1. (a) Mention five types of RNA molecules that participate in the process of gene expression.

   (b) Write down the functions of these five types of RNA molecules.

   (c) Which of these five types of RNA molecules perform their function(s) in (i) the nucleus and (ii) the cytoplasm?

   $[2 + 8 + 2 = 12]$

2. (a) What impact is DNA packaging likely to have on the expression of individual genes?

   (b) How can all of a person's cells contain exactly the same genetic material yet specialize as skin cells, nerve cells, muscle cells, and connective tissue cells?

   (c) A eukaryotic ribosome contains four different rRNA molecules and ∼82 different ribosomal proteins. Why does a eukaryotic cell contain many more copies of the rRNA genes than the ribosomal protein genes?

   $[4 + 4 + 4 = 12]$

3. (a) The genes of the MHC locus in humans are said to be highly polymorphic. (i) What does this mean? (ii) What is the significance of this in the field of medicine?

   (b) What is the process by which double-strand breaks in DNA are repaired by the non-homologous end-joining (NHEJ) mechanism?

   (c) What is the role of recombination in genome evolution?

   $[4 + 5 + 3 = 12]$

4. (a) Two teenage boys are dragonized with muscular dystrophy. The boy who is more severely affected has a

two base insertion at the start of his dystrophin gene. The other boy has the same two-base insertion but also has a third base inserted a few bases away. Explain why the second boy's illness is milder.

(b) Describe two different mechanisms by which a normal cellular proto-oncogene can be converted to a cellular oncogene.

(c) To determine whether radiation associated with the atomic bombings of Hiroshima and Nagasaki produced recessive germ-line mutations, scientists examined the sex ratio of the children of the survivors of the blasts. Can you explain why an increase in germ-line mutations might be expected to alter the sex ratio?

$[3 + 5 + 4 = 12]$

5. (a) A linear DNA molecule is subjected to single and double digestions with restriction endonucleases, and the following results are obtained:

Enzymes	Fragment size (in Kb)
EcoRI	2.9, 4.5, 7.4, 8.0
HindIII	3.9, 6.0, 12.9
EcoRI and HindIII	1.0, 2.0, 2.9, 3.5, 6.0, 7.4

Draw the restriction map defined by these data.

(b) Two couples want to know their risk of conceiving a child with cystic fibrosis. In one couple, neither partner has a family history of the disease; in the other, one partner knows he is a carrier. How do their risks differ?

(c) Inherited cancers like retinoblastoma show a dominant pattern of inheritance. However, the underlying genetic defect is a recessive loss-of-function mutation—often the result of a deletion. How can the dominant pattern of

inheritance be reconciled with the recessive nature of the mutation?

$[5 + 4 + 3 = 12]$

6. (a) Why are people on a high-protein diet instructed to drink lots of water?

   (b) How does the human body defend itself against extracellular bacterial infections? Describe at least two defense mechanism.

   (c) Explain how the properties of phospholipids help to maintain the structure of the cell surface membrane.

   $[2 + 6 + 4 = 12]$

7. A pharmaceutical company studies the relationship between fasting blood sugar levels (x) and blood pressure (y). The correlation coefficient for this relationship is r_1, and the regression equation derived is: $y = 1.2x$
   Answer the following questions:

   (a) Determine the ratio of the means of the predicted values of y to the observed values of x. How will the ratio change if we evaluate variances instead of means?

   (b) Analyze the ratio of the means of the observed values of y and x.

   (c) Given that the observed variances of y and x are 144 and 25, respectively, compute the value of r_1.

   (d) If, for a different group of individuals, the correlation coefficient is r_2, and the regression equation obtained is $y = 1.1x$, can we conclude that $r_1 > r_2$? Justify your answer.

   $[(2 + 2) + 4 + 6 + 4 = 18]$