

Chapter

1

Biology of Bacteria, Viruses, Fungi and Parasites and the Host–Pathogen Interactions

Microbial and host cellular biology and interactions dictate the breadth of clinical infection practice, from colonisation to invasion to infection. Understanding the classifications used for bacteria, viruses, fungi and parasites aids clinical and laboratory diagnosis and ultimately patient management. Understanding the common host responses to infective agents at the cellular level enables appropriate clinical management both with direct acting anti-infectives and other supportive therapy.

Questions

- Q1.1** A 21-year-old female presents with a fever, and a novel viral infection is suspected. Electron microscopy is performed. Which of the following might be present in a virus?
- A. Nucleus
 - B. An envelope
 - C. Metabolic pathways
 - D. Ribosomes
 - E. A cell wall
- Q1.2** A 46-year-old male presents with a fever of unknown origin, and a whole blood sample is sent to the virology laboratory for polymerase chain reaction testing. The test identifies a DNA virus. Which of the following class of viruses contain DNA?
- A. Rhabdoviridae
 - B. Orthomyxoviridae
 - C. Enteroviridae
 - D. Flaviviridae
 - E. Parvoviridae
- Q1.3** A 1-year-old male awaiting repair of a ventricular septal defect is being considered for palivizumab prophylactic therapy for respiratory syncytial virus (RSV). What type of virus is RSV?
- A. Single-stranded (–) RNA
 - B. Single-stranded (+) RNA
 - C. Double-stranded RNA

- D. Single-stranded DNA
- E. Double-stranded DNA

- Q1.4** A 21-year-old female presents with a fever and leucopaenia, and a viral infection is suspected. Which of the following is a paramyxovirus?
- A. Rubella virus
 - B. Influenza B virus
 - C. Polio virus
 - D. Nipah virus
 - E. Parvovirus B19
- Q1.5** A 25-year-old female is recalled after cervical screening. Which of the following is true regarding human papillomavirus (HPV)-associated malignancy?
- A. HPV-6 and HPV-11 are associated with genital cancers
 - B. HPV-16 and HPV-18 are associated with genital cancers
 - C. HPV late viral proteins inhibit tumour suppressor genes
 - D. HPV-6 and HPV-11 are associated with anal in-situ neoplasia
 - E. HPV late viral proteins are products of proto-oncogenes
- Q1.6** A 27-year-old female with sickle cell anaemia presents in aplastic crisis with a fever. Her blood results demonstrate:
- Haemoglobin 50 g/L
 - Reticulocyte count 0.1%
 - White cell count $12.3 \times 10^9/L$
 - Lymphocytes $8.6 \times 10^9/L$
 - CRP 34
- Which genus is the most likely causative virus from?
- A. Dependovirus
 - B. Henipahvirus
 - C. Pneumovirus
 - D. Parvovirus
 - E. Erythrovirus
- Q1.7** A 31-year-old female is referred from occupational health. A chronic infective carrier state may occur in which viral infection?
- A. Hanta virus
 - B. Hepatitis A virus
 - C. Hepatitis E virus
 - D. Hepatitis C virus
 - E. Nipah virus

Q1.8 A 54-year-old male presents with fever, tachycardia and hypotension. A blood culture is taken and becomes positive in 12 hours. The Gram stain is shown in Figure 1.1.

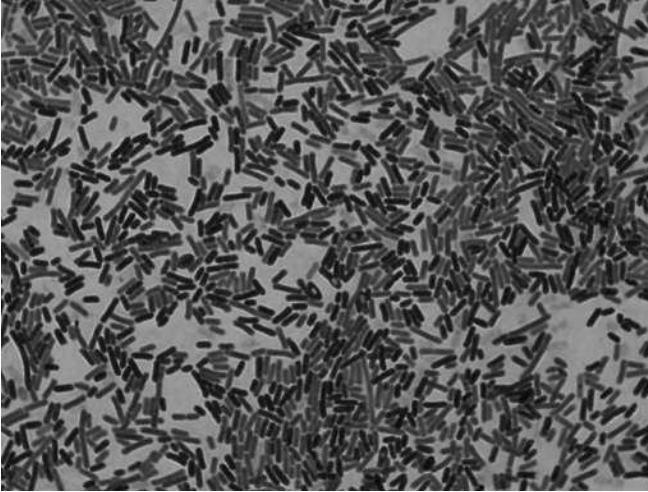


Figure 1.1 Gram stain from a positive blood culture. (A black and white version of this figure will appear in some formats. For the colour version, please refer to the plate section.)

Which of the components of the Gram stain is a fixative?

- A. Safranin
 - B. Carbol fuchsin
 - C. Acetone
 - D. Crystal violet
 - E. Iodide
- Q1.9 A 54-year-old male presents with fever, tachycardia and hypotension. A blood culture is taken and becomes positive in 12 hours, and *Escherichia coli* is identified. It is demonstrated to have in vitro resistance to many penicillins and cephalosporins. Through what mechanism is an extended-spectrum beta-lactamase gene most likely to be present in this *E. coli*?
- A. Transduction
 - B. Transformation
 - C. Conjugation
 - D. Constitutively
 - E. De novo mutation
- Q1.10 A 28-year-old male presents with diarrhoea. A non-lactose fermenting coliform is isolated from faeces, and serological investigation of the isolate is performed. The “O” antigen is positive, but the “H” antigen is negative. What is the most likely explanation for this?
- A. The isolate is non-motile
 - B. The isolate needs boiling prior to agglutination
 - C. The presence of a “Vi” antigen is masking the “H” antigen
 - D. The isolate is in a non-specific phase
 - E. The isolate is not a *Salmonella* species

- Q1.11 A 35-week pregnant female recalled a flu-like illness 2 days prior to delivery. She was treated for peri-partum sepsis, and her new-born child was born in poor condition and admitted to the neonatal intensive care department. Blood cultures (and subsequently cerebrospinal fluid) grew the organism depicted in Figure 1.2.

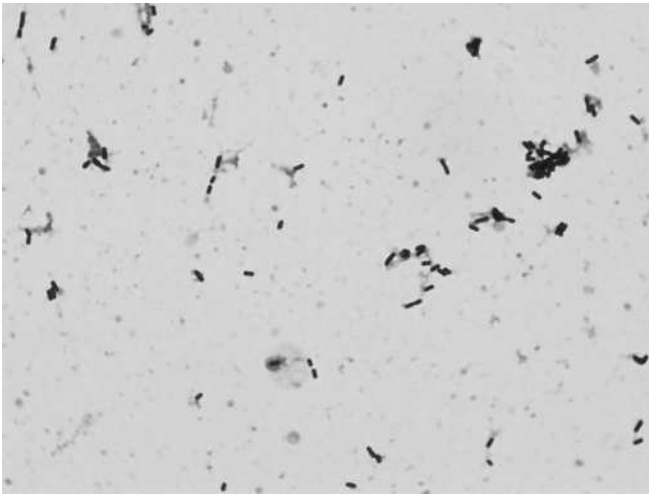


Figure 1.2 Gram stain of cerebrospinal fluid. (A black and white version of this figure will appear in some formats. For the colour version, please refer to the plate section.)

- Which laboratory test would be the most useful to confirm identification?
- A. Coagulase
 - B. Catalase
 - C. Oxidase
 - D. Haemolysis on blood agar
 - E. Tumbling motility
- Q1.12 A 34-year-old man presents with a fever, and an aerobic blood culture bottle grows a Gram-negative rod. Which one of the following organisms is a strict aerobe?
- A. *Bacteroides fragilis*
 - B. *Kluyvera* spp.
 - C. *Proteus vulgaris*
 - D. *Prevotella melaninogenica*
 - E. *Pseudomonas aeruginosa*
- Q1.13 A 42-year-old patient presents with septic shock and is found to have a soft tissue infection. Which component of the cell wall of Gram-positive bacteria may contribute to the development of septic shock in Gram-positive infections?
- A. Capsular protein
 - B. Endotoxin
 - C. Peptidoglycan
 - D. Phospholipid
 - E. Teichoic acid

- Q1.14** A 23-year-old female presents with a urinary tract infection. Which of the following is true about urease producing bacteria?
- A. Urease acidifies the urine rendering neutrophils inactive
 - B. *Escherichia coli* is urease positive
 - C. Acidifying the urine can lead to precipitation of struvite calculi
 - D. *Morganella morganii* is potentially a urea-splitting bacteria
 - E. Are commensal organisms that prevent hepatic encephalopathy
- Q1.15** A 63-year-old female is diagnosed with urosepsis. She is profoundly hypotensive. What is the most important endotoxin component leading to septic shock from Gram-negative bacteria?
- A. Lipopolysaccharide core oligosaccharides
 - B. Outer membrane vesicles
 - C. Lipid A
 - D. O antigens
 - E. Capsule
- Q1.16** A 21-year-old female presents with necrotising fasciitis. Which of the following is not a virulence factor of *Staphylococcus aureus*?
- A. Lecthinase
 - B. Toxic shock syndrome toxin-1
 - C. Panton-Valentine leukocidin
 - D. Enterotoxin A
 - E. DNase
- Q1.17** A 31-year-old male returns from Ethiopia and presents with a recurrent febrile illness. What is the cause of the relapsing nature of fever in *Borrelia recurrentis* infection?
- A. Antigenic drift
 - B. Antigenic shift
 - C. Rapidly developing antibody resistance
 - D. Antigenic variation
 - E. Encapsulation
- Q1.18** A 16-year-old male presents with respiratory distress. Which organism produces a toxin similar in action to that of *Corynebacterium diphtheriae*?
- A. *Bordetella pertussis*
 - B. *Pseudomonas aeruginosa*
 - C. *Serratia marcescens*
 - D. *Haemophilus influenzae*
 - E. *Clostridium tetani*
- Q1.19** An 18-year-old female presents with difficulty swallowing. A throat swab demonstrates club-shaped organisms with differential staining. *Corynebacterium diphtheriae* is suspected. What are *Corynebacterium diphtheriae* volutin granules made of?
- A. Carbohydrate
 - B. Protein
 - C. Lipid
 - D. Phosphate
 - E. Collagen

Q1.20 A 45-year-old female presents with a heart block following a minor dog bite to the palm of her hand (Figure 1.3).



Figure 1.3 Clinical appearance of the right hand following a minor dog bite.

Corynebacterium ulcerans is isolated from the wound, and an Elek test is positive.

How does diphtheria toxin act?

- A. ADP ribosylation of EF2
- B. Ergosterol synthesis inhibition
- C. Peptidoglycan disruption
- D. Protein synthesis inhibition at the ribosome
- E. Acetyl choline esterase inhibition

Q1.21 A 50-year-old male who underwent traumatic splenectomy two years ago presents with tachypnoea, tachycardia and hypoxia. A mucoid *Streptococcus pneumoniae* is subsequently grown (Figure 1.4).

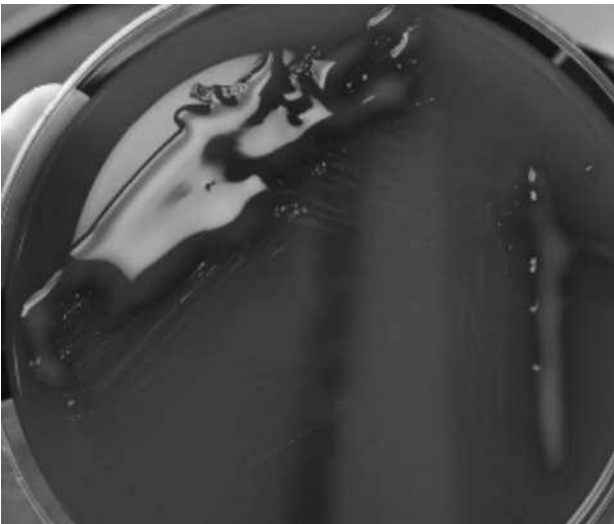


Figure 1.4 Growth on blood agar incubated in an aerobic environment at 37°C for 24 hours. (A black and white version of this figure will appear in some formats. For the colour version, please refer to the plate section.)

An avirulent, non-capsulate strain of pneumococcus can change to virulent capsulate strains through which mechanism?

- A. Plasmid transfer
- B. Bacteriophage
- C. Naked DNA transformation
- D. Homogenous recombination
- E. Slipped strand mispairing

Q1.22 A 56-year-old male is diagnosed with native valve endocarditis. A blood culture grows a Gram-positive cocci on both blood agar and MacConkey agar, which is ampicillin resistant. What is the likely identification of this organism?

- A. *Enterococcus faecalis*
- B. *Enterococcus faecium*
- C. *Streptococcus pneumoniae*
- D. *Streptococcus bovis*
- E. *Streptococcus anginosus*

Q1.23 A 14-month-old child is admitted with a two-week history of coughing and is admitted with severe paroxysms of coughing leading to hypoxia. Pertussis is suspected. Which of the following is true about *Bordetella pertussis*?

- A. Polymorphonuclear leucocytosis seen during infection
- B. Can be clinically diagnosed initially within days of onset
- C. Organism is isolated from the throat for several days following infection
- D. Vaccine gives lifelong immunity
- E. Tetracycline is effective in the paroxysmal stage

Q1.24 A 56-year-old female with urosepsis is not improving despite treatment with an intravenous third-generation cephalosporin. Which bacteria are most likely to harbour an extended-spectrum beta-lactamase gene?

- A. *Klebsiella pneumoniae*
- B. *Enterobacter cloacae*
- C. *Citrobacter freundii*
- D. *Morganella morganii*
- E. *Proteus mirabilis*

Q1.25 A 49-year-old homeless patient attends the emergency department complaining of itching and fever. He describes the onset of fever approximately 7 days ago. On examination, he has a widespread rash and excoriation marks. What is the most likely vector for this illness?

- A. *Aedes aegypti*
- B. *Anopheles gambiae*
- C. *Pediculus humanus humanus*
- D. *Glossina* spp.
- E. *Culex* spp.

- Q1.26 A 54-year-old male presents with a flitting rash and an eosinophilia eight weeks after return from the tropics. Which of the following infections require an intermediate snail host?
- A. Diphylobothriasis
 - B. Schistosomiasis
 - C. Echinococcosis
 - D. Paragonamiasis
 - E. Strongyloidiasis
- Q1.27 A 31-year-old male presents with diarrhoea several days after return from Nigeria. *Entamoeba* is seen on stool microscopy. Which of the following is a non-pathogenic variant of *Entamoeba histolytica*?
- A. *Entamoeba dispar*
 - B. *Escherichia coli*
 - C. *Entamoeba hartmanni*
 - D. *Endolimax nana*
 - E. *Enterobacter cloacae*
- Q1.28 A 21-year-old female presents with a fever, adenopathy and a rash. Blood tests demonstrate a lymphocytosis. Serological diagnosis of a primary viral infection may be made by detection of which viral-specific immunoglobulin?
- A. IgA
 - B. IgD
 - C. IgE
 - D. IgM
 - E. IgG
- Q1.29 A 23-year-old male student has been recently admitted with invasive meningococcal disease. He has made a good recovery but gives a history of a previous episode of meningococcal septicaemia when he was 15 years old. There is no history of other recurrent infections. Which immunodeficiency is most likely in this patient?
- A. Adenosine deaminase deficiency
 - B. C7 deficiency
 - C. Job's syndrome
 - D. Myeloperoxidase deficiency
 - E. Selective IgM deficiency
- Q1.30 An 18-year-old male with chronic granulomatous disease (CGD) has recurrent staphylococcal infection. What is the mechanism behind this?
- A. Chemotaxis inhibition
 - B. Defect in phagocyte oxidase
 - C. Lack of C3d receptor
 - D. Failure of phago-lysosome fusion
 - E. IgM deficiency

- Q1.31 A 63-year-old female is diagnosed with urosepsis. She is profoundly hypotensive. The lipopolysaccharide of Gram-negative bacteria is the principle ligand for which specific toll-like receptor (TLR)?
- A. TLR3
 - B. TLR4
 - C. TLR5
 - D. TLR7
 - E. TLR10
- Q1.32 A 31-year-old male presents with acute hepatitis. He is found to have hepatitis C, but subsequently clears this infection. Which pattern of cytokines is produced by TH1 lymphocytes?
- A. IL4 and IL10
 - B. TNF- β and IL1
 - C. IL2 and IFN- γ
 - D. IL1 and IL12
 - E. IL4, IL5, IL6 and IL13

Answers

A1.1 Answer B: An envelope

Viruses (Latin for toxin) contain DNA or RNA but not both. The central ribonucleic core is surrounded by a protective shell (not a cell wall) of repeating protein units called capsomeres. This has a symmetry which is either helical or icosahedral. Viral particles contain polymerases and integrases but no true metabolic pathways. As completed virions move from the host cell nucleus to the cytoplasm or from the cytoplasm to the extracellular space, an external lipid-containing envelope may be added to the nucleocapsid.

Further Reading

Abrescia NGA, Bamford DH, Grimes JM, Stuart DI. Structure unifies the viral universe. *Ann Rev Biochem.* 2012;81:795–782.

A1.2 Answer E: Parvoviridae

There are several methods of classifying viruses, but perhaps the most widely used is the Baltimore system developed in 1971, which designates viruses into one of seven groups depending on the nature of the nucleic acid within the virus. Four aspects are considered: (i) whether the nucleic acid is DNA or RNA, (ii) whether it is single stranded or double stranded, (iii) whether it is positive or negative sense, and (iv) the method of replication.

Table 1 Classification of viruses.

I	II	III	IV	V	VI	VII
Double-stranded DNA	Single-stranded DNA	Double-stranded RNA	Single-stranded (+) RNA	Single-stranded (–) RNA	Single-stranded (+) reverse transcriptase RNA	Double-stranded reverse transcriptase DNA
Adeno	Parvo	Reo	Picorna	Orthomyxo	Retro	Hepadna
Herpes			Toga	Paramyxo		
Pox			Flavi	Rhabdo		
Papilloma			Corona	Filo		
			Calici	Arena		
			Hepe	Bunya		

Data from Baltimore (1971).

Further Reading

Baltimore D. Expression of animal virus genomes. *Bacteriol Rev.* 1971;35(3):235–241.

A1.3 Answer A: Single-stranded (–) RNA

RSV is a single-stranded (–) RNA virus of the family Paramyxoviridae. Infection with this virus usually produces only mild symptoms, often indistinguishable from common cold and minor illnesses. It is, however, also the most common cause of bronchiolitis and pneumonia in children less than 1 year of age and can also cause croup. These syndromes are more likely to occur in patients that are immunocompromised or infants born prematurely. No antivirals are effective – the mainstay of therapy is oxygen. Palivizumab (a monoclonal antibody against RSV surface fusion protein) can be given as monthly injections begun just prior to the RSV season (usually for five months) as RSV prophylaxis for infants that are premature or have either cardiac or lung disease.

Further Reading

Andabaka T, Nickerson JW, Rojas-Reyes MX, Rueda JD, Bacic Vrca V, Barsic B. Monoclonal antibody for reducing the risk of respiratory syncytial virus infection in children. *Cochrane Database Syst Rev.* 2013;4:CD006602.

A1.4 Answer D: Nipah virus

The paramyxoviridae (ss(–)RNA) family includes viruses causing many common infections. However, it has a complex taxonomy:

Subfamily Paramyxovirinae

Genus Henipavirus (Hendra virus and Nipah virus)

Genus Morbillivirus (Measles virus)