MMI 100 Questions
Medical Microbiology and Immunology Track
University of Toledo College of Medicine and Life Sciences

This document contains a list of 104 questions that will be asked during the Preliminary Examination, given at the end of the first year to students in the MMI MSBS and Ph.D. programs. The MMI graduate program believes that all MMI students should know the answers to these questions in order to be successful in their research projects and future scientific careers. These questions are provided at the start of your first year to help guide your studies. Some of these questions deal with material that is presented in first-year courses, while other questions cover material that you presumably learned as undergraduates. If you feel that you need help with a question, your advisor can suggest resources that may be helpful. In addition, MMI faculty encourage MMI students to work together to answer these questions.

A.   Research Methods
1. What are "Student's t test" and "ANOVA," and how are they used?
2. What is the meaning and use of "standard deviation" values?
3. How do you calculate molarity, and what is the difference between "1 mM" and "1 mmol?"
4. How does one measure, and what are, pH, ionic strength, and osmolarity?
5. How does gel electrophoresis separate different DNA or protein molecules? What are the differences between native and denaturing gels ? What is the difference between agarose and polyacrylamide gels?
6. What are the differences between chromatography methods based on gel filtration, ion exchange, and use of affinity tags? What are the advantages and potential disadvantages of affinity tags?
7. How does a spectrophotometer work? How do the terms optical density and absorbance differ in meaning? How can a spectrophotometer be used to distinguish between proteins and nucleic acids?
8. How can growth of cell cultures be measured and why is growth generally shown on a semilogarithmic plot?
9. Why are CO_2 incubators used for culturing of cells derived from eukaryotic organisms?
10. What are transposons, and how are they used to determine the roles of various genes?
11. What is the difference between a "selection" and a "screen?" To illustrate your answer, compare selection for lactose catabolism with blue/white screening on X-gal indicator agar.
12. What does it mean to say two genes are "orthologous" and what is the difference between "percent identity" and "percent similarity" in this context?
13. How are tissue or cell type-specific transgenic and knock-out mice generated?
14. How are FACS and magnetic beads used to identify and/or purify different leukocyte populations?
15. What is the polymerase chain reaction (PCR), what are its major research uses, and what can "real-time" PCR measure that standard PCR cannot?
16. What are ELISAs and how are they used?
17. How are secretion and intracellular accumulation of cytokines measured?
18. How is leukocyte homing measured in live animals?
19. What are proteins A and G (origin, function, research use)?
20. What are CRISPR systems (origin, original function, research use)?
21. What are the resolving powers of light, fluorescence, and electron microscopy, and in basic terms how do those microscopes work? What is a confocal microscope?
22. What is meant by sterile (or aseptic) technique, compared to "clean bench" technique, and how do autoclaving and filtration work to sterilize items?
23. What are the major differences between a biological safety cabinet (BSC), a laminar flow hood, and a fume hood? What user actions can compromise cabinet/hood function? Does a laminar flow hood protect you from chemical fumes?

B.   Basic Cell Biology
1.   What is a covalent bond? A disulfide bond? A hydrophobic or hydrophilic interaction?
2.   What is the basic structure of an amino acid, dipeptide (*i.e.* show a peptide bond), nucleotide, and dinucleotide (*i.e.*, show a phosphodiester bond)?
3.   How do cells generate the energy they need (fermentation, electron transport, mitochondria), and in what forms is this energy most often stored?
4.   What are the major roles of these molecules: ATP, GTP, NAD(P)H?
5.   What are the basic steps in getting from a gene to a protein in bacterial cells? In mammalian cells?
6.   What is "transcriptional polarity," and what is the relevance of a "complementation test" in assessing polarity?
7.   How are genes controlled (turned "on" and "off") in mammalian cells?
8.   What is an IRES, and how does it work?
9.   What are DNA replication errors, and how are they repaired? How is this process affected by DNA methylation that generates 5-methylcytosine?

10.   What are the major steps in cell division for mammalian cells?
11.   What happens at each phase in a typical growth curve?
12.   How do bacteria and mammalian cells ensure that that specific proteins are sent to the following compartments: cytoplasm, cytoplasmic membrane, or secreted? In the case of eukaryotes, how do proteins get into/out of the nucleus?
13.   What is the composition, and what are the roles, of the cytoskeleton?
14.   What is meant by a "bilayer" plasma (cytoplasmic) membrane and how are proteins stably embedded in those membranes?
15.   What are the major functions of the plasma membrane in mammalian cells and how is it formed?
16.   How do hydrophilic molecules get across the cytoplasmic (plasma) membrane?
17.   What is "autophagy" and how is it assessed experimentally?
18.   What are the characteristics of a "receptor" and how does it differ from other binding proteins?
19.   What are the major types of mammalian membrane receptors? [Your answer should include at least descriptions of type 1 versus 2 transmembrane receptors, GPI-linked, and GPCRs.]
20.   How do signals that are generated at the plasma membrane result in a functional outcome inside the cell?
21.   What is "apoptosis" and how is it assessed experimentally?

C.   Infectious Agents
1.   Three infectious diseases having the greatest global impact include AIDS, tuberculosis, and malaria. What are the agents that cause these three diseases, and how are those agents spread?
2.   What are the distinguishing and shared characteristics of viruses, bacteria, fungi, and protozoa?
3.   What are the major components of lipopolysaccharide (LPS), what is the significance of LPS for pathogenesis, and what group of infectious agents produce LPS?
4.   What is peptidoglycan, what is its role, and how is its biosynthesis affected by beta lactams?
5.   What are the key differences in cell wall structure, comparing Gram-positive bacteria, Gram-negative bacteria, spirochetes and mollicutes (such as Mycoplasma)?
6.   What are the major types and roles of the different surface appendages produced by bacteria?
7.   How is genetic information exchanged between different bacterial cells? Which of these mechanisms can also be used (at least in the lab) to exchange genes between mammalian cells?
8.   What strategies do pathogenic bacteria use to escape from innate and adaptive immunity? [Give an example of each: innate-cellular, innate-soluble, adaptive-cellular, and adaptive-humoral.]
9.   What strategies do pathogenic viruses use to escape from innate and adaptive immunity?
10.   What is "quorum sensing," and (in general terms) how does it work?
11.   For a disease caused by a bacterium, what are the major symptoms of the disease, what is the bacterium that causes it, and what is one major virulence mechanism used by that bacterium?
12.   Choose one antibacterial and one antiviral drug. Explain how each one works and why it is

selectively toxic (*i.e.*, why the human host is not killed by each of the two drugs).
13. What is a viral "plaque," and why don't all viruses form plaques? How can noncytolytic viruses be quantitated?
14. How are viruses and bacteriophages classified? What is the Baltimore system?
15. How are genes expressed by negative-strand RNA and DNA viruses?
16. In viral and phage infections of cells, what are the phases on an infectious cycle and what happens during each phase?
17. What are the major steps in the replication of HIV, and how does HIV infection affect the immune system?
18. What are the different types of viral infections, as defined by the effect on cells or organisms and by the extent of replication?
19. How can selection lead to changes in virulence?
20. Why are some viruses oncolytic?

D. Innate Immunity
1. What are the similarities and differences between innate and adaptive immunity?
2. What are the major innate barriers and soluble mediators possessed by eukaryotic hosts?
3. What role is played by endothelial cells in initiating inflammation?
4. What are the major steps in leukocyte development from hematopoietic stem cells?
5. What are the key differences between macrophages, dendritic cells, neutrophils, and natural killer cells?
6. How do phagocytosis and pinocytosis differ?
7. What is opsonization, and which proteins are responsible?
8. How do dendritic cells and macrophages take up, process, and present exogenous antigens to T cells?
9. What are the major dendritic cell subsets in the body, and how do they differ?
10. What are "reactive oxygen species" (ROS) and "reactive nitrogen species" (RNS)?
11. How are bacteria killed inside professional phagocytes?
12. What are chemokines, what major effects do they have, and how do they cause their effects?
13. What are pathogen-associated molecular patterns (PAMPs) and pattern recognition receptors (PRRs)?
14. For at least three specific PAMPs, what are the PRRs that recognize each of them, and what are the main effects of that recognition?
15. What are antimicrobial peptides, what effects do they have, which cells produce them?
16. How do antimicrobial peptides cause their effects?

E. Adaptive Immunity and Transplantation
1. Describe how different functional T cell subsets, including T helper 1 (Th1), Th2, T follicular helper (Tfh) and Th17, differ in their responses and functions?
2. What is the basic structure of an antibody and how do antibody subclasses differ?
3. What are the major steps in B cell development, and how is antibody diversity achieved?
4. How do polyclonal and monoclonal antibody preparations differ, and how is each generated in the laboratory?
5. What are the similarities and differences between the antigen receptors of T cells and of B cells?
6. What are the major steps in T cell development?
7. What is the process of positive and negative T cell selection?
8. What are the differences between naïve T cells and memory T cells?
9. How is T cell homing regulated by adhesion molecules and chemokines/chemokine receptors?
10. What are the similarities and differences between primary and secondary lymphoid tissues, and how do immune cells enter and leave the respective organs?
11. What are the major types of antigen presenting cells and how do they influence T cell activation?
12. How are extracellular antigens presented to CD4 versus CD8 T cells?
13. How do adjuvants augment immune responses to antigens?
14. What are the major types of vaccines, and what are their respective advantages and

disadvantages?
15. What are some basic autoimmune diseases (including examples of both antibody-mediated and T-cell-mediated diseases)?
16. What are some major types of unwanted (pathogenic) immune responses? [Describe at least 3.]
17. What are syngeneic grafts, allografts, and xenografts? [Provide examples]
18. What is graft *versus* host disease?
19. Which cells initiate allograft rejection, and what are mechanisms of rejection?
20. Whyrecipients of allografts must be treated with immunosuppressive drugs?
21. What is transplantation tolerance? Explain the mechanisms of tolerance to allografts.
22. What type of testing must be performed in patients prior to kidney allograft transplantation?
23. What is the difference between acute, hyperacute, and chronic allograft rejection?
24. What is the mechanism of action by calcineurin inhibitors, namely cyclosporine and tacrolimus?

EXAMINATION FORMAT

- These questions will not only help guide your first-year studies but will help to ensure that you are properly prepared for your qualifying exam at the end of your first year (MSBS) or December of second year (PhD).
- The preliminary exam will consist of 20 randomly selected questions, with four questions selected from each of the five sections (A-E) listed above.
- Most of these questions are covered during the first-year curriculum, including the MMI modules .
- Each question will be scored on a pass-fail basis.
- To pass the overall exam, 80% (16) or more of the questions must have passing answers.
- If you provide 70-75% passing answers (14-15 questions), you will be allowed to retake the exam with a different set of questions chosen from the full set.
- If you score under 70% (13 or fewer passing answers), you may not proceed in the MMI track, but are free to join one of the other tracks.
- The preliminary exam will be given in May of your first year.