Genetics

This is a branch of biology that tries to explain the cause of similarities and difference between parents and their off springs. The first quantitative experiments on heredity of any significance were carried out in the middle of the nineteenth century by Gregor Mendel on the garden peas

Specific objectives
The learner should be able to

- Explain the concept of inheritance
- Define genetics terms
- Explain inheritance of trains using the monohybrid and dihybrid crosses.
- Discuss the challenges of inheritable disorders
- Explain gene interaction, sex linkage, sex determination, sex limitation, lethal genes and polygenes.

Terminologies.

1. **Agene**
   This is the basic unit of hereditary and occupies a discrete position on the chromosomes. The gene controls the production of enzyme which in turn determines the process that goes on in a cell and eventually in the organ and the entire organism. In sexually reproducing organism, genes occur in pairs, where each member of a pair is contributed by the female and male parents.

2. **Alleles (Allelomorphs)**
   This is one of the pair of a gene that occupy the same locus (position). Alleles are genes that are responsible for the production of contrasting characteristics such as tallness and shortness in plants and animals.

3. **Genotype**
   This is the genetical constitution of an organism i.e. the particular set alleles, leading to observable characteristics

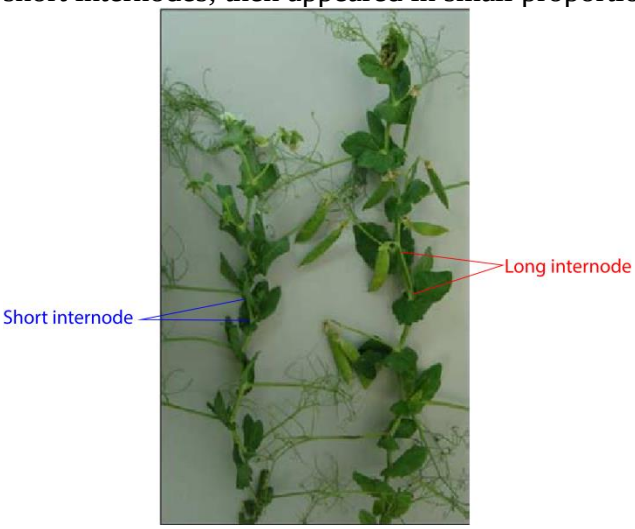
4. Phenotype
   This is the physical characteristic of an organism determined by the genotype and the environment.

Monohybrid inheritance

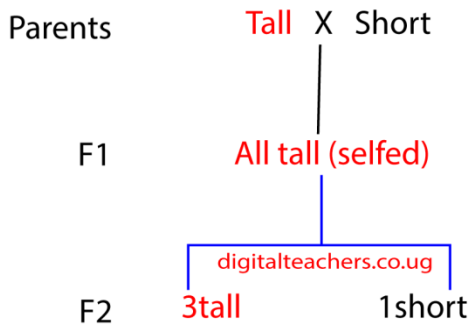
This an inheritance that deals with a single pair of contrasting characteristics such Tallness and shortness when concerned with height of peas.

In his investigation of a single pair of contrasting characteristics, Mendel observed that, in the first filial (F1) generation one of the characteristic never appeared only to appear in the second filial (F2) generation in small proportion compared to the one that appeared in the first filial (F1) generation.

For example; he crossed peas with long internode, with peas of short internode. He observed that in the F1 generation, all plants had tall internodes. When selfted to produce F2, the peas with short internodes, then appeared in small proportions.



The result of these crosses can be illustrated as follows,



It was concluded from the results that inheritance is a process in which discrete structure or particle (genes) which may or may not show themselves in the outward appearance of the organism are transmitted from parent to off spring.

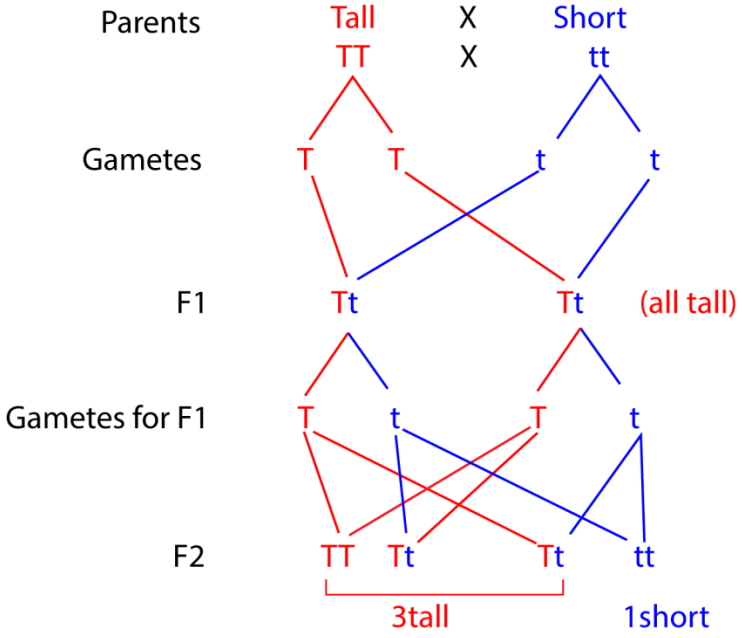
The evidence of existence of inheritable particles is got from the observation that they can be combined in one generation but separate in the next, as in witness by the recovery of the short form in F2 generation despite its absence in the F1 generation,

The characteristic that show in F1 generation (tallness in this case) is described as being **dominant** and while that which masked F1 generation (shortness) is said to be **recessive.**

Genes and their transmission

Gene normally occur in pair each of which is obtained from each parent. The cross of a tall plant and short plant is shown diagrammatically by the two methods below.

The allele for tallness (dominant) character is represented by a capital letter T while the allele for shortness (recessive character) is represented by small letter t. It is assumed that each parent plant contains a pair of identical alleles; TT in case of tall plant and tt in case of short plant.



Pannet square to show fusion of F1 gametes

	½ T	½ t
½ T	¼ TT	¼ Tt
½ t	¼ Tt	¼ tt

In terms of probability, there are 3 chances out of four for a tall plant to appear in F2 generation; and one chance of four for a short plant to appear.

Mendel's first law of segregation states that an organism's characteristics are controlled by two genes (alleles) and only one can be carried by in a gamete.

Mendel's second law of Independent Assortment:
During the formation of gametes, alleles in a pair may combine with another allele from another pair randomly.

Breeding True
Phenotypically TT and Tt are the same i.e. Tall. When an organism contains identical alleles like TT and tt is said to be **homozygous** and with dissimilar allele is **heterozygous**.

Since the homozygous (TT) and heterozygous (Tt) peas are both tall there is no way we can distinguish between the two genotypes from their external appearance.

One way of establishing whether a given tall plant is homozygous or heterozygous is to self-pollinate it. If the resultant off springs are all tall, we can conclude that the parent has the genotype TT.

If, however, we get a mixture of Tall and short plants; the parent plant must have the genotype Tt

The point is that when an organism which is homozygous at a particular locus is self- fertilized it produce off spring all of which are identical with parent. Exactly the same results occur if organism is crossed with another organism that is homozygous is said to breed true, The organism is said to belong to a pure line for the characteristics in question.

Test crosses
This is the crossing of an individual having **homozygous recessive** genotype with an individual showing a dormant trait to determine whether that individual is homozygous or heterozygous for the trait.

The homozygous individual produces all offspring having dominant trait while a heterozygous individual produces a mixture of offspring with dominant and recessive traits.

Back cross
This is a cross between hybrids in F1 generation with one of the parents or an organism genetically equivalent to the parents. Back crossing is mainly aimed at increasing the genetic contribution of one particular parent to the off spring.

Monohybrid inheritance human
A number of human conditions are known to be associated with a single pair of alleles which are inherited in Mendelian fashion.

1. **Albinism**

1. Albinism

This is a condition in human beings where the individual fail to produce skin pigments called melanin.

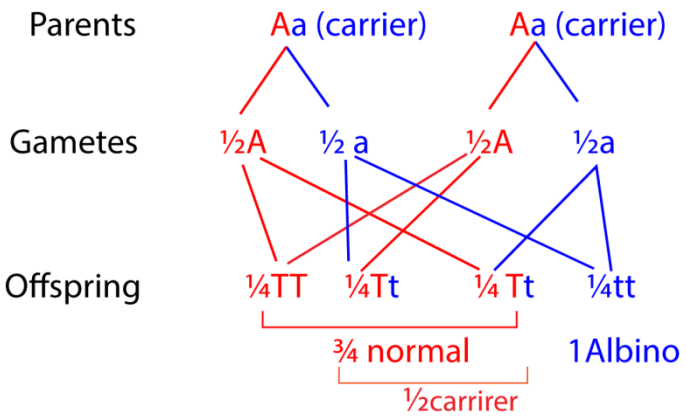
Albinos have;

- ✓ Light skin
- ✓ White hair
- ✓ Pink eyes
- ✓ They are sensitive to bright light

Albino

The allele for albinisms is caused by recessive [a] and so only exert its effect in the homozygous state [aa]. The allele for melanin production [A] is dominant.

Suppose a couple each with normal pigmentation have an albino child. For this to happen the child must have [aa]. Therefore, unless for rare mutation, the parents must both heterozygous [Aa] so each produces A and a gametes in about equal number. Therefore, randomly to produce three type of genotype AA, Aa, aa.



2. Congenital disease such as cystic fibrosis in which the connective tissue develops in glands of the body.

3. Chondrodystrophic dwarfs are characterized by shortened and deformed legs and arms. It is cause by a dominant gene and hence affect in homozygous and heterozygous state

CO-DOMINANCE

This is a condition where genes determining a particular character all show up such that the phenotype of the offspring is a mixture of that of the parents***. It mainly occurs in animals.***
Co-dominance is where in the heterozygous state neither allele is completely dominant over the other i.e. the 2 alleles are co-dominant. This results in the phenotype intermediate between the parent's appearances. The alleles for each trait are represented with different capital letters.

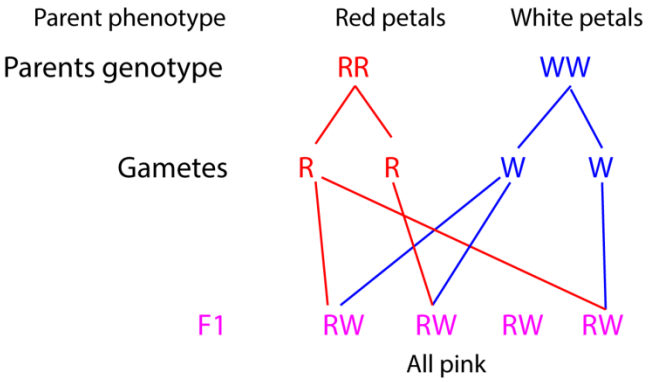
Questions:

1) In animals, the genes for fur colour are co-dominant. What will be the offsprings when a red bull is crossed with a white cow?

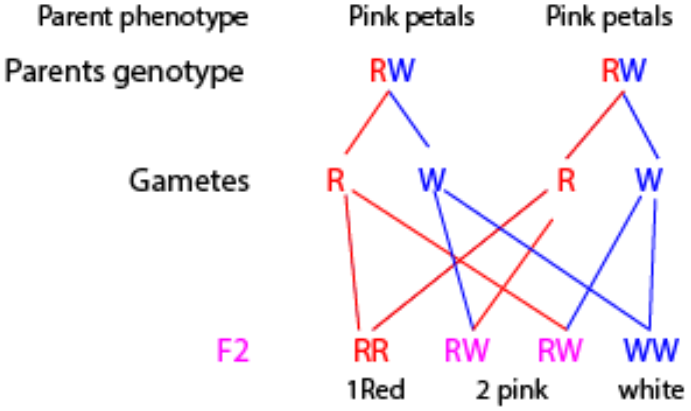
Solution:

Let R represent the allele for red bull

Let W represent the allele for white cow



2) What would be the off springs in the 2nd generation?



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INCOMPLETE DOMINANCE

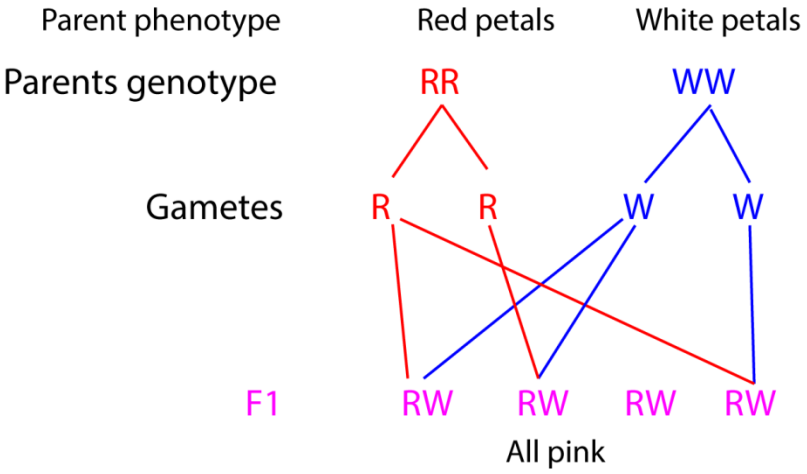
This is a condition in the heterozygous where neither of the alleles is dominant over the other and the phenotype of the offspring is an intermediate between that of the parents. ***It mainly occurs in plants.***

For example, consider petal colour in flowers: when a red flowered plant is crossed with a white flowered plant, the offspring produced are all pink coloured petal flowers.

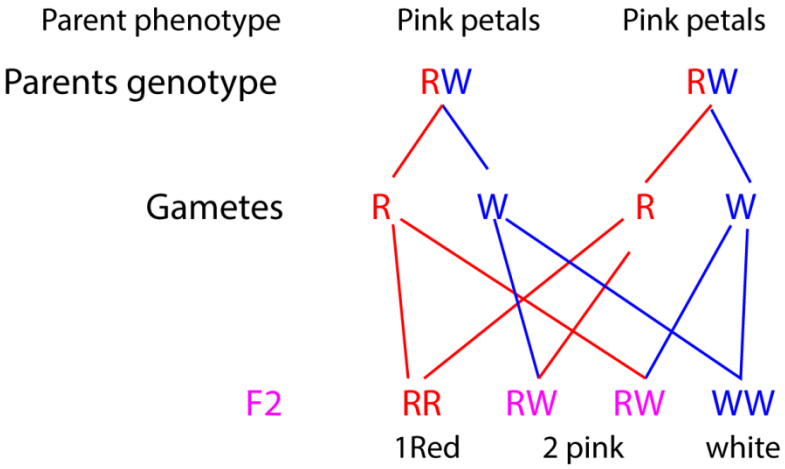
Example:

Let R represent the allele for red petal colour.

Let W represent the allele for white flowers



Then Selfing F1 (Cross between offspring in F1)



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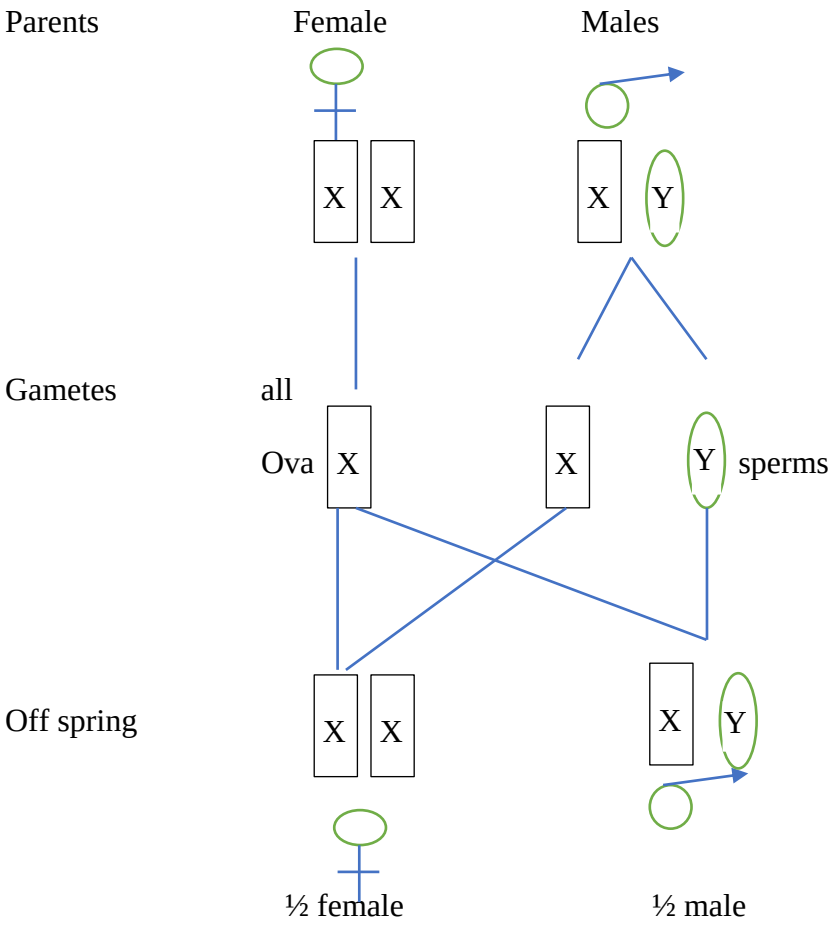
F2 Phenotypic ratio: 1 red: 2 pink: 1 white. (1:2:1)

Sex determination.

The medium size chromosome in drosophila melanogaster determine the individual's sex for which reason they are called the **sex chromosome**. In the female the two sex-chromosome, both rod shaped in appearance, are identical and are known as **X-chromosomes**. In the male, however the two sex-chromosome differ from each other one is rod- shaped X-chromosome, the other is hook- shaped and is called **Y-chromosome**.

The sex chromosomes are exception to the rule that homologous chromosomes are identical in appearance. Being different they are described as **heterosomes**; All the other chromosomes, which are identical in appearance, are called **autosomes**.
Despite this difference, the sex chromosomes are transmitted in a normal mendelian manner as shown below.



Generally, a female produces only one kind of gamete as the chromosomes are concerned; all her eggs contain an X chromosome. For this reason, in human and many other species, the female is said to be homogametic (same gametes). A male on the other produces two kinds of gametes as far as chromosome are concerned: half of the sperm contain an Y chromosome, the other half a Y. The male is therefore heterogametic (different gametes) on fusing randomly, approximately

half the zygotes receive two X chromosome and develop into female, the rest receive Y chromosomes and give rise to males. In some insects, females are XX and male XO

Multiple alleles

Multiple alleles are two or more alternative forms of a gene controlling a particular characteristic, of which any two may occupy the same gene loci on homologous chromosomes.

An example of such multiple allele is provided by the alleles controlling the ABO blood group system in humans. The ABO system is controlled by three alleles generally referred to as I^A, I^B, and I^O.

The I^A allele is responsible for production of type A antigens in the person's red blood cells, and the I^B allele for type B antigen. The I^0 produces neither antigen.

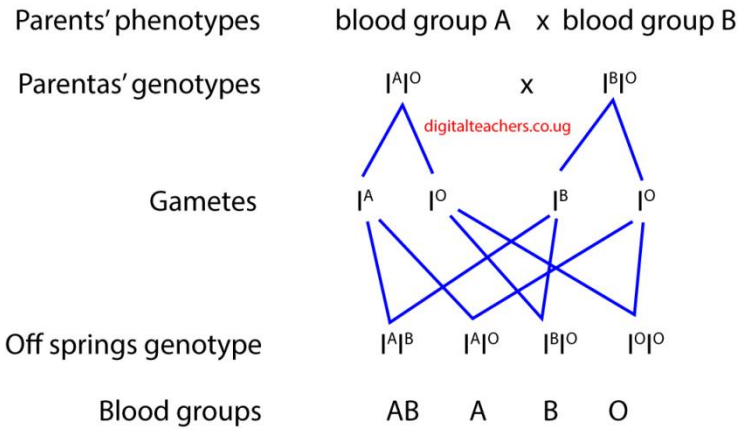
But only two of the three alleles can be present at any one time, an individual may thus, possess any of the following six genotype; I^AI^A, I^AI^0, I^BI^B, I^BI^O, I^AI^B, and I^OI^O.

I^A and I^B show equal dominance with respect to one another [i.e. they are codominant] but each is dominant to I^O thus;

- A person belongs to blood group A has genotype I^AI^A or I^AI^0
- A person belongs to blood group B has genotype I^BI^B or I^BI^O
- A person belong to blood group AB has genotype I^AI^B
- A person belongs to blood group O has genotype I^OI^O

The fact that there more than two alleles responsible for determining the blood group makes no difference to their transmission, which take place in a normal mendelian fashion.

Thus, a child whose parents are both blood group O must be group O. However, a parent with blood A or B, the child may have any of the blood group has shown below.


Parents' phenotypes
blood group A x blood group B
Parentas' genotypes
I^AI^O x I^BI^O
digitalteachers.co.ug
Gametes
I^A I^O I^B I^O
Off springs genotype
I^AI^B I^AI^O I^BI^O I^OI^O
Blood groups
AB A B O

Dihybrid inheritance

This is the inheritance of 2 pairs of characteristics. It's characterized by a phenomenon called **independent assortment** i.e. each of the alleles of one gene may combine independently with each of the alleles of another gene.

For instance, when a pure breed tall pea plant possessing purple flowers was crossed with a short plant possessing white flowers and the F1 generation plants were tall and had purple flowers. These were self-pollinated, in F2 generation there were four different phenotypes observed; tall plants with purple flowers, tall plants with white flowers, short plants with purple flowers and short plant with white flowers.

TTCC x ttcc
Tall, Purple dwarf, white

F1 TtCc (Tall and ourple

F1 selfed (TtCc X TtCc)

Possible gametes could be: TC, Tc. tC and tc

	TC	Tc	tC	tc
TC	TTCC	TTCc	TtCC	TtCc
Tc	TTCc	TTcc	TtCc	Ttcc
tC	TtCC	TtCc	ttCC	ttCc
tc	TtCc	Ttcc	ttCc	ttcc

Phenotypic ratio is

Tall and colored	9
Tall and white	3
Short and colored	3
Short and white	1

Modification of the ratio 9: 3: 3: 1. in F2 generation in hybrid inheritance.

EXCEPTIONS TO MENDELIAN INHERITANCE

The following do not conform to the process of inheritance as illustrated by Mendel.

1. Linkage
2. Incomplete dominance.
3. Co-dominance
4. Multiple alleles.

Epistasis
This a condition where one gene on a different chromosome interacts or modifies or masks the action of another gene.

Example;

1. Gene T on chromosome 9 of gives a pigment that is brown and gene C on chromosome 7 gives the same pigment but when gene T and C are both present they give another pigment purple.

   Assuming that Brown dominant to purple what would be the phenotypic ratio of the off spring.

A – B	purple	9	
A – bb	brown	3	Phenotypic ratio: 9: 6: 1
aa-B	brown	3	
aabb	colorless	1	

2. Gene T on chromosome 2 given an eyeless drosophila whereas gene C on chromosome 4 gives a brown eyed drosophila. What would be the phenotypic.

A-B	eyeless	9
A-bb	eyeless	3
aa-B	Brown	3
aa-bb	colorless or white-	1

Eyeless	brown	another color
12	:3	:1

3. Dominant complementary genes
   This is where gene T and C are necessary for the color to be expressed.
   A-B 9 colored
   A-bb 3 colorless
   aa-B 3 colorless
   aabb- 1coluorless

Ratio	colored	9:
	colorless;	7

4. Recessive complementary gene; is where the recessive alleles must be together before a pigment is formed
   Ratio 15: 1

5. Gene G in a mouse give a grey coat while gene B in mice give a black coat. But when both gene occur G is epistatic to B find the phenotypic ratio.

G-B	9 grey
G-bb	3grey
gg-B	black
ggbb	1 any other time

Ratio	Grey	12
	black	3
	colorless	1

6. In maize a gene C is necessary for coloration of the grain while gene P gives purple color to the grain and its recessive gives a red color. Find the phenotypic ratio

C-P	9 purple	Phenotypic ratio
C-pp	3 red	purple : red :colorless
Cc-P	3colourless	9 : 4 : 3
ccpp	1 red .	

Gene linkage & chromosomes

Gene linkage is the existence of many genes as a unit and not as separate individuals. Linked gene occur on the same chromosome and will always segregate together during meiosis and gamete formation.

Dihybrid inheritance and linked genes

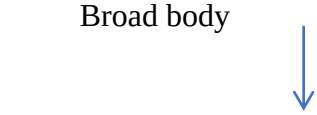
In Drosophila melanogaster [fruit fly] Broad body B is dominant to narrow body [b] and normal sized wing A is dominant to vestigial wing a.

When homozygous dominant drosophila for the 2 characters was crossed with a homozygous recessive for the two characters above mentioned, all the F1 generate drosophila were grey bodied with normal wings.

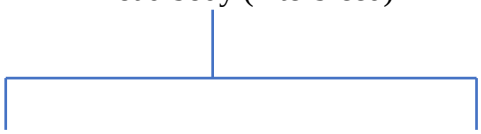
When two of F1 generation flies were mate the F2 generation failed to yield 9: 3: 3: 1 ratio we expected. Instead about ¾ of the off spring had long wings and broad body and nearly the remaining flies about ¼ of the total had vestigial with and narrow body.

Thus

Parents long wing with Broad body x Vestigial wing narrow body



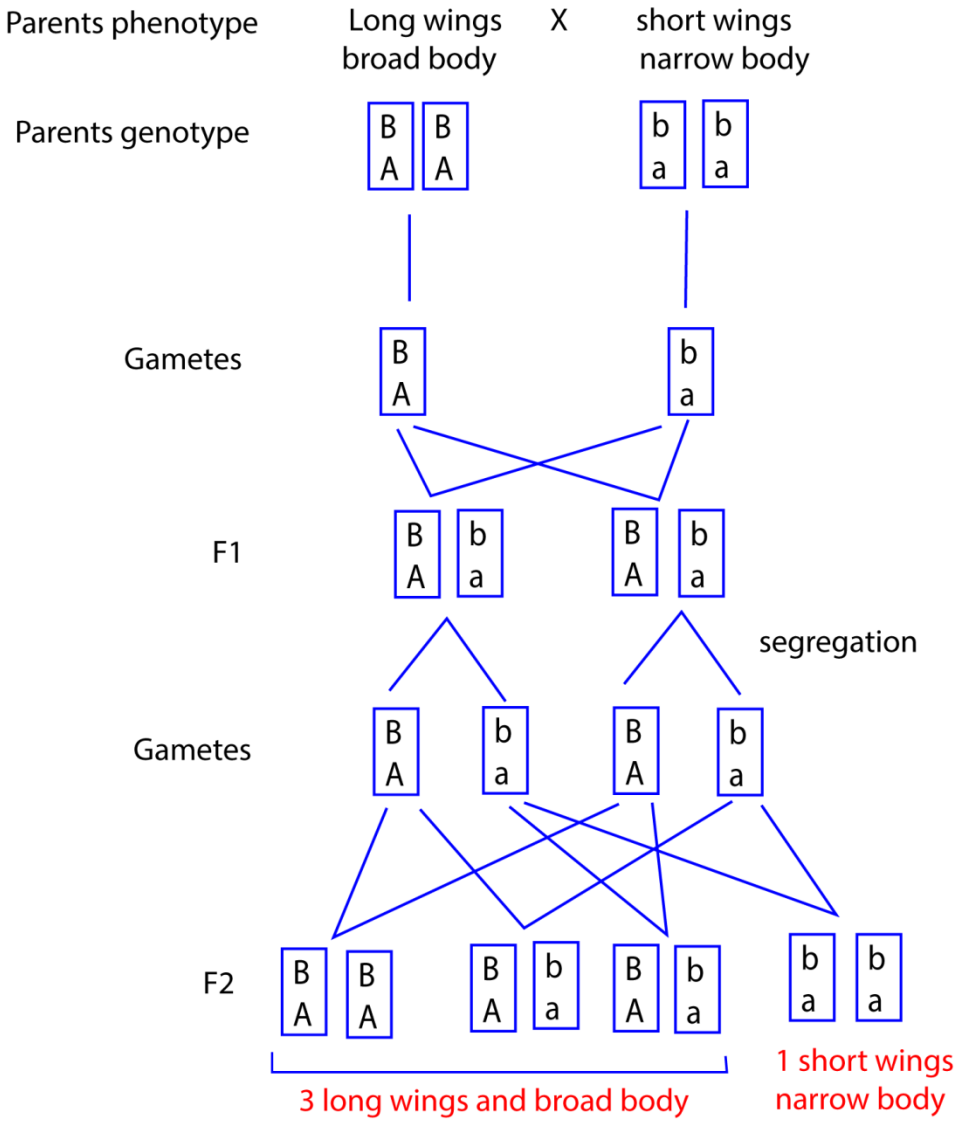
F1 Long wing Broad body (interbreed)



Long wing Broad abdomen 3

Vestigial wing narrow abdomen 1

The explanation is that the gene determining the length of the wings and the width of the abdomen are locate on the same chromosome. This result in their being transmitted together. Such gene are said to be **linked** and the general phenomenon is known as gene linkage


Parents phenotype
Long wings
broad body
X
short wings
narrow body
Parents genotype
B A B A
b a b a
Gametes
B A
b a
F1
B A b a B A b a
segregation
Gametes
B A b a B A b a
F2
B A B A B A b a B A b a b a b a
3 long wings and broad body
1 short wings
narrow body

Sex linkage

Sex linked characters are those whose genes that are carried on sex chromosomes usually X-chromosomes and is inherited along with sex for examples:

(i) red-green color blindness the decreased ability to see color or differences in color. Simple tasks such as selecting ripe fruit, choosing clothing, and reading traffic lights can be more challenging. People with total color blindness (achromatopsia) may also have decreased visual acuity and be uncomfortable in bright environments

(ii) hemophilia

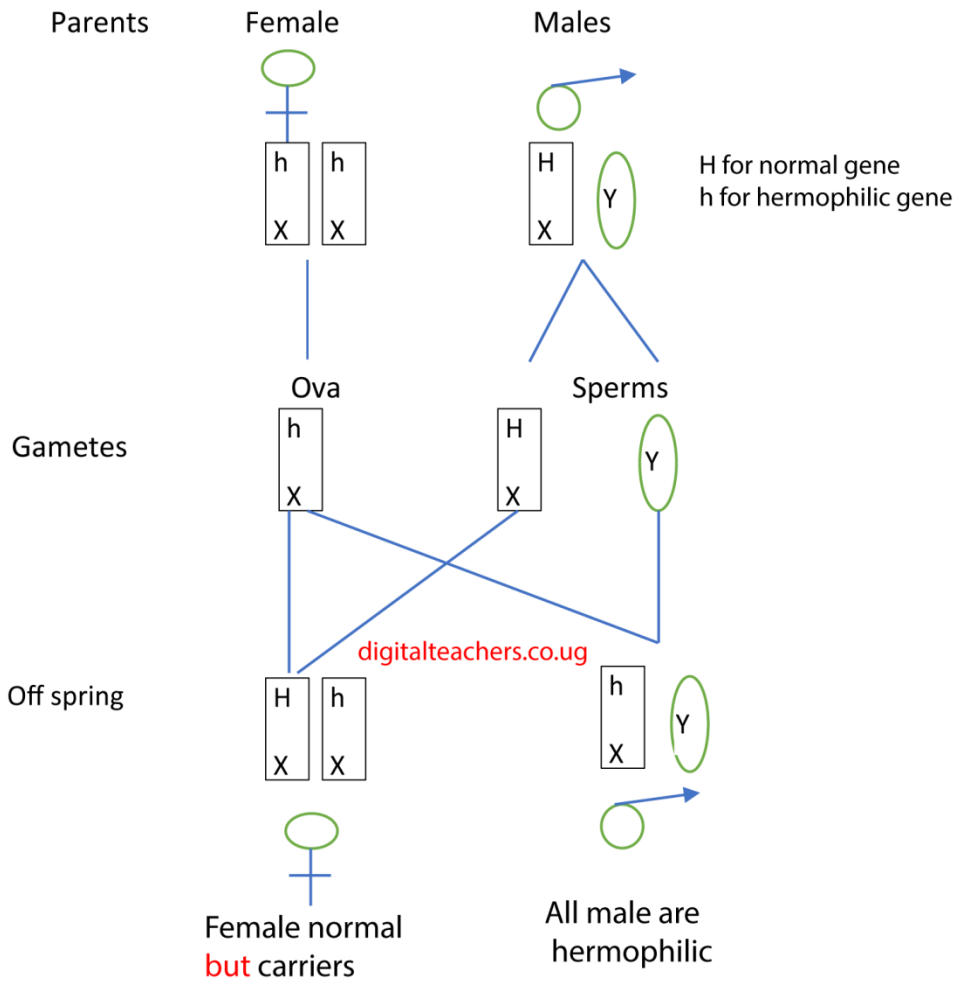
symptoms of hemophilia are

- Unexplained and excessive bleeding from cuts or injuries, or after surgery or dental work
- Many large or deep bruises
- Unusual bleeding after vaccinations
- Pain, swelling or tightness in your joints
- Blood in your urine or stool

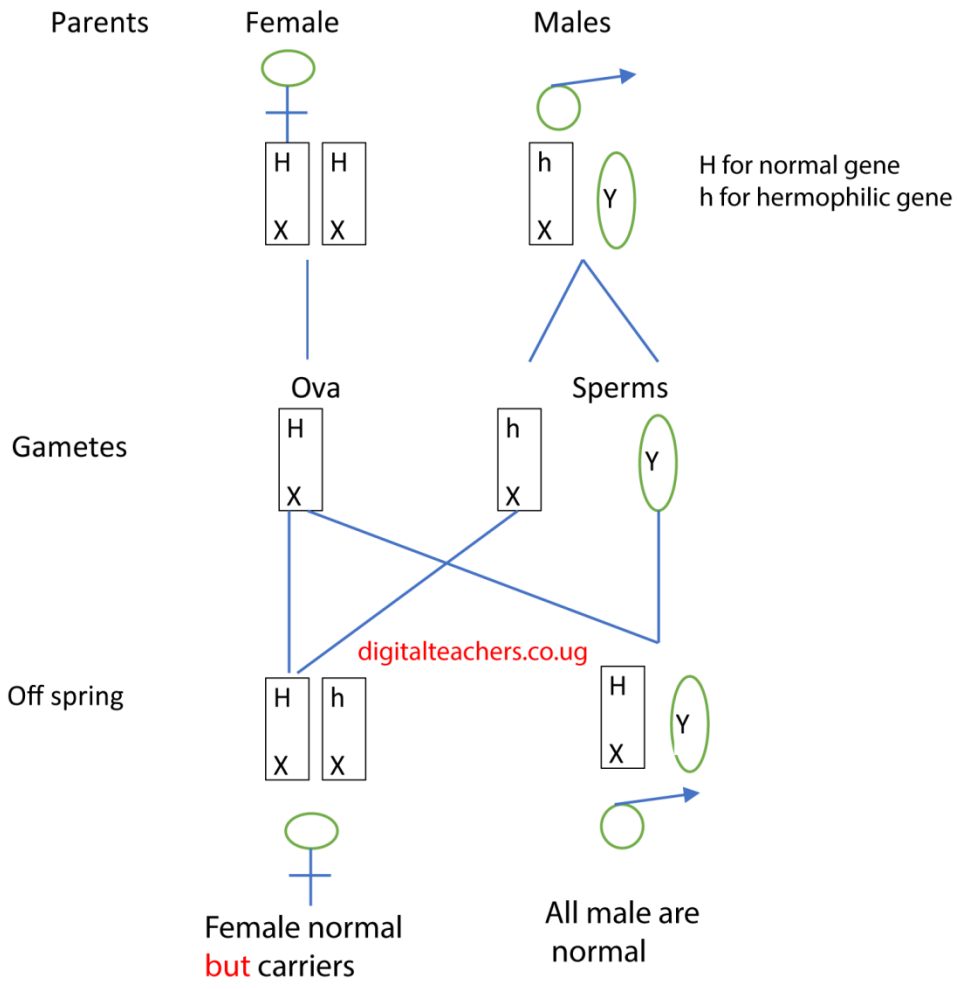
(iii) eye color in drosophila

Transmission
Hemophilia can be represented as follow

(a) Female hemophilic and normal man



(b) Female normal X male hemophilic



THE Y-CHROMOSOME.

1.If a sex-linked trait is associated exclusively with Y-chromosome, it is expected to show up exclusively in males. In general, most Y-chromosome are empty. However, the 'porcupine' man is said to have transmitted hard and spine skin exclusively to his male children.

2.The hair pinna or ear is a characteristic common in India and it is transmitted to male off spring only.

Sex linked are more common in male than female because

(i) Males have only 1 X chromosome, from their mother. If that X chromosome has the gene for red-green color blindness (instead of a normal X chromosome), they will have red-green color blindness.

(ii) Females have 2 X chromosomes, one from their mother and one from their father. To have red-green color blindness, **both** X chromosomes would need to have the gene for red-green color blindness

Sex limited characters
These are characters that that show up exclusively in one sex only e.g. ovary in female

Note: A sex – limited character is one which is controlled by a gene located on any chromosome but expresses itself in only one of the two sexes.

Crossing over.
In maize smooth kennels are dominant to shrunken ones and colored kennels are dominant to colorless. The gene for texture and color are linked. When a maize plant homozygous for kennel which are Smooth and colored is crossed with that with shrunken and colorless kennels; F1 generation yields all colored smooth kennel. However, F2 generation contains small proportions of maize with smooth and colorless or colored and shrunken kennels as opposed to what is expected,

These small proportions are explained by cross over; During prophase 1in meiosis, homologous chromosomes become intertwined and at chiasmata chromatids break and rejoin. The result is that portions of the chromatids belonging to the two homologous chromosomes change places taking their alleles with them, So the chiasmata result in crossing over.

Crossing over value $= \frac{numbe\ of\ organisms\ with\ small\ proportions\ of\ exchanged\ character}{total\ numbe\ r\ of\ individuals}$

Lethal alleles

Lethal alleles are alleles or a combination of alleles that cause the death of the organism that carries them. They are usually a result of mutations in genes that are essential for growth or development. Lethal alleles may be recessive, dominant, or conditional depending on the gene or genes involved.

Example of lethal alleles are YY genotype in the color inheritance in mice.

Yellow furs are dominant to grey. If a pair or yellow mice are mate, the results are always the same i.e. 2/3 of off spring being yellow and 1/3 grey.

They occur in ratio of 2: 1 instead of 3: 1 because homozygous individual for yellow die off before birth. i.e. genotype YY present a lethal combination of genes.

This has to been confirmed
(i) the present or dead embryo in the uterus
(ii) the yellow mice do not breed true i.e., crossing yellow mice with yellow mice does not produce exclusively yellow mice.

Question.

1.	Which one of the following representations of genotypes would produce only one type of gametes? A. TtHh B. TtHh C. TTHh D. tthh
2.	A man with allele for normal color vision married a woman whose father was color blind. The probability of a couple getting a child with a defective allele is A. ¼ B. ½ C. 1/3 D. ¾
3.	A couple had children with a disorder that appeared only in sons. Which one of the following is true about this occurrence? The disorder is A. Sex linked and the mother is a currier B. Caused by multiple allele C. Sex linked and both parents are carrier D. Sex limited to males and the father is a carrier
4.	When a tall red flowered plant was crossed with a short and white flowered plant, all the offspring were tall and red flowered. When F1 plants were selfed, the F2 plants' phenotypes were in the ratio of 3:1. This occurrence suggests the occurrence of A. Epistasis B. Recombination C. Crossing over D. Linkage
5.	A man of blood group B married a woman of blood group AB. Which one of the following blood group types would not be of their child? A. AO B. BO C. AA D. BB
6.	Sickle cell anemia is caused by a double recessive gene and sufferers usually die before maturity. This continued existence of the sickle cell allele among the human population demonstrates A. Drug resistance B. Heterozygous advantage C. In-breeding D. Genetic drift

7.	Albinism in corn plant is due to double recessive gene which causes them to die before maturity. The trait however continues to appear in generation because A. Albina plant can develop chlorophyll when exposed to light B. Normal green plants may carry recessive alleles C. New varieties may be produced by crossing-over in albino plants D. Mutation may occur to change albino plant to green
8.	An occurrence of phenotypic ratio of 3:1 in a dihybrid cross is an indication of A. Linkage B. Crossing of over of chromosome C. Failure of homologous chromosome to separate D. Dominance
9.	In flowers, the heterozygous condition of the alleles for red petal [R] and white [W], are pink. Which one of the following proportions and color of petals is correct if a pink flowered plant is crossed with a red flowered plant A. 3red : 1 white B. 3 red : 1pink C. 1pink : 1 red D. 1 pink: 1 white
10	Use the information to answer questions 10 and 11 In mice, yellow for [Y] is dominant over grey for [y] when two mice were mated, the off spring were in the ratio of 2 yellow :1 grey. From the results, which of the following were likely genotype of the parents? A. Both were homozygous dominant B. Both are heterozygous C. one was heterozygous and the other homozygous dominant D. Both were homozygous recessive
11	Which of the following best explains results? A. Double recessive allele for color is lethal B. Heterozygous condition for color is lethal C. For color could be sex link D. Double dominant allele for color is lethal.
12	According to Mendel, all the following are correct except A. Each characteristic of an organism is controlled by a pair of alleles B. Each allele is transmitted from generation to generation in a discrete unit C. There are several varieties of allele of each from each parent D. Each organism inherits one allele of each pair, from each parent

13.	Which one of the following statement is not correct about a test cross? A. It is carried out on an organism with dominant phenotype B. The offspring of the cross may all have dominant phenotype C. The organism of unknown genotype is crossed with a homologous dominant individual D. The offspring of the cross may have the ratio of 1 dominant phenotype: 1 recessive phenotype
14.	Mendelian expected probabilities of genotypes in a cross occur when A. Small number of offspring are produced B. Migrations occur in the population C. Mutation arise D. Fertilization is random
15.	Establishing the genotype of an organism by crossing it with a homologous recessive individual is carrying out a A. Test cross B. Dihybrid cross C. Back cross D. Monohybrid cross
16.	In guinea pigs, the allele for rough coat (R) is dominant over one for smooth coat (r) and that for black coat (B) is dominant over one for white coat (b). the alleles for coat type and color are not linked. A cross between rough black pig and rough white one produced 28 rough black, 31 rough white, 11 smooth black and 10 smooth white. Which one of the following could be the genotype of the parent? A. RrBb xRrbb B. RRBB x RRbb C. RRBb x Rrbb D. RrBB x Rrbb
17.	Which one of the following is true about sex-linked characters in human? A. Female never suffers from the trait B. Father do not pass on the character to their son C. Females are either normal or carriers D. Male are either carriers or sufferers
18.	Which of the following cannot be a parent of a child of blood group O? A. Man, of blood group A and woman of blood group B B. Both man and woman of blood group A C. Both man and woman of blood group B D. Man of blood group AB and woman of blood group O
19.	A rhesus positive fetus whose mother is rhesus negative may not be born alive because the A. Mothers body produces antigens against fetal antibodies B. Fetus lack antibodies against the mothers' antigens C. Mother's body produces antibodies against the fetal antigens D. Mother's red blood cells mix with the fetal blood

20.	Which one of the following is true of linked characteristics? They A. Are always transmitted as a single block B. Are allelic to each other C. Occur on non-homologous chromosomes D. Can be transmitted independently
21.	Assuming that in humans, allele for the length and color of hair are linked and the ones for long and brown hair are dominant over those for short and dark hair. A child with long and dark hair from a mother who is homozygous for long and brown hair and a father with short and dark hair would be due to A. Mutation B. Crossing over C. Recombination D. Closeness of the alleles on the chromosome
22.	Which one of the following hereditary characteristics is known to be sex linked? A. Hemophilia B. Baldness C. Albinism D. Short neck
23.	In a plant species, the allele for tallness (T) and blue flower (B) is dominant to that for shortness (t) and white flowers (b). A tall plant with blue flowers was crossed with sort plants with white flowers. The results obtained are: 1tallblue: 1tallwhite: 1shortblue: 1short white The genotype of the blue flowered plant was A. TtBb B. ttBB C. TTBB D. TtBB
24.	Which one of the following is caused by a defect on a recessive sex linked allele? A. Albinism B. Color blindness C. Sickle cell D. ABO blood group system
25.	In flower, the heterozygous condition of allele for red petal (R) and white petal (W), is pink. Which of the following proportions and color of petals is correct if a pink plant is crossed with a red flowered plant? A. 3 red: 1white B. 3 red: 1 pink C. 1pink:1 red D. 1pink: 1 white

Use the information below to answer 26 and 27
In mice, yellow fur (Y) is dominant over grey fur (y), when two yellow mice were mated, the offspring were in ratio of 2 yellow to 1 grey

26 From the results, which of the following were the likely genotype of the parent
A. Both were homozygous dominant
B. Both were heterozygous
C. One was heterozygous and the other homozygous dominant
D. Both were homozygous recessive

27. Which of the following best explains the result?
A. Double recessive allele for color are lethal
B. Heterozygous condition for color is lethal
C. Fur color could be linked
D. Double dominant alleles for fur is lethal

28. What would be phenotypes of children born of a colorblind man and a normal worm?
A. All normal
B. Only girls normal
C. Only boy color blind
D. All color blind

29. A woman produces five children. The first two children were girls, followed a boy. The last two are girls. What is the probability that the sixth child will be a boy
A. ¼
B. ½
C. 1/6
D. 1/8

30. A boy has blood group A and his sister has blood group B. which combination of genotype **cannot** belong to their parents?

	Mother	Father
A	I^AI^A	I^BI^O
B	I^AI^B	I^BI^B
C	I^OI^O	I^AI^B
D	I^BI^O	I^AI^O

31. A ratio of 3:1 obtained among the offspring in a dihybrid cross is a result of
A. Crossover
B. Linkage
C. Non-disjunction
D. Dominance

32.	The phenotype resulting from a cross between red eyed and white eyed fruit flies depends on which parent is red eyed. This means that the gene for eye color is A. polygenic B. sex linked C. homogametic D. sex limited
33	Which one of the following would lead to genetic death in an animal population? A. Hemophilia in a population B. Sickle Cell trait in a population C. Infertile males in a population D. Albinism in a population
34.	The following can result in some variation of offspring **except** A. Haploid parthenogenesis B. Conjugation C. Fragmentation D. Self-fertilization
35.	A coffee plant known to be heterozygous for a recessive defect which makes the plant fail to produce viable seeds, was self-pollinated and gave rise to 600 seedlings. How many of the seedling were heterozygous? A. 150 B. 200 C. 300 D. 400
36	If a father has blood group A and the mother blood group AB then the number of possible genotype of their offspring is A. 2 B. 3 C. 4 D. 6
37.	Which one of the following phenotypic ratios results from a recombination due to the linkage? A. 4:1:1:4 B. 1:2:1 C. 2:1 D. 1:1
38.	What is the maximum number of triplets of nucleotides that could code for the 20 amino acids? A. 3 B. 6 C. 48 D. 63

39 The following results were obtained from the selfing of F1 generation of pure breading parents for tall and dwarf plants

Dominant trait	Recessive trait	Number of F2 offspring
Tall plants	Dwarf plants	8250

What would be the actual number of F2 offspring with tall plants?

A. 6189
B. 4126
C. 2063
D. 1500

Structured questions

40. In human albinism is caused by an autosomal receive allele. On average, 1 person in 10,000 is an albino.

(a) Give two characteristic of an albino.

(b) Using Hardly formula $P^2 + 2Pq + q^2 = 1$, determine the

(i) Frequency of the albino allele in the human population.

(ii) Frequency of the heterozygous genotypes in the population.

(c) Explain why it is difficult to eliminate allele from a population.

Solution

(a) Light coloured skin

White hair

Pink eyes.

(b) (i) frequency of the albino allele = q

Frequency of albinism (q^2) = $\frac{1}{10000}$

i.e. q^2 = 0.0001

= $\sqrt{0.0001}$

Q = 0.01

Hence the frequency of the albino allele in the human population is 0.01.

(ii) $P + q = 1$

$P + 0.01 = 1$

But $p + 2pq + q = 0.99$

But $p^2 + 2pq + q^2 = 1$

$(0.99)^2 + 2pq + (0.01)^2 = 1$

$0.9801 + 2pq + 0.0001 = 1$

$2pq = 1 - 0.9802$

2pq = 0.0198.

Hence the frequency of the heterozygous in the population is 0.0198.

(c) A large proportion of the recessive alleles in a population exist in the carrier heterozygotes. As a result, very few can be eliminated from the population in each generation. Only alleles present in the homozygous recessive organism will be expressed in the phenotype and so be exposed to environmental selection and possible elimination.

Also, certain recessive alleles confer extra advantage to organism containing then I heterozygous state. This maintains the allele in the population. For example, the sickle cell allele.

41. (a) Explain the meaning of the Hardy-Weinberg equilibrium principle

(b) State four conditions that must be fulfilled in order for the principle to hold true

(c) Brown eyes in a human population is caused by a dominant. If in a population, 84% of the people have brown eye, using Hardy-Weinberg formula, determine the percentage of the population who are.

(i) Heterozygous for eye colour. show your working.

(ii) Homozygous dominant for eye colour. Show your working

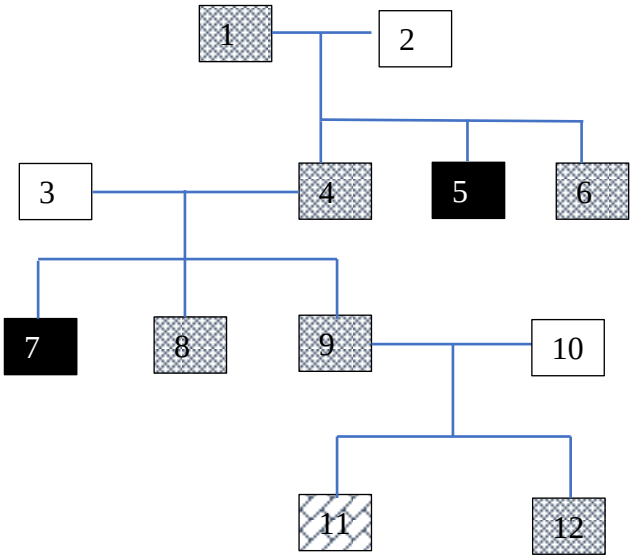
42. In an oil seed plant species, the allele for tallness is dominant over that for dwarfness. Meanwhile the allele for chlorophyll production and non-chlorophyll show incomplete dominance. The heterozygous plants are variegated.

(a) Using suitable symbols, construct a diagram of a cross between a tall plant with green leaves and a dwarf plant with variegated leaves, to show the genotype and phenotypes of the offspring

(b) Explain why 25% of the offspring of the cross in (a) would fail to survive.

43. In poultry feather color is controlled by two sets of alleles, **W** [white] dominant over **w** [colored] and B [black] dominant over b [brown] A foul heterozygous for both alleles [WwBb] is white.
    a. Explain why the genetic constitution of WwBb is white?
    b. Work out to show the phenotypic ratio of crossing a white cock (WwBb), with brown hen.
    c. State the possible genotype of a black fowl

44. The figure below shows how sickle cell anemia has affected a family line. Sickle cell anemia is a recessive genetic defect which is not sex linked individuals are numbered 1 2 3……..12



Key

Affected female

Unaffected male

Unaffected female

Affected male

(a) State the number of all individuals in the family line that are certain to be heterozygous for this gene (2marks)
(b) What is the probability that individual 6 is heterozygous for this gene? (show your working)
(c) The parasite which cause malaria digest hemoglobin in the red blood cells. Suggest two reasons an individual who is heterozygous for this gene may show resistance to malaria.

(d) State the difference between individuals who have sickle cell anemia and those that have sickle cell trait. (3marks)

45. (a) Distinguish between sex linked and sex limited genes

(b) Color blindness in man is caused by a recessive gene found on X-chromosome.

(i) A boy with normal eye sight married a color blond girl. Using suitable symbols, work out the probability of producing a normal girl.

(ii) If one the daughters from the marriage in (b)(i) above married a man with normal eyesight, what is the probability that they will produce a boy with normal eyesight?

46 (a) State four situations where Mendel's laws do not apply. (4marks)

(b) In animal species, individual that are homologous for gene A or its alleles die. Another independent gene B in homozygous blocks this lethal effect, otherwise B has no effect on the organism.

(i) Work out the expected phenotypic ratio of the viable offspring in a cross of individual of AaBB and AaBB genotype. (5marks)

(ii) State the type of gene interaction in (b)(i) (1mark)

47 In drosophila, the gene for Broad abdomen and long wings are dominant over the genes for narrow abdomen and vestigial wings. Pure breeding strains of the double dominant variety were crossed with a double recessive variety and a test cross was carried out on F1 generation.

(a) Using suitable symbols, work out the expected phenotypic ratio of the test cross of the F1generation. If the genes for abdomen and length of the wing are liked. (7marks)

(b) It was however observed that when the test cross of F1 generation was carried out, the following results were obtained (3marks)

Broad abdomen, long wings	380
Narrow abdomen, vestigial wings	396
Broad abdomen, vestigial wing	14
Narrow abdomen, long wing	10

Calculate the distance in units between the genes for abdomen width and wing length

48 (a) Define the following terms: backcross, sex linked and sex limited characters

(c) Which cells in in cereals are haploid, diploid and triploid?

Haploid .....

Diploid .....

Triploid .....

(c) Describe one method by which polyploidy can be artificially induced

(d) In sugarcane the gene for yellow midrib (y) and long internode (n) are recessive to green midrib (Y) and short internode (N), and are on the same chromosomes. A yellow sugar cane

with long internodes was crossed with sugar cane heterozygous for yellow midrib and long internodes. The off spring were

256 YyNn, 38Yynn

272yynn, 34 yyNn

Calculate the cross over value

49 (a) What is a sex-linked character?

(b) (i) Why are sex linked traits most common in males among humans?

(ii) Hemophilia is a condition caused by a recessive gene carried on X -chromosome. Determine the phenotype of the children from a carrier mother and normal father.

50. (a) State Mendel's first law of inheritance and explain what it means

(b) (i) state the stages of meiosis that illustrate this law

(ii) explain what takes place in the stages you have named in (a)(ii) above

(c) In human beings, brown eyes are usually dominant over blue eyes. Suppose a blue-eyed man marries a brown-eyed woman whose father was blue-eyed. What proportion of their children would predict that will have blue eyes? Show your working.

51. Both hemophilia and color blindness are transmitted in the same way

(a) What is the effect of each disease? (04marks)

(b) Describe the transmission of the diseases (08marks)

(c) Explain why there are more color-blind individuals than hemophilic among the population in spite of similar way of transmission (8marks)

Answer to objective type questions

1	D	11	D	21	B	31	B		
2	A	12	C	22	A/D				
3	A	13	C	23	A				
4	D	14	D	24	B				
5	C	15	A	25	C				
6	B	16	A	26	B				
7	B	17	B	27	D				
8	A	18	D	28	A				
9	C	19	C	29	B				
10	B	20	A	30	B				

40. Solution

(d) Light coloured skin

White hair

Pink eyes.

(e) (i) frequency of the albino allele = q

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= $\sqrt{0.0001}$

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Hence the frequency of the albino allele in the human population is 0.01.

(ii) P + q = 1

P + 0.01 = 1

But p + 2pq + q = 0.99

But $p^2 + 2pq + q^2$ = 1

$(0.99)^2 + 2pq + (0.01)^2$ = 1

0.9801 + 2pq + 0.0001 = 1

2pq = 1- 0.9802

2pq = 0.0198.

Hence the frequency of the heterozygous in the population is 0.0198.

(f) A large proportion of the recessive alleles in a population exist in the carrier heterozygotes. As a result, very few can be eliminated from the population in each generation. Only alleles present in the homozygous recessive organism will be expressed in the phenotype and so be exposed to environmental selection and possible elimination.

Also, certain recessive alleles confer extra advantage to organism containing then I heterozygous state. This maintains the allele in the population. For example, the sickle cell allele.

43. (a) State four situation where Mendel's laws would not apply.

(b) In an animals species, individual that are homologous for gene A or its allele die. Another independent gene B in the homozygous state, blocks this lethal effect, otherwise gene B as no other effect on the organism.

(i) Workout the expected phenotypic ratio of the viable offspring in a cross of individuals of AaBb and AaBB genotypes.

(ii) State the type of gene interaction in (b) (i)

(a) Multiple alleles
Linkage
Gene interaction e.g., epitasis complementary genes or polygenic inheritance
Others
Mutation

(b) (i)

	male	x	female
Parental genotype	AaBb	X	AaBB
Gametes	AB, Ab, aB, ab		AB, aB

Cross are shown in the pannet squre below:

	AB	Ab	aB	Ab
AB	AA Bb Survives	Aa BB dies	AaBB survives	AaBb Dies
aB	Aa BB Survives	AaBb dies	aa BB survives	aaBb dies

From the table, there 4 viable offspring and 4 non-viable offspring

(ii) Epistasis

42. Solution

(a) Provided there are no disruptive influence such as mutations or selection, the frequency of alleles in a population remains constant, generation after generation.

There is continued movement of gene (gene flow) within the population due to breeding but the overall gene frequencies remain constant. This stability is referred to as genetic equilibrium.

(b) No mutation occurs

Mating must be random

The population must be large.

No emigration or immigration from or into the population should occur

Generations should not overlap

All genotypes should be equally fertile, so that no selection occurs.

(c) Let the allele for brown eyes be B

The allele for other eye colour be b

Frequency of allele B be p

Frequency of allele b be q

Given BB+ Bb constitute 84%

The hardy-Weinberg equation states

$P^2 + 2pq + q^2 = 1$

given $p^2 + 2pq = 0.84$

$q^2 = 1 - 0.84$

$q^2 = 0.16$

$\Rightarrow q = 0.4$

Also $p + q = 1$

$P = 1-0.4$

$P = 0.6$

$\Rightarrow (0.6)^2 + 2pq = 0.84$

$2pq = 0.84-0.36$

$2pq = 0.48$

Hence 0.48% of the population is heterozygous.

(ii) from above

$P = 0.6$

$\Rightarrow$ BB = p2 = (0.6)2

.; BB = 0.36

% 0f BB = 36%

Hence, the percentage of individual homozygous dominant for eye color is 36%

42. Solution

(a) let

T be the allele for tall plant,

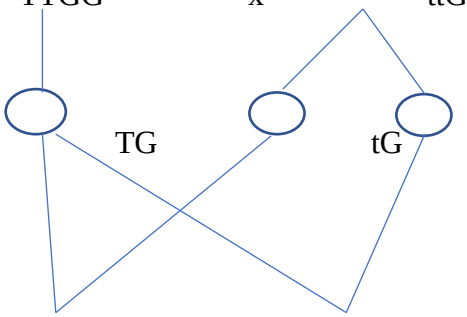
t be the allele for dwarf plant

G be the allele for chlorophyll production

W be the allele for non- chlorophyll production

A tall plant with green leaves would have genotype TTGG or TtGG. While the dwarf plant with variegated would gave genotype ttGW. Two crosses are possible in this case.

Parents TTGG x ttGW

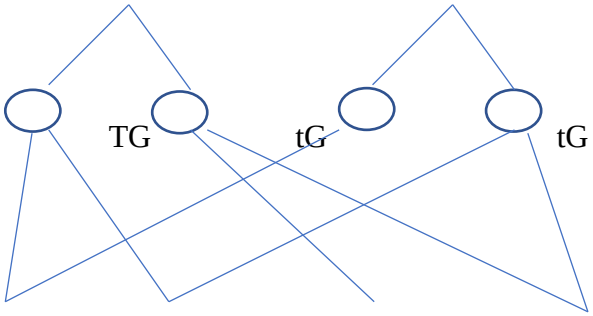


Gametes TG tG tW

Offspring TtGG TtGW

Or

Parents TtGG x ttGW



Gametes TG tG tG tW

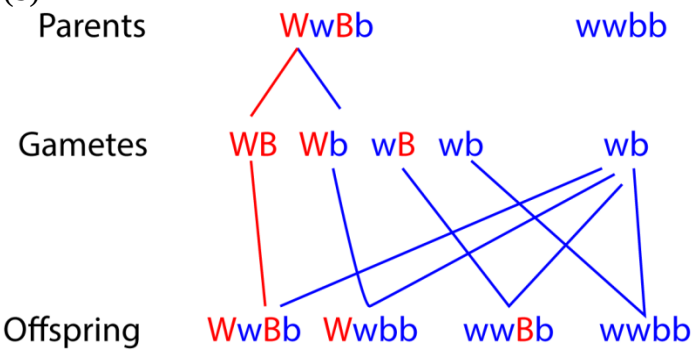
Offspring	TtGG	TtGW	Dwarf with Green	Dwarf with Variegated

(b) In the second cross, 25% of the offspring survival disadvantage in being dwarf with variegated leave. They cannot reach out for enough light do not have enough chlorophyll to absorb light for photosynthesis.

43. Solution

(a) When both genes are present in the genotype, gene W presents the expression of gene B in phenotype, a condition called epistasis.

(b)



(c) wwBB and wwBb

44 (a) 4, 9

Note that 3 and 3, 9 and 10 must heterozygous to produce affected person of their offspring. But 3 and 10 are just partners while 4 and 9 belong to the family line.

(b) Possible heterozygous include: 1, 2, 3, 4, 6, 8, 9, 10, 12

Number of possible heterozygotes = 9

Probability that 6 is heterozygous = 1/9

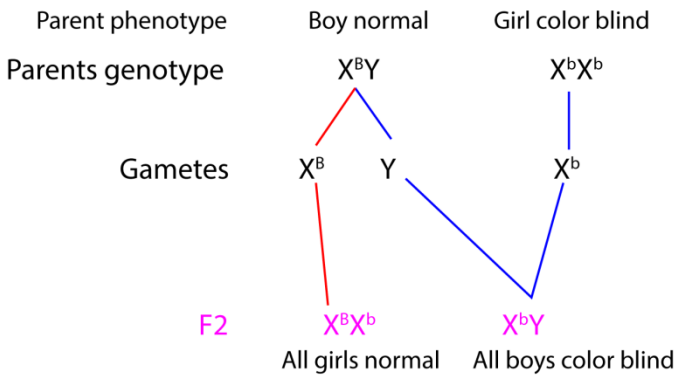
(c)

- some of their red blood cells have reduced capacity of oxygen that they may not be able to support intracellular parasite
- the sickle shaped have reduced life span to complete the life span of parasite
- haemoglobin s may not be digestible

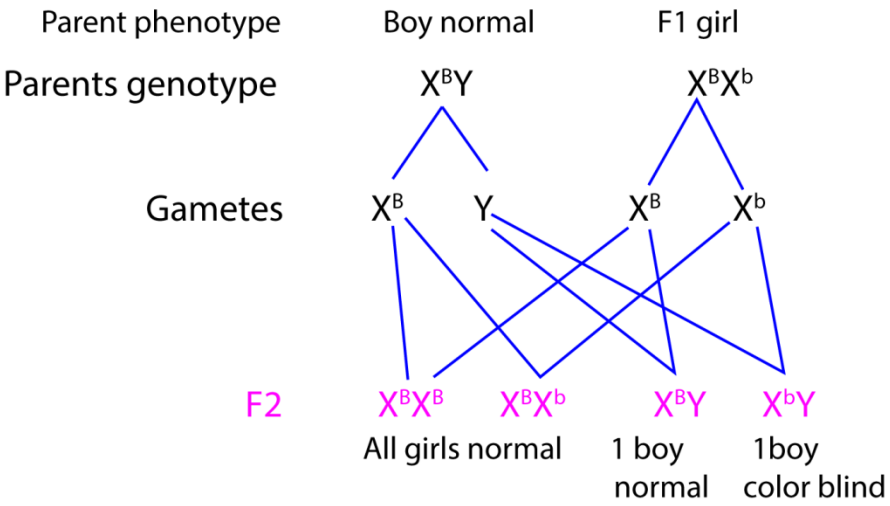
(d) Individuals with sickle cell anemia have over 60% of their red blood cells containing haemoglobin S which is defective. While those with the sickle cell trait have not more than 50% of abnormal haemoglobin S.

45 (a) Sex-linked characteristics are those whose genes are carried on the sex (X-) chromosomes for example in humans are color blindness, and hemophilia while sex limited traits are characters that that show up exclusively in one sex only e.g. ovary in female

(b)



The probability of producing a normal girl is 1



Probability of a normal boy = ½

46 (a) situations where Mendel's laws do not apply

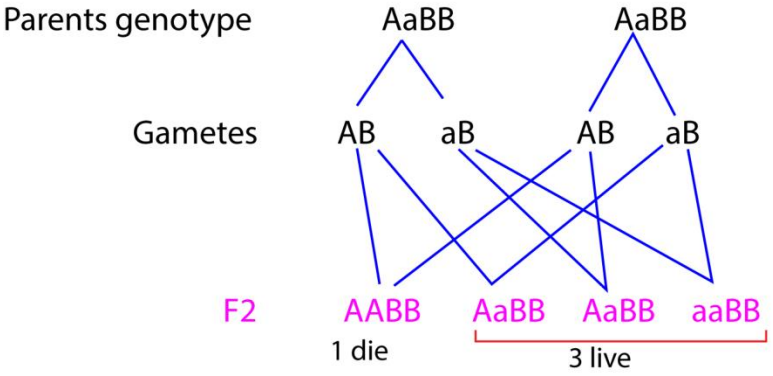
(i) Linkage

(ii) Incomplete dominance.

(iii)Co-dominance

(iv)Multiple alleles.

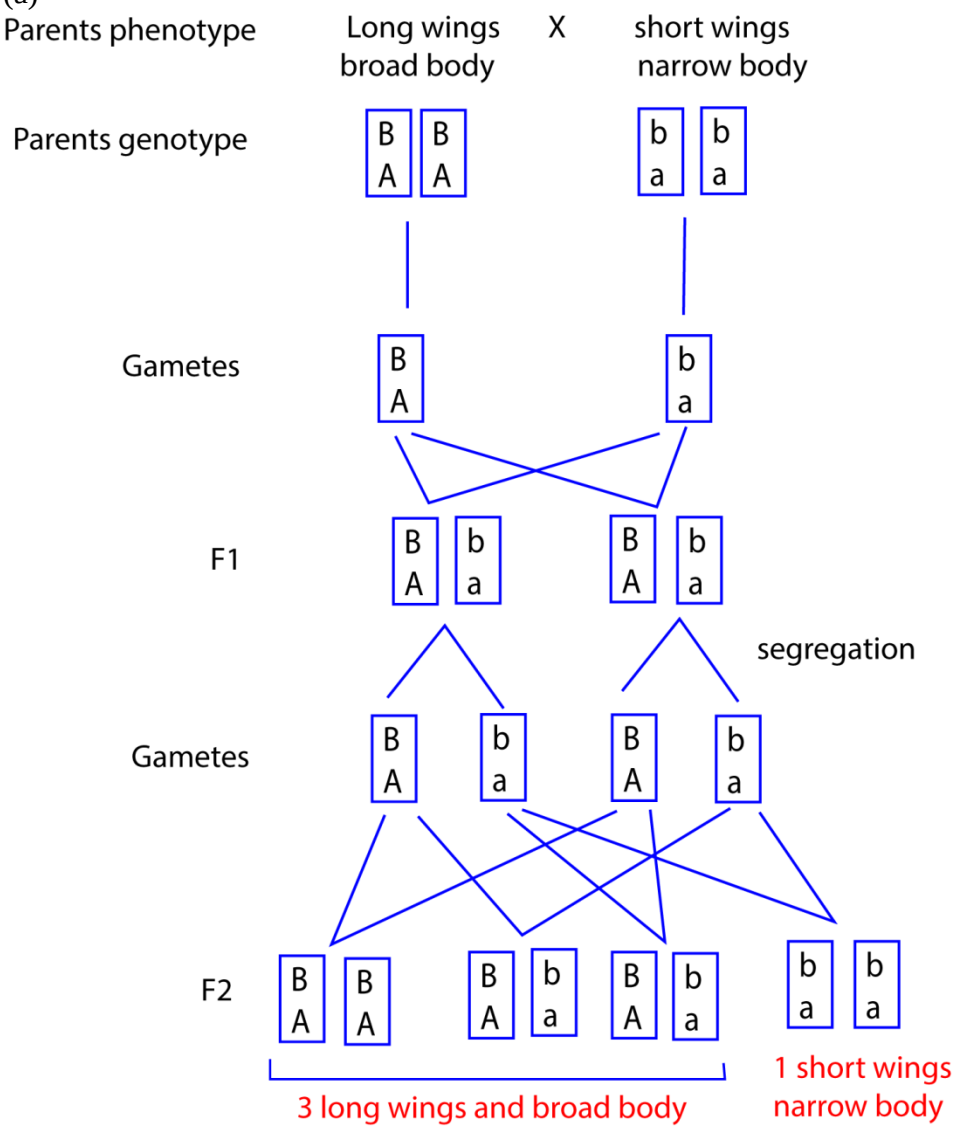
(b) (i)



(ii) Epistasis

47. Solution

(a)



(b)

Crossing over value $= \frac{numbe\ of\ organisms\ with\ small\ proportions\ of\ exchanged\ character}{total\ numbe\ r\ of\ individuals}$

$$= \frac{10+14}{380+396+10+14} = \frac{24}{4220} = 0.006\ or\ 0.6\%$$

48.