BIOLOGY-XII | Self-Study notes / Assignment - II
Principles of Inheritance and Variation

Back cross and Test cross :-

Back cross :- cross between F_1 hybrid with one of the two parents is called back cross.

♂ TT × tt
↓ ↓
T t ← g_1

Tt ← F_1

Back cross - F_1 X any one parent (either dominant or recessive)

Tt X TT OR Tt X tt.

Test cross :- cross between F_1 hybrid with its recessive parent. or otherwords back cross to the recessive parent is known as Test cross. it means, all test crosses are back cross but all back crosses are not test crosses.

♂ TT × tt
↓ ↓
T t ← g_1

Tt ← F_1

Test cross :- Tt X tt

Monohybrid Test cross ratio = 1 : 1

T t × t t
↓ ↓
T t t ← g_1

Tt — Tall
tt — Dwarf

Dihybrid Test cross :-

Tall & Round × Dwarf & wrinkled

TTRR × tt rr
↓ ↓
TR ← g_1 tr

F_1 ← TtRr

Dihybrid Test cross Ratio = 1 : 1 : 1 : 1

TtRr × ttrr
↓ ↓
TR Tr tR tr ← tr

TtRr — Tall & Round
Ttrr — Tall & wrinkled
ttRr — Dwarf & Round
ttrr — Dwarf & wrinkled

Polygenic Inheritance

Inheritance is of two types :—

(I) Qualitative Inheritance (Monogenic inheritance)

(II) Quantitative Inheritance (Polygenic inheritance)

(I) Qualitative Inheritance (Monogenic inheritance)

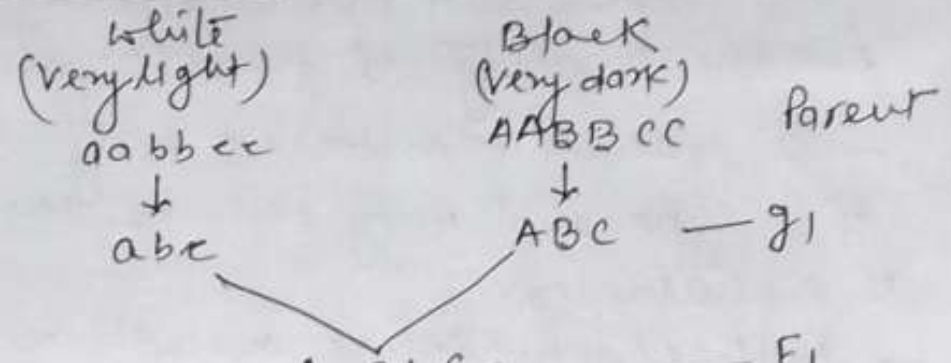
- a type of inheritance in which a single dominant gene influences a completely trait. Presence of two such dominant ~~allele~~ gene does not alter the phenotype
- The gene in which dominant allele expresses the complete trait are called monogenes. eg- TT or Tt for Tallness in Pea.
- monogenic inheritance produces a sort of discontinuous trait variation eg. either tallness or dwarfness.
- Intermediate forms or continuous trait variations are not produced.

(II) Quantitative Inheritance (polygenic inheritance)

- a type of inheritance controlled by generally three or more genes in which the dominant alleles have cumulative effect with each dominant alleles expressing a part or unit of the trait, the full trait being shown only when all the dominant alleles are present. The genes involved in quantitative inheritance are called polygenes.
- Polygene produce continuous variation in the expression of traits. A single dominant allele express only a unit of the trait.
- A character is represented by three to several pairs of alleles.

eg- Human skin colour.

Human skin colour.



Ratio = 1:6:15:20:15:6:1

Very Dark Black = 1
Dark = 6
Fairly Dark = 15
Intermediate = 20
Fairly light = 15
light = 6
Very light (white) = 1

Chromosomal theory of inheritance :—

- Proposed by Sutton & Boveri (1902)
- Previously according to Mendel's law alleles or genes are inherited generation to generation but chromosomal theory of inheritance states that characters are not only inherited through gene but inherited through chromosome.

The salient features of chromosomal theory of inheritance :—

- Gametes (i.e sperm and ova) constitute bridge between one generation and the next generation.

- both sperm and ovum equally contribute in the heridity of the offspring.
- a gamete containing only one chromosome of a type and only one of the two alleles of a character.
- both chromosome as well as gene occur in pairs in the somatic or diploid cells.
- The paired condition of both chromosomes as well as genes is restored during fertilization.

Linkage:

The tendency of genes to stay together during inheritance through generation without any change or separation due to their being present on the same chromosome is called as linkage.
The genes located in the same chromosome are called linked genes and those present in different chromosomes are termed unlinked genes.

Types of linkage

① complete linkage ⑪ Incomplete linkage

① complete linkage - The genes located in the same chromosome do not separate and are inherited together over the generations due to the absence of crossing over. ~~There~~ There is no chance of recombinants in complete linkage
eg- Male Drosophila

(11) Incomplete linkage :- Linkage is incomplete when new or nonparental combinations of linked genes are also formed. It is due to crossing over and hence produce recombinants progeny besides the parental type.
eg- female Drosophila

Linkage group :- Genes that are present on the same chromosome make one linkage group. They inherit together except for crossing over.
The no. of linkage group is equivalent to number of chromosomes present in a genome.

Drosophila melanogaster 4 Pairs of chromosome = 4 linkage group

In human - 23 pairs of chromosome = 23 linkage group.

Pea (Pisum Sativum) 7 Pairs of chromosome = 7 linkage group.

Maize - 10 Pairs of chromosome = 10 linkage group.

Neurospora - 7 Pairs of chromosome = 7 linkage group.

Linkage map :- A linkage or genetic or chromosome map is a linear graphic representation of the sequence and relative distance of the various genes present in a chromosome.

Map units :- 1% crossing over between two linked genes is known as 1 map unit or CentiMorgan (cM). 100% crossing over is termed as Morgan (M) and 10% crossing over as deciMorgan (dM)

Crossing over: Crossing over is the mutual exchange of segment between nonsister chromatids of homologous chromosomes.
Crossing over occurs in the pachytene stage of Prophase I of meiotic cell division. Crossing over produces recombinants.

Mechanism of crossing over:-
Following steps:-
1. Synapsis
2. Tetrad formation
3. Crossing over and chiasma formation

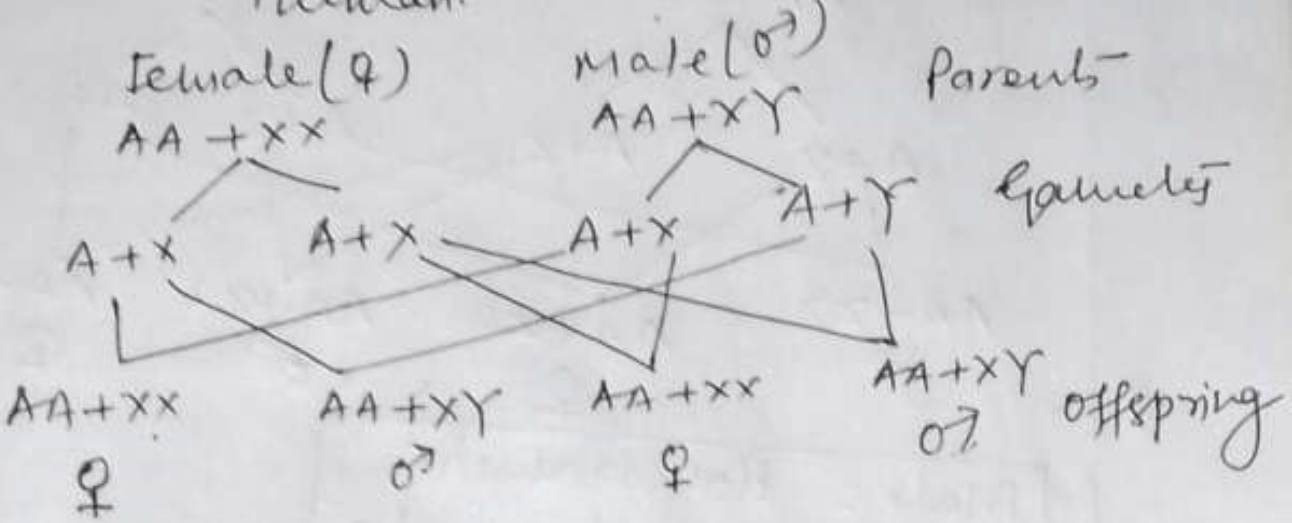
H.W
Q- Differentiate between linkage and crossing over.

Sex-Determination
Establishment of male and female individual or male and female organs of an individual is called as sex determination.

Types of chromosomal sex determination

(I) XX-XY type:

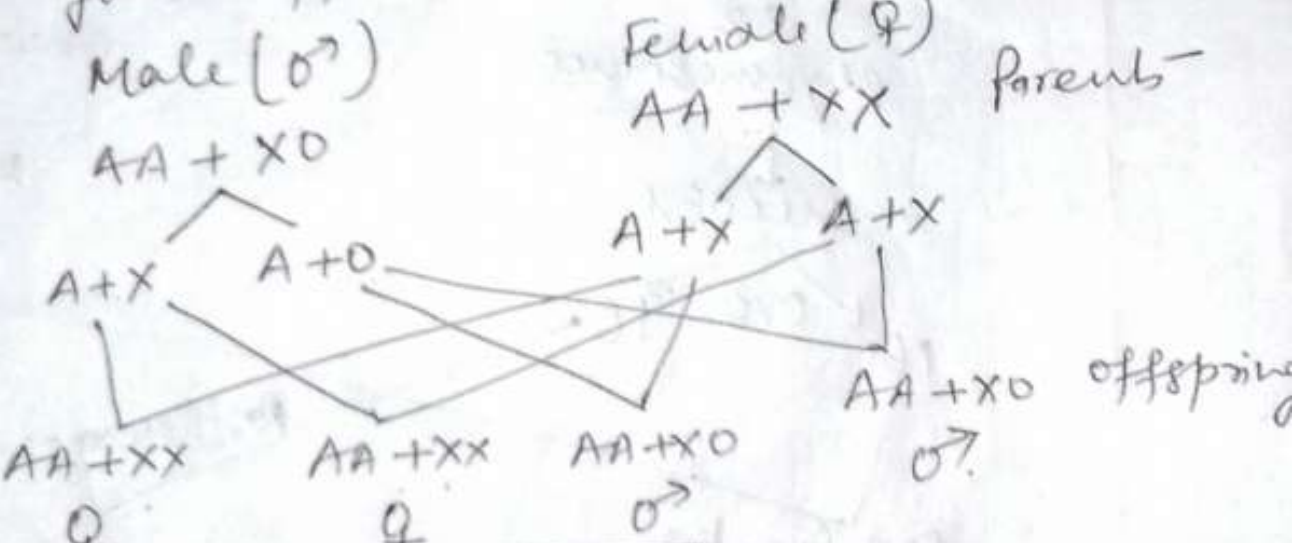
eg- fruit fly { Drosophila melanogaster)
Human.



Male = Heterogametic
Female = Homogametic

(II) XX-XO Type

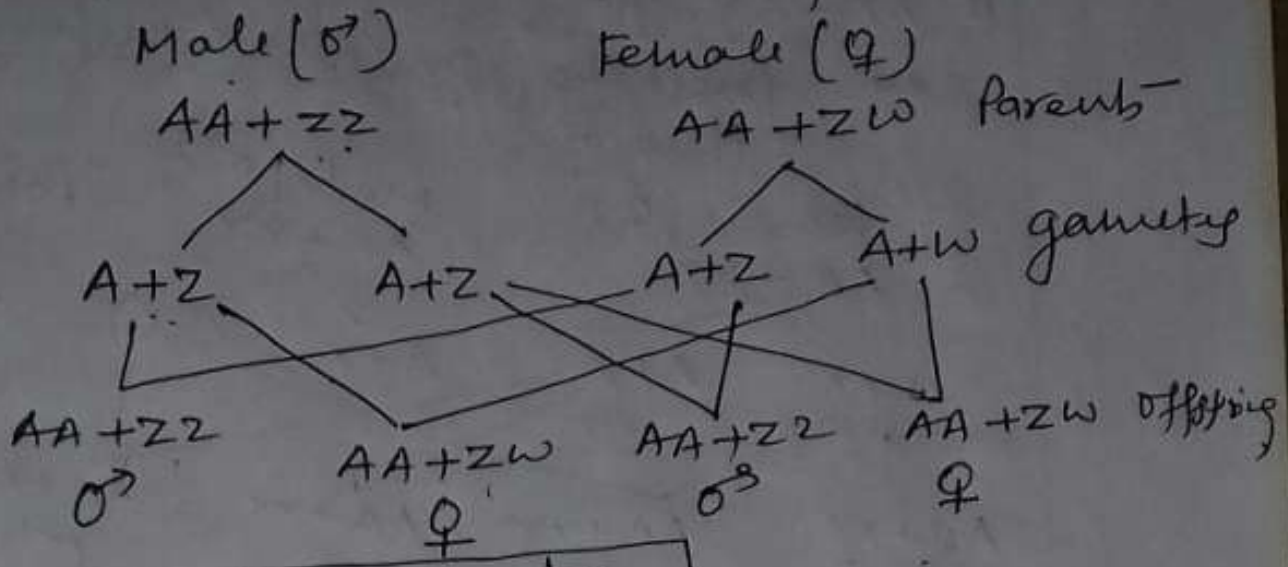
eg- In roundworms, some insects (true bugs grasshoppers, cockroaches)



Male = Heterogametic
Female = Homogametic

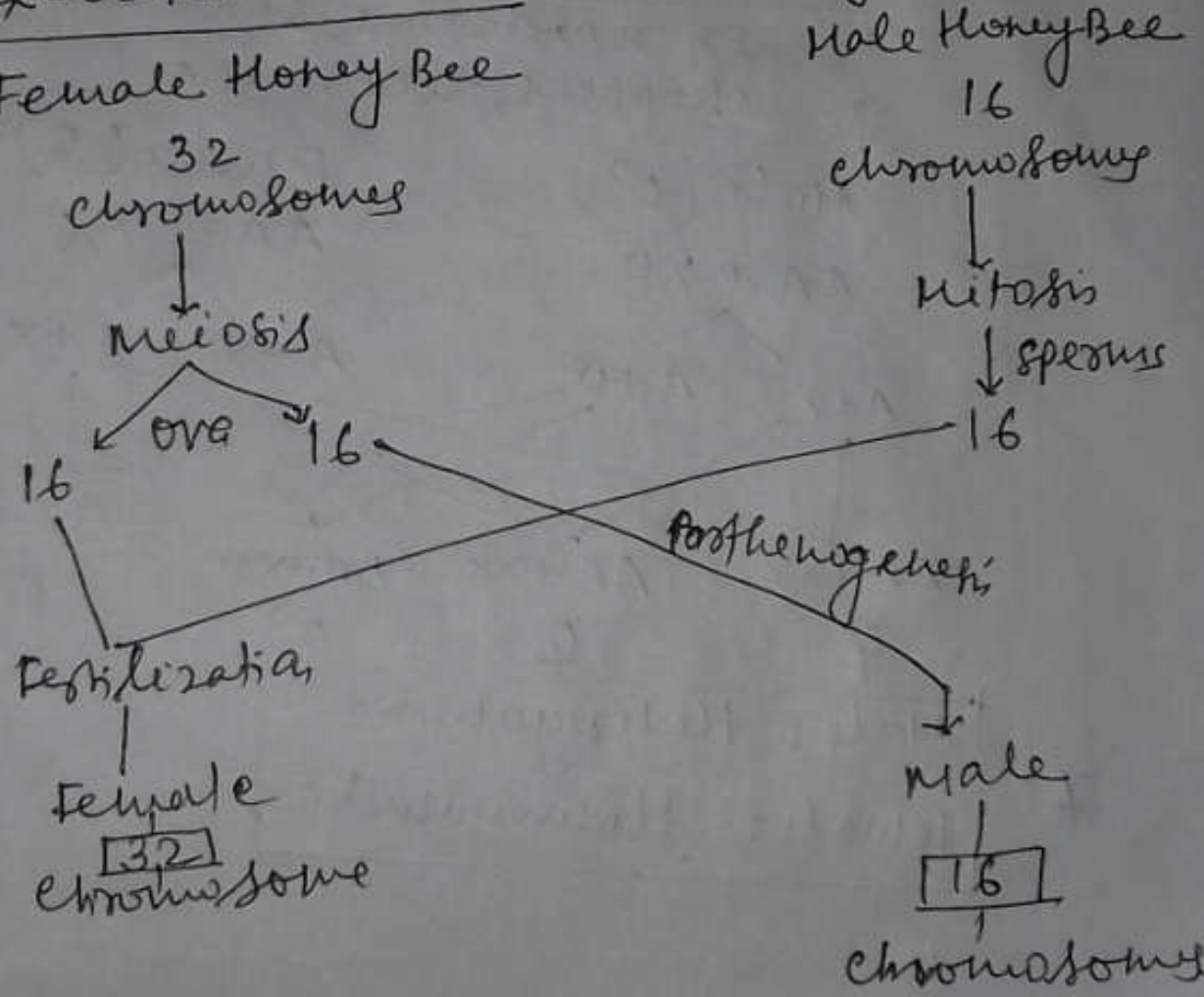
(III) ZW – ZZ type :–

eg- In birds and some reptiles.



Male = Homogametic
Female = Heterogametic

(IV) Haploid – Diploid Mechanism of sex-determination eg- Honey Bee.



In this type of sex determination male is haploid while female is diploid. Male insects are haploid because they develop Parthenogenetically from unfertilized eggs.

Sex linked inheritance

- X-linked inheritance
- Y-linked inheritance

eg-
(i) Haemophilia (Bleeder's disease)
(ii) Colour Blindness

- Holandric inheritance
- eg- Hypertrichosis

(i) Haemophilia – Blood fails to clot – in haemophilia, blood doesn't clot within 3-8 minutes. It takes one hour or more.

(ii) Colour Blindness – Eye fails to distinguish red and green colours.

Symbols:	Normal	Carrier	Diseased (Haemophilic)
Male	XY	—	X^hY
female	XX	XX^h	X^hX^h.

Note- Put 'c' for colourblindness in place of 'h'

Male	XY	—	X^cY
female	XX	XX^c	X^cX^c

Q1. The male fruit fly and female fowl are heterogametic while the female fruit fly and male fowl are homogametic. Why are they called so?

Q2. A non haemophilic couple was informed by their doctor that there is possibility of a haemophilic child being born to them. Draw a checker board and find out the the percentage of possibility of such a child among the progeny.

Q3. What is heterogamety? Explain the mechanism of sex determination in Drosophila.

Q4. What is test cross? How can it decipher the heterozygosity of a plant?

Q5. During his studies on genes in Drosophila that were sex linked. T.H. Morgan found F_2 Population phenotypic ratios deviated from expected 9:3:3:1. Explain the conclusion he arrived at.

Q6. Why is haemophilia generally observed in human males. Explain the conditions under which a human female can be haemophilic?

Q7. Explain Polygenic inheritance and multiple alleles with the help of suitable examples.

10.

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Sickle-cell anaemia :—

- autosome linked recessive trait.
- this defect is caused by the substitution of glutamic acid (Glu) by valine (val) at the 6th position of the beta globin chain of the haemoglobin molecule. The substitution of amino acid in the globin protein results due to the single base substitution at the 6th codon of the beta globin gene from GAG to GUG.
- the mutant haemoglobin molecule undergoes polymerisation under low oxygen tension causing the change in the shape of the RBC from biconcave disc to elongated sickle like structure.

Symbol – Normal — $Hb^A Hb^A$
Carrier — $Hb^A Hb^S$
Sickle cell/ (Diseased) — $Hb^S Hb^S$

Phenylketonuria :—

- This inborn error of metabolism is also inherited as the autosomal recessive trait.
- the affected individuals lacks an enzyme which converts the amino acid phenylalanine into tyrosine. As a result of this phenylalanine is accumulated and converted into phenylpyruvic acid and other derivatives. Accumulation of these in brain results in mental retardation. These are also excreted through urine because of its poor absorption by kidney.

Q1. Why do normal red blood cells become elongated sickle shaped structures in a person suffering from sickle cell anaemia. ?

Q2 Linkage and crossing over of genes are alternatives of each other. Justify with the help of an example.

Q3. Write the Symptoms of haemophilia and sickle-cell anaemia in humans. Explain how the inheritance pattern of the two diseases differs from each other.

Q4. "phenylketonuria is a good example that explains pleiotropy". Justify.

Q5. How does a test cross help in identifying the genotype of the organism? Explain.

Q6. How can you say that the sex of a child is determined by the father and not by the mother. ?

Q7. How many types of gametes are Produced by the individual with genotype AABBCc DD and AaBbCc Dd ?