons.

Tasks and responses

a) Using a genetic diagram, explain how Brian could have inherited colour blindness from his mother, who shows no symptoms.

Genetic illustration showing how Brian inherited colour blindness from his mother:

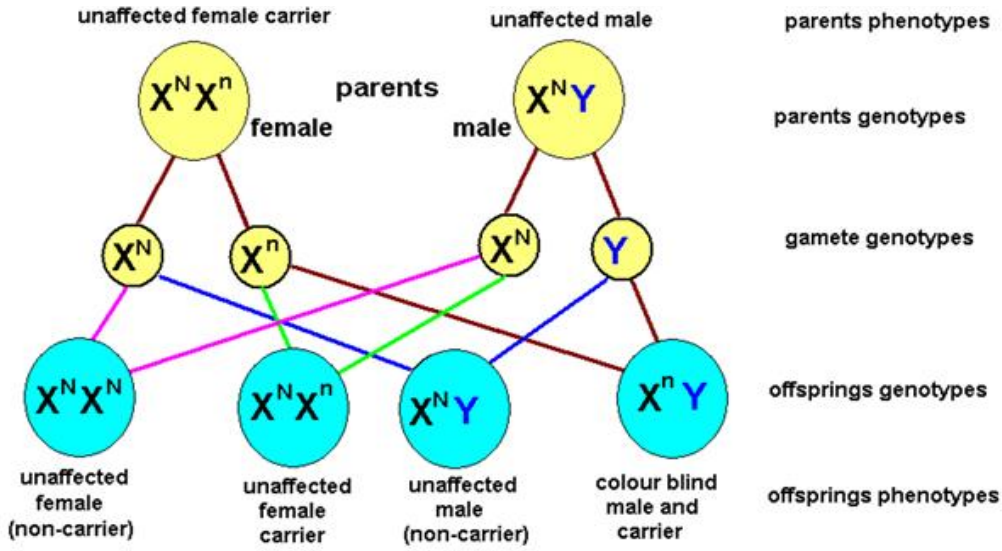
Let:

- X^N = normal vision allele (dominant)
- X^n = colour blindness allele (recessive)
- Y = male chromosome

Brian's mother is a carrier (X^NX^n)

Brian's father has normal vision (X^NY)

Cross: $X^NX^n \times X^NY$



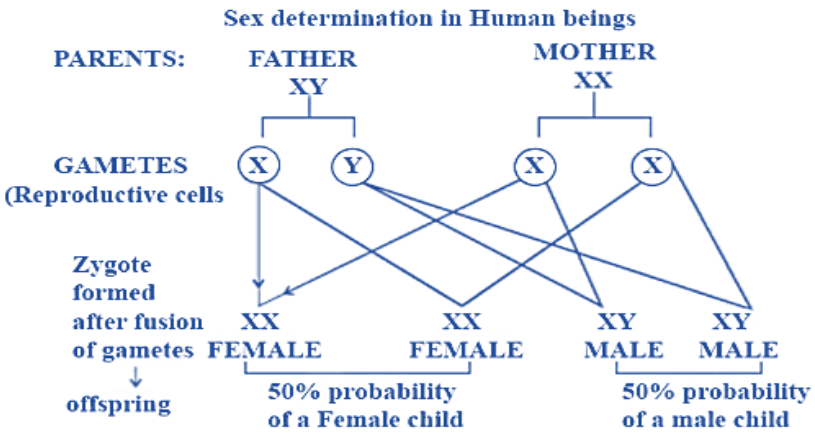
Conclusion:

- *Brian inherited the X^n allele from his mother and Y from his father, making him X^nY (colour blind)*
- *His mother shows no symptoms because she has a dominant normal allele (X^N) that masks the recessive allele*

b) Describe how sex determination and sex linkage are connected, and explain why such conditions affect boys more often than girls.

How sex determination and sex linkage are connected, and why such conditions affect boys more:

- Sex determination depends on the combination of sex chromosomes:
  - Females are **XX**
  - Males are **XY**



- Sex linkage refers to traits carried on the X chromosome, like colour blindness males have only one X chromosome, so any recessive gene on it will be expressed, because there's no second X to mask it females would need two copies of the recessive gene (X^nX^n) to show the condition, making it less common in girls
- Therefore, sex-linked disorders like colour blindness affect boys more often

c) Explain the role of meiosis in the formation of gametes that carry sex-linked traits like the one above.

Role of meiosis in forming gametes that carry sex-linked traits:

- Meiosis produces gametes (egg and sperm) by halving the number of chromosomes during meiosis, the X and Y chromosomes are separated into different gametes;
  In males: some sperm carry X, others carry Y
  In females: all eggs carry X (either X^N or X^n in carriers)
- This separation ensures that offspring inherit one sex chromosome from each parent
- Sex-linked traits like colour blindness are passed when an egg or sperm carries an X chromosome with a defective gene

Activity 26.3:

A family in Soroti has three children, one of whom was born with albinism, a condition where there's a lack of melanin in the skin, hair, and eyes. The parents, both with dark skin, are confused. A local health worker explains that albinism is caused by a recessive gene and both parents must be carriers.

Tasks and responses

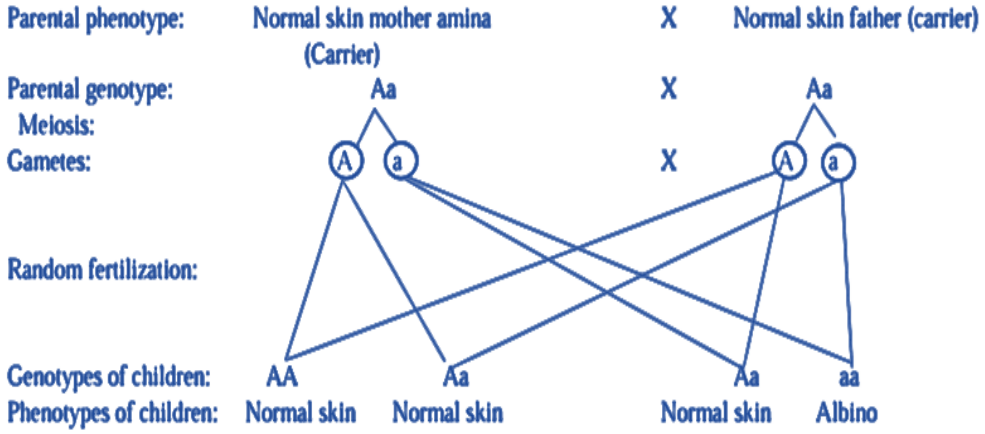
a) Use a genetic diagram to show how two parents with normal pigmentation but carriers of the albinism gene can have a child with albinism.

Genetic diagram and explanation

let; **A** represent allele for normal skin colour.

a represent defective allele for albinism.

A Cross between two parents who are both normal but carriers of defective allele for albinism



Genotypes and ratios:

- ✓ **AA**- Normal (not a carrier) = 1 (25%)
- ✓ **Aa** -Normal (carrier) = 2 (50%)
- ✓ **Aa** - Albino = 1 (25%)

Therefore, although both parents appear normal, there's **a 1 in 4 chance (25%)** of having a child with albinism in every pregnancy.

b) Explain how meiosis is involved in passing on the albinism gene from both parents.

How meiosis is involved in passing on albinism gene.

- ❖ Separation of alleles: During meiosis, the two alleles (A and a) in each parent separate, so each gamete carries only one.
- ❖ The father produces sperm with A or a, and the mother produces eggs with A or a.
- ❖ Random fertilization: When gametes combine, four possible outcomes occur (AA, Aa, Aa, aa).
- ❖ If both gametes carry the recessive a, the child will be aa (albino).

- ❖ Meiosis ensures variation, which explains why siblings from the same parents can differ in traits.

c) State two challenges people with albinism face in Uganda and suggest how schools and communities can support them.

Challenges faced by people with albinism in Uganda:

- High risk of skin cancer from excessive UV exposure.
- Poor eyesight (photophobia, low vision).
- Discrimination and stigma from peers or community.
- Cultural myths that may lead to fear, rejection, or even violence.
- Bullying and isolation in schools.
- Limited opportunities for jobs due to prejudice.
- Costs of skin care and visual aids are often unaffordable.

How schools and communities can support albinos

- ❖ Allow learners to sit at the front to see clearly.
- ❖ Provide learning materials in large print or use magnifiers like projectors to enable them see clearly.
- ❖ Encourage peer support and inclusion to prevent bullying.
- ❖ Offer sunscreen, hats, and shaded spaces during outdoor activities.
- ❖ Carry out awareness campaigns to fight myths and reduce stigma.
- ❖ Promote equal rights and opportunities for education and employment.
- ❖ Ensure health services provide affordable sunscreen and eye care.
- ❖ Strengthen laws and protection against attacks and discrimination.

Activity 26.4:

At Arua Regional Referral Hospital, a baby needs an urgent blood transfusion. The medical team is surprised when the mother's blood group is O, the father's is AB, and the baby is blood group O.

A student nurse suspects an error. The lead doctor explains how blood group inheritance works and reviews the genetic combinations involved.

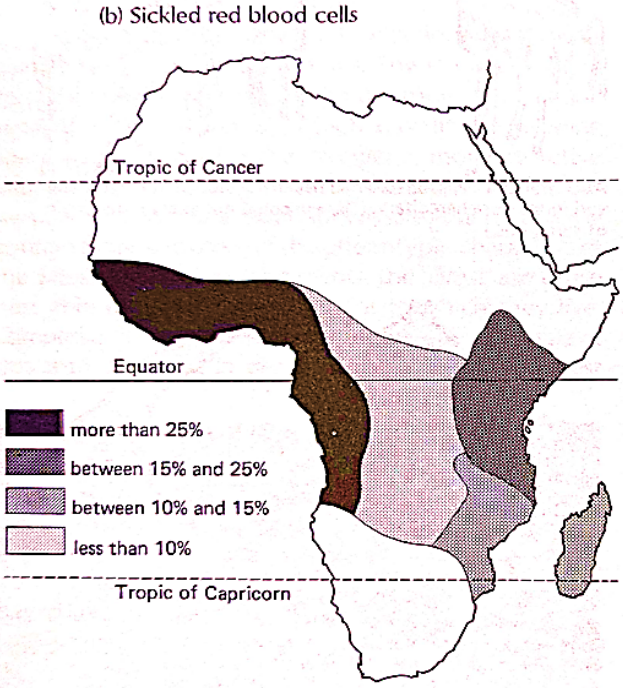
Tasks:

a) Use your knowledge and skills on genetics to show that a parent with blood group AB cannot have a child with blood group O, and explain your reasoning.

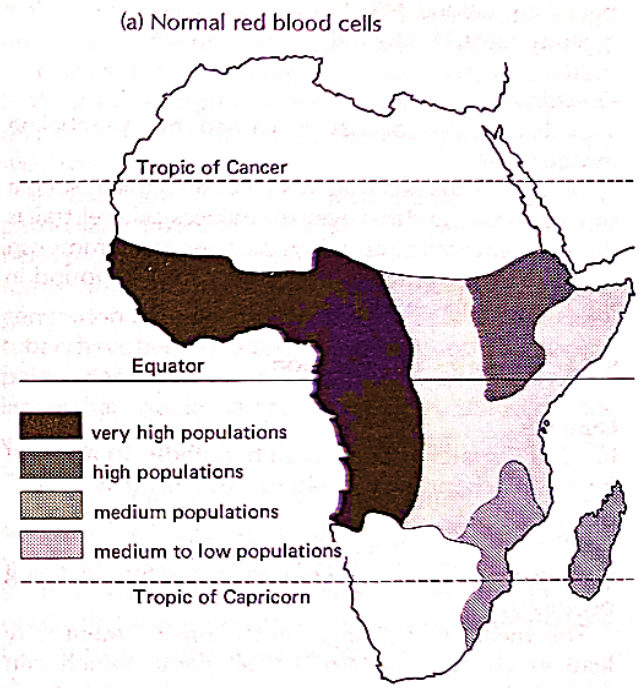
b) Describe the inheritance of blood groups using the concept of codominance (A and B) and recessiveness (O).

c) Explain how genetic testing can be used to resolve family disputes or confirm biological parentage in such cases.

Geographical distribution of sickle cell anaemia and malaria in the tropics



A map showing the distribution frequency of people carrying the gene for sickle cell haemoglobin



A map showing the distribution frequency of *Anopheles* mosquitoes which act as vectors for the organisms causing malaria