Exam 2 – Zoology 250

Instructor: John Godwin, Fall 2005

Name (please print): KEY

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This exam has 7 pages, Please check that your copy is complete.

Terminology/Short answer - These questions require terms or brief answers. (14 questions + 2 bonus questions, 1 pt. each except where noted, 28 total pts plus two bonus pts)

1. Pick either the fish or bird respiratory system and explain the features that make it especially efficient. Make specific reference to each of the basic requirements of systems that exchange materials with the environment by diffusion and highlight the countercurrent exchange mechanism seen in fish gills and bird lungs and why specifically it is important. You may find it helpful to include a drawing or figure. (4 pts)

Fish: Distance – very thin epithelia, Area – large surface area to the gill, Gradients – pumping water over the gills and especially the countercurrent exchange mechanism that has water and blood flowing in opposite directions, preventing oxygen concentrations in the water and blood from coming into equilibrium.

Bird lung (quite similar): Distance – very thin epithelia, Area – large surface area to the lungs, Gradients – pumping air through the lungs and especially the countercurrent exchange mechanism that has air and blood flowing in opposite directions, preventing oxygen concentrations in the air and blood from coming into equilibrium.

2. Does exchange of gases take place across the epithelium of the air sacs in a bird? (1 pt) What experiment demonstrated that this either is or is not true? (1 pt, 2 pts total)

No, gas exchange does not take place in air sacs. This was demonstrated by injecting carbon monoxide (CO) into an air sac and monitoring the bird. Had the gas crossed into the circulation, the bird would have died. It did not, indicating the air sacs do not participate in gas exchange (solely a ‘bellows’ or pumping function instead).

3. Briefly, why is it important that the affinity of hemoglobin for oxygen is reduced as pH drops? (1 pt) What causes this drop in pH in a working muscle? (1 pt, 2 pts total for this question)

This increases the offloading of O₂ where it is needed most (i.e., in the working muscles). High CO₂ in working muscles leads to higher H⁺ (and HCO₃⁻) concentrations, reducing pH.
4. What basic physical feature of water makes respiratory pigments necessary for most animals? (1 pt) List one other physical feature of water that would make an insect-like respiratory system unsuitable for a crustacean. (1 pt, 2 pts total)

The solubility of O\textsubscript{2} in water is very low (i.e., water cannot hold much O\textsubscript{2}). Two possible features as well: i) Water is very dense and ii) diffusion is slow in water.

5. On the axes to the right here, illustrate the relationship between hemoglobin oxygen saturation and blood oxygen concentration in adult humans with a solid line and do the same for fetal humans with a dashed line. Note that both the approximate shape and the relative position of the fetal line relative to that for adults are important here. (1 pt each, 2 pts) What is the functional significance of the difference between the adult and fetal lines? (1 pt., 3 pts total)

The higher O\textsubscript{2} affinity of fetal hemoglobin facilitates the transfer of oxygen from the maternal circulation to the fetal circulation during development in the uterus.

6. What are ‘respiratory turbinates’? (1 pt) It appears that, despite being active predators, these structures were lacking in dinosaurs like the theropod Velociraptor. Briefly, what is the importance of this finding? (hint: what are these structures important for and what sorts of animals do we find them in? 1 pt, 2 pts total).

i) Respiratory turbinates: bony shelves covered with epithelium in the nasal passages.

ii) These are found in 99+% of endothermic animals (i.e., birds and mammals), so this suggests that Velociraptor specifically and dinosaurs more generally were not endotherms.

7. What does lysozyme do? If you wanted to find this enzyme, where in the body would you look? (1 pt each, 2 pts total)

a. breaks down bacterial cell walls
b. tears, mucus secretions

8. Your pet guinea pig seems sick. You take her temperature and find she has a fever. First, you lower the temperature in your apartment to see if that helps bring her temperature down. Will this work? (1 pt). You also have some medicine that would definitely bring the fever down. Is this a good idea? Why or why not? (1 pt) (2 pts total for this question)

• No, it will not work. She is regulating her temperature and it will remain high even if the environment cools.
• Fever is typically a defense mechanism, so suppressing it with drugs would likely prolong the infection.

9. List the four key features of specific immunity we talked about. (1/2 pt each, 2 pts total)

Specificity, Diversity, Memory, Self/Non-self recognition
10. Two different B cells taken from a person’s blood produce different antibodies, but have identical genomes. Making reference to the appropriate gene (1 pt), explain briefly how this is possible. (1 pt for explanation, 2 pts total)

**Immunoglobulin** genes (1 pt) have a variety of exons for the variable region of the molecule that can be used and these can be ‘mixed and matched’ to create an enormous diversity of different antibodies or receptors. (1 pt)

11. What two proteins does HIV have to bind to enter a cell during infection? (1/2 pt each)
CD4 and the CCR5 receptor (CD4 and CRXR5/fusin okay too, although these appear more important in the latter stages of infection)

12. Briefly, why is the decline in helper T cells seen in AIDS so crippling for the immune system?
Helper T cells play a critical role in stimulating other components of the immune system to respond to infections.

13. Briefly, why can the function of vertebrate kidneys be summarized as “indiscriminate filtration followed by selective reabsorption”?!
Vertebrates essentially force filter the blood, separating indiscriminately and only by size (i.e., water, ions, sugars, etc., but not blood cells or big proteins), and then **selectively** recover valuable materials (Na+, glucose, etc.) from the filtrate.

14. What kind of nephron is found in birds and mammals but **not** in other vertebrates?
Juxtamedullary nephron

**Bonus Questions (1 pt each)**

Can the bacterium *Escherichia coli* contribute to the body’s general defenses? Explain your answer (i.e., answering only yes/no will not be considered for credit).

Yes, *E. coli* can outcompete pathogenic organisms for resources (this forms the basis of the ‘competition’ general defense)

What is the main ‘job’ of IgE antibodies? (1 pt)
IgE antibodies respond to foreign antigens near the body surface, being primarily adapted to deal with invading worms we think.
Multiple Choice Section (25 questions, 1 pt each)

1. I am doing version __ of this exam:  A)  a,  B)  b

2. Air rushes into the lungs of humans during inhalation because
   a)  the rib muscles and diaphragm contract, increasing the lung volume.
   b)  pressure in the alveoli increases.
   c)  gas flows from a region of lower pressure to a region of higher pressure.
   d)  pulmonary muscles contract and pull on the outer surface of the lungs.
   e)  a positive respiratory pressure is created when the diaphragm relaxes.

3. Which of the following occurs with the exhalation of air from human lungs?
   a)  The volume of the thoracic cavity decreases.
   b)  The residual volume of the lungs decreases.
   c)  The diaphragm contracts.
   d)  The epiglottis closes.
   e)  The rib cage expands.

4. An oil-water mixture is used as a spray against mosquitoes. How might this spray also affect gas exchange in other insects?
   a)  The oil might coat their lungs.
   b)  The oil might block the openings into the tracheal system.
   c)  The oil might interfere with gas exchange across the capillaries.
   d)  Only A and B are correct.
   e)  A, B, and C are correct.

5. Which one of the following statements about gills operating in water is false?
   a)  Water can support the delicate gill features.
   b)  Most fish actively pump water over their gills.
   c)  Keeping membranes moist is no problem.
   d)  Water carries more oxygen than air, and therefore gills need to be more efficient than lungs.
   e)  Gills have evolved many times in aquatic animals.

6. Inflammatory responses may include all of the following except
   a)  clotting proteins sealing off a localized area.
   b)  increased activity of phagocytes in an inflamed area.
   c)  reduced permeability of blood vessels to conserve plasma.
   d)  release of substances to increase the blood supply to an inflamed area.

7. In the inflammatory response, the absence of which of the following would prevent all the others from happening?
   a)  dilation of arterioles
   b)  increased permeability of blood vessels
   c)  increased population of phagocytes in the area
   d)  release of histamine
   e)  leakage of plasma to the affected area
8. The clonal selection theory is an explanation for how
   a) a single type of stem cell can produce both red blood cells and white blood cells.
   b) V gene and J gene segments are rearranged.
   c) an antigen can provoke the replication of very few cells to result in production of high levels of specific antibodies.
   d) HIV can disrupt the immune system.
   e) macrophages can recognize specific T cells and B cells.

9. Which of the following cell types participate in the body’s general defenses against pathogens?
   a) Neutrophils
   b) Monocytes
   c) Eosinophils
   d) Natural killer cells
   e) All of the above

10. MHC II proteins are found on all cell types in the body.
    a) This statement is true
    b) This statement is false

11. The following events occur when a mammalian immune system first encounters a pathogen. Place them in correct sequence and then choose the answer that indicates that sequence.
    I. Pathogen is destroyed.
    II. Lymphocytes secrete antibodies.
    III. Antigenic determinants from pathogen bind to antigen receptors on lymphocytes.
    IV. Lymphocytes specific to antigenic determinants from pathogen become numerous.
    V. Only memory cells remain.

    A) I, III, II, IV, V
    B) III, II, I, V, IV
    C) II, I, IV, III, V
    D) IV, II, III, I, V
    E) III, IV, II, I, V

12. A patient can produce antibodies against pathogens, but he has trouble dealing with viral infections. This is probably due to a disorder in which cells of the immune system?
    a) B cells
    b) plasma cells
    c) natural killer cells
    d) T cells
    e) macrophages

13. Which statement about antibodies is false?
    a) Antibodies are immunoglobulin proteins.
    b) Antibodies bind with foreign cells and lyse them.
    c) The structure of antibodies includes both a constant and a variable region.
    d) Antibodies act as signals to macrophages.
    e) Plasma cells are responsible for the production of antibodies.
14. Naturally acquired passive immunity would include which of the following examples?
   a) injection of vaccine.
   b) ingestion of interferon.
   c) placental transfer of antibodies.
   d) absorption of pathogens through mucous membranes.

15. A patient reports severe symptoms of watery, itchy eyes and sneezing after being given a flower bouquet as a birthday gift. A reasonable initial treatment would involve the use of
   a) a vaccine.
   b) complement.
   c) sterile pollen.
   d) antihistamines.
   e) monoclonal antibodies.

16. Which cells will respond whether you have a viral infection or a bacterial infection?
   a) plasma cells
   b) helper T cells
   c) cytotoxic T cells
   d) only A and B
   e) A, B, and C

17. When antibodies attack antigens, clumping of the affected cells generally occurs. This is best explained by
   a) the shape of the antibody with at least two binding regions.
   b) disulfide bridges between the antigens.
   c) complement that makes the affected cells sticky.
   d) bonds between class I and class II MHC molecules.
   e) denaturation of the antibodies.

18. The genetic material of HIV consists of
   a) single-stranded DNA.
   b) single-stranded RNA.
   c) double-stranded DNA.
   d) none of the above

19. Which of the following mechanisms for osmoregulation or nitrogen removal is incorrectly paired with its corresponding animal?
   a) metanephridium-earthworm
   b) Malpighian tubule-insect
   c) kidney-frog
   d) flame bulb-snake

20. Which of the following excretory systems is partly based on the filtration of fluid under high hydrostatic pressure?
   a) flame-bulb system of flatworms
   b) protonephridia of rotifers
   c) metanephridia of earthworms
   d) Malpighian tubules of insects
   e) kidneys of vertebrates
21. Which of the following is true of urea? It is
   a) insoluble in water.
   b) more toxic to human cells than ammonia.
   c) **the primary nitrogenous waste product of humans.**
   d) the primary nitrogenous waste product of most birds.
   e) the primary nitrogenous waste product of most aquatic invertebrates.

22. The advantage of excreting wastes as urea rather than as ammonia is that
   a) urea can be exchanged for Na⁺.
   b) **urea is less toxic than ammonia.**
   c) urea requires more water for excretion than ammonia.
   d) urea does not affect the osmolar gradient.
   e) less nitrogen is removed from the body.

23. Proper functioning of the human kidney requires considerable active transport of sodium in the kidney tubules. If these active transport mechanisms were to stop completely, how would urine production be affected?
   a) No urine would be produced.
   b) A less-than-normal volume of hypoosmotic urine (less concentrated than the blood) would be produced.
   c) **A greater-than-normal volume of isoosmotic urine (same concentration as the blood) would be produced.**
   d) A greater-than-normal volume of hyperosmotic urine (more concentrated than the blood) would be produced.
   e) A less-than-normal volume of isoosmotic urine would be produced.

24. The blood and tissues of sharks has a _____ osmotic concentration to/than seawater due to retention of _____.
   a) Greater, ammonia
   b) Similar, ammonia
   c) **Similar, urea**
   d) Lower, urea
   e) Lower, uric acid

25. Which statement is true about marine fishes?
   a) **The kidneys of marine fishes excrete little urine.**
   b) Marine fishes lack proximal tubules.
   c) Marine fishes secrete uric acid to conserve water.
   d) Their kidneys produce filtrate at high rates.