Terminology/short answer - These questions require terms or brief answers. (13 questions, 1 pt. each except where noted, 25 pts total)

1. A digestive system that is essentially a blind-ended tube (i.e., not a 'flow through system') is referred to as: **A gastrovascular cavity**

2. What is the name of the structure that prevents food from entering the trachea in a mammal? **Epiglottis**

3. List three features responsible for the large surface area of the small intestine in a mammal (3 pts) **Four are possible: i) it is long, ii) large folds in the walls, iii) villi, and iv) microvilli**

4. List the two mechanisms we discussed that help protect stomach tissues from digestive processes. (2 pts) **Three are good for points here: i) extensive mucus secretion, ii) rapid epithelial renewal, and iii) secretion of pepsin in zymogen form as pepsinogen**

5. Which gland or structure is the main source of digestive enzymes released in the duodenum? **The pancreas**

6. Among vertebrates, the large intestine occurs only in lineages that are primarily terrestrial (amphibians, reptiles, birds, and mammals). Based on what you know about the function of the large intestine, what is the most likely reason for this? (2 pts) **These are terrestrial animals and the key function of the large intestine is water conservation.**

7. What three basic types of skeletons are found in animals? (3 pts) **Exoskeletons, Endoskeletons, and hydrostatic skeletons**
8. Cells within vertebrate bone occupy spaces termed _lacunae_ that are connected to each other by _canaliculi_. (2 pts)

9. List three differences you would expect to find between the quadriceps muscles of a world class sprinter and a world class distance runner (besides the obvious likely difference in overall muscle size; at least four answers are possible here). (3 pts).

**Greater in distance runner:** i) vascularization (higher capillary densities), ii) mitochondria numbers, iii) greater myoglobin concentrations, iv) greater proportion of slow twitch muscle fibers

**Greater in sprinter:** i) more myofibrils per muscle fiber (contributing to greater overall size of muscles), ii) greater proportion of fast twitch muscle fibers, iii) more sarcoplasmic reticulum

10. List two important differences between cardiac and smooth muscle (2 pts)

Five are possible: i) cardiac muscle fibers are branched, smooth muscle fibers are not, ii) cardiac muscle fibers have intercalated disks while smooth muscle fibers do not, iii) cardiac muscle fibers are striated while smooth muscle fibers are not, iv) cardiac muscle fibers have a T-tubule system while smooth muscle fibers do not, v) cardiac muscle is in the heart while smooth muscle is found in vessels, digestive system, etc.

11. The figure below shows a typical length-tension curve for skeletal muscle. Briefly explain what produces the broad peak in force between 100 and 120% of muscle resting length (2 pts).

![The peak in force here is due to the number of cross-bridges (1) formed during contraction being maximized (1). Overlap of the thick and thin filaments is less optimal at shorter and longer muscle lengths.]

12. Humans and other mammals have two structures that adapt the fetal circulation to 'aquatic life' before birth. List these two structural adaptations below. (2 pts)

**Foramen ovale, ii) Ductus arteriosus**
13. The axes below have a line showing the typical relationship between core body temperature and water temperature in ectothermic fishes (slope here = 1). Swordfish maintain a temperature in their brain that is warmer than the environment when they are in cool waters. **Draw a line** on the figure below to indicate this general relationship between swordfish brain temperature and water temperature. (1 pt)

Multiple Choice: **Use the scantron sheet for these questions** (1 pt each, 22 pts total)

1. I am writing version ___ of this exam (No credit for this one, but it makes sure we know which version you wrote)
   a) A
   b) B

2. On average, larger animals use __________ per gram of tissue than smaller animals
   a) about the same amount of energy
   b) more energy
   c) less energy

3. This tissue type is found covering body surfaces and lining tubes in the body
   a) muscle
   b) epithelium
   c) connective tissue
   d) nerve

4. Why does carbohydrate 'loading' increase the performance of distance athletes?
   a) **It increases glycogen stores in muscle and liver.**
   b) It increases fat storage
   c) It increases the blood's capacity to deliver oxygen to the tissues.
   d) It increases fatty acid levels in the blood.

5. How are carbohydrates digested?
   a) by lipases in the small intestine
   b) by pepsin and HCl in the stomach
   c) by aquaporins in the large intestine
   d) **by amylases in the mouth and small intestine**
6. What role do bile salts play in the digestion of complex fats?
   a) They catalyze the cleavage of bonds, releasing fatty acids and other small lipids.
   b) **They emulsify lipids, reducing large masses of fat molecules into smaller masses.**
   c) They include fatty acid binding proteins, which are involved in fat absorption.
   d) They activate the enzymes that are responsible for digesting fats.

7. The liver plays an important role in reproduction by synthesizing yolk proteins in oviparous vertebrates.
   a) **This statement is true**
   b) This statement is false

8. The cardiac and pyloric sphincters are composed of what tissue type primarily?
   a) cardiac muscle
   b) intercalated disks
   c) adipose tissue
   d) stratified epithelium
   e) smooth muscle

9. What bacterial species is thought to be a major contributor to the development of ulcers?
   a) *Escherichia coli*
   b) *Staphylococcus aureus*
   c) *Entamoeba histolytica*
   d) *Mycobacterium leprae*
   e) **Helicobacter pylori**

10. The significance of the *Shigella* experiment discussed in class was to show that:
    a) **diarrhea can be an effective defense mechanism to rid the digestive system of a virulent pathogen**
    b) diarrhea is worse than an intestinal pathogen due to the immediate danger of dehydration
    c) diarrhea can make you more sick if you are already infected with an intestinal pathogen
    d) B and C only

11. In muscle cells, myosin molecules continue attaching to and detaching from actin molecules as long as:
    a) ADP is present and tropomyosin is released from intracellular stores
    b) **ATP is present and intracellular Ca\(^{2+}\) is high.**
    c) ADP is present and intracellular acetylcholine is high
    d) Intracellular Ca\(^{2+}\) is high and the T-tubules are closed
12. In resting skeletal muscles, most of the calcium ions are found
   a) in the sarcoplasmic reticulum
   b) in the t-tubules
   c) bound to troponin
   d) bound to myosin

13. A "knock-out" mouse is genetically engineered so that it does not produce the protein tropomyosin. This would result in a skeletal muscle where:
   a) cross bridges would not be broken once formed
   b) intracellular calcium concentrations would remain very low
   c) cross bridges would form and break rapidly, but there would be no control over contraction
   d) contraction would be normal

14. Cross bridge formation stops after a stimulus because
   a) ATP is used up
   b) calcium is taken up by the sarcoplasmic reticulum
   c) calcium is taken up by the transverse T-tubules
   d) calcium binds to troponin
   e) a and c

15. Which of the following is the correct sequence for muscle organization going from the smallest components to the largest?
   a) sarcomere, myofibril, muscle fiber, motor unit
   b) myofibril, sarcomere, muscle fiber, motor unit
   c) sarcomere, muscle fiber, myofibril, motor unit
   d) myofibril, muscle fiber, sarcomere, motor unit

16. Individuals afflicted with the disease Myasthenia gravis suffer from a grave weakness of the muscles due to a relative lack of acetylcholine receptors where?
   a) on the motor axons innervating the muscles
   b) along the T-tubules
   c) on the sarcoplasmic reticulum
   d) along the thick filaments
   e) at the neuromuscular junction
17. If you made measurements from the muscles of a person suffering from Myasthenia gravis, you would expect muscular contraction to fail first at which point in the sequence leading to muscle contraction (based on what you know about the role of acetylcholine receptors)?
   a) relatively little calcium would be released from the sarcoplasmic reticulum
   b) cross bridge formation would be limited
   c) few action potentials would be carried by the motor axons
   d) neurotransmitter release into the synapse would be much less than that of a healthy person
   e) few action potentials would be generated in the muscle cell itself

18. Strength training with weights:
   a) increases both myofibril and muscle fiber numbers
   b) increases myofibril numbers, but not muscle fiber numbers
   c) increases muscle fiber numbers, but not myofibril numbers
   d) increases sarcomere numbers, but not myofibril numbers
   e) does not increase either myofibril or muscle fiber numbers

19. Conduction of action potentials through the atrioventricular node of the heart is _______ than in the Bundle of His found in the ventricle.
   a) faster
   b) slower
   c) about the same speed

20. Of the pressures involved in determining net fluid movement in or out of capillaries, the highest pressure at the arterial end of a capillary is usually:
   a) blood hydrostatic pressure and blood osmotic pressure are always equally high
   b) osmotic pressure from interstitial fluids (extracellular fluid)
   c) osmotic pressure from the blood
   d) hydrostatic pressure from interstitial fluid
   e) hydrostatic pressure from blood flow

21. If you had a patient drink a lot of distilled water that lowered the osmolarity of their blood below that of the interstitial (extracellular) fluid, what do you expect would happen to their level of lymph production? **Note that this became a bonus question**
   a) it would increase
   b) it would decrease
   c) it would stay the same
22. Assuming they pump blood out of the heart at the same pressure, you would expect the blood pressure in the dorsal aorta (leading to the muscles, intestines, etc.) of a fish to be ______ than in the dorsal aorta of a tetrapod vertebrate such as the pigs you are dissecting in lab.
   a) about the same
   b) higher
   c) lower

23. The heartbeat originates in the:
   a) sinoatrial node
   b) atrioventricular node
   c) vagus nerve to the heart
   d) Purkinje fibers
   e) semilunar node

24. The layer of an artery that contains the epithelium actually facing the blood stream is the:
   a) tunica intima
   b) tunica media
   c) tunica adventitia
   d) tunica sandwich

**Bonus Question (2 pt)**

Barney’s in Cary does an interesting thing when cooking hamburgers. They compress the middle of the burger. This has the effect of increasing the surface area-to-volume ratio and helps to ensure more even cooking. Red blood cells have a similar shape to Barney’s burgers (but probably don’t stand up to cooking as well). **Briefly**, how might this shape contribute to their function?

This shape maximizes diffusion of oxygen across their membrane to perform their oxygen transport function because of the large surface area for the volume of the cell and the decrease in distance over which oxygen must diffuse to and from the hemoglobin contained within the cells. Note that this shape doesn’t really increase surface area overall, just the S.A./volume ratio.