Answer all the questions **Total marks = 50**

Q1. Write the **full forms** of the following: 3 marks

a) TCR b) CAR-T c) GVHD d) AAV e) AML f) NHEJ

Q2. Write **True or False**: 7 marks

a) B cells can generate higher affinity antibodies for antigens over time.

b) T cells can generate higher affinity T cell receptors for antigens over time.

c) A single B cell might make antibodies that recognize many different epitopes on a viral capsid protein.

d) Each of us is born with hundreds of genes each of which encodes an antibody to recognize a specific virus.

e) Macrophages envelope and digest foreign antigens non-specifically.

f) T-cell receptors are membrane bound and thus can signal the T cell to ingest antigen.

g) Cytotoxic T cells can activate B cells to proliferate.

Q3. a) What are T cells and how it is different from a CAR-T cell? 2x3=6 marks

b) Draw structure of receptor of CAR-T cells of different generations (from 1st generation to the 4th generation).

c) What is CAR-T Cell Therapy and how does it work?

Q4. Which ONE of the following does NOT provide innate immunity against pathogens?

a) blinking b) lysozyme in tears c) macrophages d) plasma cells e) skin

Q5. a) What is base editing? 4 marks

b) Name the enzymes used in editing C to T.

c) What is Base Excision Repair pathway? Which enzyme recognizes Uracil in the DNA strand?

d) Name the inhibitor enzyme used in cytosine base editors.

Q6. Write and explain two applications of CRISPR-Cas9 technique. 4 marks

Q7. A CRISPR-Cas9 experiment aimed at knocking out a specific gene is conducted in a mouse model. If the knockout efficiency is 80%, and there are 15 mice in the experiment, how many mice would be expected to have the target gene knocked out? 2 marks

Q8. Provide four differences between Cas12 and Cas13 CRISPR system. 4 marks

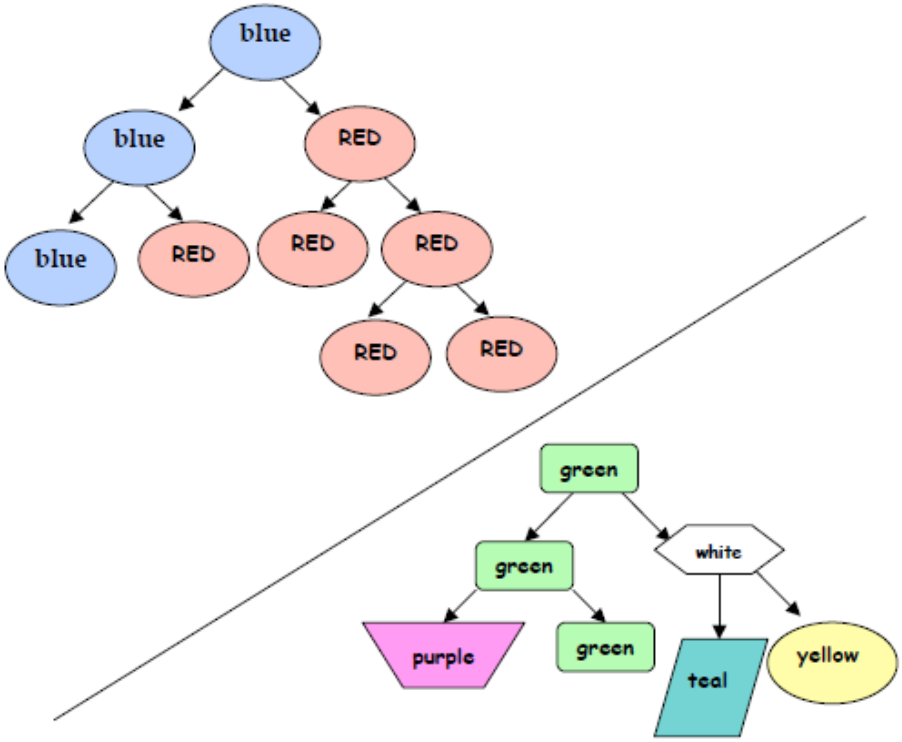
Q9. The adaptation process of CRISPR-Cas systems involves the acquisition of new spacers from foreign DNA and their addition to the CRISPR array in the bacterial chromosome.

a) Draw a pictorial representation of a new spacer acquisition and its addition into the CRISPR array. 1 mark

b) Based on the PCR amplifications utilizing specific primers, you have confirmed addition of two new spacers. Draw a gel electrophoresis picture i) depicting the amplified acquired spacers, after the infection and compare it with original/before infection; ii) Also draw the primers (forward and reverse) location on the CRISPR array. 2 marks

Q10. Bacteria have the CRISPR-Cas9 defense mechanism that protects them from the invading viruses. Give **one similarity and one difference** between this CRISPR–Cas9 defense mechanism in bacteria and the adaptive immune response in vertebrates. 2 marks

Q11. Divya finds a new brightly colored mammalian species, which she names *Magnificus colores*. She isolates blue and green cells from different parts of this organism, and cultures each cell individually. 4 marks



a) Are the blue cells stem cells? Why or why not?

b) Given that the green cell is a stem cell, can Divya tell whether it is pluripotent or unipotent? Explain your answer.

c) Divya finds out that development in *M. colores* is similar to human development. She wants to obtain a single cell that can give rise to an individual *M. colores*. Do you have any suggestions? What is the property that this cell possesses?

d) She now wants to isolate embryonic stem cells from an *M. colores* embryo. Where exactly in a developing embryo can she find such cells?

Q12. Rajesh, an avid cigarette smoker, detects tumors in 3 of his 6 dogs. Snoopy has an ear tumor, Tom has a paw tumor, and Bob has a tail tumor. Sarika, a biologist friend, takes cells from each tumor as well as cheek cell samples from the dogs as controls and cultures them in

Petri dishes. All of the cheek cell cultures grow as a monolayer but all of the tumor cell cultures exhibit foci.

i) Which one of the following properties do the tumor cells lack, resulting in this growth difference?

a) ATP hydrolysis b) Contact Inhibition c) Retinoblastoma d) Signaling cascade

ii) Sarika brushes up on the molecular nature of different cancer mutations. Match the following mutations to their respective phenotypes at the cellular level.

a) _____ Tumor Suppressor mutation

b) _____ Oncogene mutation

l) dominant

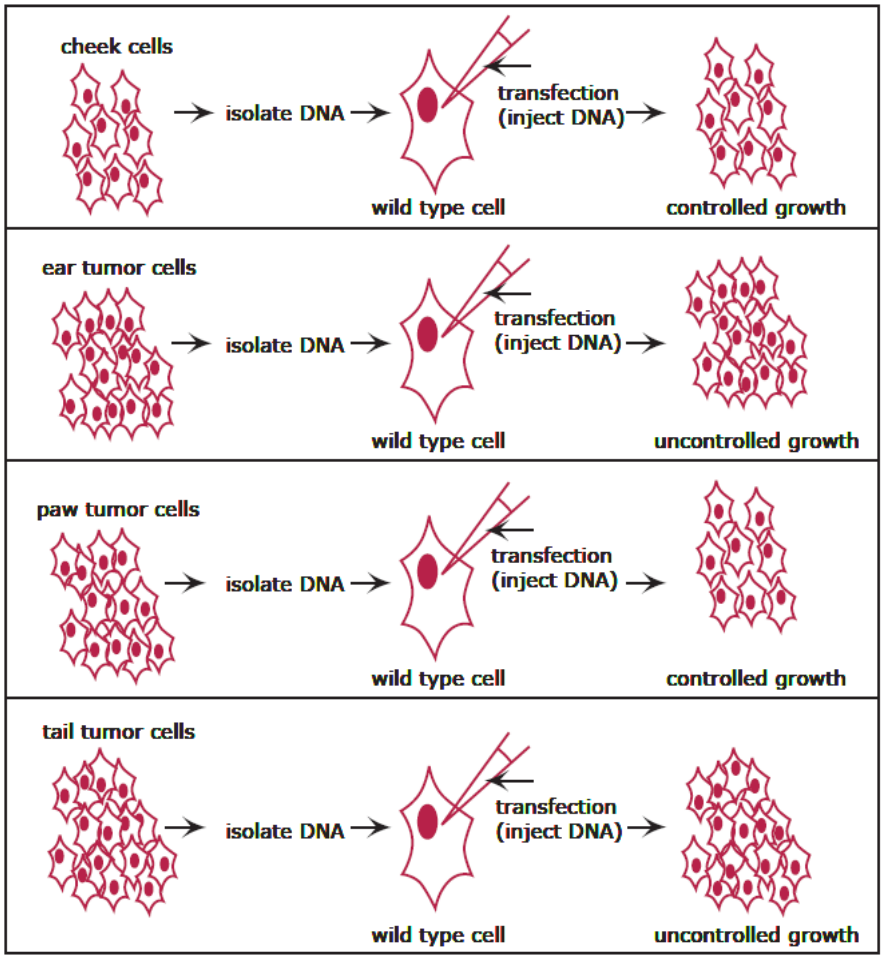
m) opportunistic

n) recessive

o) none of these

m)

To determine the cause of each dog's tumors, Sarika performs the following experiments.



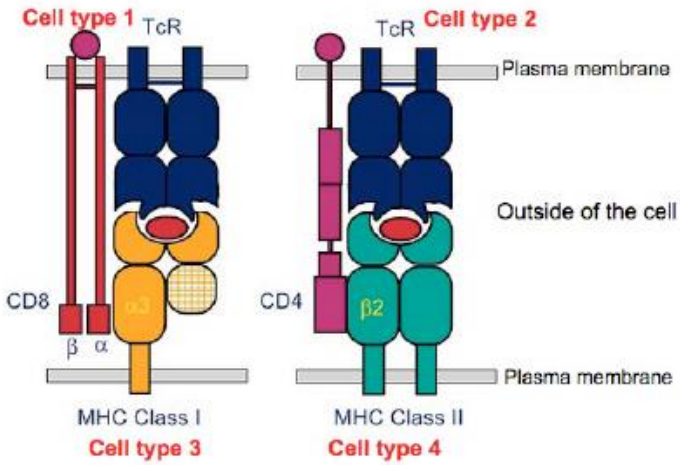
iii) Based on the data, which tumor(s) has/have a mutation in a tumor suppressor gene? Write all that apply.

a) Cheek b) Ear c) Paw d) Tail

iv) Based on the data, which tumor(s) has/have a mutation resulting in an oncogene? Write all that apply.

a) Cheek b) Ear c) Paw d) Tail

Q13. The schematic below shows the interaction between the T cell receptors **(TcR)**, Major Histocompatibility Complexes Class I and II **(MHC Class I** and **MHC Class II**) and the accessory cell surface glycoproteins **(CD4 and CD8)** located on the surface of **cell types 1-4.** 4 marks



i) Which cell type is likely a helper T cell (T_H):

a) Cell type 1 b) Cell type 2 c) Cell type 3 d) Cell type 4

ii) Which cell surface marker(s) would this (T_H) cell type have:

a) MHCI b) MHCII c) CD4 d) CD8

iii) Which cell type is likely a cytotoxic T cell (T_C):

a) Cell type 1 b) Cell type 2 c) Cell type 3 d) Cell type 4

iv) Which cell surface marker(s) would this (T_C) cell type have:

a) MHCI b) MHCII c) CD4 d) CD8

v) Which cell type is most likely an antigen presenting cell (APC):

a) Cell type 1 b) Cell type 2 c) Cell type 3 d) Cell type 4

vi) Which cell surface marker(s) would this (APC) cell type have:

a) MHCI b) MHCII c) CD4 d) CD8

vii) Identify the cell types that interact with each other to trigger:

a) B cell activation and humoral (antibody-mediated) immune response: _____

b) Cytotoxic T cell mediated killing of an infected cell: _____

Q14. Write your views on “Designer Babies”. 2 marks