Devaj Rathore

2023190

Time: 1 hour | GMB Quiz Number: First | 10 marks each question | All questions are mandatory

Question 1: During DNA replication, the error rate before any proofreading or repair mechanisms is about 1 error per 100,000 nucleotides added. If a human genome consists of approximately 3 billion base pairs, calculate the expected number of initial replication errors in the entire genome before proofreading occurs. How might the presence of these errors affect genetic integrity, and what mechanisms mitigate this issue?

Question 2: Two different species have DNA with varying GC content: Species A has 40% GC content, and Species B has 60% GC content. Which species is likely to have a higher DNA melting temperature, and why? How does the GC content impact the structural stability of DNA under heat or chemical stress?

Question 3: In a plant species, flower color is determined by a single gene with two alleles, where allele **R** (red) shows incomplete dominance over allele **r** (white). The heterozygous genotype **Rr** results in pink flowers. If two pink-flowered plants are crossed, calculate the expected phenotypic ratios of the offspring. Additionally, explain how this ratio differs from a typical Mendelian dominant-recessive pattern.

Question 4: The ABO blood group system is determined by a single gene with three alleles: I^A, I^B, and **i**. The alleles I^A and I^B are codominant, while **i** is recessive. A child has blood type O, while one parent has blood type A and the other has blood type B.

a) What are the possible genotypes of the parents?
b) Explain how the child can inherit blood type O from these parents.
c) If this couple has another child, what is the probability that the child will have blood type AB?

Question 5: Mutations can occur at various levels of the genome, from a single nucleotide change to large chromosomal rearrangements. Consider the following types of mutations: point mutations (silent, missense, nonsense), frameshift mutations, and chromosomal inversions.

a) Describe how a **missense mutation** and a **nonsense mutation** can impact protein function differently.
b) Explain how a **frameshift mutation** might affect the reading frame of a gene and the resulting protein.
c) How might a **chromosomal inversion** affect gene expression, even if no genes are directly disrupted by the inversion?

Question 1: In an updated version of the Avery-MacLeod-McCarty experiment, a researcher is testing the role of various enzyme treatments on the ability of a heat-killed virulent bacterial extract to transform non-virulent bacteria. Mg2+ and Ca2+ ions are cofactors for DNAse activity. EDTA is a chelating agent used in DNA isolation which sequesters divalent cations. The researcher prepares extracts from heat-killed *Streptococcus pneumoniae* and treats them with the following conditions:

Condition A: Extract treated with DNase (which degrades DNA).
Condition B: Extract treated with RNase (which degrades RNA).
Condition C: Extract treated with protease (which degrades proteins).
Condition D: Extract with no enzyme treatment (control).
Condition E: Extract treated with DNase and EDTA
After treatment, each extract is mixed with non-virulent *S. pneumoniae* and the transformation of non-virulent bacteria into virulent strains is assessed by their ability to form colonies on selective media. Give reason for each case.

Question 3: Quantifying DNA and Protein in Hershey and Chase Experiment
In the Hershey and Chase experiment, researchers labeled T2 bacteriophages with radioactive phosphorus-32 (^32P) to label the DNA and radioactive sulfur-35 (^35S) to label the protein coat. After the infection and separation steps, they quantified the amount of radioactive material inside the bacterial cells and outside in the protein coats.Suppose that after the experiment, they found that 80% of the total radioactivity was detected inside the bacterial cells, and 20% of the total radioactivity was detected in the protein coats. If the initial amount of ^32P-labeled DNA injected into the bacterial culture was 500 units of radioactivity, what would be the amount of radioactivity detected in the protein coats?

Question 4: Hydrogen Bonding in DNA
Describe the role of hydrogen bonding in maintaining the stability of the DNA double helix. How many hydrogen bonds are formed between an adenine (A) base and a thymine (T) base? How does this compare to the number of hydrogen bonds between a guanine (G) base and a cytosine (C) base?

INDRAPRASTHA INSTITUTE OF INFORMATION TECHNOLOGY DELHI
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INTERNAL ASSESSMENT SHEET

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Semester : ☑ Monsoon 2024 ☐ Winter 20__ ☐ Summer 20__

Name : Devaj Rathore
Roll No. : 2023190
Course Code : B10214
Course Title : Genetics and Molecular Bio
Date : 25/9/24
No. of Additional Sheet :
Student Sig : Dev
Invigilator Sig :

1. Mutations rate = $\frac{1}{10^5}$ nucleotides

For 3 billion base pairs, 6×10^9 nucleotides are added.

Nucleotides with mutation based on rate

= nucleotides × rate

= 6×10^4 mutations

Every mutation will create its own replication error when the strand is split.

∴ 6×10^4 replication errors.

- Replication errors might express themselves as harmless, silent / polymorphism or cause missense / nonsense frameshifts in the encoding, resulting in codons coding for different amino acids than the ones intended
- Mechanism like proofreading and repairing help

maintain genetic integrity by repairing mutations and maintaining proper stop sequencing.

2. Species B will have a higher Tm (melting temprature) as a higher G-C content translates to more hydrogen bonds across strands per base pair. (G-C has 3, A-T has 2) resulting in higher stability

r, En ph

- Under heat stress, higher G-C content results in higher stability due to more hydrogen bonds.
- Under chemical stress, b/w pH 4.3 and 13 more number of hydrogen bonds (because of GC) increase stability in presence of ions, otherwise denaturation.

3. ~~Out~~ of

500 units of radioactivity in DNA, all of this is trasferred to the progeny.

$500 = \frac{480}{5100} \times$ total radioactivity

Total radiactivity = $\frac{2500}{4} = \frac{1250}{2}$ units

radioactivity in sulfur (coats) = total - phosphorous (DNA)

$= \frac{1250}{2} - 500 = \frac{250}{2} = 125$

∴ 125 units of radioactivity is from the protein coat.

4. Hydrogen bonding occurs between nucleotides of complimentary strands of a DNA double helix, Adenine forms 2 ~~dou~~ hydrogen bonds with thymine, while Guanine forms 3 hydrogen bonds with Cytosine.

- G-C has one hydrogen bond more than A-T.

5. a) Both nonsense and missense are point mutations, in nonsense, a point mutation results in a codon that does not code for any amino acid from a well functioning coding codon. In missense, the new codon formed, results in codons that codes for a different amino acid, Different from the original codon's amino acid.

b) A frameshift mutation, (-1 or +1), removes (-1) or adds (+1) a nucleotide in a codon resulting in all following codons having an offset of -1 or +1.

- Considering that codons are read in sets of 3 (frames), the preceding might result in will result in codons for different amino acids than the one intended. The stop

codon will be disrupted too.

- The improper reading of the sequence will result in improper RNA replicates which will manufacture incorrect proteins.

c) Chromosomes read in the inverted direction will be read as codons other than the ones encoded. Stop condons won't be read, expression will be severely disrupted.