GENETICS AND INHERITANCE

Activity: Understanding the concept of inheritance using genetic diagrams

Teacher's Instruction:

1. *Organize learners into manageable groups or pairs*
2. *Ensure learners have access to charts, textbooks, digital devices and internet connection for internet search where possible and also provide learners with colored beads.*
3. *Engage learners in the activity by tasking them to brainstorm, research and discuss the meaning of the terms; genetics, chromosome, gene, dominant and recessive, heterozygous and homozygous, phenotype and genotype, and understand the laws of genetics and monohybrid inheritance in plants and animals.*
4. *In groups, learners research the meanings of the following terms: chromosome, gene, dominant and recessive, heterozygous and homozygous, phenotype and genotype. Share their understanding with the whole class using visual aids they create. Ensure that individuals explain using annotated diagrams.*
5. *In groups, learners research on inheritance, and develop an activity using coloured beads to explain the concept to the rest of the class. Ensure that individuals explain using annotated diagrams.*
6. *Observe groups and ensure that they are carrying out activities effectively, and making progress in terms of achieving learning outcomes.*
7. *Listen to learners' group and whole class conversations, prompt them and ask questions to ensure that they grasp difficult concepts.*
8. *Evaluate quality of contributions to group and whole class discussions. Use products like annotated diagrams and genetic diagrams to gauge understanding.*

Genetics refers to the study of inheritance and **inheritance** refers to transmission of characteristics from parents through offsprings from one generation to another.

Terms used in Genetics

a) ***Chromosome:*** A chromosome is a DNA thread wrapped in protein. Chromosomes carry inherited information from one generation to the next

b) ***Gene:*** This is a portion/segment of DNA controlling one particular characteristic.

c) ***Allele:*** This is an alternative form of a given gene. Each sexually-reproducing organism has two alleles for each of its characteristics. The alleles may be similar or different. One of the alleles is inherited from the male parent while the other one is from the female parent. Alleles which have more than two alternative forms are called multiple alleles.

d) ***Genotype:*** This is the combination of alleles an organism has for a given characteristic. It is also defined as the genetic composition of an organism for a particular characteristic. The genotype is normally written using a pair of letters, each representing one allele e.g. AA, Aa and aa.

e) ***Phenotype:*** This is the out-ward expression of the genotype in the form of physical characteristics of an organism.

f) ***Dominant:*** A dominant allele is one that gets expressed in the phenotype to the exclusion of another. It is always represented by a capital letter e.g. A, B, T and so on Recessive: A recessive allele is one that is over-shadowed in the phenotype by the presence of a dominant allele. It is always represented by a small/lowercase letter e.g. a, b, t and so on.

g) *Recessive:* A recessive allele is one that is over-shadowed in the phenotype by the presence of a dominant allele. It is always represented by a small/lowercase letter e.g. a, b, t and so on.

h) ***Codominance:*** Codominant alleles are two different alleles which are equally expressed in the phenotype when present together e.g. the alleles A and B for blood group

i) ***Homozygous:*** This a type of genotype where both alleles are the same i.e. both dominant or both recessive e.g. AA, aa, BB, bb and so on. Organisms which are homozygous are called homozygotes or pure breeds.

j) ***Heterozygous:*** This is a type of genotype where the two alleles are different, such as one allele is dominant while the other is recessive e.g. Aa, Tt and Bb. Organisms which are heterozygous are called heterozygotes or hybrids.

k) ***Incomplete dominance:*** This is a condition where neither of the genes is dominant over the other.

l) ***Gametes:*** These are reproductive cells. Fertilization: This is the fusion of the male and female gametes to form a zygote.

m)***Monohybrid inheritance***: This is a type of inheritance, which involves studying a single pair of contrasting characteristics.

n) ***Dihybrid inheritance:*** This is a type of inheritance, which involves studying two pairs of contrasting characteristics at ago. Test cross: This is a type of back cross which involves crossing an offspring having a dominant character with its recessive parent in order to determine the test of that offspring.

o) ***Back cross:*** This is the mating of an offspring with one of its parents.

Mendel's Experiments

Mendel used garden peas because:

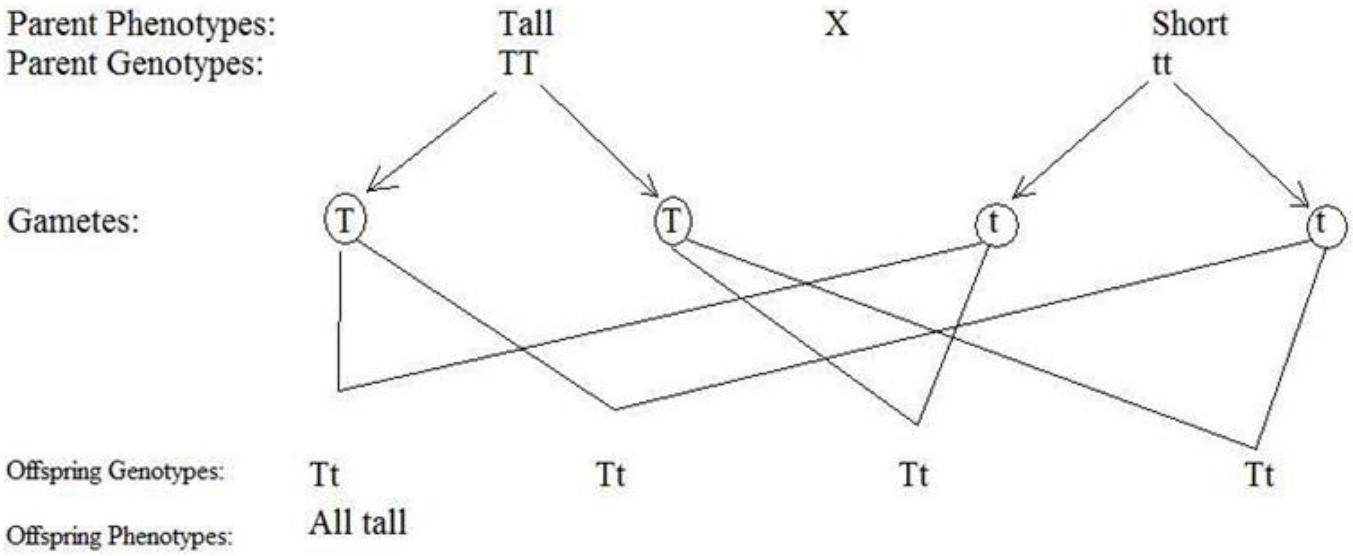
- They have a short life cycle
- They show contrasting characteristics e.g. short plants are always below 1 meter while tall plants always grow above 1 meter

Experiment 1

Mendel crossed homozygous tall plants with homozygous short plants. The seeds produced all grew into tall plants. From this Mendel concluded that the allele for tallness was dominant to the allele for shortness. This experiment can be explained using the following genetic diagram:

Let T represent the dominant allele for tallness and t represent the recessive allele for shortness

Let T= allele for tallness and t=allele for shortness

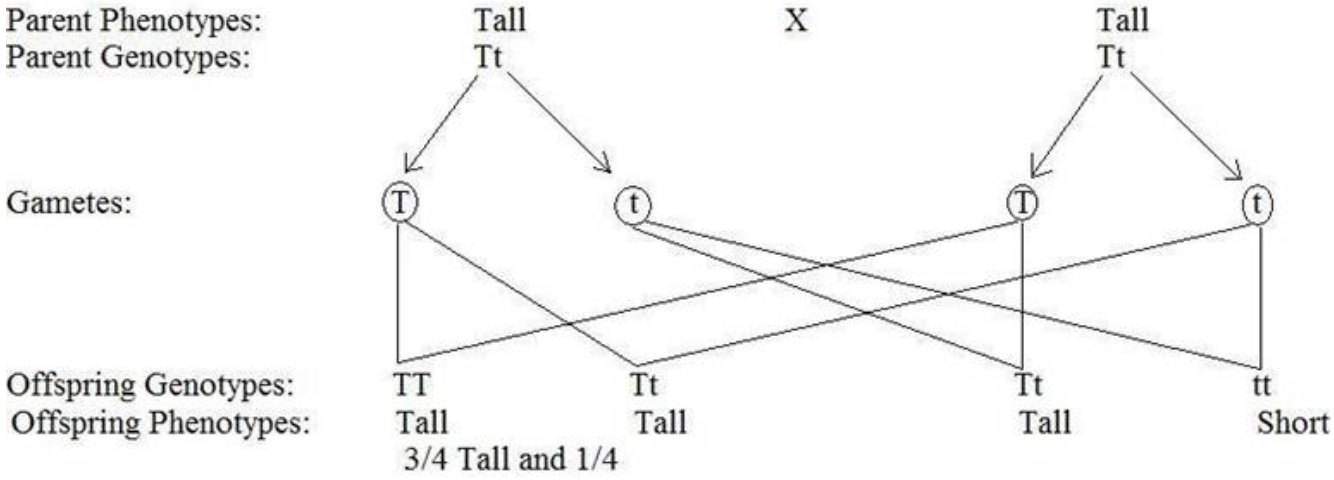


Note: The parents used at the beginning of any genetic experiment are called the first parental generation (P1 generation). The offspring of the P1 generation are called the first filial generation (F1-generation). The offspring of the F1 generation are called the second filial generation (F2-generation) and so on.

Experiment 2

Mendel allowed the F1 plants to self pollinate. ¾ of the offspring were tall while ¼ were short. This is explained by the following genetic diagram:

Let T= allele for tallness and t=allele for shortness



From the above crosses, Mendel came up with two laws that govern the inheritance of traits/ characters in the study of Genetics.

Mendel's laws of inheritance

First law: The law of segregation. This law states that the character of an organism is determined by a pair of alleles. Only one allele of such a pair is carried in a gamete.

Second law: The law of independent assortment. This states that each of the alleles in a pair may combine with another allele from another pair randomly.

Monohybrid inheritance

Inheritance is the passing over of characteristics of the parents to their off springs. Monohybrid inheritance involves the study of how one character is inherited from the parents to the off springs.

Monohybrid inheritance in human beings

The examples of Monohybrid inheritance in man include genetic disorders such as albinism, and sicklecell anaemia and genetic conditions such as skin colour, height, weight, tongue rolling, etc.

a) Genetic conditions

These include;

- Skin colour
- Height
- Weight
- Intelligence, etc.

Inheritance of skin Colour

Africans are either dark-skinned or brown in colour. The allele for dark skin colour is dominant over the allele for brown skin colour.

Let B represent the allele for dominant dark skin colour

Let b resent the allele for recessive brown skin colour

Possible genotypes and Phenotypes

Genotype	Phenotype
BB	Dark skinned
Bb	Dark skinned
bb	Brown skinned

Thus, when a brown skinned woman marries a dark-skinned man, all children produced by the couple all dark skinned as illustrated below;

Let B represent the dominant allele for dark skin colour and b represent the recessive allele for brown skin colour.

Parental Phenotype: Dark skinned man ***X*** *Brown skinned woman*

Parental Genotype: *BB* *bb*

Meiosis:

Gametes: **B** **B** **b** **b**

Random Fertilization:

Offspring Genotype: *Bb* *Bb* *Bb* *Bb*

Offspring Phenotype: All are dark skinned children

Note:

i) A heterozygous couple can produce both dark and brown skinned children since their genotype consists of two alleles, one for each trait as illustrated in the cross below;
Let B represent the dominant allele for dark skin colour and b represent the recessive allele for brown skin colour.

Parental Phenotype: Dark skinned man ***X*** *Dark skinned woman*

Parental Genotype: *Bb* *Bb*

Meiosis:

Gametes: **B** **b** **B** **b**

Random Fertilization:

Offspring Genotype: *BB* *Bb* *Bb* *bb*

Offspring Phenotype: 3 dark skinned children and one brown skinned child.

ii) Bleaching only changes the physical appearance/ phenotype of an individual and has no impact on the genetic constitution of an individual. This is the reason why dark children are produced when a dark skinned man marries a brown woman due to bleaching or when a brown man marries a bleached brown woman as illustrated in the crosses below;

a) When dark skinned man marries a brown woman due to bleaching

Let B represent the dominant allele for dark skin colour and b represent the recessive allele for brown skin colour.

Parental Phenotype: Dark skinned man ***X*** *Brown skinned woman*

Parental Genotype: *BB* *BB*

Meiosis:

Gametes: **B** **B** **B** **B**

Random Fertilization:

Offspring Genotype: *BB* *BB* *BB* *BB*

Offspring Phenotype: All dark skinned children

b) When a brown skinned man marries a brown woman due to bleaching

Let B represent the dominant allele for dark skin colour and b represent the recessive allele for brown skin colour.

Parental Phenotype: Brown skinned man ***X*** *Brown skinned woman*

Parental Genotype: ***bb*** ***BB***

Meiosis:

Gametes: **b** **b** **B** **B**

Random Fertilization:

Offspring Genotype: ***Bb*** ***Bb*** ***Bb*** ***Bb***

Offspring Phenotype: All dark skinned children

Trial Item

Mudoki a dark skinned man and married Ritah also dark skinned and a chair person of their Village Kirungu Coffee farmers Association. Ritah Associates with many peoples mostly investors and fellow farmers. In the past five years, the couple has had two dark skinned children and they have been living happily until last year when they produced a brown skinned baby girl. This raised a lot of concern among the couple as the husband suspects the wife of cheating. The woman has denied the husband's allegations.

Task.

As a Biology learner;

a) Using suitable genetic symbols show the man how it is possible for them to also have a brown child.
b) Show how it is possible for the man not to be responsible of the brown-girl child if the woman cheated.

Inheritance of height

The alleles for tallness are dominant over the alleles for shortness/ dwarfism.

Let T represent the dominant allele for tallness and **t** represent the recessive allele for shortness

Possible genotypes and Phenotypes

Genotype	Phenotype
TT	Tall indivual
Tt	Tall individual
tt	Short/ dwarf individual

Thus, when a short woman marries a tall man, all offsprings produced are tall as shown below;

Let T represent the dominant allele for Tallness and b represent the recessive allele for shortness.

Parental Phenotype: Tall man ***X*** *Short woman*

Parental Genotype: ***TT*** ***tt***

Meiosis:

Gametes: **T** **T** **t** **t**

Random Fertilization:

Offspring Genotype: ***Tt*** ***Tt*** ***Tt*** ***Tt***

Offspring Phenotype: All tall children

The couple produces both tall and short children if the parents are in a heterozygous condition as shown below;

Let T represent the dominant allele for Tallness and b represent the recessive allele for shortness.

Parental Phenotype: Tall man ***X*** *Short woman*

Parental Genotype: ***Tt*** ***Tt***

Meiosis:

Gametes: **T** **t** **T** **t**

Random Fertilization:

Offspring Genotype: ***TT*** ***Tt*** ***Tt*** ***tt***

Offspring Phenotype: 3 tall children and one short child

Thus the probability of producing tall children to short children will be 3:1.

Note: Physical shortness due to accident or certain diseases like polio, sickle cell anaemia, etc, only affect the individual's phenotype. It is for this reason why tall children are usually produced by some short individuals due to factors highlighted above.

Trial Item 1

Wabuyi a police Constable in at Bukwe police post is praised by many people for being gigantic and extremely tall. In Few years back, he married Annatalia the shortest lady in Bukwe village.Many expected the couple to produce only short child, to their surprise the couple has now produced two children and all are tall.

Task.

a) Explain to the residents how it's possible for the couple to have such children
b) Using suitable genetic symbols show how the couple was able to produce only tall children.
c) Explain to the residents how it may also possible to the couple to some short children and illustrate it using suitable genetic symbols.

Trial item 2

Nathan a short Boda boda rider in Wafula village was involved in a fatal accident that left many people killed at the age of 13years which affected his normal growth pattern and became stunted. In 2020, Nathan married Wabuyi a slender tall lady in in the same village. Since then, the couple has produced a total number of 3 children and all are tall. Nathan and many residents in the community believe that the woman may be cheating on him and are proposing to have a divorce and that the children may not be his.

Task:

As a Biology learner, use suitable genetic symbols to;

a) Explain to Nathan how he may be responsible for his children's height.
b) How he may not be responsible for these children.

Note: Intelligence, tongue rolling and body weight are inherited in the same way as the examples above.

c) Genetic disorders

They are caused by mutant recessive alleles. They includes; albinism and sickle cell anaemia

Albinism

This is a condition in human beings where the individual fail to produce skin pigments called melanin. ***Albinos have***; Light skin, vision problems due to abnormal development of the retina and optic nerve, skin problems including increased risk to skin cancer, white hair, Pink eyes, they are sensitive to bright light and difficulty in hearing

Management strategies

- Limiting exposure to direct sunlight/ ultra violet rays; that may cause kin damage.
- Vision correction by wearing glasses or eye surgery; to avoid damage of the eyes by UV light.
- Offering Genetic counseling especially to parents; for psychosocial support and minimize Going for guidance and counseling; for psychosocial support.
- Use of hearing aids/ cochlear implants; to aid hearing. Wearing protective clothes to prevent skin damage
- Regular medical check-ups in order to manage timely any skin damages and associated conditions.
- Feeding on a balanced diet rich in vitamin A; to improve sight/ for a healthy skin/ boost body's immune system.

Note: Albinism is caused by a recessive gene. When a normal man marries an albino, the possible genotypes and phenotypes include the following.

If A represents the allele for normal skin colour

Let a represent the allele for no skin colour/ albinism.

Genotype	Phenotype
AA	Normal skin colour
Aa	Normal but Carrier for albinism
aa	Albino

Note:

i) If a woman with normal skin colour (brown or black) marries an albino man all children will be normal skinned.

Let **A** represent the dominant allele for normal skin colour and **a** represent the recessive allele for albinism.

Parental Phenotype: Albino man ***X*** *Normal skinned woman*

Parental Genotype: ***aa*** ***AA***

Meiosis:

Gametes: **a** **a** **A** **A**

Random Fertilization:

Offspring Genotype: ***Aa*** ***Aa*** ***Aa*** ***Aa***

Offspring Phenotype: All normal skinned children

They are normal skinned because the dominant allele for normal skin colour suppresses the recessive allele for albinism in the phenotype of a heterozygous individual making them appear normal

ii) Also when a normal woman marries a carrier man for albinism, only normal children are produced.

*Let **A** represent the dominant allele for normal skin colour and **a** represent the recessive allele for albinism.*

Parental Phenotype: Normal skinned woman ***X*** *Normal skinned man*

Parental Genotype: ***aa*** ***AA***

Meiosis:

Gametes: **a** **a** **A** **A**

Random Fertilization:

Offspring Genotype: ***Aa*** ***Aa*** ***Aa*** ***Aa***

Offspring Phenotype: All normal skinned children

iii)If both parents are heterozygous for albinism, some of their children will be normal while others will be carriers and albinos as shown below;

Let **A** represent the dominant allele for normal skin colour and **a** represent the recessive allele for albinism.

Parental Phenotype: Normal skinned woman ***X*** *Normal skinned man*

Parental Genotype: ***Aa*** ***Aa***

Meiosis:

Gametes: **A** **a** **A** **a**

Random Fertilization:

Offspring Genotype: ***AA*** ***Aa*** ***Aa*** ***aa***

Offspring Phenotype: 3 normal skinned children and 1 albino child

Therefore, the chance of producing normal children is $\frac{3}{4}$ and that of producing albinos is $1/4$

2. Sickle cell anaemia

It is a genetic condition caused by a recessive mutant gene in which an individual's hemoglobin becomes defective. When the concentration of oxygen is low in blood, the red blood cells assume the shape of a sickle since the cells cannot absorb oxygen properly. **Note**: People who are heterozygous i.e. they have mutated and non-mutated genes have normal red blood cells.

Likely appearance/ symptoms

- Anaemia
- Pain episodes as sickle cells get stuck in small blood vessels.
- Vision problem.
- Increased risk of stroke
- Organ damage including the kidney, liver and heart
- Body weakness.
- Joint pains
- Dehydration
- Frequent sickness/ low immunity
- Stunted growth
- Muscle wasting
- Low birth weight

Management strategies for sickle cell anemia

- Blood transfusion; to maintain normal blood volumes in the body/ to improve oxygen transportation.
- Use of pain killers to relieve pain/ avoid joint pains.
- Immediate treatment of any infection; to maintain the body healthy
- Use of stem cell pills; to boost numbers of red blood cells.
- Frequent rehydration of the body; to maintain adequate blood volumes in the body.
- Feeding on a balanced diet reach in iron and vitamin B12, for manufacture of red blood cells.
- Genetic counseling; for psychosocial support and prevent mental distress.

- Regular medical checkup and follow ups; to ensure timely treatment of any infections/ maintain the body healthy.
- Use of antibiotics to prevent infections
- Use of folic acid supplements to increase red blood cell production
- Avoiding extreme temperatures
- Regular physical exercises; for normal healthy growth of the body.
- Getting enough rest to manage fatigue.

If **S** represents the allele for normal Rd blood cell shape
Let **s** represent the allele for sickle shaped Redblood cell.

Genotype	Phenotype
SS	Normal
Ss	Normal
ss	Sickler

Note:

i) If a normal woman marries a sickler man all children produced are normal.

Let **S** represent the dominant allele for normal red blood cell shape and **a** represent the recessive allele for sickle cell anaemia.

Parental Phenotype: Normal woman ***X*** *Sickler man*

Parental Genotype: ***SS*** ***ss***

Meiosis:

Gametes: **S** **S** **s** **s**

Random Fertilization:

Offspring Genotype: ***Ss*** ***Ss*** ***Ss*** ***Ss***

Offspring Phenotype: All are carriers but normal.

ii) Also when a normal woman marries a carrier man for sickle cell, only normal children are produced

Let S represent the dominant allele for normal red blood cell shape and a represent the recessive allele for sickle cell anaemia.

Parental phenotype: Normal Woman X Normal man

Parental genotype: ***SS*** ***Ss***

Meiosis:

Gametes: **S** **S** **S** **s**

Random fertilization:

Offspring genotype: ***SS*** ***Ss*** ***SS*** ***Ss***

Offspring Phenotype: All normal/ are Not sicklers

iii) If both parents are heterozygous for sickle cell, some of their children will be normal while others will be carriers and sicklers as shown.

Let S represent the dominant allele for normal red blood cell shape and a represent the recessive allele for sickle cell anaemia.

Parental phenotype: Normal Woman X Normal man

Parental genotype: ***Ss*** ***Ss***

Meiosis:

Gametes: **S** **s** **S** **s**

Random fertilization:

Offspring genotype: ***SS*** ***Ss*** ***Ss*** ***ss***

Offspring Phenotype: 3Normal children and 1 sickler.

Thus, the probability of such a couple producing normal children is $3/4$ *and to produce an albino is* $1/4$.

Monohybrid Inheritance in plants

This includes; plant height, flower colour, seed shape and seed/ pod colour.

Inheritance of plant height

In plants, the allele for tallness is dominant over that for shortness.

Let the allele for tallness be **T** and that for shortness be **t**

Possible genotypes and Phenotypes

Genotype	Phenotype
TT	Tall plant
Tt	Tall plant
tt	Short/ dwarf plant

Thus, when a short pea plant is cross pollinated with a tall pea plant, all offsprings produced are tall, however if controlled breeding is conducted on any two of the F1 plants, a mixture of tall and short plants are produced in a ratio of 3:1 as shown below;

Let **T** represent the dominant allele for tallness and **t** represent the recessive allele for shortness.

Parental phenotype: Short pea plant X Tall pea plant

Parental genotype: ***tt*** ***TT***

Meiosis:

Gametes: **t** **t** **T** **T**

Random fertilization:

Offspring genotype: ***Tt*** ***Tt*** ***Tt*** ***Tt***

Offspring Phenotype: All tall.

Selfing of F1 Plants;

Parental phenotype: Tall pea plant X Tall pea plant

Parental genotype: ***Tt*** ***Tt***

Meiosis:

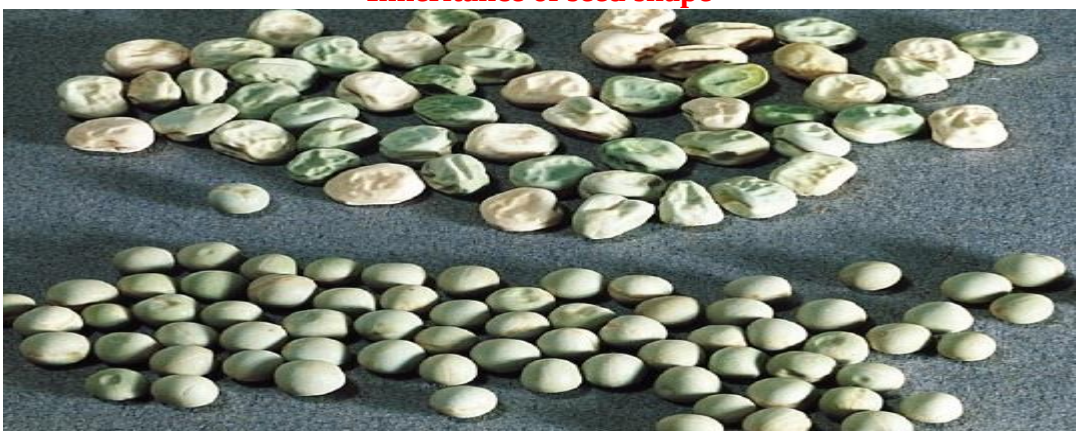
Gametes: **T** **t** **T** **t**

Random fertilization:

F_2 Offspring genotype: ***TT*** ***Tt*** ***Tt*** ***tt***

Offspring Phenotype: 3 tall pea plants and 1 short pea plants

Inheritance of seed shape



In plants, the allele for round seed shape is dominant over that for wrinkled seed shape.
Let the allele for Round seed shape be **R** and that for wrinkled seed shape be **r**

Possible genotypes and Phenotypes

Genotype	Phenotype
RR	Round seeded plant
Rr	Round seeded plant
Rr	Wrinkled seeded plant

Thus, in controlled breeding when a round seeded plant is cross pollinated with a wrinkled seeded plant, all offsprings produced are round seeded, however if any two of the F1 plants are crossed, a mixture of round seeded and wrinkled seeded plants are produced in a ratio of 3:1 as shown below;
Let **R** represent the dominant allele for round seed shape and **r** represent the recessive allele for wrinkled seed shape.

Parental phenotype: Round seeded pea plant X Wrinkled seeded pea plant

Parental genotype: ***RR*** ***rr***

Meiosis:

Gametes: **R** **R** **r** **r**

Random fertilization:

Offspring genotype: ***Rr*** ***Rr*** ***Rr*** ***Rr***

Offspring Phenotype: All Round seeded plants.

Selfing of F1 Plants;

Parental phenotype: Round seeded plant X Round seeded plant

Parental genotype: ***Rr*** ***Rr***

Meiosis:

Gametes: **R** **r** **R** **r**

Random fertilization:

F_2 Offspring genotype: ***RR*** ***Rr*** ***Rr*** ***rr***

Offspring Phenotype: 3 round seeded pea plants and 1 wrinkled seeded pea plants

Inheritance of seed colour

In plants, the allele for Yellow seed colour is dominant over that for green seed colour.
If the dominant allele for Yellow seed colour is **Y** and the recessive allele for wrinkled seed shape be **y**

Possible genotypes and Phenotypes

Genotype	Phenotype
YY	Yellow seeded plant
Yy	Yellow seeded plant
yy	Green seeded plant

Thus, in controlled breeding when a yellow seeded plant is cross pollinated with a green seeded plant, all offsprings produced are yellow seeded, however if any two of the F1 plants are crossed, a mixture of yellow seeded and green seeded plants are produced in a ratio of 3:1 as shown below;

Illustration

Let **Y** represent the dominant allele for yellow seed colour and **r** represent the recessive allele for green seed colour.

Parental phenotype: Yellow seeded pea plant X Green seeded pea plant

Parental genotype: ***YY*** ***yy***

Meiosis:

Gametes: **Y** **Y** **y** **y**

Random fertilization:

Offspring genotype: ***Yy*** ***Yy*** ***Yy*** ***Yy***

Offspring Phenotype: All Yellow seeded plants.

Selfing of F1 Plants;

Parental phenotype: Yellow seeded plant X Yellow seeded plant

Parental genotype: ***Yy*** ***Yy***

Meiosis:

Gametes: **Y** **y** **Y** **y**

Random fertilization:

F_2 Offspring genotype: ***YY*** ***Yy*** ***Yy*** ***yy***

Offspring Phenotype: 3 yellow seeded pea plants and 1 green seeded pea plants

Inheritance of Flower colour

In hibiscus plants, the allele for red flowered plants is dominant over that for white flowers.
Let the allele for red flower colour be **R** and that for white flower colour be **r**

Possible genotypes and Phenotypes

Genotype	Phenotype
RR	Red flowered plant
Rr	Red flowered plant
rr	White flowered plant

Thus, when a red flowered plant is cross pollinated with a white flowered plant, all F1 plants are red flowered plants, however if controlled breeding is conducted on any two of the F1 plants, a mixture of red and white flowered plants are produced in a ratio of 3:1 as shown below;

Illustration

Let **R** represent the dominant allele for red flowered pea and **r** represent the recessive allele for white flowered pea plant.

Parental phenotype: Red flowered pea plant X White flowered pea plant

Parental genotype: ***RR*** ***rr***

Meiosis:

Gametes: **R** **R** **r** **r**

Random fertilization:

Offspring genotype: ***Rr*** ***Rr*** ***Rr*** ***Rr***

Offspring Phenotype: All Red flowered plants.

Note: All F_1 offsprings are red flowered because the dominant alleles for red flowers suppresses the recessive alleles for white flowers

Selfing of F1 Plants;

Parental phenotype: Red flowered pea plant X Red flowered pea plant

Parental genotype: ***Rr*** ***Rr***

Meiosis:

Gametes: **R** **r** **R** **r**

Random fertilization:

F_2 Offspring genotype: ***RR*** ***Rr*** ***Rr*** ***rr***

Offspring Phenotype: 3 red flowered pea plants and 1 white flowered pea plants

SEX DETERMINATION IN HUMAN BEINGS

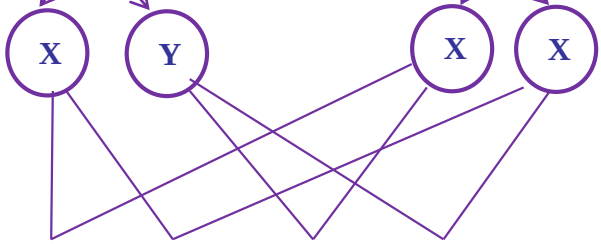
Males are heterogametic as XY and females are homogametic as XX. At fertilization, a sperm fuses with the egg. If the X sperm fuses with an egg (X), the resulting offspring is XX and is a female. If a Y sperm fuses with an egg (X), the resulting individual is XY and is a male. Therefore, the male determines the sex of the offspring. This is because the male produces two different sperms (X and Y) while the female produces only eggs with X chromosomes and the chance of producing either a boy or a girl is usually a half as shown below;

Parental phenotype: *Man* *X* *Woman*

Parental genotype: ***XY*** ***XX***

Meiosis:

Gametes:



Random fertilization:

F_2 Offspring genotype: ***XX*** ***XX*** ***YX*** ***XY***

Offspring Phenotype: Two girls and Two boys

The probability of producing a girl $= \frac{Number\ of\ girls\ produced}{Total\ number\ of\ children\ produced}$

$= \frac{2}{4}$

Thus, the probability of producing a girl $= \frac{1}{2}$

The probability of producing a boy $= \frac{Number\ of\ boys\ produced}{Total\ number\ of\ children\ produced}$

$= \frac{2}{4}$

Thus, the probability of producing a boy $= \frac{1}{2}$

Therefore, the probability of producing either a girl or a boy is usually the same and equals to a half.

Note: The sperms with a Y-chromosome are more active and persistent than the sperms with an X-chromosome. This increases the chances of an ovum to be fertilized by a Y sperm. So, to every 100 girls, 120 boys are born but more boys than girls die at the time of birth.

SEX LINKED TRAITS/CHARACTERS

These are traits or genes associated with the sex of the individual and are carried on the sex chromosomes, controlled or determined by the genes on those chromosomes.

Characteristics of sex- linked traits

- Influenced by genes carried on X-chromosome
- Influenced by recessive genes
- Usually disadvantageous
- If the character is with the mother, it affects the boy child and if it is with the father, it affects the boy child.
- Females may be normal, carriers or sufferers of the condition because they have two X-chromosomes in their genotype.
- Males can either be normal or sufferers because by only have a single X-chromosome in their genotype.
- These characters appear in a recessive form and are very common in males than in females

Examples of Sex linked traits include;

1. Colour blindness
1. Haemophilia (bleeder disease)

Inheritance of color blindness

Color blindness is a genetic defect of the eyes caused by a recessive gene on the X chromosome. Color blind individuals are unable to distinguish between red and green colors.

Example

Let C represent the allele for normal color vision

Let c represent the allele for color blindness

Genotype	Phenotype
X^CX^C	Woman with Normal Colour vision
X^CX^c	Woman with Normal colour vision
X^cX^c	Colour blind woman
X^CY	Man with Normal colour vision
X^cY	Colour blind man

Note:

i) When a colour blind man is married to a normal woman for colour vision, all girl children produced by the couple will be carriers and all boys normal as shown.

Illustration

Let **C** represent the all for normal colour vision and **c** represent the allele for colour blindness

Parental phenotype: Colourblind Man X Woman with normal colour vision

Parental genotype: X^cY X^CX^C

Meiosis:

Gametes: X^c Y X^C X^C

Random fertilization:

F_2 Offspring genotype: X^CX^c X^CX^c X^CY X^CY

Offspring Phenotype: All normal/ have normal colour vision

ii) When a colour blind woman is married to a man with normal colour vision, all their boy children will be sufferers and all the girls carriers of the condition as shown below;

Let **C** represent the all for normal colour vision and **c** represent the allele for colour blindness

Parental phenotype: *Normal Man X Colourblind woman*

Parental genotype: X^CY X^cX^c

Meiosis:

Gametes: X^C Y X^c X^c

Random fertilization:

F_2 Offspring genotype: X^CX^c X^CX^c X^cY X^cY

Offspring Phenotype: *All girls have normal colour vision and the boys are colourblind*

iii)When a woman heterozygous for colour vision is married to a man with normal colour vision, all their girl children will be normal and some of the boys will be normal while others will be sufferers of the condition as shown below;

Let **C** represent the all for normal colour vision and **c** represent the allele for colour blindness

Parental phenotype: *Normal Man X Normal woman*

Parental genotype: X^CY X^CX^c

Meiosis:

Gametes: X^C Y X^C X^c

Random fertilization:

F_2 Offspring genotype: X^CX^C X^CX^c X^CY X^cY

F_2 Offspring Phenotype: *three children with normal colour vision and One colour blind boy*

Inheritance of hemophilia (bleeders disease)

It is a genetic disease in which blood takes a long time to clot at a wound. It is also known as the bleeder's disease. This disease is caused by a recessive gene which is carried on the X chromosome.

Symptoms

- Dehydration
- Recurring joint bleeding
- Swelling in the joints
- Muscle pain and weakness
- Internal bleeding
- Easy bruising
- Anemia
- Body weakness and fatigue
- Excessive/ prolonged bleeding from cuts and wounds
- Prolonged clotting of blood
- Frequent sickness/ low immunity

Management strategies

- Blood transfusion to replace lost blood/ increase blood volume
- Avoid contact sports or activities that may increase the risk of injury
- Regular physical exercise to maintain joint mobility and strength
- Maintain a healthy weight to reduce pressure on joints.
- Joint replacement surgery/ replacing damaged joints with artificial ones
- Synovectomy/ removing inflamed synovial tissue to reduce bleeding and pain
- Providing genetic counseling to cope with emotional and psychological aspects of condition.
- Administration of clotting factors to improve blood clotting

- Feeding on a balanced diet rich in vitamins to increase blood volumes.
- Having dietary supplements rich in Vitamin K and calcium to improve on blood clotting

If **H** represents allele for normal blood clotting and **h** represents the allele for haemophilia

Genotype	Phenotype
X^HX^H	Normal woman
X^HX^h	Normal woman
X^hX^h	Haemophiliac woman
X^HY	Normal man
X^hY	Haemophiliac man

Note:

i) When a haemophiliac man is married to a normal woman, all girl children produced by the couple will be carriers of haemophilia and the boys will be normal as shown below;

Let **H** represent the all for normal blood clotting and **c** represent the allele for haemophilia

Parental phenotype: *Haemophiliac Man X Normal woman*

Parental genotype: X^hY X^HX^H

Meiosis:

Gametes: X^h Y X^H X^H

Random fertilization:

F_2 Offspring genotype: X^HX^h X^HX^h X^HY X^HY

F_2 Offspring Phenotype: *All Normal*

ii) When a haemophiliac woman is married to a normal man, all their boy children will be sufferers and all the girls carriers of the condition as shown below;

Let **H** represent the all for normal blood clotting and **c** represent the allele for haemophilia

Parental phenotype: *Normal Man X Haemophiliac woman*

Parental genotype: X^HY X^hX^h

Meiosis:

Gametes: X^H Y X^h X^h

Random fertilization:

F_2 Offspring genotype: X^HX^h X^HX^h X^hY X^hY

F_2 Offspring Phenotype: *Two Normalgirls and Two haemophiliac boys*

iii)When a woman heterozygous for haemophilia is married to a normal man with, some of their boy children will be sufferers and others haemophiliacs while the girls will be normal as shown below;

Let **H** represent the all for normal blood clotting and **c** represent the allele for haemophilia

Parental phenotype: *Normal Man X Normal woman*

Parental genotype: X^HY X^HX^h

Meiosis:

Gametes: X^H Y X^H X^h

Random fertilization:

F_2 Offspring genotype: X^HX^H X^HX^h X^HY X^hY

F_2 Offspring Phenotype: *Three normal girls and One haemophiliac boy*

Sample Items

Item1

David got married to Joan and they produced a son. Their son, when injured, bleeds a lot even with a slight cut on the skin and this causes a lot of distress in the family. When Joan got pregnant for the second time, David advised her to abortion the belief that they would get a a child with similar condition like that of their first born son.

However, when David and Joan went to the hospital concerning their son's condition, they were told that the condition was as a result of Joan being a carrier of haemophilia.

Task:

a) Explain why Joan should not take David's advice.

b) Show how their son inherited the condition.

c) What should Joan and David do to manage the challenges associated with the condition of their son?

Item 2

Alinaitwe a nice looking lady in Hoima, got married in her mid-40s, lucky enough; she got pregnant and eventually gave birth to a daughter characterized with round flat face, small ears and below average performance in classroom work. The doctors told her that the daughters were having a condition called trisomy 21. Alinaitwe advised by her colleagues to poison the daughter as she was a disgrace and curse to their clan and family.

Task

a) Evaluate the advice by Alinaitwe's colleagues.

b) Show how Alinaitwe's daughter obtained the condition

c) What should Alinaitwe do to manage the challenges associated with the condition of her daughter?

Item 3

Jane, a 28-year-old pregnant mother is now in her 39th week of gestation. She has not attended antenatal care throughout her pregnancy and has been consuming alcohol frequently. She would often drink beer and wine with friends and family, thinking it was harmless. Jane has started experiencing contractions and is preparing to give birth soon. However, Jane's healthcare provider is concerned about the potential risks associated with her alcohol consumption and lack of antenatal care.

Tasks

a) What are the likely impacts of her lifestyle?

b) Advice the community on how such a life style can be managed for a better life and safety of the child.

c) Advise Jane on how it is important to take up advice of her health care provider.

Item 4

Mr. and Mrs. Ayoleka, both tall individuals, are concerned about their newborn baby's height. Despite their expectations, their child is significantly shorter than average. They visit the pediatrician, worried that the midwives may have mistakenly switched their baby at birth or the failure of the wife to attend antenatal care.

Task

a) Explain to the couple how it is possible to have such a child in their family.
b) What could be the other likely causes of the child's condition?
c)Why would it be important for Mrs. Ayoleka to go for antenatal care?

Item 5

Monica and Allan a dark skinned couple in Alwar village, Kigorobya county produced an albino child. This has confused the couple since they all have a normal skin color.

Task

As a Biology student:

a) Advise the couple on how it's possible for them to have such a child.
b) What is the likely appearance of this family's child?
c) What can be done for the child to live a healthy life?