ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2021
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR GENETICS

Date : October 31, 2021
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 Minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
   - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
     Part II - 4 Short Answer Questions

     All questions under SECTION A are COMPULSORY.
   - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must to hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **9 printed pages**, including this instruction page.

GOOD LUCK

SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. What is the relationship among DNA, a gene, and a chromosome?
   a) A chromosome contains hundreds of genes, which are composed of DNA.
   b) A chromosome contains hundreds of DNA, which are composed of a gene.
   c) A DNA contains hundreds of chromosomes, which are which makes up a gene.
   d) A gene contains hundreds of chromosomes, which are composed of DNA.

2. The process that have transformed the life on earth from its earliest form to the vast diversity is called
   a) Transformation
   b) Evolution
   c) Reproduction
   d) Succession

3. The word homologous literally means same location. How does this relate to homologous chromosomes?
   a) The bands resulting from staining are found on the same location.
   b) The chromosomes have the same genes in the same location.
   c) The chromosomes always move to the same location during the cell during division.
   d) Both a) and b) are correct.

4. Gregor Mendel was
   a) an English scientist who carried out research with Charles Darwin.
   b) a little known Central European monk.
   c) an early 20th century Dutch biologist who carried out genetics research.
   d) the Italian explorer who discovered America.

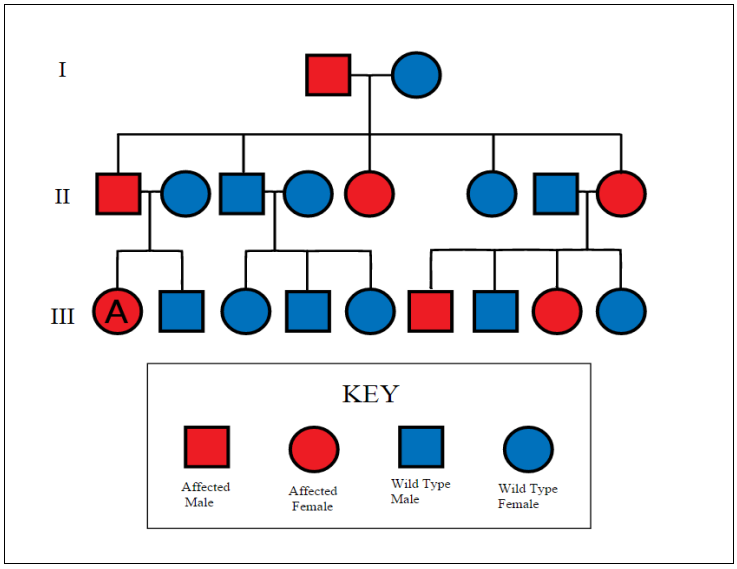
5. The **"one gene – one polypeptide"** theory states that
   a) the synthesis of each gene is catalyzed by one specific polypeptide.
   b) the synthesis of each enzyme is catalyzed by one specific gene.
   c) the function of an individual gene is to dictate the production of a specific polypeptide
   d) each polypeptide catalyzes a specific reaction.

6. Any change in the nucleotide sequence of the DNA of a gene is called
   a) A mutation
   b) An advantage
   c) An anticodon
   d) Translocation

7. A base substitution mutation in a gene sometimes has no effect on the protein the gene codes for. Which of the following factors could account for this?
   a) The rarity of such mutations.
   b) Some amino acids have more than one codon.
   c) A correcting mechanism that is part of the mRNA molecule.
   d) Both a) and b)

8. Amino acids are building blocks of
   a) Carbohydrates
   b) Proteins
   c) Lipids
   d) DNA and RNA

9. Based on the pedigree chart describing the inheritance of an autosomal-dominant disease, what is the probability that person A will give birth to an affected child if she mates with a wild-type male?



   a) 25%
   b) 50%
   c) 75%
   d) 100%

10. When a gene for a given trait comes in alternative versions that specify different forms of the trait (for example, purple-flower and white-flower versions of a flower color gene), the versions of the gene are called
    a) A loci
    b) A supergene
    c) A chromosome
    d) An allele

11. In crossing a homozygous recessive with a heterozygote, what is the chance of getting an offspring with the homozygous recessive phenotype?
    a) 25%
    b) 50%
    c) 75%
    d) 100%

12. An allele that is fully expressed is referred to as (fully expressed means that the allele is transcribed and translated into a perfectly functional protein)
    a) Dominant
    b) Recessive
    c) Homologous
    d) Heterozygous

13. The first genetically engineered plant to be produced is
    a) Brinjal
    b) Tobacco
    c) Rice
    d) Cotton

14. In genetic engineering, the expression of a trans-gene in the target tissue is identified by
    a) Promoter
    b) Enhancer
    c) Reporter
    d) Quencher

15. According to human genome project, there are about 3 billion chemical base pairs in human DNA. What percent of these base pairs actually code for genes approximately?
    a) 75%
    b) 30 - 50%
    c) 10 - 20%
    d) 1 - 2 %

16. A gene is essentially
    a) sequence of many codons in a DNA molecule.
    b) single codon in a DNA molecule.
    c) chromosome.
    d) specific allele.

17. Which of the following is a correct type of mutation?
    a) Transcription
    b) Polymerization
    c) Substitution
    d) Translation

18. Of the world's population, 47% is blood group O. Calculate the proportion of the world that has a different blood group?
    a) 53
    b) 0.53
    c) 53%
    d) 0.53%

19. Who introduced the binomial nomenclature for naming of species?
    a) Darwin
    b) Linneaus
    c) Lamarck
    d) Lyell

20. Historical remnants of structures that had important functions in the ancestors are called
    a) Vestigial organs
    b) Useful organs
    c) Wasted organs
    d) None of the above.

21. Classic Klienfielter's syndrome is associated with which of the following?
    a) 47, XXY
    b) 45, XO
    c) 47, XY / 47, XXY
    d) 47, iXqY

22. Down's syndrome is a condition in which a child is born with
    a) a deficient X chromosome.
    b) an extra copy of chromosome 21.
    c) an extra copy of chromosome 18.
    d) an extra copy of chromosome 13.

23. In the ABO blood group system in humans, if a person of type-B blood has children with a person of type-AB blood, what blood types could their children have?
    a) Type-AB, type-A, and type-B
    b) Type-AB, and type-B
    c) Type-AB, type-A, type-B and type O
    d) Type-A, and type-B

24. In a cross between two heterozygous (Aa), results will be
    a) in the ratio 1:3 homozygous to heterozygous.
    b) in the ratio 1:1 homozygous to heterozygous.
    c) all heterozygous.
    d) all homozygous.

25. A DNA codon consists of
    a) one nucleotide
    b) two nucleotides
    c) three nucleotides
    d) four nucleotides

26. Number of autosomes in human sperm is
    a) 11
    b) 22
    c) 33
    d) 44

27. Determination of a child's gender depends on
    a) Nature of sperm
    b) Nature of eggs
    c) Health of father
    d) Health of mother

28. Universal plasma donors are blood group:
    a) 'A' Positive
    b) 'B' Positive
    c) 'AB' Positive
    d) 'O' Positive

29. A gene for corn has two alleles, one for yellow kernels and one for white kernels. Cross pollination of yellow corn and white corn results in corn that have an approximately even mix of yellow and white kernels. Which term best describes the relationship between the two alleles?
    a) Genetic recombination
    b) Complete dominance
    c) Incomplete dominance
    d) Co-dominance

30. Suppose that in barley plants, the allele for tall stalks is dominant over short stalks and the allele for wide leaves is dominant over thin leaves. What would be the best way to determine the genotype of a barley plant with a tall stalk and wide leaves?
    a) Perform a test-cross with a barley plant of tall stalks and thin leaves.
    b) Perform a test-cross with a barley plant of short stalks and thin leaves.
    c) Perform a test-cross with a barley plant of tall stalks and wide leaves.
    d) Perform a test-cross with a known heterozygous barley plant.

PART II – Short Answer Questions [20 marks]

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

Question 1

a) Define genetics? Briefly explain the role of genetics in medicine. (2.5 marks)

b) What is Natural selection? Explain its role in evolution. (2.5 marks)

Question 2

a) Complete the Punnett square below to show the cross between a male with genotype **BB** for brown eyes and a female with genotype **bb** for blue eyes. (1 mark)

Female / **Male**	**b**	**b**
B	**Bb**	**-----**
B	**-----**	**-----**

b) What percent of the off spring have Black eyes? (1 mark)

c) What percent of the off spring have Blue eyes? (1 mark)

d) What percent of the off spring are heterozygous? (1 mark)

e) What percent of the off spring are homozygous recessive or homozygous dominant? (1 mark)

Question 3

a) If 0.5 mL of serum is added to 4.5 mL of saline, what is the final dilution of the solution? (1 mark)

b) How much sodium chloride (common salt) need to be dissolved in water to make a saturated salt solution? (1 mark)

c) How would you prepare a 20% Glucose solution from the commercially available Glucon-D powder? (1 mark)

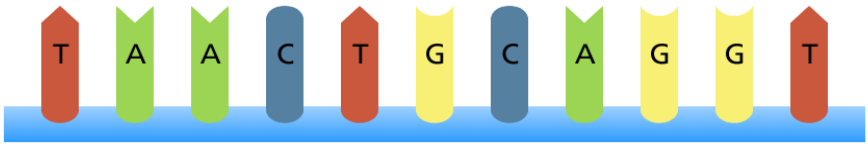
d) One litre of 70% alcohol is needed for a purpose. How much 95% alcohol is required to make 1 litre of 70% solution? (2 marks)

Question 4

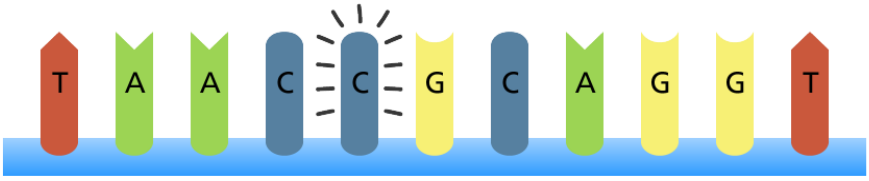
a) What are genetically modified organisms (GMOs)? (1 mark)

b) What causes mutations? Name some types of mutations? Refer to the diagram below and identify the type of mutation in sequence B. (2 marks)

Sequence A: original sequence



Sequence B: Mutated sequence



c) Describe the role of mutations in evolution. (2 marks)

SECTION B: Case Study [50 marks]

Choose either CASE I OR CASE II from this section. Each case study carries 50 marks.

CASE I

Sometimes called "molecular photocopying," the polymerase chain reaction (PCR) is a fast and inexpensive technique used to "amplify" - copy - small segments of DNA. Because significant amounts of a sample of DNA are necessary for molecular and genetic analyses, studies of isolated pieces of DNA are nearly impossible without PCR amplification. Mega projects like Human Genome project has employed advanced molecular techniques like PCR and gene sequencing.

1. What is Polymerase chain reaction? State the principles and list out the three major steps of PCR? (10 marks)

2. In general, what are the five key basic requirements for running a PCR test? Explain what happens inside a PCR tube during the process of PCR? Use diagram to explain your answer. List some areas of applications of PCR. (25 marks)

3. What is gene sequencing? How important is genome sequencing to the medical advancements? (5 marks)

4. What is a restriction enzyme? What is it used for? Name some commonly used restriction enzymes. (5 marks)

5. The base composition of a virus was found to be 11% A, 32% G, 18% U and 39% C. Is this a DNA or RNA virus? Is it single-stranded or double-stranded? How can you tell? (3 marks**)**

6. Which of these DNA fragments will have a higher melting temperature? (2 marks)

   a) GCATTGACCGGAGGGACT
      CGTAACTGGCCTCCCTGA

   b) GGATTTCAATTACTTAAT
      CCTAAAGTTAATGAATTA

CASE II

"The healthcare industry has come a long way in terms of technological advances. These advances have had significant benefits in diagnosis, treatment, and the way medicine is practiced today. Unfortunately, these technological advances also come with ethical issues and dilemmas the healthcare professionals must face".

1. What is genetic testing? Mention some areas of application. What are some advantages and disadvantages of genetic testing? (10 marks)

2. What are some ethical issues in genetics? Is gene editing a good thing or a bad thing, discuss your take on the subject as a geneticist. (8 Marks)

3. What is informed consent? Who can give consent for a genetic testing and why is it necessary? What are some of the important elements or necessary information that the client should understand before giving his/her consent for genetic testing? (10 marks)

4. Applying genetic engineering in plants, why are GM foods produced? Discuss potential risks on environment and human health? (8 marks)

5. What is Quality Control in a diagnostic laboratory? Assume that you are the owner of a private diagnostic laboratory; briefly discuss some general aspects of quality management system that you would put in place to ensure quality controlled result from your laboratory? Include use of QC samples and QC charts in your discussion. (10 marks)

6. With the covid-19 pandemic, personal protective equipment (PPE) have greatly benefitted the health workers from staying safe from the deadly virus. Any negligence in donning (putting on) and doffing (putting off) the PPEs are crucial for the safety of the health worker. (4 marks)

   a) Write down the correct steps in donning the PPEs.

   b) Write down the correct steps in doffing the PPEs.