1. (5 pts) Select one difference between the innate and acquired immune system. Summarize that difference and use one example from each branch of the immune system (innate or acquired) to illustrate your answer.

2. (3 pts) Please select one of the following items and briefly describe why the item represents both a physical barrier and a mechanical (or physiological) barrier to pathogens.
   Choice A: Mucosal membrane.
   Choice B: Skin

3. (6 pts) In what way are the three complement pathways similar? In what way do they differ? Your answer should comment on the activation processes and the list convergent down-stream events that occur after activation.

4. (5 pts) How is C3b formed and what is one of its roles in either the innate or acquired immune system (you can also comment on the role of its degradation products, e.g. C3dg)
5. (3 pts) Why is it important to regulate complement pathways? Provide one example of how this pathway is regulated.

6. (1 pt) Regarding the major effector functions of macrophages, which of the following specifically triggers inflammation and serves to enhance adaptive immunity?
   a) Secretion of IL-1, IL-6, IL-12 and TNF
   b) Phagocyte oxidase and iNOS producing ROS and NO, respectively
   c) Secretion of fibroblast growth factors such as FGF, and angiogenic factors such as VEGF
   d) Downregulation of inhibitory MHC I expression at the cell surface during viral infections

7. (1 pt) Upon phagocytizing a bacterium, an activated macrophage releases cytokines and chemokines to attract and activate neighboring neutrophils. This action can be described as _____ signaling.
   a) autocine
   b) paracrine
   c) endocrine
   d) neurocrine

8. (6 pts) Please do one of the following choices:
   Choice A: Briefly describe the molecular signaling cascade of a chemokine-activated 7-transmembrane G-protein coupled chemokine receptor (GPCR).
   Choice B: Briefly trace the intracellular molecular signaling events that result from cytokine IL-2 binding the IL-2R, including what happens to the IL-2R and subsequent downstream events, ending with gene expression.
9. (3 pts) Briefly describe or list three specific type I IFN-induced anti-viral effects, at the molecular level, that can occur in virus-infected cells.

10. (5 pts) NK cells, like CD8+ cytotoxic T-lymphocytes, can recognize and kill host cells infected by an intracellular pathogen using a unique granule-based mechanism. Describe how NK cells function in the presence of healthy vs. virally-infected host cells and how this granule-based system leads to host cell killing.

11. (6 pts) In response to a minor injury to the skin and exposure to an extracellular pathogen, briefly describe the innate inflammatory immune response. Include in your description a) the key responding immune cells and soluble factors, b) any cytokines/inflammatory molecules that are secreted, and c) how the pathogens are killed.
12. **(3 pts)** Briefly describe antigen (peptide) presentation on **either** class I **or** class II MHC. Your answer should indicate:
   i) source of the peptide,
   ii) type of cells that present on the class of MHC that you selected.
   iii) The type of T-cell that would recognize the MHC that you selected.

13. **(5 pts)** Briefly discuss **either** of the two mechanism by which $T_c$ cells are activated to $T_{CTL}$.

14. **(5 pts)** Please do one of the following two choices:
   - **Choice A**: Briefly describe the circulation of lymph and briefly discuss why the circulation of lymph is an important component of the acquired immune system.
   - **Choice B**: What properties of the lymph nodes (and the spleen) important in the activation of cells in the acquired system?
   - **Choice C**: How is mucosal tissue protected by the acquired system – what are the important cell types and what specific antibody is produced?
15. (4 pts) Sketch the immunoglobulin component of a B-cell receptor. Indicate on your diagram the location of antigen binding, $F_{ab}$ fragment, and $F_v$ fragment.

16. (5 pts) Please do one of the following choices:
   
   **Choice A:** Why are IgG molecules good at physical blocking of pathogens, but IgM is more proficient at agglutination of pathogens.
   
   **Choice B:** Why is IgM particularly good at activating complement while most forms of IgG are not.
   
   **Choice C:** How do Fc receptors enhance pathogen destruction by either macrophages or NK cells?
   
   **Choice D:** What immunoglobulin is responsible for allergies? What cell does it bind to?
   
   **Choice E:** How do babies benefit from the immune system of their mothers? What antibodies are involved and how are they transferred to the baby?

17. (3 pts) The following is a segment of DNA:
   
   i) Correct the mistakes in the diagram. Briefly justify your answer.

   ii) Does this DNA represent the light or heavy chain? Why?
18. **(6 pts)** Select one of the following and briefly describe how it occurs and its contribution to the diversity of antibodies.

**Choice A:** p-bases
**Choice B:** n-bases
**Choice C:** junctional diversity (imprecise joining)

19. **(10 pts)** Complete the following image of B-cell development and activation by labeling a) the correct stages of B-cell development; b) what type of V(D)J recombination happens at which stage, c) what surface Ig molecules are expressed at which stage, and d) where the key checkpoints occur. Also, below, please describe at least one attribute/function of plasma and memory B-cells.

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V(D)J

surface Ig expression
20. (5 pts) Please do one of the following choices:
   Choice A. Briefly describe the process of allelic exclusion in relation to the Ig heavy chain during B-cell development.
   Choice B: In B-cell development there are two self-tolerance checkpoints: one in the bone marrow and one in the lymph node. Briefly describe what happens at each checkpoint during b-cell development and why.

21. (10pts) Describe or draw-annotate the key steps in a T<sub>H</sub> cell dependent activation of a B cell, including the key molecules that must be expressed to generate both activating signals #1 and #2.