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GENETICS

By: Prieti Gupta

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GENETICS

Question Bank – (Previous Year Solved Question Papers)

Sample Preview of the Solved Sample Question Papers

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QUESTION PAPER

(June – 2019)

(Solved)

GENETICS

Time: 2 Hours] *[Maximum Marks: 50*

Note: *Question no. 1 is* ***compulsory.*** *Attempt any* ***four*** *questions from questions No. 2 to 7.*

Q. 1. ***(a)*** **Fill in the blanks with appropriate alternatives given in the parentheses.**

(i) **Epistasis is the interaction of_____ (allelic/non-allelic) genes in which one gene masks the expression of the other gene.**

(ii) Drosophila **flies having white eyes and vestigial wings have_____(lower/higher) viability than their wild types.**

(iii) **In prokaryotes, reproduction is usually of _____(asexual/sexual) type.**

(iv) **_____(Mendel/Morgan) worked on fruit fly.**

Ans. Ans. *(i)* non-allelic, *(ii)* lower, *(iii)* asexual *(iv)* Morgan.

(b) **Read the following statements and write *True (T)* or *False (F)* against each.**

(i) **Mendel did a number of tests to ensure the validity of his results while formulating the law of segregation.**

(ii) **Isogamy occurs in several prokaryotes.**

(iii) **Sex-limited traits are traits that are expressed in all sexes.**

(iv) **In the female birds, normally one gonad develops and the other is suppressed.**

Ans. *(i)* True (T), *(ii)* False (F), *(iii)* False (F), *(iv)* True (T).

(c) **Match the items given under column A and column B correctly and rewrite them. 4**

Column A	*Column B*
(1) Pleiotropy	**I. Grow on medium containing salts and glucose**
(2) *Bonellia*	**II. Physical defects or deformities in developing embryo**
(3) *Escherichia coli*	**III. Highly reduced form of male in the reproductive tract of female**
(4) Teratogenesis	**IV. Gene has multiple action**

Ans. (1) *–(iv)*, (2) *–(iii)*, (3) *–(i)*, (4) *–(ii)*.

Q. 2. Write short notes on the following :

(a) **Effect of environmental factors in sex determination**

Ans. Ref.: See Chapter-3, Page No. 22, 'Effect of Environmental Factors'.

(b) **Mitochondrial proteins**

Ans. Ref.: See Chapter-7, Page No. 53, 'Mitochondrial Proteins'.

(c) **Quinic acid metabolic genes in *Neurospora crassa***

Ans. Ref.: See Chapter-15, Page No. 110, 'Quinic Acid Metabolic Genes in Neurospora Crassa'.

(d) **Oncogenic viruses**

Ans. Ref.: See Chapter-17, Page No. 121, 'Oncogenic Viruses'.

(e) **Genetic drift**

Ans. Ref.: See Chapter-20, Page No. 142, 'Genetic Drift'.

Q. 3. ***(a)*** **Explain how environment affects the gene expression in organisms.**

Ans. The expression of genes in an organism can be influenced by the environment, including the external world in which the organism is located or develops, as well as the organism's internal world, which includes such factors as its hormones

and metabolism. One major internal environmental influence that affects gene expression is gender, as is the case with sex-influenced and sex-limited traits. Similarly, drugs, chemicals, temperature, and light are among the external environmental factors that can determine which genes are turned on and off, thereby influencing the way an organism develops and functions.

Sex-Influenced and Sex-Limited Traits

Sex-influenced traits are those that are expressed differently in the two sexes. Such traits are autosomal, which means that the genes responsible for their expression are not carried on the sex chromosomes. An example of a sex-influenced trait is male-pattern baldness. The baldness allele, which causes hair loss, is influenced by the hormones testosterone and dihydrotestosterone, but only when levels of the two hormones are high.

Sex-limited traits are also autosomal. Unlike sex-influenced traits, whose expression differs according to sex, sex-limited traits are expressed in individuals of only one sex. An example of a sex-limited trait is lactation, or milk production. Although the genes for producing milk are carried by both males and females, only lactating females express these genes.

Drugs and Chemicals

The presence of drugs or chemicals in an organism's environment can also influence gene expression in the organism. Cyclops fish are a dramatic example of the way in which an environmental chemical can affect development.

Temperature and Light

In addition to drugs and chemicals, temperature and light are external environmental factors that may influence gene expression in certain organisms. For example, Himalayan rabbits carry the C gene, which is required for the development of pigments in the fur, skin, and eyes, and whose expression is regulated by temperature. Specifically, the C gene is inactive above 35°C, and it is maximally active from 15°C to 25°C. This temperature regulation of gene expression produces rabbits with a distinctive coat colouring. Light can also influence gene expression, as in the case of butterfly wing development and growth. Exposure to red light resulted in intensely coloured wings, while exposure to green light resulted in dusky wings. Blue light and darkness led to paler coloured wings. These examples illustrate the specific instances of environmental influences on gene expression.

***(b)* Describe sex mosaics.**

Ans. Ref.: See Chapter-5, Page No. 35, 'Sex Mosaics'.

Q. 4. Describe the origin, diagnostic features and the phenotypic effects of inversions and translocations.

Ans. Ref.: See Chapter-9, Page No. 67, 'Inversions' and 'Translocations'.

Q. 5. What is mutation? Differentiate between:
***(i)* Somatic and Gametic Mutations, and**
***(ii)* Spontaneous and Induced Mutations.**

Ans. Ref.: See Chapter-16, Page No. 114, 'What is Mutations?', 'Somatic and Gametic Mutations', 'Spontaneous and Induced Mutations'.

Q. 6. Discuss the role of heredity and environment with the example of twin studies.

Ans. Ref.: See Chapter-21, Page No. 148, 'Twin Studies'.

Q. 7. Write short notes on the following :

***(a)* Linkage**

Ans. Ref.: See Chapter-6, Page No. 39, 'Linkage'.

***(b)* RNA as Genetic Material**

Ans. Ref.: See Chapter-11, Page No. 79, 'RNA as Genetic Material'.

***(c)* ABO Blood Group System**

Ans. Ref.: See Chapter-19, Page No. 134, 'ABO Blood Group Systems'.

***(d)* Hardy-Weinberg Law**

Ans. Ref.: See Chapter-20, Page No. 139, 'Hardy-Weinberg Law'.

■■

Sample Preview of The Chapter

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GENETICS

HEREDITY AND PHENOTYPE

Mendel's Laws of Inheritance

1

INTRODUCTION

Genetics is the study of heredity, which deals with the structure and functions of genes and the mechanism of their transmission from one generation to the next. Genetics not only describes the inheritance of genes but also the developmental processes whereby the characters are produced. Genetics have been used since 4000 years ago, when the farmers in Sumeria, Egypt and other parts of the world became familiar that they could improve their crops and their animals by using the technique of selective breeding as many features of plants and animals were passed from one generation to the next. In this chapter, we will start with a brief outline of the history of development of modern genetics. We will also describe the classic work of Gregor Mendel, his contributions to the science of genetics by providing some basic principles and one of the most important laws i.e. Mendel's laws of inheritance. We will also define some important terms related to genetical study such as gene, allele, locus, genotype, phenotype etc. By illustrating Mendel's breeding experiments, we will apply Mendel's laws to solve problems in genetics involving monohybrid, dihybrid and trihybrid crosses.

CHAPTER AT A GLANCE

DEVELOPMENT OF GENETICS: A HISTORICAL PERSPECTIVE

As we know that since many years before, the farmers recognized that many features of plants and animals were passed on from generation to generations, but the ancient breeding programmes were not based on the experimental study. The eagerness of human nature to find the answer of the questions like why are we like our parents or why the organisms belonging to a group are possessed by similar characters, compel the beginning of the genetics. The geneticists first observed the basic "like begets like" and then domestication of animals like dogs, cats and cattle, helped them in producing the desired breed by controlling the matings of these animals. The same process was adopted for the cultivation of crops by protecting the seeds obtained from the largest and the healthiest plants. The answer of the remaining questions was began to emerge after the publishing of Mendel's experiments in 1860s.

Birth of Genetics

Gregor Mendel is known as the *father of modern genetics*. Through his paper entitled "*Experiments in Plant Hybridization*" published in 1866, he provided the details of his experiments related to inheritance in garden pea. He kept accurate records of the results of experiments of plant hybridization, which helped him to formulate the basic principles of inheritance. He is the first one to propose the concept of hereditary units, which is now called as genes. He concluded that these hereditary units are inherited from each parent in equal number, that determines the observable characters of the offspring. This first conceptualization now is known as 'particulate inheritance'. In the offspring, the appearance of the character is determined by the hereditary units, which are transmitted from parents to offsprings in a particular combination from the two parents.

Mendel's conclusions were largely ignored until 1900. In 1900, however, his work was "re-discovered" by three European scientists, Hugo de Vries, Carl Correns and Erich von Tschermak after each had independently reached similar conclusions. An English scientist, Wiam Bateson, gave the term "genetics" (Greek meaning 'to generate') in 1905 for this developing science. Many scientists consider Bateson as the real founder of genetics as he was the first to have Mendel's papers translated into English and the first one to show that Mendel's theory was also applicable to animals.

Growth of Genetics:
From Mendel to Genetic Engineering

The history and growth of genetics has come a long way from Mendel's experiments to Genetic Engineering and a large number of scientists had contributed in its growth. It is difficult to mention all the names here. Besides Mendel, Hugo de Vries, Carl Correns, Erich von Tschermak Bateson and many other scientists like Miescher, Muller, Griffith, Johannsen etc. gave this subject a significant growth through their works in the field of genetics. Most of the important contributions were made between 1970s and 1980s. The field is so vast and it is continuously providing scope for further research.

SOME BASIC GENETIC TERMINOLOGY

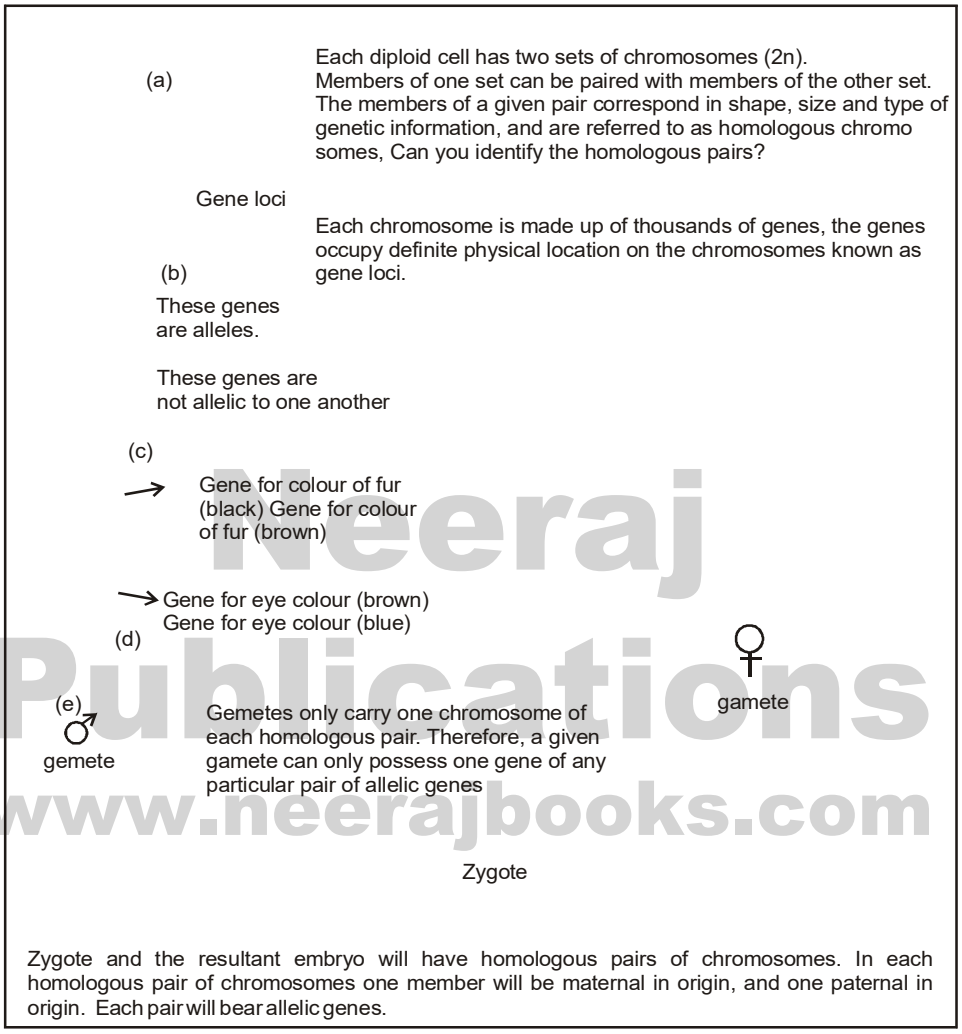
It is necessary to understand some basic genetic terminology before discussing the details of Mendel's experiments with plea and the laws provided by him.

Gene

Mendel proposed the concept of hereditary units, which were later on identified as genes. A gene is a molecular unit of heredity of a living organism found in chromosomes. Different traits such as colour of the flower, seed shape or height in plants, each of these characters is controlled by a different gene.

Genes and Alleles

Genes that govern variations of the same characteristic and that occupy corresponding loci on the homologous chromosomes are termed alleles.



Homologous chromosomes and Alleles

According to the geneticists, there are two or more alternative forms of a gene occuring at corresponding specific loci and the possible variants of a gene at any given locus are known as alleles. For example, if tall trait of plants is denoted by 'T' and the short ones are denoted by 't', then 'T' and 't' are the alleles of the same gene. The dominant allele is generally represented through capital letter and a recessive allele through a lower case letter. The term locus helps not only in determining the location on a chromosome but also a kind of "generic" gene controlling a particular kind of characteristic. The dominant allele is always written before the recessive allele such that in Tt, the tall trait is dominant and in tT, the short trait is dominant.

There are many genes within each chromosome, which are generally different from the other and all of them control the inheritance of one or more characteristics. The members of a homologous pair of chromosome have similar set of alleles arranged in the same order. During the mitotic division, each diploid daughter cell receives a pair of each chromosome and thus it obtains a pair of each gene. While during the process of meiosis, the separated chromosomes got combined with their new partners at the time of fertilization the alleles also separate and associate with new partners.

Homozygous and Heterozygous

An individual that carries two identical alleles for a locus is said to be *homozygous* for that locus. If the two alleles are different, then the individual is said to be *heterozygous* (e.g. Aa).

The gene which occur maximum in nature in an individual is called the 'wild type', while the alteration in the genetic material produces 'mutant type' gene.

The alleles, which are significant in both homozygous and heterozygous conditions, are known as the dominant alleles. For example, in Tt and TT, the tallness is the dominant trait. The alleles, which are significant in homozygous condition, are called the recessive alleles. The individuals possessing the alleles 'tt' exhibit dwarfness.

Phenotype and Genotype

Phenotypes result from the expression of the genes of an organism as well as the influence of environmental factors, while the genetic makeup of an individual is referred to the genotype of that organism. The phenotype includes physical characteristics, behaviours corresponding to such species, structures, organs, behaviours, reflexes, etc. and those traits that can be observed through the eyes. Genotype refers to the genetic traits in an organism. It has to do with the genetic coding of an organism. Such coding is inheritable. The genotype is the genetic load that is copied every time a cell divides, and therefore is inherited down to the next generation. Genotype is something we can't see with our eyes (e.g. dominant, recessive, heterozygous). In other words, the genotype is the genetic programming that provides the phenotype.

MENDEL'S CLASSICAL EXPERIMENTS WITH PEA

Mendel was the first scientist to examine in a quantitative manner, the behaviour of traits between generations by selecting a well suited study material.

Choice of Material

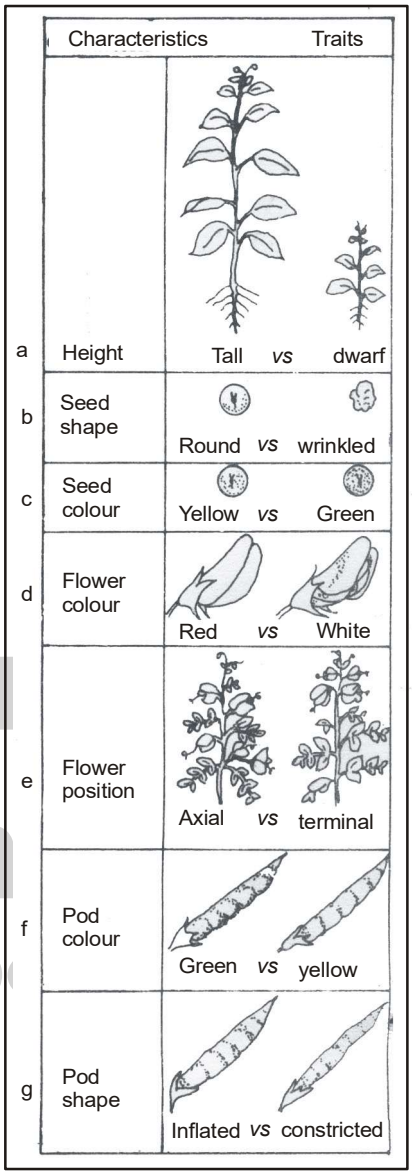
Many scientists failed before Mendel in understanding the theory of inheritance because of not choosing an appropriate material. Mendel probably chose to work with garden pea plants because of the many variants that exist in their morphology (physical appearance). The colour of the flowers, seeds, and pods can differ between individuals, as well as the position of the flower on the stem, the length of the stem, and the shape of the seeds and pods. Also, the pea plants were cheap, easily available and these required little space and the most importantly, their growth time is short. In addition, these produce a large number of offsprings and could be crossed easily. In short, these provided Mendel with a wide variety of characteristics in order to examine patterns of inheritance. Mendel also probably chose to study peas because their reproduction can be easily controlled, which afforded him strict control over the mating of different individuals. The pea flowers are bisexual and are usually self-fertilised, but these can be fertilized through cross-pollination also.

MONOHYBRID CROSSES AND MENDEL'S LAW OF SEGREGATION

Before discussing the Mendel's experiment, it is important to note some basic terminology regarding the experiments. P_1 generation is the parent generation and the first progeny produced through the mating of P_1 generation individuals is called as F_1, which further produces F_2 generation followed by F_3, F_4, F_5 and so on. A cross is a mating between two individuals for the fusion of gametes and in the monohybrid crosses, only one pair of contrasting or alternative trait is involved.

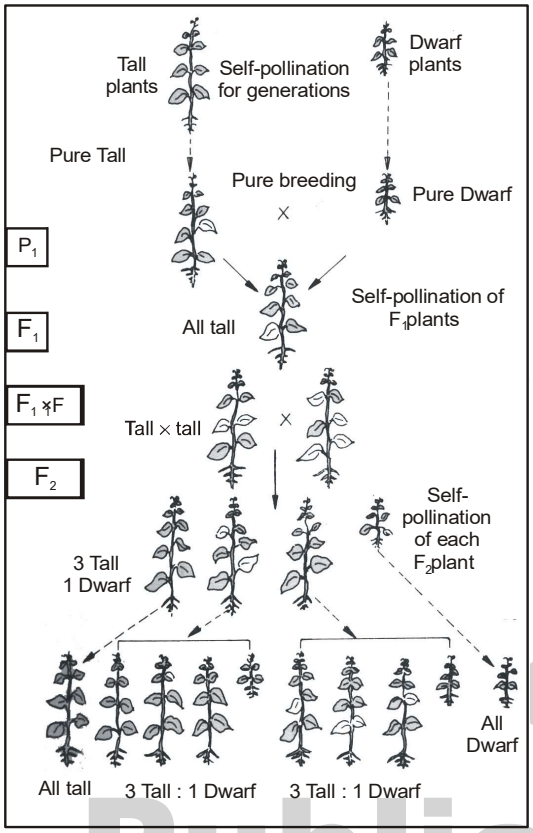
Mendel's Experiment and Results

Mendel made research over the seven characters of pea plants as described below:



The seven characteristics (a-g) in pea plant studied by Mendel. Each character has two well defined phenotypes that are easily recognized.

He performed the monohybrid crosses between two contrasting traits. The crossing of two true-breeding parents produced an F_1 generation of hybrid individuals that exhibited only the trait found in one of the two parents. The trait that was expressed in the F_1 generation was termed a dominant trait. The F_1 generation hybrids were then each self-pollinated, producing an F_2 generation. Although not present in the F_1 generation, the trait exhibited by the one parent reappeared in this generation, invariably at approximately a 3:1 ratio of one parental trait to the other. The trait that reappeared in the F_2 generation was termed a recessive trait because it receded in the previous generation.

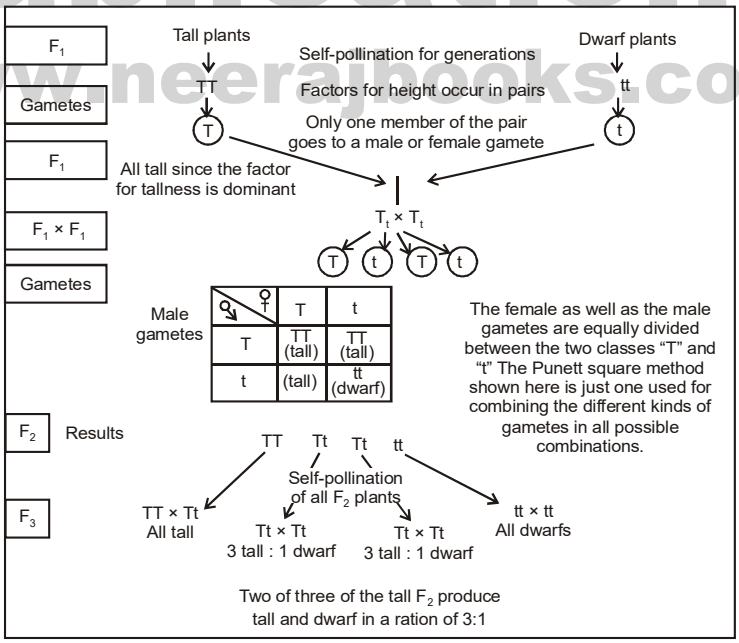


Monohybrid cross in the pea plant followed through three generations. The results of the reciprocal cross, i.e. dwarf × tall are identical.

Mendel used the same quantitative approach to the other six pairs of traits and the results were strikingly similar to that of the height of plants.

Mendel's Explanation and Derivation of the Law of Segregation

The eagerness to find the reason for the disappearance of trait in F_1 generation and reappearance of the same trait with full expression in F_2 generation led Mendel to reach the conclusion that the traits tallness and dwarfness, each were determined by a particular factor, which transmits the hereditary information from parents to progeny. They are now called genes. Thus, for pure breeding strains of the peas, both the parent were possessed by both the traits, which would fully appeared in F_2 generation and the character, which was appeared in F_1 only is called dominant character. Therefore, for the tall × dwarf cross, all the F_1 plants were tall, hence the allele for the tallness is dominant and for the dwarfness is recessive. The explanation can be well understood from the following diagram:



Monohybrid cross of tall and dwarf pea plants. The results of the reciprocal cross are the same.