Medical Microbiology Exam—Bacteriology Block
May 18, 2004

Instructions:
1. Fill in name and count pages—there should be 9 pp (39 questions; 64 pts.).
2. Read questions carefully—format varies.
3. For multiple matching format, read through all the choices in order to pick the one that best, i.e., most specifically, fits each statement.

Short answer section. (Total of 33 points)

1. Dr. Leong outlined a simple “taxonomic” system to organize bacterial pathogens, such that all bacterial pathogens fall into one of five main categories (2 pts.).
   a. What are the categories? (1 pt.)
      gram + cocci
      gram - cocci
      gram + rods
      gram - rods
      atypicals
   b. Which category has the greatest number of medically important pathogens? (1 pt.)
      gram - rods

2. What feature of Clostridium difficile biology is thought to be responsible for both its long-term survival on inanimate surfaces and for relapse following treatment of pseudomembranous colitis with antibiotics? (2 pts.)
   clostridia are spore-forming.

3. Although tetanus toxin (tetanospasmin) and botulinual toxin are highly homologous toxins that block neuroexocytosis (release of neurotransmitters). (5 pts.)
   a. In general terms, how do they work? (2 pts)
      AB model toxins: B subunit binds the cell and the A subunit has the enzymatic action.
   b. Which one produces flaccid paralysis and which spastic paralysis? (1 pt.)
      Flaccid paralysis is produced by botulinum toxin + spastic paralysis is produced by tetanospasmin.
   c. What site, the CNS or PNS, does each toxin act at? (2 pts)
      Tetanus at the CNS
      botulinum at the PNS
4. Cholera. (3 pts.)
   a. What is the enzymatic activity of cholera toxin and what is its target protein in the host cell? (1 pt.)
      Cholera toxin ADP-ribosylates the gsp protein subunit.
   b. What is the physiologic effect of this activity? (1 pt.)
      It turns Adenylyl Cyclase tonically on → cAMP → Na+ Absorption → loss of H2O + electrolytes
   c. What is the most important treatment modality for victims of cholera? (1 pt.)
      Oral Rehydration Therapy - fluid with Na+ and glucose.

5. Streptococcus pyogenes (Group A strep or GAS) and Neisseria gonorrhoeae can both colonize epithelial surfaces and elicit an inflammatory reaction. (4 pt.)
   a. Which, if any, of these pathogens makes LPS? (1 pt.) Neisseria gonorrhoeae
   b. Both organisms can cause chronic infection. Do neither, one, or both of these pathogens vary a putative (presumed) bacterial virulence factor (or factors)? If only one does, identify that organism. (1 pt.) Both vary show Antigenic Variation
      Neisseria shows both Antigen Variation and Phase Variation of its pili proteins.
   c. They are both capable of serum (complement) resistance and causing systemic infection. Identify a molecule on the surface of GAS that promotes complement resistance. (1 pt.) M protein of GAS promotes complement resistance.
   d. Identify a molecule on the surface of N. gonorrhoeae that promotes complement resistance. (1 pt.)
      N. gonorrhoeae coats itself with sialic acid from the host via a bacterial enzyme sialyl transferase.
6. *Mycobacterium tuberculosis* and *Borrelia burgdorferi* (the Lyme disease spirochete) are both capable of causing a chronic systemic infection. (9 pts)

a. How are infections by each of these organisms acquired? (2 pt.)

*M. tuberculosis* is acquired via aerosol droplets (droplet nuclei).
*B. burgdorferi* is acquired by bite of the Ixodes deer tick.

b. Which, if any, of these pathogens gram stains well? (1 pt.)

Neither - *M. tuberculosis* is acid-fast staining + *B. burgdorferi* is a spirochete that resembles gram (+) but doesn’t stain well.

c. Which, if any, is an intracellular pathogen? (1 pt.)

*M. tuberculosis*

d. Which, if any, requires bacterial motility to cause systemic disease? (1 pt.)

*B. burgdorferi*

e. Does infection by *M. tuberculosis* necessarily mean that the person has active disease? (1 pt.)

No.

f. How is *M. tuberculosis* infection (vs. disease) most frequently recognized in people? (1 pt.)

PPD test.

g. What is the relative bacterial load in persons with *M. tuberculosis* disease vs. persons with simple infection? (1 pt.)

People with disease have many more bacteria - but more importantly it is uncontrolled.

h. How does this affect how one pharmacologically treats the two conditions? (don’t need to give any specific drug names.) (1 pt.)

People with disease are given a variety of drugs to attack the bacteria, while those with infection are given only one drug.
7. *Listeria monocytogenes* is taken up by phagocytic cells into a phagosome, but soon thereafter escapes the phagosome to grow in the host cell cytoplasm. Bacterial mutants that lack the ability to escape are eventually killed. **What does the host cell do to promote killing of phagocytosed organisms?** (2 pts.)

Macrophages with phagocytosed bacteria will activate an oxidative burst and fuse the phagosome with a lysosome to digest the bacteria. It will also call mast cells (mast cells inhibit infected cells) digest the bacteria. Nf will down-regulate transferrin receptors starving the intracellular bacteria of iron it needs to thrive/live.

8. Consider *Listeria monocytogenes*, *Salmonella typhi*, and *Shigella dysenteriae*. (6 pts.)

a. All of these organisms have a strong propensity to produce systemic disease, but only two are generally associated with systemic infection. Which one produces systemic disease but only a local infection? (1 pt.)  
   **Shigella**

b. What virulence factor produced by this organism not only exacerbates local tissue damage, but can also cause hemolytic-uremic syndrome (HUS)?  
   **Shiga toxin** (2 pts).

c. What relationship between the bacteria and leukocytes (often associated with the ability to cause systemic infection) is shared by the two deep-tissue invaders in this group? (2 pts)  
   *Listeria* induce uptake and travel with macrophages throughout the body.

d. One of these organisms can colonize the gall bladder following systemic infection, producing a long-lived carrier state. Which organism has this ability? (1 pt)  
   **Salmonella typhi**
Ques. 9-10. LUNG INFECTIONS

A. Anaerobic lung abscess.
B. Cavitary lesion of tuberculosis. — also anaerobic?
C. Both
D. Neither

Indicate which of the choices above best applies to the statements below. Each answer may be used once, more than once, or not at all.

9. Typically results in foul-smelling breath. □ C
10. A polymicrobial infection. □ A

Ques. 11. MENINGITIS

A. Streptococcus pneumoniae
B. Haemophilus influenzae
C. Both of the above.
D. Neither of the above.

Indicate which of the choices above best applies to the statements below. Each answer may be used once, more than once, or not at all.

11. A conjugated capsule vaccine (i.e., capsular polysaccharide linked to a protein “carrier”) elicits antibody that protects against invasive disease by this pathogen. □ C
A. *Streptococcus pneumoniae* (pneumococcus) \( \text{gram}^+ \text{ cocc}i \)
B. *Neisseria meningitidis* (meningococcus) \( \text{gram}^- \text{ cocci} \)
C. Both
D. Neither

Indicate which of the choices above best applies to the statements below. Each answer may be used once, more than once, or not at all.

12. Often seeds the central nervous system by direct extension from colonized pharynx, sinuses, or middle ear.  
13. Grows to high concentration in the bloodstream, particularly in individuals with defects in complement fixation or phagocytic clearance.  
14. Initial site of colonization of the host is usually the pharynx.  
15. Escapes immune clearance by antigenic variation of pili and outer membrane proteins.  
16. Commonly lyses itself, thereby releasing toxins that are in the bacterial cytoplasm.  
17. An important cause of pelvic inflammatory disease.  
18. This endotoxin-producing pathogen secretes a protease that specifically cleaves IgA.

Ques. 19-22. SYSTEMIC MANIFESTATIONS OF INFECTION.

A. The endotoxin of Gram-negative bacteria  
B. Streptococcal toxic shock syndrome toxin  
C. Both  
D. Neither

Indicate which of the choices above best applies to the statements below. Each answer may be used once, more than once, or not at all.

19. Induces production of pro-inflammatory cytokines.  
20. Binds to Vβ chain of the T-cell receptor, resulting in polyclonal T cell activation.  
21. Can cause a constellation of signs and symptoms including fever, hypotension, endothelial damage and disseminated intravascular coagulation, leading to multi-organ system failure.  
22. Is a protein.
A. Vibrio cholerae
B. Shigella flexneri
C. Group A Streptococcus (Streptococcus pyogenes)
D. Clostridium difficile
E. Clostridium tetani
F. Clostridium botulinum
G. Mycobacterium tuberculosis
H. Treponema pallidum
I. Mycoplasma pneumoniae
J. Legionella pneumophila
K. None of the above.

Indicate which of the choices above best applies to the statements below. Each answer may be used once, more than once, or not at all.

23. Infection by this organism is often divided into primary, secondary, and tertiary (or chronic) phases, with signs and symptoms that can come and go (i.e., a waxing and waning clinical picture).

24. This organism is acquired from contaminated water or food and produces epidemics of fulminant watery diarrhea.

25. This pathogen, which does not cause a life-threatening infection, has an unusual bacterial structure that makes antibiotics that target cell wall biosynthesis ineffective.

26. This organism, which replicates within macrophages, is acquired only from environmental sources.

27. While colonization of the colon by this organism is not infrequent, suppression of the normal flora—often by antibiotic treatment—is required for growth and toxin production to reach levels high enough to cause serious disease.

28. Congenital infection by this organism can lead to prematurity and characteristic bony deformities.
Ques. 29-31. DIARRHEAL PATHOGENS
A. Enterotoxigenic E. coli (ETEC)
B. Enteropathogenic E. coli (EPEC)
C. Enterohemorrhagic E. coli (EHEC), serotype O157:H7
D. Enteroinvasive E. coli (EIEC)
E. Salmonella typhi
F. Shigella flexneri
G. Clostridium difficile
H. None of the above.

Indicate which of the choices above best applies to the statements below. Each answer may be used once, more than once, or not at all.

29. This bacterium is a common cause of traveler's diarrhea in Central and South America. 
A

30. Colonization of the gall bladder by this organism can result in a persistent carrier state. 
C

31. This bacterium is a major cause of kidney failure in children under 10. 
C

Ques. 32-33. BACTERIAL FACTORS THAT PROMOTE DAMAGE OR COLONIZATION.

A. Hyaluronic acid capsule
B. Superantigen
C. Lipopolysaccharide
D. Siderophores
E. Listeriolysin O
F. Lipoprotein
G. Lipoteichoic acid
H. Streptokinase
I. Streptococcal Sic protein
J. Flagella

Indicate which of the choices above best applies to the statements below. Each answer may be used once, more than once, or not at all.

32. Mediates escape of the bacterium from phagosome into the cytoplasm. 
E

33. This component triggers much of inflammation that is responsible for tissue damage seen in Lyme disease. 
F
A. Vibrio cholerae
B. Enterotoxigenic E. coli (ETEC)
C. Group A Streptococcus (Streptococcus pyogenes)
D. Clostridium difficile
E. Clostridium tetani
F. Clostridium botulinum
G. Mycobacterium tuberculosis
H. Mycoplasma pneumoniae
I. Legionella pneumophila
J. Treponema pallidum.
K. None of the above.

Indicate which of the choices above best applies to the statements below. Each answer may be used once, more than once, or not at all.

34. This pathogen, which is typically acquired from other individuals, can trigger rheumatic fever. C
35. In parasitizing the eukaryotic cell, this pathogen utilizes a specialized secretion system related to those that transfer DNA from one bacterium to another. This system modifies phagosomal maturation in the host cell. I
36. The scarcity and variation of exposed antigenic targets is a major contributor to its ability to cause chronic disease. J
37. Grows within macrophages and can spread to diverse sites, resulting in many different manifestations of infection. G
38. Infection of humans is a “dead end” for this organism—no human-to-human transmission. I
39. Often infects young adults. Important cause of “atypical” pneumonia, which usually is not severe or life threatening. H
Circle the NUMBERED choices which corresponds to the correct answer (1 point each)

I. The following parasites produce hypnozoites in the liver.
A. *Plasmodia falciparum*
B. *Plasmodia malariae*
C. *Plasmodia ovale*
D. *Plasmodia vivax*

1. A is correct
2. B is correct
3. C is correct
4. D is correct
5. all are correct

II. Determining which plasmodial specie(s) produce hypnozoites is important to clinical understanding and treatment of malaria because.
A. Hypnozoites are the sole cause of cerebral malaria ✗
B. The production of hypnozoites is the primary cause of relapsing malaria which can occur weeks to years after the initial infection has occurred ✓
C. Hypnozoites are associated with the susceptibility of Duffy antigen negative individuals to disease - both *vivax* associated
D. It defines racial groups predisposed to disease ✗

1. A is correct
2. B is correct
3. C is correct
4. D is correct
5. all are correct

III. Some human resistance to clinical malarial disease can be conferred by
A. Glucose 6-Phosphate deficiency ✓
B. β-Thalassemia deficiency ✓
C. Sickle Cell Anemia carrier state ✓
D. Duffy Blood Group absence ✓

1. A and C are correct
2. A and B are correct
3. B and C are correct
4. A and D are correct
5. all are correct

IV. Understanding 'allelic polymorphism' such as the absence of Duffy antigen is useful because
A. It helps us to categorize individuals by ethnicity ✗
B. It helps us in establishing predisposition/resistance to infection. ✓
C. It helps in narrowing down which particular species an individual may be infected with ✓
D. Is really unimportant to physicians who will only treat the overt signs of disease ✓

1. A and C are correct
2. A and B are correct
3. B and C are correct
4. A and D are correct
5. all are correct
V. Among some of the typical features associated with *P. falciparum* infections are:
A. The identification of extracellular gametocytes in thin blood smears ✓
B. The identification of intracellular gametocytes in thin blood smears.
C. The formation/appearance of ring trophozoites in red blood cells ✓
D. The appearance of ring trophozoites in neurons ✗
1. A and C are correct
2. A and B are correct
3. B and C are correct
4. A and D are correct
5. all are correct

VI. For individuals returning from the tropics or Asia in the last 1-2 weeks complaining of general malaise, presenting with anemia should be asked the following questions:
A. Have you and are you taking anti-malarial prophylactics? ✓
B. Have you experienced insect/mosquito bites. ✓
C. The formation/appearance of ring trophozoites in red blood cells ✗<sup>3</sup>  Typo?
D. The appearance of ring trophozoites in neurons ✗
1. A and C are correct
2. A and B are correct
3. B and C are correct
4. A and D are correct
5. all are correct

VII. The following are sufficient to exclude malaria as an infectious agent:
A. Negative thin blood smears ✓
B. The absence of a periodic fever. ✓
C. The presence of ring trophozoites which are typically characteristic of Babesia ✓
D. The appearance of ring trophozoites in neurons ❌
1. A and C are correct
2. A and B are correct
3. B and C are correct
4. A and D are correct
5. all are correct

VIII. The simplest non-invasive way to establish the presence of Schistosomal infections would be to
A. Check urine for eggs ✓
B. Use antibodies against hemoglobinase to detect circulating hemoglobinase in the blood of the patient
C. Check for eggs in the stool ✓
D. Check for miracidial hatching/swimming when egg burden is too low to confirm infection
1. A and C are correct
2. B and C are correct
3. C and D are correct
4. A, B and D are correct
5. All are correct
IX. Miracidia infected freshwater snails
A. Release cercariae which infect their human hosts by penetrating the skin. ✓
B. Release eggs which are consumed by humans thus transmitting the disease, schistosomiasis
C. Are susceptible to cercarial infections
D. Eventually release larval forms that transform into schistosomula which migrate through the human lungs and become fully mature worms in mesenteric venules.

1. A and B are correct
2. B and C are correct
3. C and D are correct
4. A and D are correct
5. All are correct

X. Plasmodium vivax
A. Is associated with relapsing malarial disease. ✓
B. Will infect the bone marrow ✓
C. Is associated with recrudescence ✓
D. When infecting red cells causes the appearance of Schuffner's dots. ✓

1. A and B are correct
2. B and C are correct
3. C and D are correct
4. A and D are correct
5. All are correct

XI. Plasmodium vivax
A. Will produce dormant sporozoites in the liver of infected individuals. ✓
B. Is transmitted only by Blackfly (Buffalo gnat) ×
C. Do not produce immature parasites that might be found in the circulatory system ×
D. Infection of red blood cells causes enlargement of the cells. ✓

1. A and B are correct
2. B and C are correct
3. C and D are correct
4. A and D are correct
5. All are correct

XII. Stages in the life cycle of parasites belonging to the plasmodial genus include
A. Tachyzoites, Pseudocysts and Bradyzoites (depending on the species) ×
B. Cysts, microfilarial forms and adult organisms (only in the insect). ×
C. Sporozoites, liver schizonts and hypnozoites (depending on the species). ✓
D. Merozoites and Ring-like trophozoites ✓

1. A and B are correct
2. B and C are correct
3. C and D are correct
4. A and D are correct
5. All are correct

XIII. Stages in the life cycle of parasites belong to the plasmodial genus include
A. A latent pseudocyst stage in cardiac muscle and the brain × + ×
B. An exoerythrocytic stage in liver. ✓
C. An asexual stage in erythrocytes. ✓
D. A hypnozoite phase in red blood cells

1. A and B are correct ✓
2. B and C are correct ✓
3. C and D are correct
4. A and D are correct
5. All are correct

XIV. Chloroquine
A. Is the only and most effective treatment for malarial infections ✓
B. Resistance can develop in malaria that is usually treatable with mefloquine.
C. May function by acidifying parasite food vacuoles in which hemoglobinase functions.
D. Supplants Mefloquine as the drug of choice in treating malarial infections ✓

1. A and B are correct ✓
2. B and C are correct ✓
3. C and D are correct ✓
4. A and D are correct
5. All are correct

XV. Malaria infected red blood cells are readily apparent to the eye because
A. Parasites can be seen producing the dormant pseudocysts in both smooth muscle cells and RBCs
B. They all have Schuffner's dots. X
C. Ring-like trophozoites are usually visible in RBCs.
D. Hemozoin can be seen in the cytoplasm of the pale red blood cells

1. A and B are correct
2. B and C are correct
3. C and D are correct ✓
4. A and D are correct
5. All are correct

XVI. Toxoplasma gondii
A. Definitive host is the cat ✓
B. Transmitted Transplacentally /via Organ transplant/Oocyst inhalation & consumption/Transfusions.
C. Has broad tissue tropism but primarily infects brain and muscle and macrophage cells.
D. Is an opportunistic infections prevalent in AIDS patient/causes toxoplasma encephalitis ✓

1. A and B are correct ✓
2. B and C are correct
3. C and D are correct ✓
4. A and D are correct
5. All are correct

XVII. Toxoplasma gondii
A. Infection of women in their first trimester of pregnancy can lead to congenital toxoplasmosis ✓
B. Is a parasite found only in homosexuals and women X
C. is resistant to Pyrimethamine treatment which normally block nucleotide biosynthesis elsewhere
D. Prior exposure is equivalent to vaccination since antibodies are protective against invasive parasitemia
1. A and B are correct
2. B and C are correct
3. C and D are correct
4. A and D are correct
5. All are correct

FOR THE FOLLOWING CIRCLE ALL THE INCORRECT LETTERED CHOICES

ENTAMOEBA/GIARDIA

XVIII. Regarding both Entamoeba and Giardial infections.
A. Both are transmitted via the oral/fecal route
B. Both produce multinucleate cysts that are passed anally
C. 90% or greater of the infected individuals are typically asymptomatic for disease
D. The form responsible for much of the disease is the flagellated trophozoite
E. The disease becomes systemic (not inevitably)

XIX. Regarding Entamoeba infections.
A. Trophozoites can contribute to slow smoldering and initially asymptomatic infections leading to the formation of Amoebomas; large space-filling voids that can be mis-diagnosed as tumors
B. Can cause extra-intestinal abscesses of the liver, brain and possible other major organs
C. Disease never presents as dysentery (bloody diarrhea with pain and intestinal ulcerations)
D. The clinical picture without laboratory diagnosis may resemble inflammatory bowel disease

XX. Regarding Entamoeba and Giardia infections.
A. One risk factor for infection/disease is sexual activity
B. One risk factor for infection/disease is post-operative (gastric surgery) care
C. Both can show are relapsing course of disease
D. Institutionalized individuals are typically at higher risk for disease
E. Respond to Metronidazole (flagyl)

XXI. Regarding either Entamoeba or Giardia infections.
A. May cause secondary bacterial infections which, without proper identification of parasite trophozoites, can lead to mis-diagnosis and wrong or insufficient therapy
B. Is rare in HLA-B12 deficient than in HLA-B12 sufficient populations
C. More common among pregnant women than women in the general population
D. Is common among individuals with IgA deficiency
E. Much of the immunity associated with protection against disease is likely to be mucosal immunity

XXII. Regarding either Entamoeba or Giardia infections.
A. Each organism has the capacity to produce 300 - 3000 eggs per day
B. Like many worms, which also reside preliminary in body cavities such as the intestines, Entamoeba and/or Giardia will illicit eosinophilia
C. Relapsing disease in Giardia is due to their unusual capacity to change the antigenic properties of their surface antigen
D. Little to no disease is caused by eggs lodging in deep tissue
E. Are both protozoa
1. Which of the following types of Malaria is the most lethal:
   A. *Plasmodium falciparum*
   B. *Plasmodium vivax*
   C. *Plasmodium ovale*
   D. *Plasmodium malariae*

2. Name two opportunistic infections that would suggest a diagnosis of AIDS.
   Toxoplasma encephalitis
   Pseudomonas aeruginosa

3. Name one indication that would suggest a differential diagnosis of sCJD as opposed to vCJD.
   vCJD would present in a younger individual than sCJD

4. T/F The incubation period of influenza is 7-14 days.
   True False

5. Describe the transmission cycle of West Nile Virus.
   Birds → mosquitoes → horses → people

6. Name two key tenets of infection control used to manage SARS outbreaks.
   Isolation of infected individuals
   Closure of public facilities

7. Name two of the most important organisms associated with bacterial meningitis in children and adults.
   *Pneumococcus* (*S. pneumoniae*)
   *Meningococcus* (*N. meningitidis*)

8. What sexually transmitted disease is caused by the microorganism *Treponema pallidum*?
   Syphilis