CHROMOSOMES, GENES, & DNA

CHROMOSOME.

- Is a fine, coiled, thread like structure found in a cell nucleus, on which genes are carried at points called **loci**.
- Made up of a pair of chromatids, joined at the **centromere**
- Most chromosomes exist in pairs; each pair of such chromosomes similar in structure, but chemically different is known as **a pair of homologous chromosomes**
- Exist in different number in the body cells of organisms of the same species, but half in their gametes e.g human body cell contains 46 chromosomes, and 23 in sperms and ova.
- Can replicate(make copies of itself, doubling in number)
- Number and structure can change through mutation.
- Homologous chromosomes can exchange parts during crossing over.

QN. Describe the structure and state the characteristics of chromosomes.

GENE;

- Is a basic unit inheritance for a given characteristic e.g. colour of seeds, flower position etc
- Control specific characters in organisms
- Are inherited as discrete/complete units
- Can be affected by chemicals, heat and radiations
- Chemically made up of nucleic acid , Deoxyribonucleic acid(DNA)

DNA ;

- Is a carrier of genetic information consisting of long molecules, coiled in a double helix; whose strands are chains of **5carbon sugar** (deoxyribose) , **phosphates**, and **nitrogenous bases**.(see DGmackean, page 184 for details).

CELL DIVISION.

- Is a process by which a parent cell divides forming daughter cells(new cells)
- Results into increase in cell number
- Two types exist i.e
  - ✓ Mitosis(mitotic cell division)
  - ✓ Meiosis(meiotic cell division)

(a) MITOSIS(Mitotic cell division)

- ✓ is the division of a parent cell into two identical daughter cells; each having the same number and kind of chromosomes as the parent cell.
- ✓ Cells produced are genetically identical to the parent cell and each other
- ✓ involves four major stages namely: **Prophase**, **metaphase** ,**anaphase** and **telophase** with a resting stage called **inter phase**.

Description of the process of mitosis

Stage/phase and diagram	Description of events
i. i**nterphase**	-chromosome material is inform of very loosely coiled threads(chromatins) -Energy is built up for the process of cell division -New cell organelles are formed e.g mitochondria ,chloroplasts etc -Nucleolus is visible -Centrioles duplicate itself -DNA /Genetic material duplicate.
ii. **Prophase**.(first stage of nuclear division)	-chromosomes,thicken, shorten and become visible -Centriole moves towards the opposite pole of cell(Animal cells) -Spindle fibre form -Spindle fibre spread from one pole towards each other to form microtubules - aster radiate from each centriole -Nucleolus disappear at late prophase -Nuclear envelope breaks down & completely disappears at late prophase ,causing chromosome to lie free in the cytoplasm.

(iii) **metaphase**(second stage of nuclear division)	-spindle fibres are fully formed from centriole to centriole -Chromosomes arrange themselves at centre/equator of spindle
(iv) **anaphase**(third stage of nuclear division)	-centromere split into two separating each pair of sister chromatids. -spindle fibre contract pulling chromatids along behind at centromere toward opposite poles -At late Anaphase chromatids reach their respective poles
(v) **telophase**(fourth &final stage of nuclear division)	-At early telophase, chromatids reach their respective poles, change into chromosomes -Spindle fibre disappear -Nuclear envelope reforms around the chromosomes at each pole. -chromosome become thread like and invisible -centriole duplicate itself -Nucleoli reappear - cytoplasm divides(cytokinesis occurs) and the new cells formed at late telophase.

QUESTION .**Describe the process of Mitosis**

Importance /significance of mitosis

- ✓ Growth as it increases the number of cells in the body
- ✓ Basis for a sexual mode of reproduction
- ✓ Replacement of damaged/dead cells in the body .Exisiting cells divide by mitosis to provide additional cells.
- ✓ Ensuring that each cell is genetically identical

NB;

- ✓ In plants, mitosis occurs in **meristematic tissues** at tips of shoot and roots, **cambium tissue** and **buds.**
- ✓ In Animals, mitosis occurs in all somatic cells e.g. bone cells ,malpighian layer of the epidermis of the skin.

(b) MEIOSIS/REDUCTIVE DIVISION

- ✓ It's the type of cell division that gives rise to four reproductive cells(gametes) each containing half the chromosome number to that of the parent cells.
- ✓ occurs in
  - (i). **Testes** and **Ovaries** in animals; and
  - (ii) **ovary** and **anther heads** of flowers.
- ✓ occurs in two phases;

  -First meiotic division involving; **prophase I**, **metaphaseI** ,**Anaphase I** and **Telophase I**

  -Second meiotic division (same as mitotic divisions) ,which involve **prophase II**, **metaphase II**, **Anaphase II** and **Telophase II**.

NB; Both these divisions i.e first and second meiotic divisions are followed by a resting stage, interphase.

Description of the process of meiosis.

Stage/phase and diagram	Description of events
(i) **Prophase I**	-chromosomes shorter , thicken and become visible -Nucleolus disappear -Homologous chromosomes pair up to form bivalents, and split into chromatids. -Adjacent chromatids/non sister chromatids in the bivalent cross over each other forming a chiasma. -crossing over cause exchange of genetic materials leading to genetic variations. -centrioles migrate to opposite poles -spindle fibres start forming -nucleolus and nuclear membrane shrinks and disappear.
(ii)**Metaphase I**	-Homologous chromosomes arrange themselves at the equator of the spindle fibre. -spindle fibres are fully formed. -nuclear membrane continues shrinking, and eventually disappears.
(iii) **Anaphase I**	- Spindles fibres contract pulling each chromosomes apart -One chromosome in each pair is pulled towards one pole; separating bivalents.
(iv) **Telophase I**	-sprindle fibre disappear -New nuclear membranes form to surround each set of chromosomes - cell constricts across the middle, dividing into new cells -Chromosomes number is halved -Nucleolus re-appear
Prophase II	-Chromosome become visible -chromosome shorten and thicken -Centrioles move to opposite poles -Spindle fibres form from centrioles -Nucleolus and Nuclear membrane disappear.

Metaphase II	-chromosome (with chromatids) arrange themselves along the equator of the cells; on the spindle fibres.
Anaphase II	-Spindle fibres contract and shorten separating the sister chromatids. -Sister chromatids are pulled to opposite poles.
Telophase II	-Chromatids reach the poles and cells constrict at equator -Nuclear membranes and Nucleolus reform -chromatids change into chromosomes -Spindle fibres disappear -Each new cell from 1st meiotic results into two daughters,making a total of four new daughter cells.

Significance of Meiosis

- ✓ results in the formation of gametes
- ✓ ensures that each gamete has half the number of chromosomes those found in original cells(haploid cells)
- ✓ Ensures variation of genetic material during crossing over in prophase I
- ✓ By forming gametes meiosis serves as a basis for sexual reproduction.

Comparison between Mitosis and Meiosis

(A) Similarities

- ✓ Both involve interphase, prophase,metaphase,Anaphase and Telophase
- ✓ In both ,there is disappearance of Nucleolus and Nuclear membrane.
- ✓ Bothe cell division involve use of energy
- ✓ In both ,daughter cells are formed from parent ones
- ✓ Both involve division of the cell
- ✓ involve formation of the spindle fibres, centriole and DNA replication.
- ✓ In both homologous chromosomes assemble on the spindle fibres.
- ✓ Both involve single duplication of chromosomes.

(B) Differences;

Mitosis	Meiosis
Take place in somatic cells	Takes place in Gamete producing cells
Mainly for growth, repair and sexual reproduction	Mainly for gamete formation
Two daughter cell are formed from parents cells	Four daughter haploid cells are formed as a result
Each daughter cell has diploid number of chromosomes	Each daughter cell has haploid number of chromosomes
It takes place in a single phase of stages	Takes place in two phases i.e. Meiosis I and Meiosis II
There are No bivalent formations	Bivalent formation takes place

Daughter cells are identical to parent cells	Daughter cells are not identical to the parent one
The number of chromosomes are retained	The number of chromosomes is not retained i.e. its halved
Chiasmata do not form	Chiasmata form
No crossing over occurs	Crossing over may occur
Takes a short period of time	Takes a long period of time
No genetic variation occurs	Leads to genetic variation

REVISION QUESTIONS.

1. At what stage of meiosis does the pairing up of homologous chromosomes occur?
   A. Prophase I
   B. Prophase II
   C. Metaphase II
   D. Metaphase III
2. Name the part marked X on the pair of the chromosomes.

   A. Crossing over
   B. Centromere
   C. Chisama
   D. Chromoatid
3. The following occur during mitosis in animal cells;
   i. Chromosomes thicken and become more visible
   ii. Centromeres divide
   iii. Chromosomes line up at the equator of the spindle
   iv. Daughter centromeres are pulled to the opposite pole of the spindle

   Which of the above occurs during anaphase period?
   A. (i) and (ii)
   B. (i) and (iii)
   C. (ii) and (iv)
   D. (iii) and (iv)
4. (a). What is mitosis?
   (b) What is the importance of mitosis to living things?
   (c) Give differences between mitosis and meiosis
5. Which is the correct sequence of phases during mitosis?
   A. Metaphase , anaphase, prophase, and telophase
   B. Prophase , metaphase, anaphase, and telophase
   C. Anaphase , prophase, metaphase, and telophase
   D. Prophase, anaphase, metaphase, and telophase
6. (a). Distinguish between mitosis and meiosis.
   (b). Where does mitosis occur in living organisms.
   (c). How important is meiosis to living organisms?

INHERITANCE, GENETICS AND VARIATION

- ✓ Inheritance is the passing of parental characteristics to their off springs /next generation.Genetics is the scientific study of inheritance or heredity.

Some common terms in Genetics

Term	**Definition/description**	**Examples**
Gene	Is the basic unit of inheritance for a given characteristic.	Flower position, colour of seeds etc
Allele	One of the alternative forms of the same gene on the same gene locus and affecting the same character.	-T or t representing genes controlling height in plants.
locus	Position on the chromosome where a gene is located	
Diploid(2n)	Condition whereby a cell has two complete sets of chromosomes.	
homozygous	Condition in which alleles of the gene at a locus are identical	-TT or tt , representing height in plants
heterozygous	Conditions in which alleles of a gene at a locus are different.	Tt for height, Bb for skincolour
phenotype	Observable or outward appearance of an organism	Being tall or short in plants
Genotype	Genetic constitution or make up of an organism	TT,Tt,tt are possible genotypes for height
Dominant allele	-one that expresses itself in both homozygous and heterozygous state. -represented by capital letters	-T , dominant allele for tallness Individual with genotypes, Tt, TT appear tall.

Recessive allele	One which influences the phenotype only in the presence of another identical allele. Represented by small letters of the dominant allele	-t , recessive allele for shortness, individuals with genotype ,**tt** appear short.
Generation	group of organisms of approximately the same age within the population	
Pure breeding	When bred with each other, produce consistently same characteristics over many generations. Are always homozygous	
Traits/characters	Observable aspects of an organism,s structure.	Weight, height and seed shape
Contrasting characteristics	Characteristics which are extremely opposite to each other	Short and tall Round and wrinkled
F1 generation	offspring produced by two pure breeds carrying contrasting characteristics	
F2 generation	are the off springs produced by mating the F1 generation	

MONOHYBRID INHERITANCE.

- Is the passing of one pair of sharply contrasting characteristic by parents to off springs.
- Formed a basis of ***Gregor Mendel's*** group of experiment on inheritance.
- Mendel carried out several experiments using garden pea , ***Pisum sativum*** which he formulated the first law of inheritance
- The first law of inheritance (law of segregation) states that "**the characteristics of an organism are determined by internal factors, that occur in pairs; only one of a pair of such factors can be represented in a single gamete during gamete formation"**

Reasons why Mendel chose Garden peas

- ❖ pea plant has several sharply contrasting characteristics e.g
  (i). position of flowers(axial or termimal)
  (ii). Length of stems (tall or dwarf)
  (iii). Shape of seeds (round or wrinkled)
  (iv). Colour of pods(green or yellow)
  (v). colour of flower(red or white)
- ❖ It naturally pollinates itself and can also cross pollinated
- ❖ It matures at a faster rate /have short life cycle
- ❖ It produces many seeds and hence many off springs could be obtained in a single season

Mendel' experiment on Monohybrid Inheritance

- ❖ Mendel identified two pure /true breeding pea plants, one homozygous dominant tall and another homozygous recessive short and cross-pollinated;
- ❖ The F1 generation were all tall pea plants.
- ❖ When he selfed/self-pollinated the F1 generation offspring, he obtained both tall and short pea plants.
- ❖ Relative numbers of these plants were in the ratio of 3 tall pea plants to 1 short pea plants,
- ❖ described the above ratio as the **monohybrid inheritance ratio.**

Using the genetic diagram, Mendel explained the occurrence as follows:

Let T represent the allele for Tallness in a pea plant

t represent an allele for shortness in a pea plant

2n –diploid state(with a pair of chromosomes)

n-haploid state(with single chromosomes)

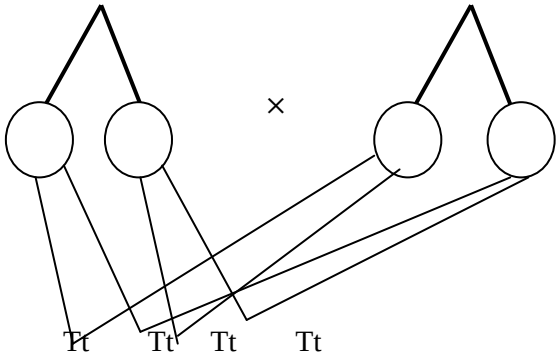
Parental phenotype: homozygous Tall plant x homozygous short plant

Parent Genotype(2n) TT t t

Meiosis;

Gamete(n)

Random fertilisation



F1 genotype(2n) Tt Tt Tt Tt

F1 phenotype all heterozygous tall pea plants

Explanation

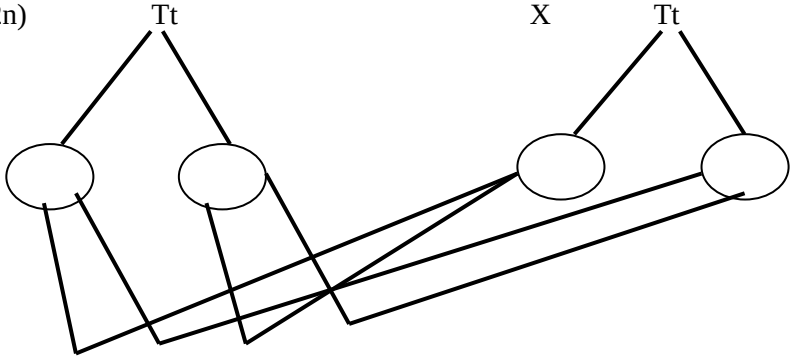
- All the off springs in F1 generation are tall pea plants ,there are no dwarf/short plant pea, because the allele for tallness is dominant over that for shortness, therefore suppressed the recessive allele for dwarfism/shortness .

b) **SELFING F1 GENERATION**

Parental phenotype: Heterozygous tall pea plant X Heterozygous Tall pea plant

Parental Genotype(2n) Tt X Tt

Meiosis:



Gamete(n)

Random fertilisation

F2 genotype (2n) TT Tt Tt tt

F2 phenotype tall short

F2 phenotypic ratio 3 tall : 1 short

NB: The random crosses above can also be illustrated by use of Table known as a **Punnett square**; only after gamete formation.

Table showing summary of results obtained by Mendel after investigating inheritance (monohybrid using various characteristics in pea plant (Garden Pea)

Contrasting characteristic of pea plant	**F1 generation phenotype**	**F2 phenotypic ratio**
Smooth seeded crossed(x) with wrinkled seeded plants	All smooth	3 smooth :1 wrinkled
Green pod X yellow poded plants	All Green	3 Green:1 yellow
Axil placed flowered X Terminal placed flowered plants	All Axil	3 Axil:1 Terminal flowered
Tall crossed X Dwarf Plants	All Tall plants	3 Tall:1 Dwarf Plant

Mendel's Conclusion from the above investigation

- There are alternative forms for genes i.e. a single characteristic exists in two forms e.g. Gene that determines pod color can either be (G) for green pod color and (g) for yellow pod color.
- For each characteristic /trait ,organism inherit two alternative forms of that gene, one from each parent
- During Gamete formation /meiosis, allele pairs separate/segregate leaving each gamete with one of the alleles.
- During Random fertilization/Random fusion ,resultant off spring will contain two sets of alleles, one from each parent
- When two alleles of a pair are different i.e. One is dominant and other is Recessive one , recessive one is NOT lost , in the F1 generation , but is suppressed and reappears once F1 generation is selfed.

TEST CROSS.

- Is a test carried out to establish whether an organism of a dominant phenotype is heterozygous or homozygous.
- Involves crossing an organism showing a dominant characteristics with another organism that is homozygous recessive
- Two possible results can be obtained e.g , in establishing the genotype of pea plant showing the dominant phenotype of round seed coat. i.e .

(i). if the off springs all show dominant trait, then genotype of the organism of a dominant phenotype is homozygous.

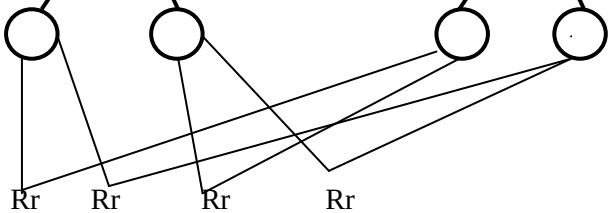
Let the dominant allele for round seed coat be R

Recessive allele for wrinkled seed coat be r

Test cross phenotype; homozygous round seed coat × homozygous wrinkled seed coat.

Test cross genotype (2n) RR X rr

Meiosis



Gametes(n)

Random fusion

Offspring genotype Rr Rr Rr Rr

Offspring phenotype all are heterozygous round seed coat.

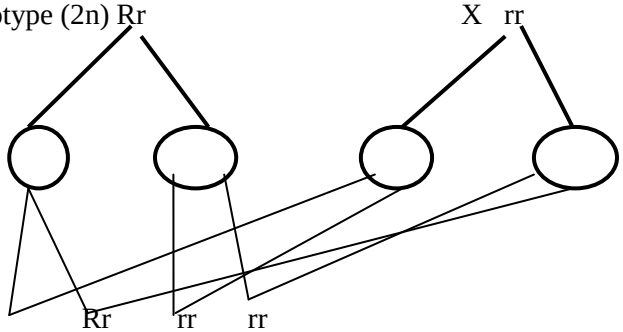
Therefore the unknown round seed coat pea plant was homozygous round seed coat.

(ii). If the off springs are a mixture of phenotypes in ratio of 1:1, then the genotype of the organism of a dominant phenotype is heterozygous.

Test cross phenotype; heterozygous round seed coat X wrinkled seed coat

Test cross genotype (2n) Rr X rr

meiosis



gametes (n)

random fusion

offspring genotype Rr Rr rr rr

offspring phenotype 50% heterozygous round seed coat and 50% homozygous wrinkled seed coat.

The unknown round seed coat pea plant was heterozygous round seed coat.

Question.In pea plants, the allele for purple flowers is dominant over the allele for white flowers. How would you find out if a purple flowered plant is homozygous or heterozygous?

Solution

- Carrying out a test cross, by crossing with a white flowered plant
- If some offsprings are white flowered, then the plant was heterozygous
- If all purple flowered off springs are produced, then the plant was homozygous

INCOMPLETE DOMINANCE, COMPLETE DOMINANCE AND CODOMINANCE

(a) INCOMPLETE DOMINANCE;

- ✓ Is a type is inheritance where two alleles forming a gene pair, neither of them dominate the other, part contribute equally to determine a particualr character.

  Examples include;

  i. Production of pink flowers by snapdragon plants, when red floweredplants are crossed with white flowered plants.

  ii. Inheritance of sickle cell anaemia

Representation

Consider a cross between red flowered plants with white flowered plants

Let R be the allele for red flowered plant

W be the allele for white flowered plant

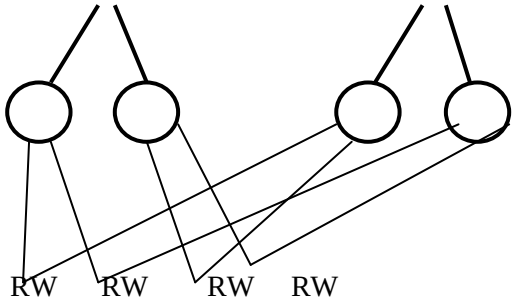
Parental phenotype; red folowered plant X white flowered plant

Parenta geneotype(2n) RR x WW

Meiosis

Gametes(n)

Random fusion



F1 genotype(2n) RW RW RW RW

F1 phenotype All are pink flowered plants

Selfing F1 offsprings

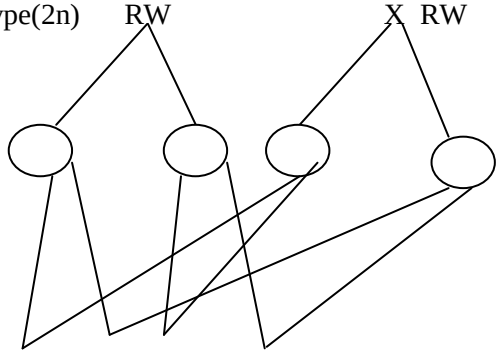
Parental phenotype; pink flowered plant X pink floweredplant

Parental genotype(2n) RW X RW

Meiosis

Gametes(n)

Random fusion



F2

genotype(2n) RR RW RW WW

F2 phenotype Red flowered plant, pink flowered plant, white flowered plant

QUESTION.

1. In a breeding experiment, plants which were homozygous for white flowers were crossed with those homozygous for red flowers. The F1 offspring were all pink.

   (i). Explain the results observed among the F1-offspring

   (ii) Using appropriate genetic symbols, show the formation of the F2 offspring, indicating their genotypes and phenotypes.

(b) COMPLETE DOMINANCE

- ✓ Is a condition where a dominant gene completely suppresses/masks a recessive gene.
- ✓ Eg Inheritance of Height, appearance of seed Testa, colour of unripe pod and colour of cotyledon in Garden pea plant.

(c)CO-DOMINANCE

- ✓ Is when alleles express themselves equally in the phenotype
  Examples include.

i. -Inheritance of Blood groups; The ABO –Blood group are controlled by a single gene with multiple Alleles A, B and O, A and B are co-dominant to each other, while allele O is recessive to A and B.

ii. Inheritance of Sickle cell anaemia,

iii. Roan coat color in certain cattle, by crossing short horned red with short horned red cattle

- ✓ In co-dominant crosses, **different letters** are used and they must be in **capital** for different characteristics.

<u>Co-dominance in inheritance of blood group and Sickle cell anaemia</u>

(a)**ABO Blood group**

- Inheritance of ABO-Blood group is controlled by three alleles (multiple alleles) that are responsible for presence of Antigen types on the surface of Red blood cells.
- These multiple alleles include A,B and O where A determines the formation of Antigen A,B determines the formation of Antigen B and O prevents the formation of antigens A and B on red blood cells in their homozygous states.
- Any two alleles occupy a locus on the homologous chromosome in order to determine the blood group in an individual.
- Alleles A and B show co-dominance to each other, yet both are dominant to allele O.
- The three alleles give 6 possible genotypes and four phenotypes.

Blood group(phenotype)	genotype
A	AA, AO
B	BB,BO
AB	AB
O	OO

Question.

1. A man of blood group A married a woman homozygous for blood group B, ant they produced a son of blood group B.

(a) work out the genotypes of the father and the son

(b) T he son married a wife of blood group O, showing your working, show the percentages of the possible phenoptypes of their offsprings.

2. What are the genotypes of blood groups of the children borne to a man of blood group A and a woman of blood group B both of whom are heterozygous.

3. A man who is homozygous for blood group A married a woman who is homozygous of blood group B. What are the genotypes of their off springs?

(b) **Sickle cell anaemia.**

- ✓ It's a condition where by the R.B.C have abnormal shape (crescent/sickle shape) caused by gene mutation and as a result are unable to transport oxygen efficiently .
- ✓ -The shape of R.B.C is determined by the type of haemoglobin produced by two alleles ie One for normal (HbA) and other for abnormal Haemoglobin.(HbS).

Genotype	**Type of Haemoglobin formed**	**Appearance of R.B.C**	**Phenotype**
HbA HbA	Normal Haemoglobin	Biconcave Disc	Normal
HbAHbS	Both Normal and abnormal Haemoglobin	Mixture of Biconcave &sickle shaped	Sickle cell trait (mildly Anaemic)
HbSHbS	Abnormal Haemoglobin	All sickle shaped	Sickle cell anaemic

NB.

- ➢ Heterozygous individuals only have symptoms of suffering from lack of oxygen when exposed to low partial pressures of oxygen e.g at high altitude, during strenuous physical activity like race.
- ➢ Are also resistant to attack by malaria parasite, and therefore mildly affected by malaria

QUESTION.

1.A man who is a carrier of sickle cell anaemia married a woman who is a carrier of sickle cell anaemia. What are genotypes and phenotypes of the offsprings.

2.**Sickle cell anaemia is a hereditary disease due to gene mutation that changes Normal Haemoglobin(HbA) to Abnormal Haemoglobin(HbS).**

(a)What are the possible phenotype of offsprings of a man who is heterozygous and a woman who is also heteroyzygous for the sickle cell trait.

(b)What proportion of the offspring would be; (i)Severly anaemic (ii) Mildly anaemic

Role of principles of Heredity in plants and Animal Breeding.

These include practical applications of Genetics such as :

(a)**Blood Transfusion**, enabling one to understand how blood groups are inherited and their successful blood transfusion.

(b)**Genetic counseling**; The knowledge of genetics is useful in explaining to families /individuals how a given genetic disorder occurs. They equip them with the knowledge on their chances/probability/likelihoods of certain genetic disorders recurring in the family.

(c.) **solving disputes on percentage /paternity suites.**i.e determining the parents of the chilld

c) **Biotechnology/Genetic engineering**

It involves deliberate modification of the characteristics of an organism by manipulating its genetic material like altering genes, transffering genes from one organism into another.

Biotechnology has been used up to produce, Biofuels, mycoproteins, Antibiotics, Insulin, genetically modified Organism (GMOs) pest-Resistant crops.

d)**Plant and Animal Breeding using Artificial selection**; that involves selection of parental breeds of Animals and varieties of plant with desired qualities eg production of cattle breed with high milk yield ,New crops with high growth rate and resistant to drought

Question . Give two benefits of studying human genetics

- ✓ Enables humans to choose partners with good characteristics for reproduction
- ✓ Used in legal profession to determine the parents of a child , where parental disputes are involved
- ✓ Enables elimination of harmful characters from human population
- ✓ Solving criminal cases such as rape.

Hybirdization

- It's the process of producing an offspring by use of two different species to obtain better qualities from both parents.
- The resulting offspring is called **Hybrid.**
- Hybridization is useful in Agriculture to produce hybrid crops and some hybrid Animals.
- The parents involved are usually carrying specific dominant genes e.g. In maize crossing, two parents one having a characteristic of producing large sized maize cobs and other that grow faster produce a Hybrid Offspring with both characteristics.
- In livestock, Hybridization is useful in production of:

-Goats with high milk yields
-Fast growing chicken
-Cattle with high milk yields

IMPORTANCE OF HYBIRDIZATION

- It ensures production of high quality offspring
- It ensures that offspring adapt better in Environment than their offspring parents
- It leads to development of high yielding of species and varieties of crops and livestock .Hence an increased Agricultural output.
- It leads to production of diseases resistant crops eg Maize, cassava, Banana suckers etc
- Production of pest resistant crops
- Produces new breeds capable of surviving in specific ecological zones e.g. Drought Tolerant Livestock.
- Produce faster growing varieties of crops and livestock that mature in a short period of time.

SEX DETERMINATION IN HUMANS

- ❖ is the method by which the distinction between males and females is established in a species.
- ❖ variation in sexes in humans is determined by two chromosomes i.e. X and Y chromosomes. These chromosomes are referred to as **sex-chromosomes**. They make up the 23rd pair of homologous chromosomes in humans. The 22 pairs of chromosomes are described as **Autosomes. (body chromosomes).**

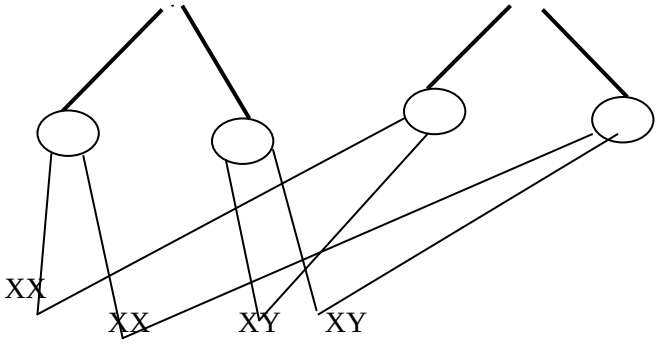
  During formation of gametes,
  - ✓ Females produce gametes that all have X- chromosomes; are therefore described as **Homogametic**
  - ✓ Males produces gametes(sperms) that have either X and Y chromosomes in them; are therefore described as **Heterogametic**
- ❖ Male and female once mate, fertilization occur, the resulting offspring can be either a male or female depending on which of the sperm X or Y fertilizes the ovum.

Illustration

Parental phenotype male X female

Parental genotype(2n) XY X XX

Meiosis



Gametes(n)

Random fertilization

Offspring genotype(n) XX XX XY XY

Offspring phenotype female female male male

Phenotypic ratio 2 females : 2 males

Revision question

1.(a). Distinguish between homogametic and heterogametic .

(b). How is sex determined in humans?

TWINS

- Are two humans or animals born to the same mother from the same pregnancy at the same time.
  Two types exist i.e

(a) Identical /monozygotic twins;

- ✓ develop from one egg fertilized by one sperm but the zygote later splits into two each developing into an offspring.
- ✓ Have the same genetic material;
- ✓ Have the same sex

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Identical twins result from

A. One ovum being fertilized by one sperm
B. An ovum splitting into two before fertilization
C. Two ova being fertilized by one sperm
D. Two ova being fertilized by two sperms

(b) Fraternal / dizygotic twins;

- ✓ Are non identical twins resulting from two different ova fertilized by two different sperm cells.
- ✓ Differ genetically because they arise from different genetic material
- ✓ Can be of the same sex or different sex

LINKAGE.

- ✓ is the location of genes determining different characteristics on the same chromosome.
- ✓ such genes are thus referred as **linked**; move in the same gamete; and therefore inherited together.

SEX LINKAGE.

- ✓ Is the carrying of genes on the sex chromosomes.
- ✓ Sex linked genes(genes carried on the sex chromosomes), may be on the X chromosome or on the Y chromosome.
- ✓ Because of the larger size of the X chromosome than the Y chromosome, it carries most of the sex linked genes.

SEX LINKED CHARACTERS/ TRAITS

- ✓ Are characters controlled by genes carried on the sex chromosomes.
- ✓ More common in males than females
- ✓ Caused by recessive alleles.

Examples include.

- Red green colour blindness } Examinable
- Haemophilia
- Premature balding
- Very hairy ears

ASSIGNMENT; Why are sex linked characters more common in males than females.

(a) **Haemophilia.**

- ❖ Is a condition in which blood does not clot normally, due to lack of one or more clotting factors responsible for blood clotting.

Inheritance of haemophilia.

Consider a cross between a female carrier and a normal male.

Let the allele for normal blood clotting be H

Let the allele for haemophilia be h

Let X be the female sex chromosome

Let Y be the male sex chromosome

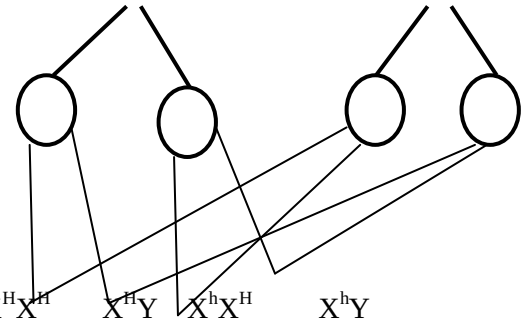
Parental phenotype carrier female X normal male

Parental genotype(2n) $X^H X^h$ X $X^H Y$

Meiosis

Gametes(n)

Random fusion



Offspring genotype $X^H X^H$ $X^H Y$ $X^h X^H$ $X^h Y$

Offspring phenotype ; normal female, normal male, carrier female, sufferer male.

(b) **red green colour blindness.**

- ❖ Is the inability to distinguish between red and green colours.
- ❖ Normal sight is dominant over red green colour blindness

Table showing possible genotypes and phenotypes of red green colour blindness.

genotypes	**phenotypes**
$X^B X^B$	Normal female
$X^B X^b$	Normal but carrier female
$X^B Y$	Normal sight male
$X^b Y$	Red green Colourblind male
$X^b X^b$	Red green colour blind female

ASSIGNMENT.

Red green colour blindness is a defect caused by a recessive gene that is sex linked.

(a) What is a

(i) recessive gene?

(ii) sex linked gene?

(iii) red green colour blindness?

(b). what will be the phenotypes of the offsprings between a marriage of a normal woman and a colour blind man? Show your working.

(c). explain why the defects in the same category as the one above are more common in males than females.

HEREDITARY DISEASES

- ➢ Haemophilia
- ➢ Red green colour blindness
- ➢ Sickle cell anaemia
- ➢ Albinism; a condition in which the skin colour pigment(melanin) fails to develop resulting into **light skin**, **white hair** and **pink eyes**

VARIATION WITHIN PLANTS AND ANIMALS

Variation refers to the differences in structures and or function observed amongst individuals of plants /Animals of the same species.

TYPES OF VARIATION;

These include

(a) Continuous Variations
(b) Discontinuous Variations

CAUSES OF VARIATION

Variation may be caused by:

(a) Environmental condition factors such as Excessive Heating/High temperature, Nutrients Availability,Light,water plants attain their full growth potential when the conditions are favorable/optimum and will become stunted whenever conditions are unfavorable irrespective of their genetic strength.

NB: Variation due to environmental factors /conditions are never inherited.

a) Genetic constitution /changes in the structure of Genes and chromosomes due to mutation; recombination during random fertilization and independent assortment during meiosis.

DISCOUNTINOUS VARIATION /QUALITATIVE VARIATION

These are clearly defined observable differences in a characteristic amongst individuals of a population

Individual showing discontinuous variation show the following;

a) Fall into a number of distinct classes/categories

b) Variation/difference in characteristics are qualitative/not measureable

c) There is no immediate condition/difference

Example of Discontinuous Variations

characteristics	**Variations**
Finger print patterns	Tent arch, loop/Double looped, mixed/whorl
Skin coat in dogs	Rough/smooth
Blood groups	A/B/AB/O
Tongue rolling	Roller/Non-Tongue roller
Eye Color	
Ear lobe	Free/fused ear lobe

Sex	Man/female

b) Plants

characteristics	**Variations**
Leaf venation	Parallel network
Flower color in garden peas	Red/pink
Pod shape in peas	Inflated/constricted
Seed shape in peas	Round smooth/wrinkled

Information /Data collected on a particular characteristic that show discontiounous variation maybe represented in form of a pie chart,Histogram,column graphs and bar graphs

Example:

i)Pie chart showing the tongue rolling ability of students in s4

ii) Histogram showing Tongue rolling ability

Continuous Variation /Quantitative Variation

It's the one with range of observable differences in a characteristic from one extreme to the other in a population.

Individuals that exhibit continuous variations have sight difference amongst themselves; have many intermediate forms between two extremes.

Examples of continuous variations include; height,weight,Handpalm,length of feet, milk yield in cows, stem diameter in plants, length in internodes, skin color in humans, size of seeds and fruits, length of fingers, skin color in humans.

Information/Data collected on a particular characteristics showing continous variation ,may be presented using histogram,frequency,polygon,and results into a normal distribution curve;

MUTATION AND EVOLUTION

a) MUTATION

-It's a sudden, ireveserable and random change that occurs in the genetic material of a cell, causing it and all cells derived from it to differ in appearance/their behavior.

- It's also defined as the sudden change in structure/amount of genetic materials (Gene/DNA/Chromosomes) in the cell of organism.

-Individuals /genes showing the effect of mutation are described as Mutants.

-Mutations are spontaneous and rare in nature but once occure, they mostly harmful even lethal (cause death).They may fail/persist in a species for more a generation/two generations. Some mutations persist leading to emergence of new varieties/strains.

b) Agents of Mutation

An agent that is capable of increasing the rate of mutation in an organism are described as Mutagens.

Mutagens include the following:

(i) Exposure to X-rays and Gamma Rays
(ii) Exposure to colchicines,mustard gas and formaldehyde/formalin)
(iii) High fluctuation of Temperature
(iv) Nitrous Acids
(v) Alpha and Beta Particles(Radiations)

b) Types of Mutation
There are two types of mutation and these include
i) Gene/point mutation
ii) Chromosomal mutations

Gene/Point Mutation

i)They involve the chemical change /structure of a gene

ii)they lead to disorders and defects(genetically inherited disorder)such as:

(a) Albiinism :Failure to synthese melanin/skin pigment ,individuals are Abinos that have light skin,white hair and pink eyes;
(b) Sickle cell Anaemia
(c) Haemophilia:Blood take longer than expected to clot as a result of a recessive gene found on the X-chromosomes.
(d) Color Blind:Failure to distinguish between green and Red colors.

Chromosomal Mutation

(a) These involve changes that occur in the structure or number /length of chromosomes in a given individual
(b) They lead to genetically inherited disorders and defects such as:-
    (i) Down's Syndrome-occur due an extra X-chromosome
    (ii) Kl'mefelter's syndrome.

EVOLUTION

It's a study of the changes that have taken place in organism over a long period of time.

It's also defined as the study of the gradual development of organism from simple forms to more complex ones over a long period of time.

Evolution is about gradual changes amongst organisms. These changes/differences amongst organisms enable them to suit to their changing environment. They enable them to survive and breed and propagate traits to their offsprings.The changes amongst organism arise as a result of competition for Food, space, mating partners, water and Light. The organism with better changes compete favorable at the expense of the less adapted ones. This enables them to acquire enough food, access to mate and reproduce hence passing on better characteristics to next generation and as the less adapted ones are eliminated :from the population.

Theories of the Origin of Life.

These include:

(a) Special creation

It's the religious belief /idea that suggest that life was created by supernatural /supreme belief called God e.g. In Christianity and Islam ,its documented in bible and Koran respectively, state in Book of Genesis Chapter One, that God's Own power the Earth and all living things in it were created.

(b) Spontaneous Generation

It suggests that the present day Life forms have arisen by gradual changes from pre-existing simple forms forming more complexing ones. Its suggests that Living organism emerged from non-Living matter whenever suitable conditions availed e.g. Lice from Dirty, Maggots from decaying matter.

(c) Theory of Steady state.

This suggests that the earth and all the species on it have no origin .That they have always existed and have only varied in their number /population with remarkably very little change.

(d) Theory of biochemical evolution

It’s the most accepted; it explains that chemicals once combined to form the simple organism

The chemical like gases methane, Nitrogen, Carbondioxide, Ammomia,Hydrogen and helium combined to energy from lightening and Volcanic activities forming simple organic compoundse.g Amino Acids and simple sugars.

These formed a cell and later became the basic unit of life.

Organic Evolution.

It’s the emergence of present forms of organisms gradually from pre-existing ones, some of which no longer exist(extinct)

Evidence of Organic Evolution

These include:

(i) Fossil Records
(ii) Geographical distribution
(iii) Comparative embryology
(iv) Comparative anatomy>Divergent-Homologous structure
Convergent-Analogous structure

Fossil Records:

The remains of organism that lived in the past are studied to reveal how organism looked like in past and their history is traced.

Comparative anatomy:

It involves studying internal structure of organism. Organism that look different /have different structure but resemble one way/other in structure are presumed to have had a common ancestors