Friday 11/12/04

7.012 Quiz 3 Answers

A $\geq$ 85 18% of test takers
B 72-84 41% of test takers
C 60-71 23% of test takers
D 50-59 11.4% of test takers
F $\leq$ 58 6.6% of test takers

REGRADE Requests with attached notes describing the problem due by November 24th noon.

<table>
<thead>
<tr>
<th>Question</th>
<th>Value</th>
<th>Score</th>
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<tr>
<td>1</td>
<td>25</td>
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<td>3</td>
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<td>5</td>
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Question 1

a) Circle whether the following antigens can be specifically and directly recognized by Antibodies and/or T cell receptors. 9 points-Graded horizontally. 1 Point each row, both have to be correct to get the point. The bottom row is 2 points.

<table>
<thead>
<tr>
<th>Can be recognized by Antibodies</th>
<th>Can be recognized by T cell receptors</th>
<th>Antigens</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES NO</td>
<td>YES NO</td>
<td>Lipids</td>
</tr>
<tr>
<td>YES NO</td>
<td>YES NO</td>
<td>Carbohydrates</td>
</tr>
<tr>
<td>YES NO</td>
<td>YES NO</td>
<td>Bacterial surface proteins</td>
</tr>
<tr>
<td>YES NO</td>
<td>YES NO</td>
<td>Viral capsids</td>
</tr>
<tr>
<td>YES NO</td>
<td>YES NO</td>
<td>3-Dimensional polypeptide folds in native proteins</td>
</tr>
<tr>
<td>YES NO</td>
<td>YES NO</td>
<td>Linear oligopeptides</td>
</tr>
<tr>
<td>YES NO</td>
<td>YES NO</td>
<td>Non-Self MHC Class I/II molecules</td>
</tr>
<tr>
<td>YES NO</td>
<td>YES NO</td>
<td>MHC Class I/II molecules complexed with linear oligopeptides</td>
</tr>
</tbody>
</table>

b) True or False. 7 points

T F i) B cells can generate higher affinity antibodies for antigens over time.

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

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

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

T F v) Macrophages envelope and digest foreign antigens nonspecifically.

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

T F vii) Cytotoxic T cells can activate B cells to proliferate.
d) Which ONE of the following does NOT provide innate immunity against pathogens?
2pts

- blinking
- macrophages
- ciliated cells in trachea
- mucous membranes
- low pH of stomach
- plasma cells
- lysozyme in tears
- skin

e) Which of the following cells can you be sure CAN NOT have the same genetic content of a skin cell. For any circled, on the adjacent line, explain why in 5 words or less. 4 pts

- Helper T cell
  - dna rearrangement of TCR or VDJ rec.
- Lung Cell
- Macrophage
- Plasma Cell
  - VDJ REC or somatic mutation or hypermutation or junctional diversity

f) Continue the graph following the exposure to rabies virus in this laboratory mouse.
3 points
Question 2

Winston, an avid cigarette smoker, detects tumors in 3 of his 6 dogs. Lucky Strike has an ear tumor, Virginia Slims has a paw tumor, and Kool has a tail tumor. Bob, 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.

a) Which ONE of the following properties do the tumor cells lack, resulting in this growth difference. 3 pts

- ATP hydrolysis
- Contact Inhibition
- G5 processing
- Retinoblastoma
- Signaling cascade

b) Bob brushes up on the molecular nature of different cancer mutations. Match the following mutations to their respective phenotypes at the cellular level. 4 pts

- l) dominant
- m) G5 processing defective
- n) opportunistic
- o) recessive
- p) none of these

To determine the cause of each of the dogs’ tumors, he performs the following experiments.

Figure by MIT OCW.
c) Based on previous data, which tumor(s) has/have a mutation in a tumor suppressor gene? Circle ALL that apply. 2 pts

Cheek   Ear   Paw   Tail


d) Based on the data above, which tumor(s) has/have a mutation resulting in an oncogene? Circle ALL that apply. 4 pts

Cheek   Ear   Paw   Tail

Bob isolates the cells from each dish and fractionates them to isolate the membranes. Bob measures the amount of phosphorylated amino acids present, using a specific antibody. See the results below.

Bob reads that the three most likely causes for canine tumors are...

1) Ras oncogene mutations.

2) Mutations resulting in constitutively active tyrosine kinase receptors.

3) Mutations inactivating the p53 tumor suppressor gene.

e) Based on the data above, match the different tumor types with the likely cancer causes listed above. 6 points

___1___Ear tumor    ___3___Paw tumor    ___2___Tail tumor
Question 3

Bob grows dog cheek cells and adds Telohalt, a chemical that arrests cells at the end of mitosis. After removing Telohalt, he adds $^3$H-Thymidine to the cells and measures its incorporation over time.

a) Bob knows M phase is 5 hours long in these cells. Label and fill in the durations of the remaining phases. You must write legibly to receive credit.

_5 hrs_  G1 - 5 hrs, S - 10 hrs, G2 - 5 hrs

9pts

b) In a similar experiment Bob adds a drug with unknown effects, 27 hours after the removal of Telohalt, and gets the results shown below.

_Please refer to the diagrams for the cell cycle phases._

Bob repeats the experiments above with p53 tumor suppressor deficient tumor cells, and gets the following results. (Assume the cell cycle phase times of the tumor cells are similar to those of cheek cells.)

_c) Circle the point in the cell cycle where the p53 tumor suppressor mutation acts._ 3 pts

_G1-G2 transition  _G1-S transition_  _G2_  _G2-G3 transition_  _G2-S transition_

G3-S transition  _G2-M transition_  _Cyclin_  _G3-G4 transition_  _G4_  _G5 processing_

6
Efficient infection by HIV requires the expression of the HIV tat gene. All tat\textsuperscript{-} mutants are unable to spread from the cells of an initial infection to infect other cells.

a) What cell type would you use to study wildtype HIV infectivity? 3 pts

- canine kidney cells
- E. coli
- human neurons
- yeast
- none of these

You choose to study how tat works so you can design a drug to combat HIV infection. You find that cells infected with WT HIV make a long viral RNA that hybridizes to the viral DNA probes, A, B and C shown below. In contrast, cells infected with tat\textsuperscript{-} mutants produce shorter viral RNAs that can only hybridize to the A probe.

![HIV DNA diagram]

b) Which of the following statements could be true based on the above observation? 3 pt

i) The tat gene product allows RNA polymerase to transcribe through a transcriptional terminator located in the DNA between probes A and B.
ii) The tat gene product is necessary for initiation of transcription.
iii) The tat gene product is necessary for initiation of translation of the + sense mRNA.
iv) In the tat- mutant, a single nucleotide insertion causes a frameshift and changes the downstream DNA making it unable to hybridize to probes B and C.

In the early 1990's AIDS researchers began to see strains of HIV that were resistant to the treatment drug AZT, a thymidine analogue.

c) What enzyme is the target of AZT? 2 pts

- Reverse Transcriptase

d) Explain briefly why HIV is liable to develop drug resistance to AZT. 3 pts

- error-prone Replication → Mutation in Reverse Transcriptase

e) A group of Eastern Europeans is resistant to infection by HIV. What is the best explanation for their immunity to infection? 4 pts

i) Their RNA polymerase does not recognize DNA of viral origin.
ii) Their cells do not use the same genetic code as HIV.
iii) Their CD4 T-cells lack a T-cell receptor.
iv) Their CD4 T-cells have a mutated CD4 co-receptor.
v) Their neurons have an unusual shape.
vi) There is a mutated receptor on HIV.
Question 5

Part A
a) Which of the following is true about viruses? (Circle all that apply.) 3 pts
   i) They encode genes for synthesizing their own ATP.
   ii) They are single cell organisms.
   iii) They can have a genome made of DNA.
   iv) They package ribosomes into their virion.
   v) They can have a single stranded or double stranded RNA genome.
   vi) They can have a membrane-like envelope.

b) Some viruses like influenza can cause disease in humans. Which of the following can clonally expand to respond to an influenza infection. (Circle all that apply.) 6 pts
   i) B cells
   ii) Macrophages
   iii) Killer T cells (CTLs)
   iv) CD4+ T cells
   v) Neurons

c) Both bacterial viruses and plasmids can be used as cloning vectors. Which of the following is true AND distinguishes a virus from a plasmid? (Circle all that apply.) 2 pts
   i) Plasmids use the translation machinery of the cell.
   ii) Viruses have a protein capsid.
   iii) Viruses can replicate in the absence of a cellular host.
   iv) Plasmids carry genes.
   v) Plasmids have restriction sites.

d) Which of the following is true about retroviruses? (Circle all that apply.) 6pts
   i) A viral genome is integrated into the host genome during infection.
   ii) Viral genome can be made of lipids.
   iii) Viral genome encodes gene for reverse transcriptase.
   iv) Viral genome encodes gene for RNA polymerase.
   v) Virus packages reverse transcriptase protein in its virion.
   vi) Virus packages RNA polymerase protein in its virion.
   vii) Virus encodes genes for synthesizing lipid envelope.
You are studying a tumor virus that is capable of transforming healthy cells into cancer cells. 5 pts

e) What is the single most likely explanation for this viral transforming property?

i) Virus genome encodes an oncogene.

ii) Virus genome encodes a tumor-suppressor gene.

iii) Virus genome encodes an inactivated tumor-suppressor gene.

iv) Virus genome encodes an inactivated proto-oncogene.

v) Virus packages growth factors in its virion.

To further study this transforming property, you make a radioactive probe that is identical to the viral genome.

f) Would you expect this probe to hybridize with genomic DNA from healthy uninfected cells? 1 pt

Yes  No

g) Would you expect this probe to hybridize with genomic DNA from infected cancerous cells? 1 pt

Yes  No

h) How can you best explain your choices from f) and g)? 2 pts

i) Uninfected cells do not contain the virus, infected cells do.

ii) Virus does not affect host genome.

iii) Virus and host both encode a version of the capsid gene.

iv) Integrated viral genome cannot be recognized by viral probe.

v) Virus and host both encode a version of the cancer-causing gene.

vi) Viral and host RNA polymerase genes are similar.

vii) Viral and host ribosomal genes are similar.