ANSWERS TO END-OF-CHAPTER QUESTIONS

Chapter 1 Answers

1.1 **A.**

1.2 **C.**

1.3 **False.**

1.4 A, myeloid; B, lymphoid; C, myeloid; D, lymphoid; E, myeloid; F, myeloid.

1.5 **B.**

1.6 **False.**

1.7 **A, 2; B, 3; C, 4; D, 1.**

1.8 **C.**

1.9 A, central; B, peripheral; C, peripheral; D, central; E, peripheral.

1.10 **A, 3; B, 1; C, 2.**

1.11 **D.**

1.12 Cytotoxic, helper.

1.13 **False.**

1.14 **False.**

1.15 **A.**

1.16 **B.**

1.17 **False.**

Chapter 2 Answers

2.1 **B.** Even though β-lactams disrupt the cell wall through a different mechanism, lysozyme also disrupts the bacterial cell wall structure via enzymatic digestion, specifically, cleavage of the β-(1,4) linkage between *N*-acetylglucosamine and *N*-acetylmuramic acid.

2.2 A single carbohydrate-recognition domain of an MBL has low affinity for mannose, fucose, and *N*-acetylglucosamine (GlcNAc) residues. Therefore, its capacity to oligomerize is important because it increases the total binding strength, or avidity, of MBL.

2.3 **D.** Ficolins have a fibrinogen-like domain that provides them with a general specificity for oligosaccharides containing acetylated sugars. Ficolins can be synthetized by the liver, lungs, and blood cells. In contrast, mannose-binding lectins contain C-type lectin domains that recognize mannose, fucose, and *N*-acetylglucosamine (GlcNAc) residues and are synthesized only in the liver.

2.4 **MASP-1; MASP-2; C4; C2; C4b2a; C3.**

2.5 Despite the fact that the initiating C3 convertase is soluble, the membrane-attack complex can develop because part of the C3b produced by the alternative C3 convertase becomes membrane-bound, allowing the formation of a membrane-bound C3 and C5 convertase.

2.6 **CD59; DAF; alternative.** Paroxysmal nocturnal hemoglobinuria is caused by a somatic mutation in an enzyme that normally synthesizes glycophosphatidylinositol tails that are necessary for anchoring and expressing proteins such as CD59 and DAF at the cell surface. Failure to express these complement-regulatory proteins in red blood cells leaves them susceptible to lysis by the complement system, particularly by the alternative pathway given the baseline spontaneous cleavage of C3 that occurs.

2.7 **A, 2; B, 1; C, 3.** The classical complement pathway can be regulated at multiple steps, and malfunction of regulatory proteins can result in multiple pathologies. For example, the activation of C1 is controlled by the plasma serine protease C1INH, and deficiency in this regulatory protein leads to episodic activation of the complement system and can cause hereditary angioedema. The critical balance between regulation and activation can also be exemplified by heterozygous mutations in factor H, factor I, or MCP. The resulting haploinsufficiency tips the balance toward complement activation and leads to a predisposition to atypical hemolytic uremic syndrome. Dysfunction of membrane-bound regulatory proteins can also result in pathology. For example, mutations in the enzyme involved in the synthesis of the glycosylphosphatidylinositol (GPI) tail that anchors DAF (and CD59) to the membrane causes paroxysmal nocturnal hemoglobinuria.

2.8 **A.** Cryoglobulinemia or systemic lupus erythematosus patients have low C4 and C3 because these autoimmune diseases activate the classical pathway. In contrast, dense deposit disease and C3 glomerulonephritis activate the alternative pathway, which does not use C2 or C4 to form the C3 convertase; therefore, the levels of C2 and C4 are usually normal.

2.9 **False.** Mucins only prevent adherence of microorganisms to the cell surface; they do not directly display microbicidal activities.

2.10 *Neisseria meningitidis* produces (1) factor H-binding protein to recruit factor H and inactivate C3b, and (2) PorA to recruit C4b-binding protein (C4BP) and inactivate C4b. *Staphylococcus aureus* bears (1) protein A, which binds to the Fc regions of Ig and interferes with C2 recruitment; (2) staphylokinase, which cleaves immunoglobulins bound to the surface; and (3) staphylococcal complement inhibitor (SCIN) to inhibit the activity of the C3 convertase.

2.11 **False.** Neutrophils produce antimicrobial peptides constitutively and store them in granules, but release them only upon stimulation or activation. Paneth cells produce and secrete antimicrobial peptides constitutively.

2.12 All complement pathways lead to the formation of the C3 convertase, which cleaves C3 to form C3a and C3b. C3b formation leads to opsonization, MAC formation/lysis, and potentiation of antibody responses (when its breakdown product C3dg is formed). C3a causes local inflammation (cell recruitment).

2.13 **True.**

Chapter 3 Answers

3.1 **A, iii; B, iv; C, ii; D, v; E, i; F, vi.**

3.2 **A, iv; B, ii; C, i; D, vi; E, iii; F, v.**

3.3 **D.** During an inflammatory response, vascular permeability increases in order to allow influx of serum factors and extravasation of immune cells into the inflamed tissue.

3.4 Conventional dendritic cells are antigen-presenting cells that bridge the innate and adaptive immune systems by integrating danger signals via PRRs and translating them into co-stimulatory signals for adequate T-cell priming, while plasmacytoid dendritic cells are dedicated high-level type I interferon producers.

3.5 **A.**

3.6 **False.** As discussed in this chapter, certain ubiquitin lysine linkages (e.g., K63) activate cellular signaling rather than target substrates for proteasomal degradation.

3.7 **A, IL-1R; B, JAK, STATs; C, TLR-4.**

3.8 **True.**

3.9 **D.** The inflammasome is composed of NLRP3, ASC, and caspase 1 oligomers. Caspase 1 is responsible for processing pro-IL-1β into IL-1β. Caspase 8 is involved in the initiation of the extrinsic pathway of apoptosis.

3.10 **False.** NK cells do not have antigen receptors, and although KIRs bind MHC class I, they are not bona fide antigen receptors, because of their broad reactivity to various MHC class I alleles.

3.11 **A, ii; B, v; C, iii; D, i; E, iv.**

3.12 B7.1 (CD80) and B7.2 (CD86) are expressed on macrophages and dendritic cells upon pathogen recognition via PRRs in order to ligate CD28 on T cells and provide a co-stimulatory signal.

Chapter 4 Answers

4.1 **False.** An antibody proteolytically cleaved by papain yields a fragment with *lower* avidity to the cognate antigen than an antibody cleaved with pepsin because it yields a single monomeric Fab fragment, while pepsin digestion will yield an $F(ab')_2$ dimer, which will have higher avidity.

4.2 CD4 and CD8 co-receptor binding to MHC is important for TCR signaling because CD4 and CD8 bind Lck on their cytoplasmic tails and brings the kinase into proximity with the T-cell receptor complex and helps to activate the signaling cascade induced by the T-cell receptor after antigen recognition.

4.3 It is advantageous to have heterozygosity of the MHC locus because having different alleles increases the diversity of the set of peptides that can be presented by each allele for a specific pathogen, thus increasing the chance of efficiently targeting a pathogen-derived epitope.

4.4 **A, i; B, iv; C, iii; D, ii.**

4.5 heavy, light, V (variable), C (constant), heavy chain only IgGs (hcIgGs), immunoglobulin new antigen receptor (IgNAR)

4.6 **A.** TCRα-chain recombination deletes the TCRδ-chain locus, thus eliminating the possibility of co-expression of an αβ and a γδ TCR during T-cell development.

4.7 **D.**

4.8 **E.**