MAHARASHTRA AGRICULTURAL UNIVERSITIES EXAMINATION BOARD, PUNE

MODEL ANSWERS OF SEMESTER END EXAMINATION

B.Sc. (Hons.) (Agri.)

Semester	: II (New)	**Academic Year :**	2018-2019		
Course No.	: GPB - 121	**Title**	: Fundamentals of Genetics		
Credits	: 3 (2+1)				
Day and Date	:	**Time**	:	**Total Marks**	: 80

Note:
1. Solve ANY EIGHT questions from SECTION "A"
2. All questions from SECTION "B" are compulsory.
3. All questions carry equal marks.
4. Draw neat diagrams wherever necessary.

SECTION "A"

Q.1. What is chromosomal aberrations. Enlist the different types and sub types of chromosomal aberrations. Explain inversion in detail.

(Definition : 1 mark, Enlist types :4 marks, Explanation of Inversion type : 3 Marks).

Answer: Any Change which alters the normal structure of chromosome is known as chromosomal abression. It may take in somatic as well as germ cell.

Different types: 1) Alteration of gene number in chromosome

i) Deletion: a) Terminal deletions b) Interstitial or intercalary deletion.
ii) Duplication: a) Tandem duplication b) Reverse tandem duplication
c) Displaced duplication d) Translocation duplication

2) Alteration of sequence of genes in chromosome

i) Inversions: a) Paracentric inversion b) Pericentric inversion
ii) Translocation: a) Simple translocation b) Shift c) Reciprocal translocation.

Explanation of Inversion: Strurtevant (1926) in Drosophila. Structural change in a chromosome in which a segment is oriented in a reverse order. Inverted segment is rotated to full 180°.

Types of Inversion:

a) **Paracentric inversion-** Centromere dose not involved. Breaks occur in one arm of the chromosome. **(Figure).**
Inversion heterozygote: Involve one chromosome of homologous pair.
Inversion Homozygote: Involve both chromosome of homologous pair.
Meiosis is normal. Crossing over within inversion loop in a paracentric inversion heterozygote results in the formation of dicentric bridge and an acentric fragment after exchange. Dicentric chromosome leads to formation of bridge at anaphase. Acentric segment is loss due to lack of movement. Out of 4 gametes, 2 are normal and 2 deficient for same genes.

b) **Pericentric inversion** - When Centromere is involved. When break occurs in each of the two arms of a chromosome, the Centromere is included in the detached segment resulting in a pericentric inversion. Crossing over within the inversion loop results in the formation of chromatids with duplication and deficiency. Out of 4 chromatids, 2 are cross products and two are normal. The viable progeny is produced by non crossover chromosomes.

Q.2. Describe in brief the operon model of protein synthesis

(Description: 6 marks, Well labeled diagram: 2 marks)

Answer : Operon is a model which explains about the on off mechanism of protein synthesis in a systematic manner. This operon model of gene regulation was proposed by jacob and monod in 1961. They were awarded Nobel prize for this discovery in 1965. This model was developed working with lactose region (lac region) of the human intestine bacteria *E. Coli.* The gene regulation was studied for degradation of the sugar lactose.

The operon model consists of seven main components viz., 1. Structural genes 2. Operator gene 3. Promoter gene 4. Regulator gene 5. Repressor 6. Co-repressor 7. Inducer

1. Structural genes :

The lac operon of *E. coli.* consists of three structural genes viz, z, y, and a. The 'z' gene is located near to the operator gene. Y is located between z and a and a is located on right end of the operon segment. These structural genes transcribe a single polycistronic m RNA molecule. This m RNA molecule controls the synthesis of three different enzymes viz. l. β-galactosidase. 2. galactosidase permease 3. galactosidase transacetylase. The enzyme galactosidase consists of 4 units and catalyses the break down of lactose into glucose and galactose as given below galactosidas

1. Lactose = glucose + galactose
2. The enzyme galactosidase permease permits entry of lactose from medium into the bacterial cell.
3. The enzyme galactosidase acetylase allow to transfer an acetyl group from acetyl co.-enzytne A to β galactosidase.

The functions of all structural genes is control by operator gene. Thus the main function of structural genes is to control synthesis of protein through messenger RNA.

2. Operator gene:

In lac operon of E. coli. the operator gene is located just near the structural gene. It consist of 35 nucleotide base pairs. It is the binding site for the repressor. The main function of operator gene is to control the function of structural genes. However its own function depends on the repressor molecule. Binding of repressor with operator makes it non functional and thus prevents the transcription. Repressor prevents transcription by activating the promoter gene mutation of operator makes it unfit for binding with repressor. In such situation operator remains free and transcription starts.

3. Promoter gene:

In lac operon of E. coli. the promoter gene is located next to operator. This is located between operator and regulator gene. The promoter segment is a place where mRNA polymerase enzyme binds with DNA. The main function of promoter gene is to initiate m RNA transcription. The m RNA transcription moves from promoter region to the structural genes through operator region.

4. Regulator gene:

Regulator gene is located on one end of operon segment in E. coli. The function of regulator gene is to divert the synthesis of repressor which is protein molecule. The repressor may be either active or inactive Active repressor has a tendency to bind with operator in absence in the inducible system. Repressor binds operator in absence of inducer and prevents m RNA transcription by inactivating the promoter gene. When an inducer (lactose) is present the repressor binds to the inducer and forms an inducer repressor complex. This complex can not bind to operator gene and protein synthesis can take place.

5. Repressor :

Repressor is a protein molecule. Its synthesis is directed by regulator gene. It has affinity with operator gene. In an active form it binds with operator gene and prevents transcription and protein synthesis by inactivating promoter gene. When it is in inactive form the transcription and protein synthesis can take place.

6. Co-repressor :

Co-represor is a product of one of the enzymes synthesized by structural gene. The corepressor makes the inactive repressor in active form. The repressor and co-repressor complex can block the operator gene and stop the protein synthesis by structural genes

7. Inducer :

Inducer is substrate (Lactose in lac operon) which promotes transcription. It binds with repressor molecule and makes the same inactive and therefore transcription and protein synthesis can take place.

Q.3. What is cell division? Enlist different stages and sub stages of mitosis and meiosis cell division. Describe in brief similarities and dissimilarities between meiosis and mitosis.

(Cell division: 1 mark. Stages: Mitosis 1 mark, Meiosis: 2 marks, Similarities and dissimilarities: 4 marks)

Answer: The division of nucleate cell is achieved by two activities such as division of nucleus i.e. karyokinesis and the division of cytoplasm i.e. cytokinesis. Both plant and animal cells are essentially alike in terms of having genes arranged in line arrays on nuclear structures called chromosomes. Chromosomes are involved in the division of individual cell cycle and reproduction of the entire organism.

Stages of mitosis i) Prophase ii) Metaphase iii) Anaphase iv) Telophase v) Cytokinesis

Stages of meiosis:

Meiosis first:

a) First prophase: i) Leptotene or leptonema ii) Zygotene or zygonema iii) Pachytene or pachynema iv) Diplotene or diplonema v) Diakinesis

b) First metaphase c) First anaphase d) First telophase

Meiosis second: l) prophase II 2) Metaphase II 3) Anaphase II 4) Telophase II

Similarities and dissimilarities between meiosis and mitosis.

	Mitosis	Meiosis
Similarities		
1	Involve nuclear division	Also involve nuclear division
2	Involve spindle apparatus	Also involve spindle apparatus
3	Genetically controlled	Also genetically controlled
4	It has various successive phages	Also it has various successive phages
5	Involve cytokinesis at end	Also involve cytokinesis at end
Dissimilarities		
1	Consist of one nuclear division	Consist of two nuclear division
2	One cell cycle resulted in production of 2 daughter cells.	One cell cycle resulted in production of 4 daughter cells.
3	Chromosome number of	Chromosome number of daughter

	daughter cells is same as mother cell (2n).	cells is half to mother cell (n).
4	Daughter cells are identical to mother cell in structure and composition.	Daughter cells are different to mother cell in structure and composition.
5	Occurs in somatic cells	Occurs in reproductive cells
6	Total DNA of nucleus replicates during S phase.	Total DNA of nucleus replicates during S phase.
7	No pairing between homologous chromosomes.	No pairing between homologous chromosomes.
8	No segregation and recombination.	No segregation and recombination.
9	Chromosomes are in the form of dyad at metaphase.	Chromosomes are in the form of dyad at metaphase.
10	At metaphase Centromere of each bivalent divides longitudinally.	At metaphase Centromere of each bivalent divides longitudinally.
11	One member of sister chromatids move to opposite poles during anaphase.	One member of sister chromatids move to opposite poles during anaphase.
12	Maintains purity due to lack of segregation and recombination.	Maintains purity due to lack of segregation and recombination.

Q.4. Define mutation. Enlist different mutagen. Describe briefly various applications of mutation.

(Definition: 1 mark Enlist: 2 mark, Applications: 5 marks)

Answer: Mutation: Sudden heritable change in phenotype of an individual.

Mutagen: Physical Mutagen: x rays, gamma rays, alpha rays, beta rays, UV rays, fasr and thermal neutrons.

Chemical mutagen: Alkylating agents: EMS, EMS, EES, EI,
Base analogue: 5 Bromo uracil , 2 Amino purine,
Acridine dyes: Acriflavin, Proflavin

Application of mutation in crop improvement:

1. Development of improved varieties
2. Induction of male sterility
3. Production of haploids
4. Creation of genetic variability
5. Overcoming self incompatibility.

(Description based on above points)

Q.5. What is DNA replication? State the different types of DNA replication and explain semi-conservative DNA replication with diagram.

(Define: 1 mark, Types: 1 Mark, Explanation: 5 marks, Diagram: 1 mark).

Answer: **DNA Replication:** The process by which a DNA molecule makes identical copies is known as DNA replication.

Types of DNA replication.

1. Dispersive replication 2. Conservative replication 3. Semi-conservative replication.

Semi-conservative DNA replication

In this method (Watson and crick) both strands of parental DNA separates from each other. Each old strand synthesizes a new strand. Thus each of the two resulting molecule are with one old and one new strand. This method has been universally accepted, because there are several evidences in support of Semi-conservative method.

This method consisted several steps.

1. **Initiation of replication :** DNA replication starts at specifics point on the chromosome. This site is known as origin.
2. **Unwinding of strands :** The two strands unwind. The opening of DNA strands takes place with help of DNA unwinding protein.
3. **Formation of RNA Primer :** Synthesis of RNA primer is essential for initiation of DNA synthesis. RNA primer is synthesized by the DNA template near the origin with the help of special type of RNA polymerase
4. **Synthesis of** DNA **on RNA primer :** After formation of RNA primer, DNA synthesis starts on the RNA primer. Deoxyribose nucleotides are added to the 3' end position of RNA primer. The main DNA strand is synthesized on the DNA template with help of DNA polymerase. The DNA synthesis takes place in short pieces which are known as okazaki fragments. Synthesis on the new strand takes place in 5'- 3'and that of other in opposite 3'- 5' direction. It is possible that during replication, one strand is synthesized continuously while other discontinuous in pieces. The strand synthesize continuously is known as leading strand and discontinusly synthesized strand is lagging strand.
5. **Removal of RNA primer :** The RNA primer is degraded DNA polymerase I. This DNA enzyme also catalyzes the synthesis of short DNA to replace the RNA primer. The newly synthesize segment is joined to main DNA strand with help of DNA ligase enzyme.
6. **Union of okazaki segment :** The discontinuous fragments of okazaki are joined to make continuous strand. The union of okazaki segment is takes place by using joining enzyme polynucleotide ligase.

Q. 6. Define inheritance. Enlist characters studied by Mendel.. Explain law of independent assortment with example.

(Definition: 1 marks, Enlist characters:2 mark, Law explanation: 2 Marks, Example: F_1 and F_2 explanation 3 marks)

Answer : Definition of Inheritance : Transmission of characters from one generation to another generation is known as Inheritance.

Characters studied by Mendel:

1. Plant stature : Tall /Dwarf
2. Position of flower: Axial/ Terminal
3. Shape of pod: Inflated/ constricted
4. Colour of pod: green / yellow
5. Seed shape: Round/ wrinkled
6. Seed colour: Yellow/ green
7. Seed coat colour: Grey/ white.

Law of independent assortment:

When two or more pairs of alleles are brought together in hybrid combination, they express independent dominant effects, while formation of gametes by the hybrids and they assorts independently and separately. Mendel's second law or the law of independent assortment can therefore be expressed as, the segregation in one pairs of alleles is independent of the segregation in any other pair of alleles.

Example:

Parents	Red flower and Tall	x	White flower and dwarf
Genotype	RRTT'		rrtt
Gametes	(RT)		(rt)
	Fl	RrTt (Red Tall)	

(**Selfing** of F_1 and showing the recombination by checkerboard.)

Q.7. What is genetic code. Enlist types of genetic codon. Describe in short the properties of genetic code.

(Genetic code: 1 mark, Types: 1 Mark, Properties 6 Marks)

Answer : Genetic code : A triplet set of RNA bases which codes for particular amino acid.

Types of genetic codon:

1) Sense codon
2) Signal codon i) Start codon ii) Stop codon

Properties of Genetic code:

1) The code is triplet. The triplet code has 64 codons which are sufficient to code for 20 Amino acids and also for start and stop signals in synthesis of polypeptide chain.
2) The code is universal. The same codons are assigned to same amino acids and to the same start and stop signals of genes in animals, plants and micro-organisms.
3) The code is commaless. The codons are continuous and there is no demarcation lines between codons.
4) The code is Non-Overlapping. Three nucleotides or bases code for one amino acid. In a non-overlapping code, six bases will code for two amino acids. In non-overlapping code, one letter is read only once.
6) The code is non-ambiguous. The genetic code has 64 codons, out of these 61 codons code for 20 different amino acids each codon codes only for one amino acid. This clearly indicates that genetic code is non ambiguous.
7) The code is redundant. In most of cases several codons code for same amino acid. This multiple system of coding is known as degenerated or redundant code system.
8) The code has polarity. The code has a definite direction for reading of message, which referred as polarity.

Q.8. Define linkage. Enlist types of linkage and explain coupling phase with example.

(Define: 1 mark, Enlist types: 3 marks, Description coupling phase: 4 marks)

Answer: Linkage :-It is the tendency of two or more genes to remain together in the same chromosome during inheritance is referred as linkage.

Types of linkage:

1) Based on crossing over
   a) Complete linkage
   b) Incomplete linkage
2) Based on gene involved
   a) Coupling linkage
   b) Repulsion linkage
3) Based on chromosome involved
   a) Autosomal linkage
   b) X-chromosomal linkage

Phases of linkage: a) Coupling phase b) Repulsion phase

a) Coupling phase

The linkage between two or more either dominant (AB) or recessive (ab) allels is referred to as coupling. A good example of coupling was reported by Hutchinson in maize for genes governing colour of seed (coloured or colourless) and shape of seed (full or shrunken). The colored seed is governed by dominant gene (C) and full seed is also governed by dominant gene (S) He made cross between plants having coloured full seeds (CCSS) and colourless shrunken seeds (ccss) The F_1 seeds were colouredfull. When the F_1 was test crossed with double recessive parent the following results were obtained instead of 1:1:1:1 ratio.

Parents	Colouredfull	x	Colourless shrunken
Genotype	CCSS		ccss
F_1		CcSs	(colouredfull)
Test cross	CcSs x ccss		

Test cross progeny

1)	Colouredfull	(CS) 4032 Parental type
2)	Coloured shrunken	(Cs) 149 Recombinant type
3)	Colourless full	(cS) 152 Recombinant type
4)	Colourless shrunken	(cs) 4035 Parental type

Total = 8368

This indicates that parental combinations are higher than recombinations, indicating presence of linkage. The parental recombinations occurred in 96.4% instead of 50% and recombinations were 3.6% instead of 50% in this case.

Q.9. Describe Nilsson -Ehle concept of multiple factor hypothesis in wheat.

(Hypothesis: 2 marks, Description of example with illustration of ratio: 6 marks)

Answer: Multiple factor hypothesis (Nelson-Ehle 1908) :- This hypothesis states that for a given quantitative traits there could be several genes which were independent in their segregation but had cumulative effect on phenotype.

Example of Kernel colour in wheat explanation with checker board method.

Kernel seed in wheat is governed by one, two, three gene pairs because in cross between red and white kernel the F1 is intermediate between the parental values. The red seed of 15:1 ratio is devided in 4 classed based on shade of colour: dark red, medium dark red, medium red and

light red. This suggested seed colour in wheat is controlled by genes which show lack of dominance and have small cumulative effects.

(Illustration of Ratio 1:4:6:4:1 i.e. 15:1 with Checker board)

Q.10. Write Short notes (Any two)

1) Benzer fine structure of gene
2) Gene interactions
3) Significance of Cytoplasmic inheritance in plant breeding

(4 marks each)

Answer:

1) Benzer fine structure of gene :

Benzer in 1955,divided gene into recon, muton and cistron which are the units of recombination, mutation and function within a gene. The fine structure of gene deals with mapping of individual locus of gene. This is parallel to the mapping of the chromosomes. In chromosome mapping various genes are assigned to the chromosome, whereas, in case of a gene several alleles are assigned to the same locus. Thc individual gene maps are prepared with the help of intragenic recombination. But intragenic recombination is low, therefore, very large population has to be grown to obtain such rare combination.

2) Gene Interactions:

It is the phenomenon in which two pairs of non-allelic genes affect the same character. When dominant genes are crossed together, they produce usually different phenotypes than their own and it results into the modification of normal F2 ratio depending upon the type of interactions the phenotypic F2 ratios are modified on various ways. There are two types of interaction.

1) **Gene interaction without modification of normal F_2 phenotypic ratio.**

2) **Gene interaction with modification of normal F_2 Phenotypic ratio.**

(List of different gene interactions with F_2 ratio)

3) Significance of Cytoplasmic inheritance in plant breeding:

Cytoplasmic inhcritance has been useful in explaining role of various Cytoplasmic organelles in the transmission of characters in different organisms. It plays a key role in mapping of chloroplast nad mitochondrial genome in several species, viz., yeast, maize and human. It helps in development of CMS lines in several crops like maize, pearl millet, sorghum, cotton etc. Availability of CMS lines facilitates production of hybrid seeds at cheaper cost. The CMS cytoplasm can be easily transfer to various agronomic bases for their use in development of superior hybrids. Role of mitochondria in the manifestation of heterosis is gaining importance. Mutation of chloroplast DNA and mitochondrial DNA leads to generation of new varients especially in ornamental plants.

SECTION "B"

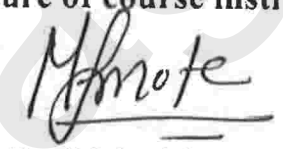
Q.11. Define the following terms

1. **Chromosome mapping:** is the assignment of genes to specific locations on a chromosome. OR A technique used in autosomal DNA testing which allow to determine which segments of DNA came from which ancestor.
2. **Genotype:** Genetic constitution of an individual.
3. **Quantitative characters:** Characters which are governed by several genes.
4. **Crossing over:** Interchange of parts between non sister chromatids of homologous chromosome during pachytene.
5. **Genetics:** A biological science which deals with the principles of heredity and variation. Or Study of structure, composition and function of genes.
6. **Multiple allele:** Existance of more than two alleles at a locus
7. **Dihybrid cross:** A cross involving two pairs of gene, each affecting different characters.
8. **Chi-square test:** Test of statistical significance which is used to test the significance of difference between observed and expected frequencies or ratio.

Q.12 Fill in the blanks

1. Germplasm theory was proposed by **August Weismann** in 1889.
2. **Mitochondria** is known as power house of cells.
3. **Test cross** is a cross of F_1 with homozygous recessive parents..
4. Mendel studied **seven** pairs of contrasting characters.
5. Alternative form of gene is known as **allele**.
6. A cross involving one pair of gene affecting one character is known as **monohybrid cross.**
7. Masking effect of one allel over the other is known as **Dominance**.
8. **Co-dominance** is the expression of both the allels in a heterozygote or F_1

Signature of course instructor:



Signature of University Head of Dept:

Name: Prof. Manisha S. Mote
Designation: Assistant Professor (Agril. Botany)
RCSM, College of Agriculture, Kolhapur
Phone No. 0231/2605851
Mobile No. 9423865070
Email.: msmote26@gmail.com

Name: Dr. R.W. Bharud
Designation: Head Dept. of Agril. Botany
MPKV, Rahuri.
Phone No. 02426-243249
Mobile No. 9850244087
Email.: raosaheb.bharud@gmail.com