

SOLUTIONS

11.1: The immune system

1. **B**
The toxin is injected to stimulate B-lymphocyte mitosis. However, antibodies are not collected directly; instead, B-cells from the spleen are fused with myeloma cells. Hybridoma cells produce identical antibodies, not a variety.
2. **A**
Passive immunity provides pre-made antibodies, but since the body does not produce memory cells, these antibodies degrade quickly, leading to short-term protection.
3. **B**
During a secondary immune response, memory B cells rapidly divide to form plasma cells, which produce large quantities of antibodies for a faster and stronger immune response.
4. **A**
T-lymphocytes assist phagocytosis by activating immune responses, while B-lymphocytes produce and secrete antibodies to neutralize pathogens.
5. **A**
The correct sequence is $Q \rightarrow S \rightarrow P \rightarrow R$. First, T-helper cells interact with macrophages (Q), then activate other lymphocytes (S). B-lymphocytes divide by mitosis (P) before plasma cells secrete antibodies (R).
6. **B**
In a primary immune response, macrophages present antigens to T-helper cells, which release cytokines. This stimulates the differentiation of lymphocytes, including B-lymphocytes that produce antibodies.
7. **B**
The electron micrograph shows extensive rough endoplasmic reticulum, indicating that the cell is actively synthesizing a large quantity of proteins, which are often necessary for cell functions like immune responses.
8. **A**
Mitosis is important in the immune response as it allows B-lymphocytes to proliferate and differentiate into plasma cells, which produce antibodies essential for fighting infections.
9. **B**
The correct sequence begins with phagocytosis (2), antigen presentation (4), activation of T-helper cells (3), activation of B-cells (1), and finally antibody release (5).
10. **B**
Activated T-lymphocytes (1) undergo mitosis (5), then T-killer cells bind to antigens on donor kidney cells (3). Finally, T-killer cells release toxins that destroy the donor kidney cells (4), completing the immune response that leads to rejection.
11. **A**
B-lymphocytes undergo mitosis (1), bind to antigens (2), produce memory cells (3), and secrete antibodies (4) as part of the immune response to pathogens.
12. **D**
Phagocytes recognize pathogens (2) and secrete enzymes (4) to destroy them. They do not undergo mitosis for memory cell production, which is a function of lymphocytes.
13. **D**
T-killer cells, unlike macrophages, neutrophils, and generic phagocytes, do not perform phagocytosis (the engulfing and digesting of particles); instead, they are part of the adaptive immune system and kill infected cells by binding to them and inducing apoptosis.
14. **C**
Phagocytes are immune cells that engulf and digest pathogens and debris. Their mode of action includes:
 1. Receptor binding: Phagocytes have receptors on their surface that can recognize and bind to particles such as bacteria or damaged cells.
 2. Endocytosis: After binding, the phagocyte engulfs the particle in a process called endocytosis, forming a phagosome.

3. Hydrolysis: The phagosome then fuses with lysosomes, and hydrolytic enzymes break down the engulfed material.
4. Exocytosis: The digested material is expelled from the cell via exocytosis.
15. **A**
The primary and secondary immune responses differ in speed and intensity due to the number of specific B-lymphocytes and memory cells available to respond to the antigen.
16. **C**
B-lymphocytes and T-lymphocytes produce memory cells for future response to an antigen, a key aspect of the adaptive immune system.
17. **D**
Statement 1 is incorrect as antibody injections provide artificial passive immunity. Statement 2 is correct as the antibodies will be broken down eventually. Statement 3 is incorrect as the memory cells will not be produced since antibodies do not initiate a proper immune response. Statement 4 is correct as the protection provided by antibodies lasts for a short period of time. Hence, option D is the correct answer.
18. **D**
Option D is the correct answer as since AB blood does not have antibodies for any antigens all blood groups can donate blood to people with the blood group AB.
19. **D**
Option D is the correct answer as cytokines influence the division of B lymphocytes and T killer cells.
20. **B**
Option B is the correct answer as memory cells recognize the antigens and immediately start to proliferate rapidly into more memory cells and plasma cells that secrete antibodies providing a much faster secondary immune response.
21. **B**
T-lymphocytes can leave the blood and accumulate at sites of inflammation, where they help mediate immune responses. They are not restricted to the blood and play roles beyond just secreting cytokines. Hence, B is the correct answer.
22. **A**
Option A is the correct answer as myasthenia gravis is caused by antibodies blocking receptor molecules on the cell surface receptors of the muscle cells resulting in weakness.
23. **D**
Option D is the correct answer as some B and T lymphocytes develop into memory cells for a faster immune response. Plasma cells secrete antibodies and T lymphocytes secrete cytokines that stimulate macrophages to kill infected cells. Each B lymphocyte can only make one specific type of antibody molecule.
24. **A**
T-lymphocytes are responsible for the production of cytokines, which regulate immune responses, the production of toxins (such as cytotoxins from cytotoxic T cells), and the recognition of antigens bound to antigen-presenting cells. All the functions are correct, making A the right answer.
25. **B**
Option B is the correct answer as memory cells divide to produce more memory cells as plasma cells when the pathogen enter the body a second time. This ensures a fast response so the person does not become ill again. They remain in the blood and lymphatic system after the pathogen has been destroyed for a long time. Memory cells do not produce antibodies plasma cells do.
26. **A**
Option A is the correct answer as E is a B memory cell as it then differentiates into a plasma cell upon receiving signals. F is a T helper cell that causes B memory cells to proliferate and differentiate. G is a T killer cells as it attached to virus infected cell to kill it. H is a plasma cell since they are the only ones that can secrete antibodies.
27. **A**
Option A is the correct answer as neutrophils can change their shape and B lymphocytes are activated only after coming into contact with antigens. Option B is incorrect as macrophages are found in organs not neutrophils. Option C is incorrect as neutrophils are short lived cells. Option D is incorrect as T helped cells secrete cytokines.

28. **A**
Option A is the correct answer as myasthenia gravis is an autoimmune condition where the body's own antibodies attack the nervous system so in order to suppress the immune system the antibodies are removed from the blood.
29. **C**
Option C is the correct answer as in the secondary response the memory cells divide to produce more memory cells and differentiate into plasma cells that secrete antibodies.
30. **A**
Option A is the correct answer as white blood cells are present in the bone marrow, lymph and macrophages can be found in the lungs.
31. **B**
Option B is the correct answer as in myasthenia gravis the action of the antibodies prevents continuous stimulation of muscles due to shortage of acetylcholine.
32. **A**
Option A is the correct answer as during an immune response antibodies are found in the blood plasma only and on the surface of the pathogens.
33. **D**
Option D is the correct answer as B lymphocytes are processed in the bone marrow and they do not release antibodies immediately after formation as they have to mature first.
34. **A**
Option A is the correct answer as this person has active immunity since ten years after vaccination all of the aforementioned values will decrease but memory cells will still remain in order to initiate a secondary immune response as soon as the virus enters the body again.
35. **C**
Option C is the correct answer as in an autoimmune condition the helper T lymphocytes will contain telomerase since they are the ones that will be rapidly dividing in order to initiate the immune response against the body's own cells. Neutrophils and B lymphocyte memory cells are not involved in an autoimmune response.
36. **D**
Option D shows the correct sequence as the mammal is first injected with antigens in order to initiate an immune response. The B lymphocytes are harvested from the spleen and fused with cancer cells not uncontrolled division. These cells are then tested for the wanted antibody and once confirmed the cells are allowed to divide to obtain a large scale culture.
37. **C**
Option C is the correct answer as phagocytosis is the first line of defense that initiates the secondary immune response when antigens are displayed by the phagocytes. Production of antibodies and memory cells are specific responses as they are initiated only when the B lymphocytes come into contact with the specific antigens.
38. **D**
Option D is the correct answer as the natural passive immunity from the mother's breast milk decreases and the active natural immunity of the baby increases as the antibodies made by it increases.
39. **B**
Option B is the correct answer as in leukemia excessive white blood cells are secreted by the bone marrow and most of these white blood cells are defective and do not function properly.
40. **B**
Option B is the correct answer as during an immune response antibodies are found on the surface of the pathogens in order to initiate further immune responses and not on the surface of memory cells.
41. **B**
Option B is the correct answer as macrophages display antigens on their surface and antigens are not found on their own in the plasma they are found on cells or pathogens.
42. **B**
Option B is the correct answer as pathogens have antigens on their surface and antigens are not found on their own in the plasma they are found on cells or pathogens.
43. **C**
Option C is the correct answer as since a short amount of time has elapsed the plasma cells from the first contact are still in the bloodstream which means that on second exposure those cells immediately start the production of the antibodies.

44. **A**
Option A is the correct answer as antigens are found on the surface of antigen as well are displayed on the surface of macrophages.
45. **A**
Option A is the correct answer as since a short amount of time has elapsed the plasma cells from the first contact are still in the bloodstream which means that on second exposure those cells immediately start the production of the antibodies resulting in a greater amount of antibodies produced than the first exposure.
46. **B**
Option B is the correct answer as hybridomas are produced by fusing B lymphocytes with cancer cells.
47. **A**
Option A is the correct answer as antigens are found on the surface of antigen as well are displayed on the surface of macrophages but are not found on their own in the blood plasma.
48. **B**
Option B is the correct answer as SCID patients can be cured using stem cells that can differentiate into the T lymphocytes they require.
49. **C**
Option C is the correct answer as tumor cells and B lymphocytes are used in the production of monoclonal antibodies.
50. **B**
Option B is the correct answer as X and Y are the memory cells that form for both the helper and the killer T cells and Z is the plasma cells that form from the activated B lymphocytes to secrete antibodies.
51. **D**
Option D is the correct answer as first when the non-self antigens are recognized the mitosis of B lymphocytes takes place and some of them mature into plasma cells and then these cells secrete antibodies.
52. **C**
Option C is the correct answer as endocytosis is a part of phagocytosis in which materials are taken into a cell and then vesicles containing these material form in the cytoplasm. It is an active process not a passive one.
53. **A**
Option A is the correct answer as when a person receives a vaccination the appropriate lymphocytes are stimulated and as a result antibodies are produced that protect against future infections. This immunity is artificial active immunity.
54. **C**
Option C is the correct answer since the parasite are intracellular meaning they are inside the cells and as a result the lymphocytes cannot detect them since they cannot go inside the cells.
55. **D**
Option D is the correct answer as T and S are macrophage and neutrophil respectively while R is a lymphocyte.
56. **A**
Option A is the correct answer as both B and T lymphocytes have specific antigen receptors on the surface of their cell membranes and both divide via mitosis. Only B lymphocytes differentiate into plasma cells not T lymphocytes.
57. **A**
Option A is the correct answer as B lymphocytes bind to infected cells that are displaying the foreign antigens. This results in rapid mitosis and as a result memory cells are produced and plasma cells as well that secrete antibodies.
58. **B**
Option B is the correct answer T lymphocytes can leave the blood and accumulate at the site of inflammation where they can differentiate into either helper or killer T cells.
59. **D**
Since people with the group AB have no antibodies against any of the other blood groups they can accept blood from any individual. Hence, option D is the correct answer.
60. **A**
Option A is the correct answer as antigen-antibody binding results in agglutination of bacteria to reduce their spread. Option B is incorrect as there is increased susceptibility to phagocytosis. Options C and D are

incorrect as more helper T cells are activated and more plasma cells are produced when antigens bind to antigen receptors on the T and B lymphocytes.

61. **A**
Option A is the correct answer as most macrophages are found in organs such as lungs than the blood and they display antigens of the cells they engulf. They can engulf pathogens, dust particles and damaged cells.
62. **C**
Option C is the correct answer as passive natural immunity is a result of the antibodies being passed from the mother to the baby in the breast milk.
63. **C**
Option C is the correct answer as phagocytosis is a non-specific immune response. Options A, B and D are incorrect as activation of T-lymphocytes, cloning of B-lymphocytes and antigen presenting are all specific immune responses.
64. **C**
Option C is the correct answer since the antigen Y is injected after a short period of time meaning it must be one of the second curves. Since this antigen was not introduced previously the antibody concentration produced would be low. Option C fits this assessment.
65. **A**
Option A is the correct answer as B lymphocytes secrete antibodies and provide humoral immunity while T lymphocytes secrete cytokines.
66. **B**
Option B is the correct answer as neutrophils can leave blood and accumulate at sites of inflammation to fight infection. Options A and C are incorrect as neutrophils cannot secrete cytokines. Option D is incorrect as macrophages represent antigens not neutrophils.
67. **A**
Option A is the correct answer as an injection of antibodies provides artificial passive immunity since the antibodies are injected into the person and not made by the body by exposing lymphocytes to antigens.
68. **D**
Option D is the correct answer as stimulation of lymphocytes by antigens of the invading pathogens causes them to activate and this is a natural response that leads to the production of memory cells and plasma cells that secrete antibodies making this type of immunity active.
69. **A**
Vaccinating the mother against the disease results in the baby receiving antibodies from the mother and this provides natural passive immunity as the baby receives them via the umbilical cord and receives antibodies making it passive.
70. **A**
Option A is the correct answer as macrophages are mainly found in tissues of organs and they can secrete cytokines in response to an infection.
71. **B**
Option B is the correct answer as B lymphocytes after coming into contact with an antigen divide rapidly to produce memory cells and plasma cells that secrete antibodies.
72. **B**
The production of antibodies in response to a vaccination is an example of artificial active immunity making option B the correct answer.
73. **D**
If the people require immediate immunity they are injected directly with antibodies which provide artificial passive immunity making option D the correct answer.
74. **B**
Option B is the correct answer as B and T lymphocytes become into memory cells in an immune response. Phagocytes do not become memory cells.
75. **A**
Option A is the correct answer as both B lymphocytes and companion cells have proteins in their cell membranes. Option B is incorrect as companion cells also have a nucleus. Option C is incorrect as companion cells do not contain chloroplasts. Option D is also incorrect as companion cells have plasmodesmata.

76. **C**
Option C is the correct answer as the B lymphocytes and goblet cells will both be more active as the dust particles may contain pathogens with them causing the B lymphocytes to be active and goblet cells produce mucus to remove the particles.
77. **B**
Option B is the correct answer as colostrum is found in breast milk and it provides natural passive immunity due to the antibodies present in it.
78. **A**
Option A is the correct answer as when a person is injected with dead bacteria the B lymphocytes bind to the antigens and begin the production of antibodies and memory cells in case live bacteria invade next time.
79. **B**
Option B is the correct answer as these stem cells divide in the bone marrow.
80. **B**
Option B is the correct answer as the production of antibodies is a specific immune response only. Release of histamine or phagocytosis are all non-specific immune responses.

11.2: Antibodies and vaccination

1. **A**
Antibodies contain hydrogen bonds (1), peptide bonds (2), and disulfide bonds (3), which stabilize their specific 3D structure.
2. **D**
The influenza virus mutates frequently, altering its surface antigens. This prevents the immune system from recognizing it, necessitating the development of a new vaccine each year to match the new strains.
3. **D**
The antigen-binding sites in antibodies have variable amino acid sequences, allowing them to bind specifically to different antigens. This variability enables the immune system to recognize a wide range of pathogens.
4. **B**
In monoclonal antibody production, B-lymphocytes (X) are fused with cancer cells to form hybridoma cells, which can produce large quantities of specific antibodies.
5. **D**
In monoclonal antibody production, a B-lymphocyte is fused with a myeloma cell to form a hybridoma. This hybridoma cell is capable of both producing specific antibodies and dividing indefinitely.
6. **A**
Influenza can occur more than once due to mutations in viral antigens (statement 1), a weak immune system producing fewer memory cells (statement 2), and untreated HIV lowering T-helper cells (statement 3).
7. **A**
Vaccines provide artificial active immunity by stimulating the body to produce antibodies against measles, which decreases the number of cases. Passive immunity is not provided by vaccines, and the reduction in hosts is due to increased immunity.
8. **C**
Monoclonal antibodies are effective because they are specific to a particular antigen (2) and can be modified to prevent them from acting as antigens themselves (3). They do not divide by mitosis (1).
9. **C**
Monoclonal antibodies are not used for active immunity (1 incorrect), but they are used in treating viral infections (2 correct) and as diagnostic tools (3 correct).
10. **B**
Vaccination reduces the number of infected individuals, thereby lowering the chances of unvaccinated individuals meeting someone who is infected, thus controlling the spread of the disease.
11. **B**
The V region of the antibody provides flexibility, allowing it to bind to two antigens simultaneously. This enhances its effectiveness in the immune response.

- 12. C**
The mRNA is translated by ribosomes (3) into a protein, which is displayed on the cell surface (4). This triggers lymphocytes to bind (1) and differentiate into memory cells (2).
- 13. B**
The factors that can affect the success of a vaccination programme are as follows:
frequent mutation of the pathogen: This factor can reduce the effectiveness of vaccines as the pathogen evolves and escapes immunity conferred by existing vaccines.
vaccination from eight weeks old: Starting vaccinations early can be important to provide immunity to diseases at a young age when susceptibility may be higher.
pathogen is able to invade T-cells: If the pathogen can evade the immune system by invading T-cells, it can be more challenging to achieve immunity through vaccination.
booster vaccinations needed frequently: Some vaccines require booster shots at regular intervals to maintain immunity over time. Frequent boosters may be necessary for certain diseases.
So, the correct row is: frequent mutation of the pathogen – pathogen is able to invade T-cells-booster vaccinations needed frequently.
- 14. C**
Natural active immunity develops through exposure to pathogens, such as in repeated malaria infections, leading to the formation of memory cells and a more effective immune response in subsequent exposures.
- 15. C**
To produce monoclonal antibodies using the hybridoma method, what is removed from the spleen of a mouse are:
C) lymphocytes
In the hybridoma method, lymphocytes from the spleen (or other sources, such as the bone marrow) are fused with myeloma cells to create hybridoma cells, which can then produce monoclonal antibodies. This process combines the antigen-specific properties of the lymphocytes with the immortal, antibody-producing capabilities of myeloma cells.
- 16. A**
Vaccination leads to the production of specific antibodies against the pathogen, resulting in artificial active immunity. It also stimulates lymphocytes (B-cells and T-cells) to respond to future infections by the same pathogen.
- 17. B**
Antibodies are proteins with tertiary and quaternary structures stabilized by peptide hydrogen and disulfide bonds. Each antibody molecule has two antigen-binding sites provided by the variable regions of the two heavy and two light polypeptide chains.
- 18. D**
The production of monoclonal antibodies involves the fusion of B-lymphocytes (not T-lymphocytes) with myeloma cells to produce hybridoma cells, which can be selected for their ability to produce a specific antibody.
- 19. D**
Statement 1 is correct as lambrilizumab binds to receptors of the surface of skin cancer cells. Statement 2 is also correct as the binding of lambrilizumab with the cancer cells prevents them from inactivating T lymphocytes and this allows the body's own immune system to kill the cancer cells making statement 4 correct. Statement 3 is incorrect as lambrilizumab allows the immune system to respond it does not kill the cells on their own.
- 20. D**
Option D is the correct answer as a person with blood group B cannot receive blood from groups A or AB since they have antibodies against the A antigen. They can receive blood from only B and O groups.
- 21. D**
Option D is the correct answer as at birth a baby has natural passive immunity as a result of the breast milk it receives from the mother.
- 22. B**
Option B is the correct answer as in the hybridoma method the clones are grown to produce the monoclonal antibodies.
- 23. B**
Option A is incorrect as the antibodies will be produced but just after some time. Option C is incorrect as the antibody concentration will decrease as antibodies are temporary molecules. Option D is incorrect as no antibody peak will occur as person H still has a relatively large concentration of the antibodies. Hence,

option B is the correct answer as antibody production will peak after day 32 in person G as he/she acquires immunity from the infection.

24. **C**
Option C is the correct answer as in order to form monoclonal antibodies B lymphocyte plasma cells and cancer cells are fused together to form hybridomas.
25. **A**
Option A is the correct answer as antibodies are found on the surface of memory cells and are found circulating in the blood plasma.
26. **B**
Option B is the correct answer as the vaccine for measles is quite inefficient meaning that some children require the use of booster doses for the development of full immunity.
27. **A**
Option A is the correct answer as cancer cells have different antigens from normal body cells and since monoclonal cells are produced from hybridomas that contain cancer cells these antibodies can target the cancer cells.
28. **B**
Option A is incorrect as memory cells produced are against a specific pathogen not multiple. Options C and D are incorrect as anti-measles antibodies bind only to measles cells and T lymphocyte memory cells are also specific to a particular pathogen. Hence, option B is the correct answer as the memory cells produced plasma cells whose antibodies bound to pathogens that closely resembled measles antigens providing the children with immunity against these pathogens as well.
29. **C**
Option C is the correct answer as the person can develop actively acquired immunity if infected by any pathogen such as the TB bacteria or being artificially being injected with antigens of the bacteria. Drinking breast milk or antibody injections provide passive immunity.
30. **C**
Option C is the correct answer as HCG injected into the mouse results in an immune response that causes the production of antibodies that can be used or single hybridoma cells are produced by fusing antibody producing plasma cells with cancer cells and their antibodies are harvested.
31. **D**
Option B is the correct answer as myeloma cells are cancerous plasma cells and they are fused with spleen cells to form hybridomas as the cancerous nature of the myeloma cells allows the hybridomas to reproduce indefinitely.
32. **B**
Option B is the correct answer as the injection of antibodies provides artificial passive immunity.
33. **C**
Option C is the correct answer as the smallpox virus showed little antigenic variation which meant that the vaccine was effective against it but not against TB since it shows considerable antigenic variation that makes the production of new vaccines necessary.
34. **B**
Option B is the correct sequence as first B lymphocytes differentiate into plasma cells after recognizing antigens. These plasma cells are removed from the spleen of the mammal and fused with cancer cells to form hybridomas. These hybridomas then divide via mitosis and secrete antibodies.
35. **D**
Statement 1 is incorrect as the constant regions do not bind the variable regions do. Statement 2 is incorrect as the viruses would be inside the cells and the phagocytes would be unable to detect them. Statement 3 is correct as the variable region binds to the same part of the virus antigens forming the antigen-antibody complex. Hence, option D is the correct answer.
36. **C**
Option C is the correct answer as injection with antitoxin provides artificial passive immunity.
37. **B**
Option B is the correct answer as inhaling the chicken pox virus would initiate an immune response that would result in the production of plasma cells that secrete specific antibodies for the virus making it natural active immunity.

38. **A**
Option A is the correct answer as the smallpox antigens remained stable mostly while the plasmodium antigens change and the cholera vaccines provide short term immunity. Vaccines work against bacteria as well.
39. **B**
Option B is the correct answer as the ability to bind to tumor associated regions is important in the treatment of cancer and the ability to deliver drugs to specific regions in order to prevent a side effects. Distinguishing between pathogens is not important as the antibodies are working against cancer cells.
40. **A**
Option A is the correct answer as the smallpox virus was stable and the antigens did not change whereas the antigens of the measles virus did change. Malaria has animals in its transmission cycle making the cycle harder to break. The vaccine for measles requires a booster does due to the poor immune response making it harder to eradicate.
41. **A**
Option A is the correct answer as all the statements are correct.
42. **C**
Option C is the correct answer as the smallpox virus was stable and not prone to mutations that caused the antigens to change. This meant that the same vaccine could be used for treatment that resulted in its eradication.
43. **B**
Option A is incorrect as immunity was achieved within 10 days as the antibody concentration increased in the body. Option C is incorrect as T helper lymphocytes were activated on day 5 that caused the antibody concentration to surge. Option D is incorrect as the second exposure occurred on day 21 as that is when the antibody concentration surged. Hence, option B is the correct answer as after the first exposure the memory cells were present in the body within 20 days.
44. **C**
Option C is the correct answer as cancer cells and hybridoma cells are going uncontrolled division so they do contain telomerase while mature B lymphocytes do not divide and so they not contain telomerase.
45. **D**
Option D is the correct answer as the specific shape of the monoclonal antibodies allows them to bind to a specific antigen of a pathogen allowing for its identification.
46. **B**
Option C is the correct answer as cancer cells and hybridoma cells divide continuously and are involved in monoclonal antibody production. Mouse B lymphocyte plasma cells are also involved in monoclonal antibody production but they do not divide continuously.
47. **B**
Option B is the correct answer as IgG has two heavy chains. IgA has four binding sites for antigen molecules and IgM has 5 hinge regions due to five single antibody molecules congregated together.
48. **C**
Option C is the correct answer as the artificial aspect is the injection of the antigens which result in the natural response that it the lymphocytes that are activated but the antigens.
49. **A**
Option A is the correct answer as this disease is not contagious so it is non-infectious and it can be describes as a type of an autoimmune disease since antibodies are produced against self-antigens.
50. **D**
Option D is the correct answer as the T lymphocytes are suppressed so that they cannot release cytokines to initiate an immune response against the transplanted organ while still making sure that the immune system can fight diseases.
51. **D**
Option A is incorrect as antigen binding sites are on the heavy chains as well. Option B is incorrect as the hinge region provides flexibility for the same antigen binding in different positions. Option C is incorrect as antibodies do not have binding sites for receptors on phagocytes. Hence, option D is the correct answer as different antigens result in variable amino acid sequences.
52. **D**
Option D is the correct answer as 1 is natural passive, 2 is natural active and 3 is artificial active.

- 53. C**
Option C is the correct answer as variable regions are present at the ends of the heavy and the light chains. Since there are 2 of each that means that there are 4 variable regions.
- 54. B**
Option B is the correct answer as monoclonal antibodies could treat cancer by binding to proteins on cancer cells and triggering the immune system or blocking molecules that inhibit T cells so that killer cells can carry out lysis. They could also block cell signaling receptors involved in division to prevent the rapid division of cancer cells.
- 55. A**
Option A is the correct answer as memory cells are responsible for long term immunity and the delay is due to the fact that memory cells have not been produced from the B lymphocytes yet.
- 56. B**
Option B is the correct answer as the vaccine is extracted from the chicken egg meaning that it contains proteins that are native to chicken and not humans. This might result in the immune system recognizing them as non-self antigens and initiate an immune response against them.
- 57. D**
Option D is the correct answer as due to the presence of different strains containing different antigens the vaccine is not effective against all the strains.
- 58. A**
Option A is the correct answer as the vaccine contained antigens of smallpox causing the people who received the vaccine to acquire artificial active immunity.
- 59. A**
Option A is the correct answer as the ingestion of the pathogens by phagocytes is the first response of the immune system to unknown particles.
- 60. D**
Statement 1 is incorrect as the constant regions do not bind the variable regions do. Statement 2 is incorrect as the viruses would be inside the cells and the phagocytes would be unable to detect them. Statement 3 is correct as the variable region binds to the same part of the virus antigens forming the antigen-antibody complex. Hence, option D is the correct answer.
- 61. A**
Option A is the correct answer as antibodies are temporary and break after a short period which is why their level decreases following the primary response. The secondary response is more rapid due to the memory cells present from the primary response that activate to produce plasma cells for rapid antibody production. The secondary response lasts longer as memory B cells live longer than plasma cells.
- 62. C**
Option C is the correct answer as in artificial active immunity antigens of a pathogen are injected into a person which initiates an immune response from the body where self-antibodies attack the non-self antigens.
- 63. B**
Option A is incorrect as antibody donation is always passive immunity. Option C is incorrect as artificial active immunity provides a faster response since the person is injected with dead pathogens or their antigens only while in natural the pathogens have to be ingested by macrophages to initiate an immune response. Option D is incorrect as binding of antigens and their recognition occurs with artificial immunity as well. Hence, option B is the correct answer as artificial active immunity results in the production of memory cells while in natural passive immunity antibodies are involved which are short lived.
- 64. A**
Option A is the correct answer as T killer cells destroy infected cells and also differentiate into memory cells for a faster secondary response. T lymphocytes do not secrete antibodies B lymphocytes do.
- 65. B**
Option B is the correct answer as person G was injected with antibodies only with provide temporary protection and deteriorate after a short period of time. They provide artificial passive immunity while person H received artificial active immunity as the antigens in the vaccines resulted in the production of specific plasma cells that increased the number of antibodies.
- 66. C**
Option C is the correct answer as of the three fragments two are the heads of the antibody molecules that contain the variable region that can bind to antigens while the other fragment is just the heavy polypeptide chains.

11.3: Multiple topics

1. **D**
Monoclonal antibodies like trastuzumab bind specific receptors to block signals (2) and have stable antigen-binding sites complementary to cancer antigens (3); variable regions do not adapt to mutations (1 is incorrect).
2. **A**
AIDS reduces the effectiveness of the immune system, so memory cells, plasma cells, and antibodies are all produced less effectively.
3. **C**
Option C is the correct answer as cell type 1 are T helper cells since they release cytokines that stimulate other cells. Cell type 2 are the T killer cells that cause the lysis of virus infected cells. Cell type 3 represents the B lymphocytes since they produce antibodies that bind to a specific antigen. Cell type 4 represents macrophage that surround the foreign antigens and engulf them.
4. **D**
Option D is the correct answer as the T lymphocytes that circulate in the blood can gather at the graft site and upon recognizing non-self antigens they can initiate an immune response. Option A is incorrect as the graft is first rejected by T lymphocytes that activate B lymphocytes. Option B is incorrect as the T lymphocytes do not produce antibodies but they stimulate B lymphocytes to do so. Option C is incorrect as T lymphocytes do not release antibodies.
5. **B**
Option B is the correct answer as longer telomeres are found in those cells that divide rapidly and those are the bone marrow stem cells and activated memory B lymphocytes.
6. **A**
Option A is the correct answer as the monoclonal antibodies target the antibodies that bind to the ACh receptors to prevent them from blocking ACh binding to the muscle cells.
7. **D**
Option D is the correct answer as activated memory T lymphocytes have a divide rapidly without the loss of telomeres and hence contain telomerase.
8. **B**
Option B is the correct answer as in myasthenia gravis the immune system produces antibodies that attack the proteins in the central nervous system.
9. **D**
Option D is the correct answer as P are root cortical cells that contain mitochondria only whereas Q are leaf mesophyll cells that contain circular DNA from mitochondria and chloroplasts.
10. **A**
Option A is the correct answer since in natural passive immunity antibodies are passed to the baby which are broken down in a short period of time providing temporary immunity.
11. **B**
Option B is the correct answer as the cells that need to secrete telomerase are the ones that are dividing rapidly like stem cells and activated memory B lymphocytes.
12. **A**
Option A is the correct answer as Trastuzumab acts as a monoclonal antibody when it binds to the growth factor receptor and causes the cell to die by not dividing.
13. **C**
Option A is incorrect as stages in life cycle has no correlation with development of a vaccine. Option B is incorrect as the immune system recognizes the pathogens as non-self. Option D is incorrect as vaccines can be administered via an injection. Hence, option C is the correct answer as the parasites can only be attacked by the immune system when they are not in liver cells or red blood cells as the immune system cannot detect and take action against pathogens inside cells.
14. **D**
Option D is the correct answer as the mutated influenza virus has different antigens meaning that there will be no secondary immune response as the antigens would not be recognized by the memory cells.

15. **D**
Option D is the correct answer as injecting dead bacteria allow the individuals to develop artificial active immunity where memory cells are also formed so that it is highly unlikely that they person develops whooping cough later in their life as well.
16. **A**
Option A is the correct answer as the blood groups each have a unique antigen on the cell surface which is what this is. Region P contains amino acids with hydrophobic R groups while region Q contains amino acids with hydrophilic R groups in the cell's cytoplasm.
17. **B**
Option A is incorrect as memory cells produced are against a specific pathogen not multiple. Options C and D are incorrect as anti-measles antibodies bind only to measles cells and T lymphocyte memory cells are also specific to a particular pathogen. Hence, option B is the correct answer as the memory cells produced plasma cells whose antibodies bound to pathogens that closely resembled measles antigens providing the children with immunity against these pathogens as well.
18. **D**
Option D is the correct answer as glycolipids, glycoproteins and proteins all help the immune system in recognition of cells. Cholesterol regulates the fluidity of the membrane.
19. **C**
Option A is incorrect as the concentration of antibodies in H would increase. Option B is incorrect as G will produce antibodies a short time after the infection as the plasma cells are produced. Option D is incorrect as H would have a new antibody peak within a day due to memory cells. Hence, option C is the correct answer as G will have a peak in antibody production 12 days after as during this time the B lymphocytes recognize the antigen and start to produce memory cells and plasma cells.
20. **A**
Option A is the correct answer as the protease would be identified as a non-self molecules and an immune response will be initiated. Option B is incorrect as proteases are not involved in the nitrogen cycle. Option C is incorrect as non-competitive inhibition is permanent and cannot be reversed. Option D is incorrect as in condensation reactions it is possible that the joining of monomers produces something other than a water molecule.
21. **C**
Option C is the correct answer as sickle cell anemia is an inherited disorder for which is no vaccine available.

