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MZO-002: Genetics and Animal Biotechnology
Guess Paper-1

Q1. Appreciate the role of independent assortment in generating genetic variation in the population.

Ans. Ancient man noted that similar traits get transferred to families; hence the concept of genetics came into origin. It was only in the 19th century that the field of genetics was scientifically developed and accepted. -The first geneticists observed "like begets like" and used this basic observation to improve their strains. Scientists started seeking answers to the question as to why we are like our parents but are also different from them in many respects. It was only after the publication of Mendel's work that answers to these questions started to emerge.

Birth of Genetics: Genetics as a scientific discipline developed from the work of Gregor Mendel in the middle of the 19th century. Mendel observed that traits get inherited as discrete units called factors (Wilhelm Johannsen coined the word gene). This became the basis of the development of the present understanding of heredity. The discovery of Mendel's laws governing the inheritance of traits laid the foundation for the present research in genetics. Mendel presented his work in the paper entitled "Experiments in Plant Hybridisation" published in 1866 in the Proceedings of the Society of Natural History in Brno.

The word genetics was introduced in 1905 by English biologist William Bateson, who was one of the discoverers of Mendel's work. He showed that Mendel's theory was also applicable to animals. His investigations in garden pea formed the basis for the formulation of laws of inheritance.

Growth of Genetics: From Mendel to Genetic Engineering: Mendel proposed the concept of hereditary units. According to him, the equal number of units inherited from each parent determined the observable characters of the offspring. This was the beginning of the concept of a gene, the modern term for hereditary units. Mendel's work remained largely unknown until 1900, when three botanists Carl Correns, Hugo de Vries, and Erich von Tschermak rediscovered his work and reached similar conclusions and cited Mendel's work in their publications.

The basic patterns of genetic inheritance established by Mendel formed the basis of studies carried out by biologists to investigate the physical nature of the gene. The experiments carried out in the 1940s and early 1950s showed that DNA is the part of the chromosomes that carries genes. A focus on new model organisms such as viruses and bacteria, along with the discovery of the double-helical structure of DNA in 1953, marked the transition to the era of molecular genetics.

In the following years, techniques for sequencing both nucleic acids and proteins were developed and the relationship between two forms of biological molecules and genetic code was worked out. The studies related to the regulation of gene expression were carried out in1960s. By 1970s, it was found that gene expression could be controlled and manipulated through genetic engineering. Biologists focused on large-scale projects of genetics and sequencing of entire genomes in the 20th century,

A large number of scientists made significant contributions and expanded the scope of this branch of science tremendously which is now divided into transmission genetics, molecular genetics, and population genetics. Molecular genetics paved the way for genetic engineering and recombinant DNA studies which have far-reaching implications in the field of agriculture and medicine.

Q2. What are the salient features of the chromosomal theory of inheritance?

Ans. The discovery of chromosomes in the nuclei of salamander cells and their behaviour during normal cell division (mitosis) by Walther Flemming in 1879 set the stage for the recognition of Mendel's work. In 1902, Theodor Boveri observed that the embryonic development of sea urchins was dependent on the presence of chromosomes. In the same year, Walter Sutton discovered the separation of chromosomes during meiosis. Both these observations put together suggested that this behaviour of chromosomes could explain the basis of Mendelian principles of segregation and independent assortment.

They assumed that Mendel's unit factors were represented by chromosomes (rather than genes on chromosomes), nonetheless, their findings led to the recognition of Mendel's work. The work of Sutton and Boveri was recognized for their theory that chromosomes house the genetic material in living organisms. Mendel's laws supported the chromosomal theory of inheritance and its postulates are as follows:

- Homologous chromosome pairs show migration as separate entities independently of other homologous pairs during meiosis.
- Movement of chromosomes from each homologous pair towards opposite poles is a random process.

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- Gametes produced by each parent contained only half the number of chromosomes.
- Despite the difference in size and morphology of male and female gametes, both had the same number of chromosomes, thus indicating that each parent contributed equal genetic information.
- Combination of gametic chromosomes during fertilization restored the chromosome number as found in parents.

Studies carried out by Thomas H Morgan, Alfred H. Sturtevant, Calvin Bridges, and others established the validity of Sutton's and Boveri's chromosomal theory of inheritance.

Q3. Discuss the Chemical Structure of Gene.

Ans. • Many components that makeup genes are coded for data pertaining to cellular activity and operation. The promoter region, coding region, and termination sequence are the three main portions of the gene.

• The promoter sequence is the initial section that the gene needs in order to bind transcription factors and RNA polymerase and start the transcription process. A gene may include many promoters, which are often located in the mRNA.

• The promoter region of eukaryotic genes is more intricate than those of prokaryotic genes. With the exception of certain viruses, which contain genes made of a chemically similar substance called ribonucleic acid, most genes are made of deoxyribonucleic acid (DNA) (RNA).

• Two strands of nucleotides that spiral around one another to resemble a twisted ladder make up a DNA molecule. The rungs of the ladder are created by bound pairs of nitrogenous bases, while the sides are constructed of sugars and phosphates. Adenine (A), guanine (G), cytosine (C), and thymine (T) are these bases (T).

• A-T ladder rungs are formed when an A on one chain associates with a T on the other; similarly, a C on one chain associates with a G on the other. The two chains unravel if the connections tying the bases together are severed, and unbound nucleotides in the cell cling to the chains' exposed bases.

• The base-pairing rule determines how the free nucleotides align along each chain: A pairs with T, and C pairs with G. Hereditary information is transmitted from one cell generation to the next through this mechanism, which produces two identical DNA molecules from a single original molecule.

Q4. Explain the Characteristics Determined by Genes.

Ans. • The human cell contains 23 pairs of chromosomes. The trait is one of the characteristics determined by one or more genes. Abnormal genes and genes that are formed due to new mutations also result in certain traits.

• Genes vary in size depending on the code or the protein they produce. All cells in the human body contain the same DNA. The difference between the cells occurs due to the different types of genes that are turned on and therefore produce a variety of proteins.

• The genes that are passed on separately from each parent to the zygote or offspring created have two copies per parent. As a result, each parent contributed one copy of the gene to the child. The two copies of each parent's genes undergo recombination, and this recombination and inheritance result in traits that distinguish and characterize each person.

• Genetic characteristics can take many different forms and are handed down from one parent to the next, including illness, blood type, eye colour, and hair colour. Autosomal dominant, autosomal recessive, Xlinked dominant, X-linked recessive, Y-linked, co-dominant, and mitochondrial inheritance patterns are all possible.

• Traits are the distinctive characteristics that characterize an organism's genotype and phenotype. Genes are passed down from one parent to the next generation, encoding and defining traits in the child. The genome, which includes a large number of genes, refers to the organism's whole genetic makeup.

• All of the genes in the human genome have been defined, identified, mapped, and sequenced as part of the human genome project.

• According to the Human genome project, the human body contains 20500 genes that code for particular features and attributes. One or more genes may be in charge of the qualities.

• A characteristic is referred to as polygenic if more than one gene codes for it. Height and skin tone are polygenic characteristics, meaning they are influenced by several genes. Moreover, a single gene may control several different traits, like ear lobe colour and iris pigmentation.

Q5. Write a brief note about the gene concept given by Mendel.

Ans. Mendel's four postulates and laws of inheritance are:

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- Principles of Paired Factors
- Principle of Dominance
- Law of Segregation or Law of Purity of Gametes (Mendel's First Law of Inheritance)
- Law of Independent Assortment (Mendel's Second Law of Inheritance).

Principles of Paired Factors

- A character in an organism (diploid) is represented by at least two components. The two components are located at the same locus on the two homologous chromosomes.
- They might be homozygous (like TT in the case of pure tall pea plants) or heterozygous (like Tt in the case of hybrid tall pea plants) for the same trait. Alleles or allelomorphs are factors that indicate the same or alternate version of a character.

Principle of Dominance

- The traits that occur in the hybrids of the F1 generation are always the dominant characters and those that do not present in F1 progeny are always the recessive characters when two homozygous individuals with one or more sets of opposing characters are crossed.
- To formulate the principles of heredity, Mendel crossed Pisum sativum plants with the plants that were of average height of one foot. When the seeds generated from this cross were sown, the size of the plants produced were not halfway between the two parents as expected. Instead all the plants resemble the parents with a height of six feets.
- According to the law of dominance, only one of the two parental qualities will be displayed in the F1 generation of a monohybrid cross between two opposing traits, and both will be expressed in the F2 generation in a 3:1 ratio.
- The dominant characteristic is the one that was expressed in the F1 generation, while the recessive trait is the one that was suppressed.
- The rule of dominance simply argues that dominant features always override or obscure recessive traits.
- For instance, all seeds in the F1 generation of pea plants were discovered to be round when round seeds (RR) were mated with wrinkled seeds (rr) (Rr).
- Both the round and the wrinkled seeds developed in the F2 generation in a 3:1 ratio after these round seeds self-fertilized.
- As a result, the recessive trait (wrinkled seeds) was repressed in the F1 generation whereas the dominant trait (round seeds) returned in the F2 generation.

Law of Segregation (Mendel's First Law of Inheritance)

- The two alleles of a characteristic that are present together in an individual do not mix together but maintain their individuality during gametogenesis or sporogenesis when gametes are randomly dispersed to various children according to the probability principle.
- The law of segregation is sometimes referred to as the "law of purity of gametes" since two alleles remain together in pure form without influencing, blending, or mixing.
- In a monohybrid cross, neither allele is blended; both alleles are expressed in the F2 generation.
- The fact that each gamete only contains one allele serves as the foundation for the law of segregation.
- There are two variations of the gene responsible for seed colour in pea plants.
- Green seed colour (G) has a different form or allele than yellow seed colour (Y) (y).
- In this instance, the gene for the colour of yellow seeds is dominant, whereas the allele for the colour of green seeds is recessive.
- When two alleles are heterozygous, the traits of the dominant allele are displayed while the recessive allele is hidden.
- Yellow seeds have the genotype (YY) or (Yy), while green seeds have the genotype (yy).

Law of Independent Assortment (Mendel's Second Law of Inheritance)

- Mendel considered two pairs of opposing characteristics and examined their inheritance after being pleased with monohybrid crossings (i.e., dihybrid cross).
- This law states that "the two components (genes) of each opposing character (trait) at the moment of gamete development assort or separate independently of the factors of other characters and become arbitrarily rearranged in the offspring".
- Cross between two pure-bred pea plants with green, wrinkled seeds and yellow, round seeds (YYRR) (yyrr). The rule of segregation states that the gametes produced by the wrinkled, green plant are all RY and the gametes produced by the round, yellow plant are all RY since each parent is homozygous. This results in F1 progeny that are all RrYy.

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- According to the capital and lowercase letters, the allele indicating round form is dominant over the allele specifying wrinkled shape, and the allele specifying yellow seed colour is dominant over the allele specifying green seed colour. This indicates that all F1 plants are spherical and yellow. The F1 plants are known as dihybrids (di- = two, -hybrid = heterozygous) because they are heterozygous for two genes.
- A dihybrid cross is a cross between two dihybrids, or, equivalently, a dihybrid that has self-fertilized. Mendel discovered that there were four distinct types of pea seeds when he performed this cross and examined the progeny: yellow and round, yellow and wrinkled, green and round, and green and wrinkled. These phenotypic categories (categories based on observable features) were distributed roughly in the ratio 9: 3: 3:1.

Q6. What is the difference between the modern concept and the classical concept of genes?
Ans. Modern Concept of Gene: On the basis of the genetic processes that each type of gene and genetic material involved, S. Benzer developed a variety of labels for them in 1957.
a) Genes as a unit of transmission or cistron

- Cistron refers to the portion of DNA that specifies a single polypeptide chain.
- A Cistron can range in size from 100 to 30,000 nucleotide pairs.
- As a unit of transmission, it conveys characters from one generation to another.

b) Genes as a unit of recombination or recon

- Recon is the name for the tiniest piece of DNA that may be detached and exchanged with another chromosome.
- A recon only contains up to two pairs of nucleotides.

c) Gene as a unit of mutation or muton

- The muton, which is the smallest genetic building block that may alter or mutate to generate a phenotypic characteristic.
- Muton has a single nucleotide as its delimiter.

Classical Concept of Gene: Sutton introduced it in 1902, and it was expanded upon by Morgan in 1913, Bidge in 1923, Muller in 1927, and others. They are listed below:

- Genes are discrete particles with a Mendelian inheritance pattern that reside at a given location on a chromosome and are in charge of expressing a certain phenotypic trait.
- As there are more genes than chromosomes in each organism, many genes are found on each chromosome.
- Like beads on a thread, the genes are organized in a single linear order.
- Every gene occupied a particular spot known as a locus.
- Character changes when a gene's location changes.
- Parents and children can share their genes.
- Genes can exist in several alternative forms known as alleles.
- During cell division, genes can be duplicated or joined together.
- Mutations, often known as abrupt changes in location and makeup, can occur in genes.
- Genes may duplicate themselves in order to create identical clones of themselves.
- As per the modern terminology for a gene, the DNA sequence that identifies one polypeptide as a gene is the basic building block of information that contains both coding and non-coding regulatory sequences.

Q7. What is the types of genes.
Ans. 1. Housekeeping genes, also known as constitutive genes, are those genes that always express in a cell because their byproducts are necessary for regular cellular functions, such as the genes for glycolysis and ATPase.
2. Genes that do not always manifest themselves in a cell are known as non-constitutive genes (Luxury Genes). They are turned on or off in accordance with the needs of cellular processes, such as the lactose system in Escherichia coli and the nitrate reductase gene in plants. Moreover, there are two types of non-constitutive genes: inducible and repressible.
3. Inducible genes are those that are activated in response to the presence of a chemical or inducer that is necessary for the function of the gene's product, such as nitrate in the case of nitrate reductase.
4. Repressible genes are those that express themselves up until a chemical, frequently an end result, inhibits or represses expression. Feedback repression is the term used to describe inhibition caused by an outcome.

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5. Multigenes (Multiple Gene Family) are a collection of genes that are identical or very similar in order to produce products that are required for certain times and tissues, such as the globin gene family (e, 5, (3, y on chromosome 11, on and 8 on chromosome 16).
6. Repeated Genes: Genes codes for histones, tRNA, rRNA, and actin contain repeated copies because their products are needed in greater quantities.
7. Genes that only exist in one copy, such as protein-coding genes, are occasionally found to have 223 copies. They make up 60270% of the genes that are active. New genes can be created by duplications, mutations, and exon shuffles.
8. Pseudogenes are homologous to functioning genes but are unable to create functional offspring because of intervening nonsense codons, insertions, deletions, and promoter region inactivation, such as numerous snRNA genes.
9. Eukaryotic genes that have been processed lack introns. Reverse transcription or retroviruses are likely to blame for the formation of processed genes. Genes that have been processed typically aren't active since they lack promoters.
10. Split Genes: Several researchers identified them in 1977, but Sharp and Roberts are awarded the credit (1977). Split genes are those that have supplementary or non-essential sections inserted between necessary or coding regions. Introns, spacer DNA, and intervening sequences constitute the nonessential components (IVS).

- Exons are crucial coding components. Before RNA exits the transcription process and enters the cytoplasm, intronic sections are cut.
- Eukaryotes are characterized by split genes. Yet, certain eukaryotic genes, such as the histone and interferon genes, are entirely exonic or non-split.
- Prokaryotes have also been shown to have split genes, including the T4 thymidylate synthase and ribonucleotide reductase genes. By deleting an exon, a gene that generates calcitonin in the thyroid creates a neuropeptide in the brain.
- Adenoviruses also have a system that uses variable splicing to create 1,5220 distinct proteins from a single transcriptional unit.

11. Transposons (Jumping Genes) are DNA segments that have the ability to migrate or jump around the genome. When Me Clintock (1951) discovered that a piece of DNA had migrated into a gene coding for pigmented kernels and generated light-colored kernels, she had made the first transposon discovery. Transposons have repeated DNA at their ends that is 5, 7, or 9 nucleotides long and can be either similar or inverted. By cleaving the repeating sequences at its ends, the enzyme transposase isolates the segment from its original. Transposons move from one location to another, rearranging the nucleotide sequences of genes. Gene expression, including that of proto-oncogenes and oncogenes, is frequently altered by intron reorganisation. By moving exons around, new genes could form. Transposons can also modify a cell's DNA through insertions, deletions, and translocations.
12. Overlapping Genes: A pair of adjacent genes with partially overlapping coding regions is referred to as an overlapping gene pair. In other words, a single DNA segment can encode for pieces of two distinct proteins. Some of the advantages of overlapping genes are that they allow the production of more proteins from a given region of DNA than is possible if the genes were arranged sequentially. For two genes to overlap, the signal to begin transcription for one must reside inside the second gene, whose transcriptional start site is further "upstream." The bacteriophage PhiX174 requires gene overlapping. If transcription proceeds linearly, one gene after another, there is not enough DNA in the circular, single-stranded DNA genome of this virus to encode the eleven bacteriophage proteins.
13. Structural genes are genes that have information encoded for the creation of chemical compounds needed for cellular machinery. The chemical compounds might be:
a) polypeptides that are used to create structural proteins (e.g., colloidal complex of protoplasm, cell membranes, elastin of ligaments, collagen of tendons or cartilage, actin of muscles, tubulin of microtubules, etc.);
b) Polypeptides used in the synthesis of enzymes;
c) Carrier proteins found in cell membranes, such as insulin, growth hormone, and parathyroid hormone;
d) Proteinaceous hormones;
e) Antibodies, antigens, specific toxins, blood coagulation factors;
f) Non-translated RNAs like tRNAs and rRNA. In general, structural genes either create non-coding RN As or mRNAs for the creation of polypeptides, proteins, and enzymes.
14. When it comes to regulating cell structure and function, regulatory genes (also known as regulatory sequences) do not transcribe RNA. Instead, they regulate how structural genes work. Promoters, terminators,

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