ANATOMY & PHYSIOLOGY

MIT Science Olympiad Invitational

January 24, 2015

Instructions:

You will have 50 minutes to complete this test. Please write your answers on the answer sheet provided to. If you mark in this test, please either erase cleanly, or let the event supervisor know. Markings inside this booklet WILL NOT be graded!

All questions in Parts A and B are worth 2 points each. Part C questions have their point values indicated following the question.

Ties will be broken based on scores on the following questions (in order): 135, 98, 49, 133, 94

INTEGUMENTARY SYSTEM

Part A: Multiple Choice, etc.

1. The acid mantle is
    a. the slightly acidic layer of the epidermis which comprises a chemical barrier against substances in contact with the skin
    b. the secretions of the apocrine glands onto the scalp
    c. fluid that regulates diffusion from capillaries
    d. a very thin film on the skin secreted by sebaceous glands
    e. the decrease in pH resulting from foreign particles entering the dermis

2. Cathelicidins are
    a. proteins that prevent Strep A infection in wounded skin
    b. proteins that regulate the dryness of skin
    c. lipids that diffuse from the bloodstream into the hypodermis
    d. pigments which, in excess, cause freckles
    e. proteins that inhibit the uptake of lipids from the skin into the bloodstream

3. Melanin
    a. is present in sparse quantities on the soles of the feet
    b. is responsible for hair color
    c. protects the skin from harmful UV radiation
    d. is a precursor to carotene
    e. carries oxygen in the capillaries of the skin

4. Melanin is synthesized from the amino acid
    a. arginine
    b. tyrosine
    c. serine
    d. methionine
    e. glycine

5. Which of these about carotene is **false**?
    a. carotene is a yellow-orange pigment
    b. carotene is a precursor for vitamin A
    c. carotene is found in the stratum lucidum
    d. excess carotene in the skin causes carotenoderma
    e. all of the above are true

6. _____ are antigen-presenting immune cells found in all layers of the epidermis
    a. Ruffini cells
    b. Meissner's cells
    c. Merkel cells
    d. Langerhans cells
    e. Pacinian cells

For questions 7-15, determine which of thick or thin skin…

7. …is 6 mm thick
8. …covers most of the body and the eyelids
9. …is hairless
10. …lacks the stratum lucidum
11. …has numerous dermal papillae
12. …has epidermal ridges
13. …lacks sebaceous glands
14. …has fewer sweat glands
15. …has less densely packed sense receptors

For questions 16-19, consider the following list of characteristics:

a. Are most abundant in the epidermis
b. Are least abundant in the epidermis
c. Produce melanin
d. Protect and waterproof the skin
e. Contain keratin
f. Arise from the red bone marrow
g. Participate in immune responses
h. Are easily damaged by UV light
i. Function in the sensation of touch
j. Are found in the epidermis

Determine which of the above (if any—characteristics may be used more than once) apply to…

16. Keratinocytes
17. Melanocytes
18. Langerhans cells
19. Merkel cells

20. Fair-skinned people have more _____, which is a reddish-yellow type of melanin, while dark-skinned people have more_____, which is a brownish-black type of melanin.
    a. pheomelanin, eumelanin
    b. eumelanin, pheomelanin
    c. basomelanin, andemelanin
    d. andemelanin, basomelanin
    e. watermelanin, honeydewmelanin

21. Goose bumps occur when the _____ contract and pulls hair in the skin taut.
    a. tensor fasci
    b. arrector pili
    c. extensor pollicis
    d. anconeous muscle
    e. peroneous brevis

22. Sudoriferous glands produce_____. Sebaceous glands produce _____. Ceruminous glands produce _____.
    a. oil, sweat, earwax
    b. earwax, sweat, oil
    c. sweat, earwax, oil
    d. sweat, oil, earwax
    e. oil, earwax, sweat

23. The sensitivity of hair to movement results from sensory nerves in the _____ at the base of each hair follicle.
    a. root bulb
    b. root hair plexus
    c. root tendon
    d. root hair disk
    e. root venule

24. _____results from blocked and inflamed sebaceous ducts
    a. acne
    b. a mole
    c. melanoma
    d. ingrown hairs
    e. freckles

25. Which of these about keratinization is true?
    a. keratinization is the formation of hypodermic layers of cells filled with keratin
    b. keratinization occurs on all exposed skin surfaces except the anterior surfaces of the eyes
    c. keratinization is responsible for the reconstruction of wounded skin
    d. keratinization only occurs in thick skin
    e. keratinization begins in the dermis

26. A victim of a house fire is an adult male whose front torso and entire left leg is burned. Using the rule of 9's, the percentage of his total body surface area burned is roughly
    a. 9%
    b. 18%
    c. 27%
    d. 36%
    e. 45%

27. Insensible perspiration results from water from interstitial fluids penetrating across the _____ into the surface.
    a. stratum lucidum
    b. stratum basale
    c. stratum granulosum
    d. stratum spinosum
    e. stratum corneum

28. Which layer of the skin shapes fingerprints?
    a. stratum lucidum of the epidermis
    b. stratum corneum of the epidermis
    c. papillary layer of the dermis
    d. reticular layer of the dermis
    e. the hypodermis

29. Albinism is caused by
    a. the inability of melanocytes to produce melanin
    b. absence of melanocytes
    c. a mutation that causes melanin to appear white
    d. presence of albumin in the epidermis
    e. absence of the stratum granulosum

30. What is **not** one way in which moisturizers work?
    a. Humectants attract water from the dermis and binds it in the stratum corneum.
    b. Occlusive agents physically trap water, preventing epidermal water loss.
    c. Emollients smooth flaky skin cells to increase occlusivity.
    d. Antioxidants fight free radicles that can destroy collagen in the skin.
    e. All of the above are ways in which moisturizers work.

31. Lines of cleavage are established by the pattern of _____ bundles in the skin
    a. nerve
    b. collagen
    c. keratin
    d. tendon
    e. venule

32. _____ are extremely fine and unpigmented hairs that appear after roughly 3 months of embryonic development
    a. Club hairs
    b. Lanugo hairs
    c. Velus hairs
    d. Sebum
    e. Terminal hairs

33. _____ are the fine "peach fuzz" hairs located over much of the body surface
    a. Club hairs
    b. Lanugo
    c. Velus hairs
    d. Sebum
    e. Terminal hairs

34. _____ are heavy, more deeply pigmented hairs, like the hair on the head and eyelashes
    a. Club hairs
    b. Lanugo
    c. Velus hairs
    d. Sebum
    e. Terminal hairs

35. _____ are hairs at the end of its growth cycle, which are attached to an inactive follicle
    a. Club hairs
    b. Lanugo
    c. Velus hairs
    d. Sebum
    e. Terminal hairs

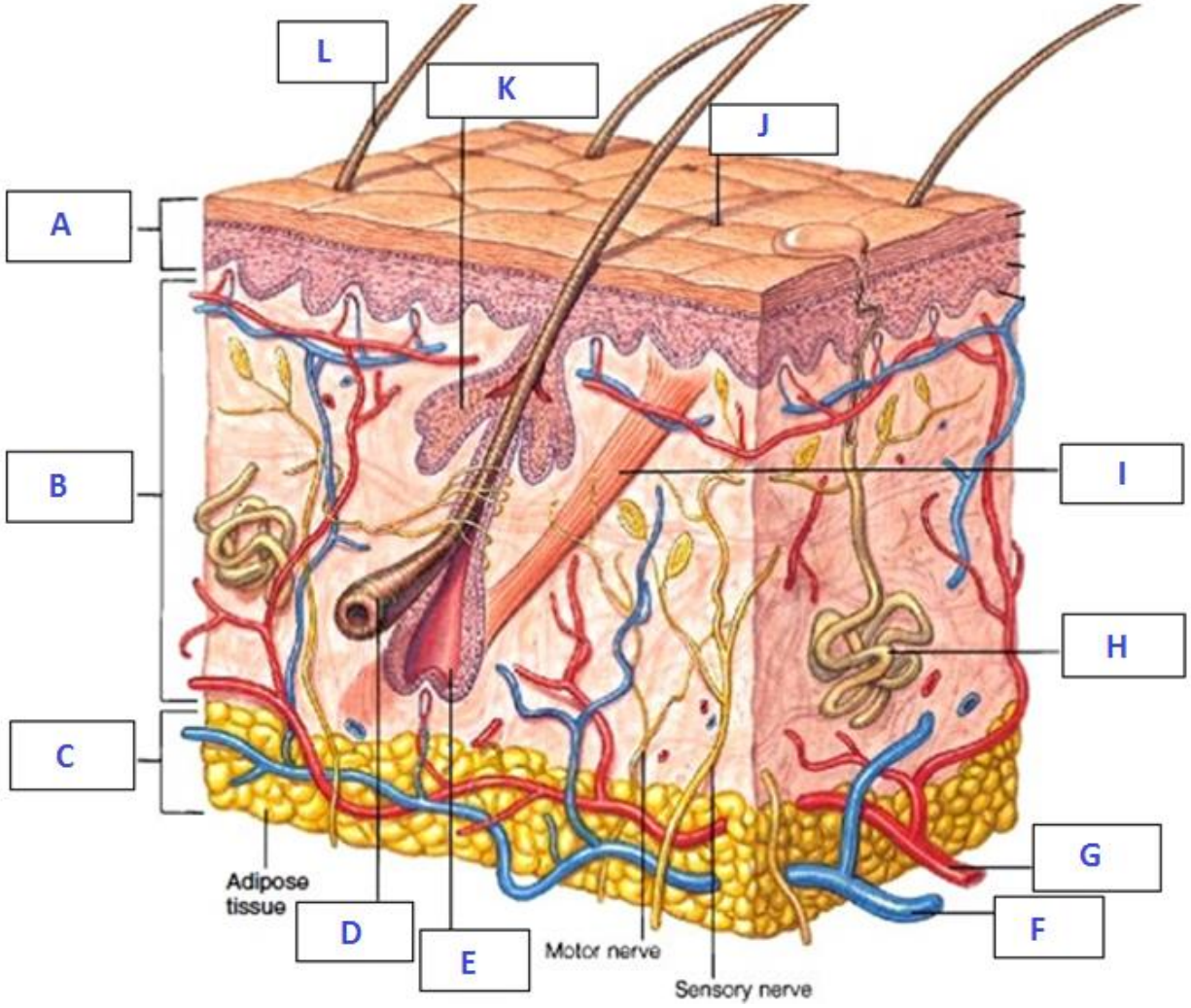
36. Excessive shampooing removes the_____. This exposes the _____, which causes hair to turn stiff and brittle.
    a. hair shaft, sebum
    b. sebum, keratin
    c. keratin, club hair
    d. sebum, follicle
    e. keratin, follicle

37. Which of these about sebaceous follicles is **false**?
    a. They are sebaceous glands associated with large terminal hair follicles.
    b. They are very active during the last few months of fetal development.
    c. Their secretions form a protective superficial layer called the vernix caseosa.
    d. They are mostly found on the face.
    e. All of the above are true.

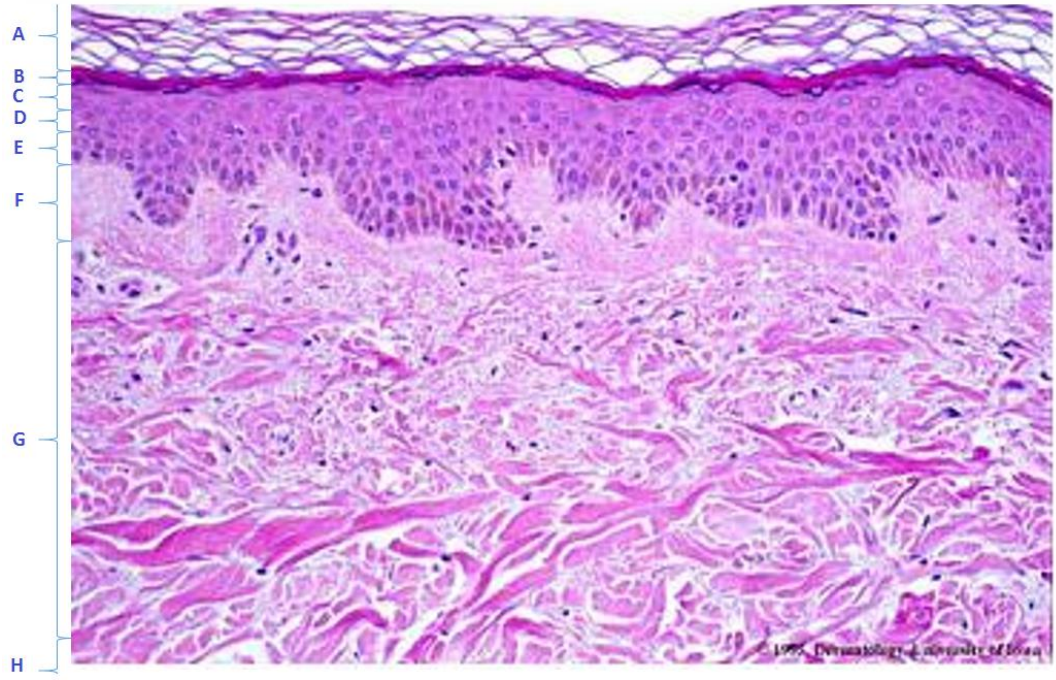
38. Keloids are
    a. moles that rise above the skin
    b. growths of papillary dermis that harden and penetrate into the epidermis
    c. patches of skin that are colored differently
    d. thickened areas of scar tissue that begin at an injury site and grow into the surrounding dermis.
    e. areas of burned hypodermis

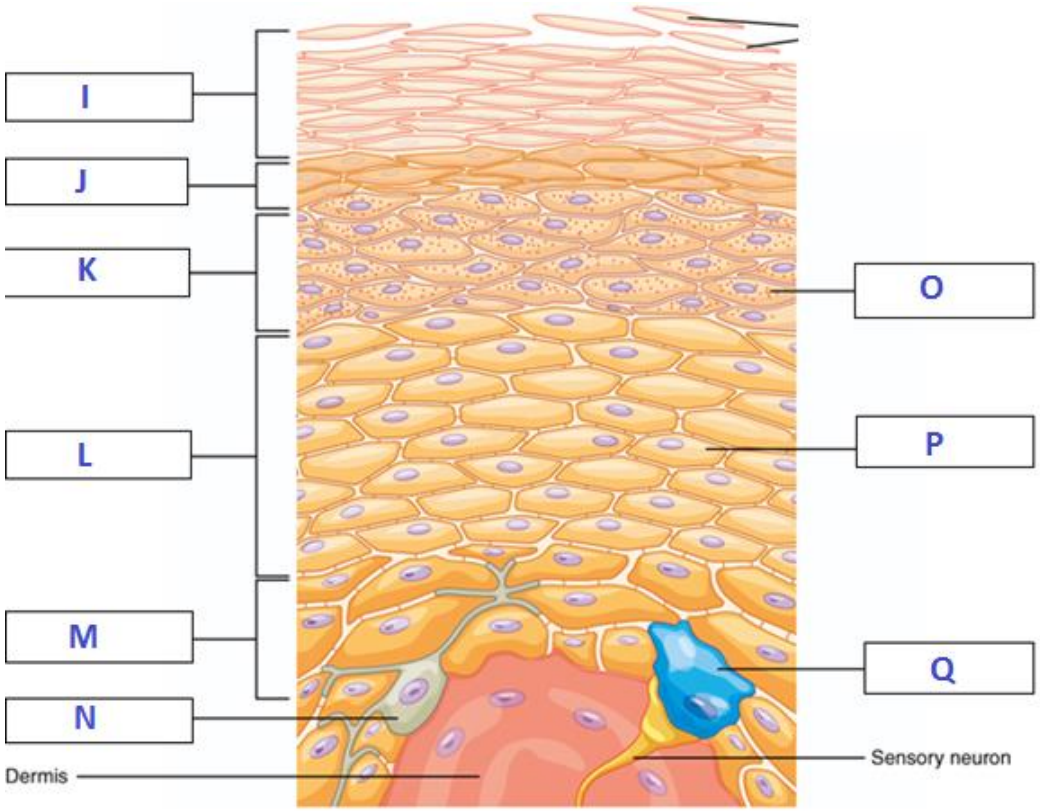
Part B: Diagrams

39. Label the following diagram of skin.

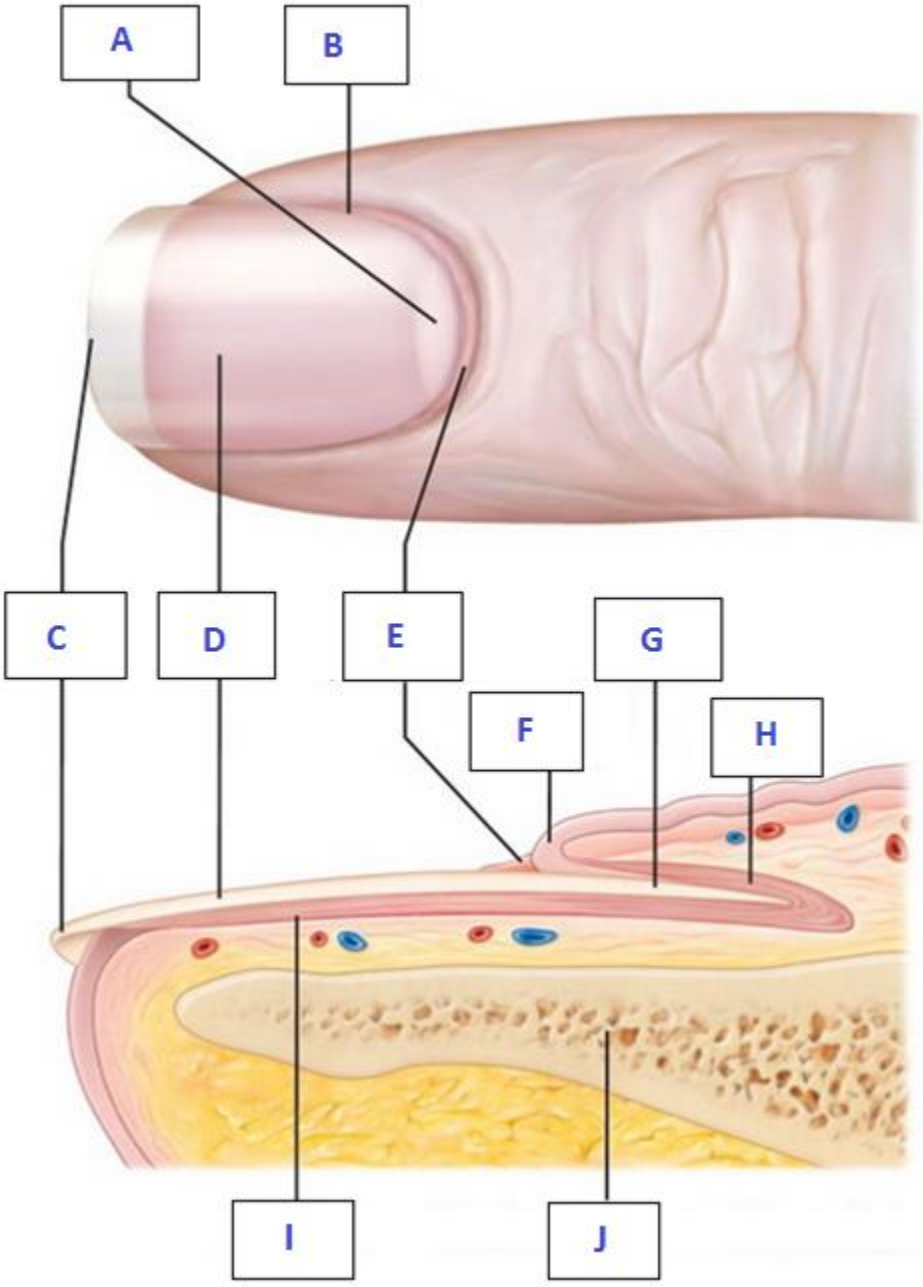


40. Label the following two diagrams of the layers of skin.





41. Label the following diagram of a nail.



Part C: Short Answer
Bullets accepted.

42. Describe two physical characteristics of skin that make it good at protecting the body. (6)

43. Describe the mechanisms by which skin regulates body temperature. (6)

44. Describe the growth cycle of the epidermis. (6)

45. Describe four factors that determine skin color. (8)

46. Why does prolonged exposure to the sun cause tanning? What biological purpose does this mechanism serve? (6)

47. List and describe four types of skin markings (12)

48. Describe five changes to the skin when we age. (10)

49. Describe four types of sensations the skin can register, the receptors associated with them, and where those receptors are located. (16)

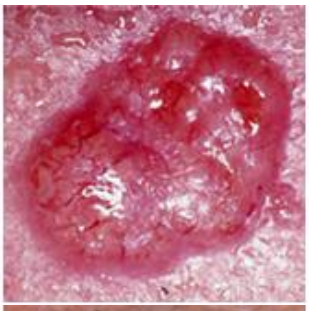
50. Identify the two types of sweat glands and describe their differences. (6)

51. List and describe the three stages of hair growth (9)

52. Compare and contrast the causes and symptoms of psoriasis and vitiligo. (6)

53. Identify the type of skin cancer shown in each picture. (6)

a.



b.

c.

54. Match the hair type with shaft shape. (6)

a.

b.

c.

IMMUNE SYSTEM

Part A: Multiple Choice, etc.

55. The functioning of the immune system hinges on its ability to distinguish between _____ molecules, components of an organism's body, and _____ molecules, or foreign substances.
    a. self, non-self
    b. antigens, antibodies
    c. innate, alien
    d. generator, displaced
    e. regular, irregular

56. Which is **not** considered a lymphatic organ?
    a. thymus
    b. spleen
    c. pituitary
    d. tonsils
    e. all of the above are considered lymphatic organs

57. Which of the following about lymph nodes is **false**?
    a. Lymph nodes are round structures found at points along lymphatic vessels that have a fibrous connective tissue capsule with incoming and outgoing vessels.
    b. Lymph nodes are filled with lymphocytes and macrophages.
    c. Lymph nodes can occur singly or in groups of nodules.
    d. Lymph nodes are typically 1-25 mm in diameter.
    e. All of the above are true.

58. Plasma cells are responsible for the production and secretion of
    a. antibodies
    b. antigens
    c. T cells
    d. lymphocytes
    e. cytokine

59. Which is **not** a type of lymphocyte?
    a. T cells
    b. B cells
    c. M cells
    d. NK cells
    e. All of the above are lymphocytes

60. What type of cells are primarily involved in cell-mediated immunity?
    a. plasma cells
    b. B cells
    c. NK cells
    d. M cells
    e. cytotoxic T cells

61. What type of cells are primarily involved in humoral immunity?
    a. plasma cells
    b. B cells
    c. NK cells
    d. M cells
    e. cytotoxic T cells

62. What type of cells are involved in immunological surveillance?
    a. plasma cells
    b. B cells
    c. NK cells
    d. M cells
    e. cytotoxic T cells

63. What type of cells are the precursors of plasma cells?
    a. stromal cells
    b. B cells
    c. NK cells
    d. M cells
    e. cytotoxic T cells

64. Bone marrow…
    a. is the site of T cell production
    b. is the site of antigen production
    c. is the site of erythropoiesis
    d. is the site of white pulp production
    e. is the site of MALT production

65. MALT can be found in all of these except
    a. Peyer's patches
    b. walls of the vermiform appendix
    c. aggregate lymphoid nodules
    d. trabeculae of the spleen
    e. MALT is found in all of the above locations

66. Without a spleen, a person will
    a. need to take antigen supplements
    b. survive without difficulty, but be more susceptible to viral infections
    c. survive without difficulty, but be more susceptible to bacterial and viral infections
    d. survive without difficulty, but be more susceptible to bacterial infections
    e. die of circulatory shock when exposed to foreign bacteria

67. After puberty, the thymus
    a. gradually diminishes in size and becomes increasingly fibrous
    b. gradually increases in size and becomes decreasingly fibrous
    c. gradually diminishes in size and becomes decreasingly fibrous
    d. gradually increases in size and becomes increasingly fibrous
    e. stays the same

68. Where is the largest collection of lymphoid tissue in the body?
    a. the thymus
    b. the tonsils
    c. the adenoid
    d. the spleen
    e. Peyer's patches

For questions 69-73, match the class of antibody to their descriptions.
    a. IgA
    b. IgD
    c. IgG
    d. IgE
    e. IgM

69. They provide the majority of antibody-based immunity against invading pathogens. They are the only antibodies capable of crossing the placenta.

70. They bind to allergens and trigger histamine release from mast cells and basophils. They are also involved in allergic reactions.

71. They mainly function as antigen receptors on B cells that have not been exposed to antigens.

72. Dimers containing two Y shaped structures. Found in mucosal areas, saliva, tears, and breast milk. They attack microbes and prevent colonization by pathogens before they reach the blood stream.

73. They are expressed on the surface of B cells and in a secreted form. They eliminate pathogens in the early stage of B cell mediated immunity.

74. Which of the following are **not** phagocytes?
    a. neutrophils
    b. eosinophils
    c. microphages
    d. macrophages
    e. All of the above are phagocytes

75. Kupffer cells
    a. contain microglia
    b. are macrophages located in and around the liver sinusoids
    c. are mobile and travel throughout the body
    d. are also known as phagocytic dust cells
    e. are types of neutrophils

76. Perforins are
    a. Proteins embedded in lymphatic capillaries that regulate diffusion
    b. Organic nitrogenous compounds involved in local immune responses
    c. Antigens produced by memory B cells
    d. Proteins produced in the Golgi apparatus of activated NK cells
    e. Chemicals in lymph fluid which attract and repel phagocytes in a process called chemotaxis

77. Histamines are
    a. Proteins embedded in lymphatic capillaries that regulate diffusion
    b. Organic nitrogenous compounds involved in local immune responses
    c. Antigens produced by memory B cells
    d. Proteins produced in the Golgi apparatus of activated NK cells
    e. Chemicals in lymph fluid which attract and repel phagocytes in a process called chemotaxis

78. Dendritic cells found in the skin are
    a. Langerhans cells
    b. Merkel cells
    c. Stromal cells
    d. Perforal cells
    e. Alpha-interferon cells

79. Which about interferons is **false**?
    a. They bind to surface receptors on the cell.
    b. They trigger the production of antiviral proteins.
    c. They are examples of cytokine.
    d. They form a functional unit called the membrane attack complex.
    e. All of the above are true

For questions 80-89, given the description of a disease, identify the disease. (Note: not all options will be used)

a. Lupus
b. Asthma
c. Addison's
d. HIV
e. Celiac disease
f. Multiple sclerosis
g. Type I diabetes
h. AIDS
i. Hashimoto's
j. Hypersensitivities
k. Allergies
l. Rheumatoid arthritis

80. An inflammatory disease thought to be caused by the immune system's destruction of myelin covers of nerve cells.

81. A reaction of the immune system triggered by relatively harmless environmental antigens that it would normally ignore

82. An obstructive pulmonary disorder characterized by recurring spasms of muscle in bronchial walls accompanied by edema and mucus production

83. With this condition, people are more susceptible to opportunistic infections and have a CD4* T cell count below 200 cells per microliter.

84. A lentivirus which infects vital cells in the human immune system, such as helper T cells, macrophages, and dendritic cells.

85. A disease resulting from the autoimmune destruction of beta cells in the pancreas.

86. A disorder in which the synovium becomes inflamed and develops fibrous tissue.

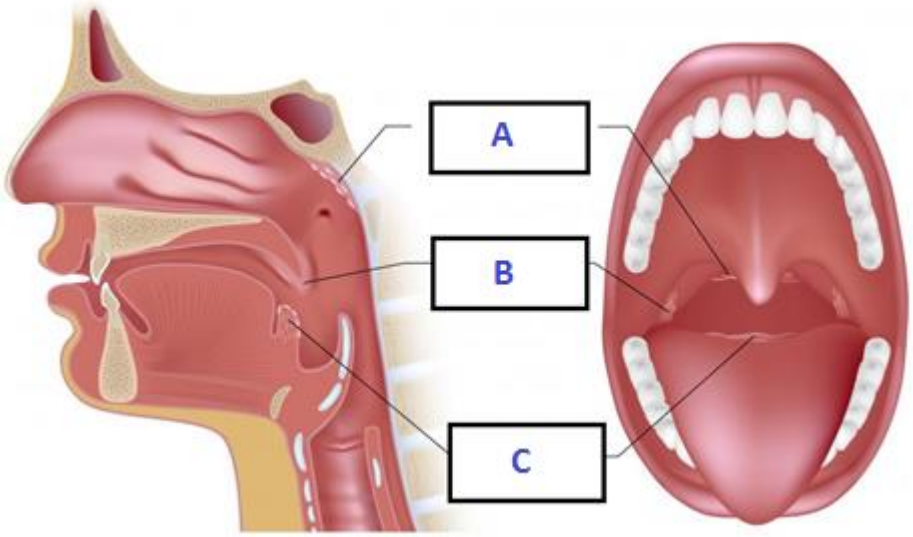
87. An autoimmune disease characterized by a butterfly rash on the face.

88. An autoimmune disorder in which the thyroid gland is attacked by a variety of immune processes.

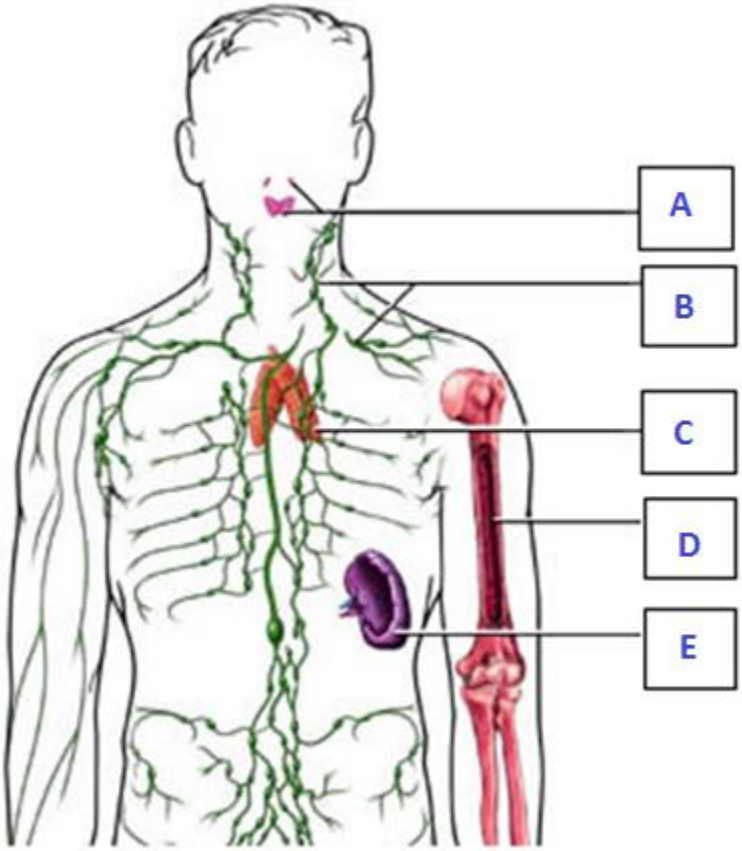
89. An autoimmune disorder of the small intestine caused by a reaction to gliadin, a gluten protein found in wheat.

Part B: Diagrams

90. Label the following diagram.



91. Label the following diagram of the major organs of the immune system.



Part C: Short Answer
Bullets accepted.

92. Describe two types of T cells and their role in the immune system. (6)

93. Describe two types of B cells and their role in the immune system. (6)

94. Describe the process of antigen presentation. (4)

95. What are nonspecific defenses? Describe two nonspecific defense mechanisms that the body employs. Which lines of defense are associated with nonspecific defenses? (8)

96. What are specific defenses? Describe two specific defense mechanisms that the body employs. Which lines of defense are associated with nonspecific defenses? (8)

97. A person is exposed to an unfamiliar antigen. A week later, the person is again exposed to the same antigen. What, if any, are the differences between the responses to the exposures? (4)

98. Define the four types of immunity and give an example of each by completing the following chart (reproduced on the answer sheet): (16)

	Active	Passive
Natural		
Artificial		

CARDIOVASCULAR SYSTEM

Part A: Multiple Choice, etc.

99. Estimate the length of blood vessels in an adult human.
    a. 6,000 miles
    b. 20,000 miles
    c. 60,000 miles
    d. 200,000 miles
    e. 600,000 miles

100. What does the cardiovascular system **not** move?
    a. red blood cells
    b. platelets
    c. white blood cells
    d. lymph
    e. the cardiovascular system moves all of the above

For questions 101-109, given a description, match it with the corresponding structure of the heart. (Each answer will only be used once.)

a. Right atrium
b. Left atrium
c. Right ventricle
d. Left ventricle
e. Aorta
f. Superior vena cava
g. Inferior vena cava
h. Pulmonary veins
i. Pulmonary arteries

101. It carries deoxygenated blood from the heart to the lungs.

102. It carries deoxygenated blood from the upper parts of the body back into the heart.

103. It's the largest artery and carries oxygenated blood from the heart to the body.

104. It carries deoxygenated blood from the lower parts of the body back into the heart.

105. It collects deoxygenated blood returning from the body and forces it through the tricuspid valve.

106. It collects deoxygenated blood and forces it into the lungs through the pulmonary valves.

107. It carries oxygenated blood from the lungs back to the heart.

108. It collects oxygenated blood returning form the lungs and forces it through the mitral valve.

109. It is the largest and strongest chamber in the heart, and pushes blood into the body.

110. A person has a blood pressure of 120/80 mmHg. What does the 120 mean?
    a. It is the systolic pressure, which measures the pressure in the arteries when the heart contracts
    b. It is the diastolic pressure, which measures the pressure in the arteries when the heart contracts
    c. It is the systolic pressure, which measures the pressure in the arteries between heartbeats
    d. It is the diastolic pressure, which measures the pressure in the arteries between heartbeats
    e. It is the upper bound on the blood pressure the body can withstand

111. A well-trained athlete may have a normal resting heart rate that is
    a. higher than average
    b. lower than average
    c. closer to the systolic heart rate
    d. higher than the systolic heart rate
    e. louder than average

112. The pulmonary circuit
    a. refers to the circulation of oxygenated blood
    b. refers to the circulation of blood from the heart to the rest of the body
    c. refers to the circulation of blood from the heart to the lungs
    d. refers to the circulation of blood in the capillaries
    e. refers to the circulation of blood within the heart

113. What does **not** affect the resistance of blood?
    a. viscosity of blood
    b. length of the blood vessel
    c. radius of the blood vessel
    d. temperature of blood
    e. all of the above affect the resistance of blood

For questions 114-118, indicate which of the following facts are true for the blood vessel indicated. (Letters may be used more than once or not at all.)

a. Are the largest vessels
b. Are the smallest vessels
c. Carry blood away from the heart
d. Carry blood towards the heart
e. Have valves
f. Have thick muscular walls
g. Have thin muscular walls
h. Have no muscle or connective tissue
i. Are the primary site of resistance to flow in the vascular system
j. Are the primary site of nutrient and waste exchange

114. Arteries
115. Arterioles
116. Capillaries
117. Venules
118. Veins

119. Which of the following about atherosclerosis is **false**?
    a. Atherosclerosis is the most common form of arteriosclerosis
    b. Atherosclerosis results from cholesterol, lipid, and calcium deposits in the walls of the arteries
    c. Atherosclerosis may be treated with stents or angioplasty
    d. Atherosclerosis causes coronary fibrillation
    e. All of the above are true

120. A patient with tachycardia has
    a. irregular and often rapid heartbeats
    b. a rapid resting heart rate, more than 100 beats per minute
    c. a slow resting heart rate, less than 60 beats per minute
    d. loss of living heart muscle as a result of coronary occlusion
    e. none of the above

121. A patient with bradycardia has
    a. irregular and often rapid heartbeats
    b. a rapid resting heart rate, more than 100 beats per minute
    c. a slow resting heart rate, less than 60 beats per minute
    d. loss of living heart muscle as a result of coronary occlusion
    e. none of the above

122. A patient with atrial fibrillation has
    a. irregular and often rapid heartbeats
    b. a rapid resting heart rate, more than 100 beats per minute
    c. a slow resting heart rate, less than 60 beats per minute
    d. loss of living heart muscle as a result of coronary occlusion
    e. none of the above

123. Which of these is **not** a common symptom of a stroke?
    a. Numbness or weakness in the face, arm, or leg, particularly on one side
    b. Confusion or trouble understanding
    c. Chest pain
    d. Severe headache
    e. All of these are symptoms of a stroke

124. What is the pulse pressure?
    a. The sum of the systolic and diastolic pressures
    b. The difference between the systolic and diastolic pressures
    c. The amount of pressure the heart exerts with one contraction
    d. The maximal arterial pressure
    e. The amount of force the blood pumped out by the heart has

125. How many human blood groups are officially recognized?
    a. 2
    b. 3
    c. 14
    d. 26
    e. 33

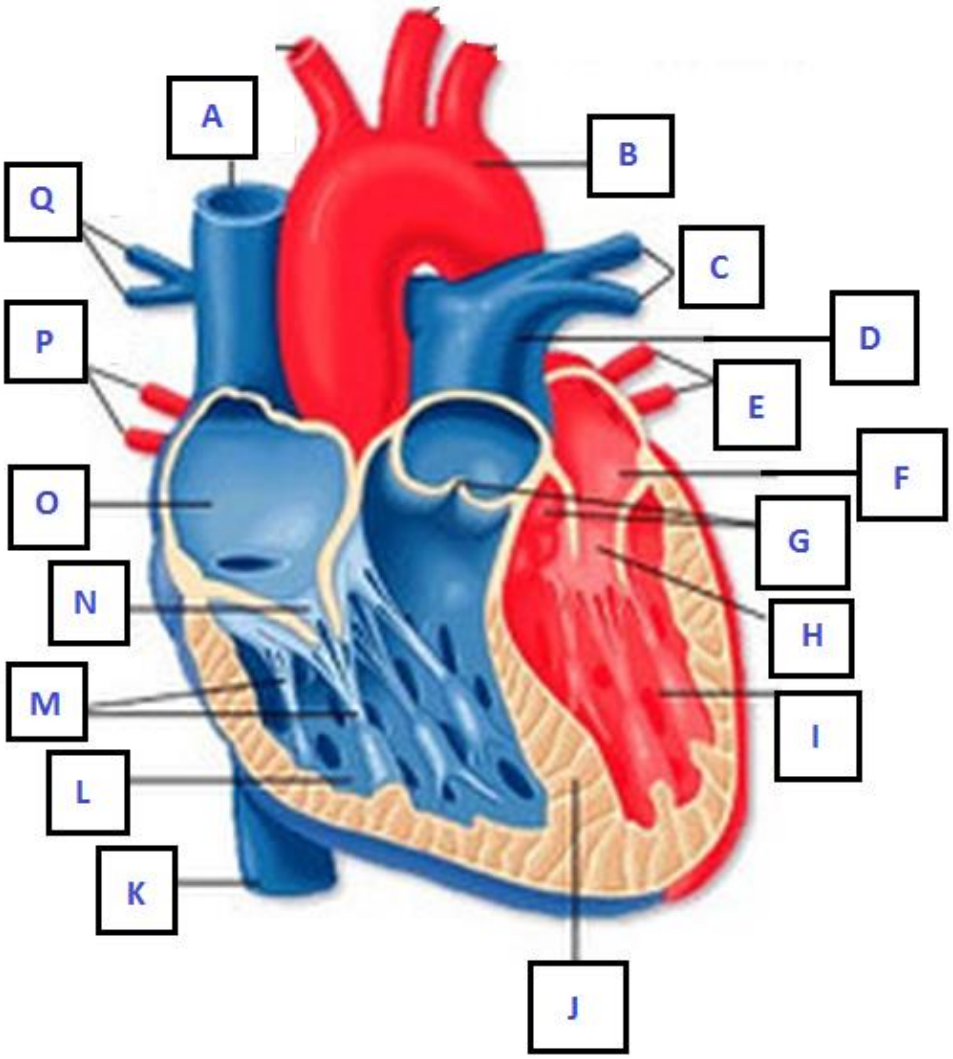
126. What blood types **cannot** receive blood from a type A+ donor?
    a. A+
    b. AB+
    c. O+
    d. All of the above can receive blood from a type A+ donor
    e. None of the above can receive blood from a type A+ donor

127. What blood types **cannot** donate blood to a type A+ receiver?
    a. A+
    b. AB+
    c. O+
    d. All of the above can donate blood to a type A+ receiver
    e. None of the above can donate blood to a type A+ receiver

128. If a mother has blood type A and a father has blood type AB, what **cannot** be the blood type of their child?
    a. A
    b. B
    c. AB
    d. O
    e. All of these blood types are possible

Part B: Diagrams

129. Label the following diagram of the heart.



Part C: Short Answer
Bullets accepted.

130. Describe how muscle cells of the heart coordinate to contract at the same time. Please include in your discussion the components of the electrical system of the heart. (16)

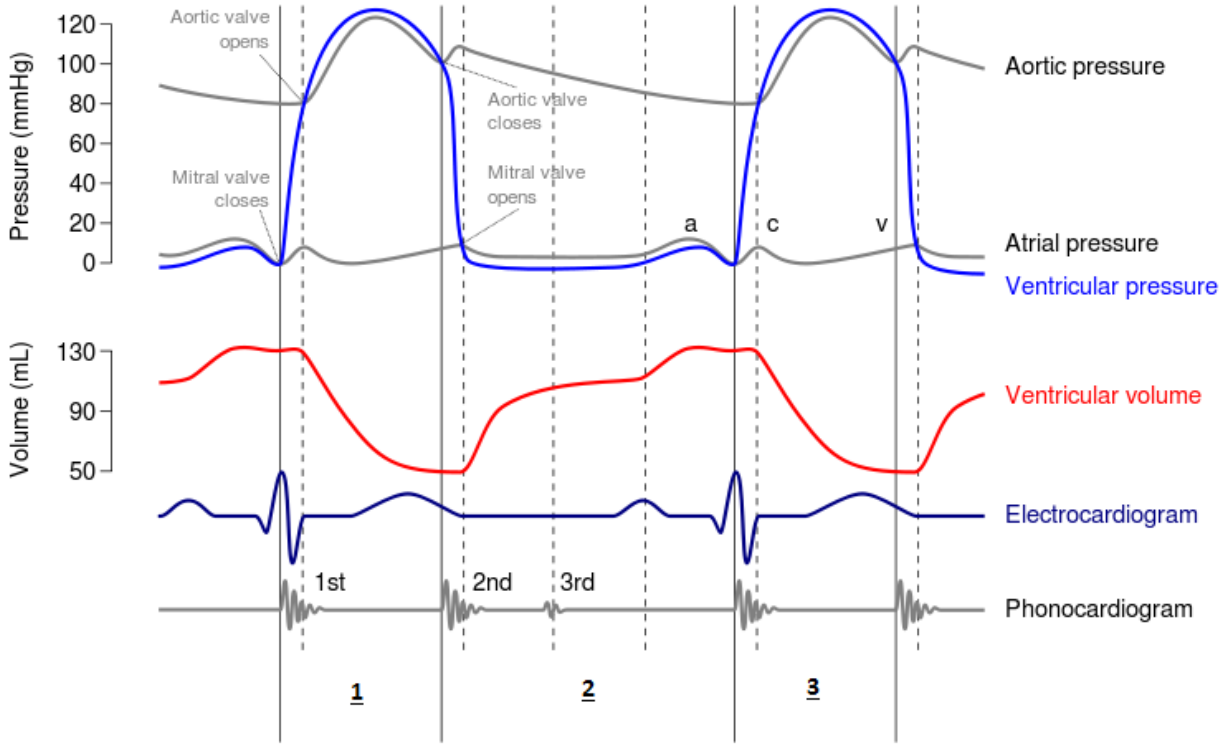
131. Describe the effects of epinephrine and vasopressin on the circulatory system. (8)

132. Name three benefits to the circulatory system as a result of exercise. (6)

133. Imagine you are holding your breath. Describe the changes to blood pH and heart rate and explain why these changes occur. (12)

134. How does a doctor determine your heart pressure using a stethoscope and a blood pressure cuff? (10)

135. Consider the following chart for a patient with heart rate of 72 BPM:



a. Estimate the stroke volume (show your reasoning) (4)

b. Calculate the cardiac output (show your reasoning) (4)

c. Calculate the pulse pressure (show your reasoning) (4)

d. Calculate the mean arterial pressure (show your reasoning) (4)

e. Which of the numbered intervals represents a systole? (2)

f. Which of the numbered intervals represents a diastole? (2)

g. Label the following diagram, an EKG of a single heartbeat (please ask if you are unsure what a particular label is referring to) (2 each):