Clemson University

Department of Biological Sciences

Thirty-First Annual

Biology Merit Exam

16 April 2010

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Please choose the **best** answer for each of the following questions. Questions marked with an "*" are worth 4 points each; questions marked with a "#" are worth 2 points each; the unmarked questions are worth 1 point each. CAUTION: Incomplete erasures and smudges can be read as marks. To avoid having a choice read incorrectly, make your marks lightly at first. After you have made all your changes, blacken in your marks just before you turn in your answer sheet.

The theme of this exam is the Carolina wren.

An old European legend says that all the birds convened to choose a king, and they agreed that the bird that flew the highest would be crowned. The eagle soared higher than any of them, and then gave a cry of triumph as it began to glide back towards earth. Just then a wren that had hidden itself on the eagle's back flew up one foot higher than the eagle had. Thus the wren was crowned "the king of all birds."

1. Why do you think we picked the Carolina wren for the theme of this exam?
   a) It is the mascot of USC, and Clemson people are big fans of USC.
   b) It is the biggest bird in South Carolina.
   c) It is the most beautiful bird in South Carolina.
   d) It is the state bird of South Carolina.

#2. Humans are members of the family Hominidae, the order Primates, the class Mammalia, the Phylum Chordata, and the Kingdom Animalia. Which of these taxonomic groups also contain the Carolina wren?
   a) only the Animalia
   b) the Animalia and Chordata
   c) the Animalia, Chordata, and Mammalia
   d) <u>All</u> of the listed taxa contain both humans and Carolina wrens.

3. All organisms are given two Latin names. This naming tradition is called "... nomenclature" and originated with
   a) phylogenetic ... Darwin.
   b) hierarchical ... Aristotle.
   c) redundant ... Lamarck.
   d) binomial ... Linnaeus.

#4. A National Geographic "Kids' Site" lists the Latin name of the Carolina wren as *Thryothorus Ludovicianus*. Later, they give the name as *Thryothorus ludovicianus*. The spelling is correct in both cases, but are both of these correct ways of presenting the name?

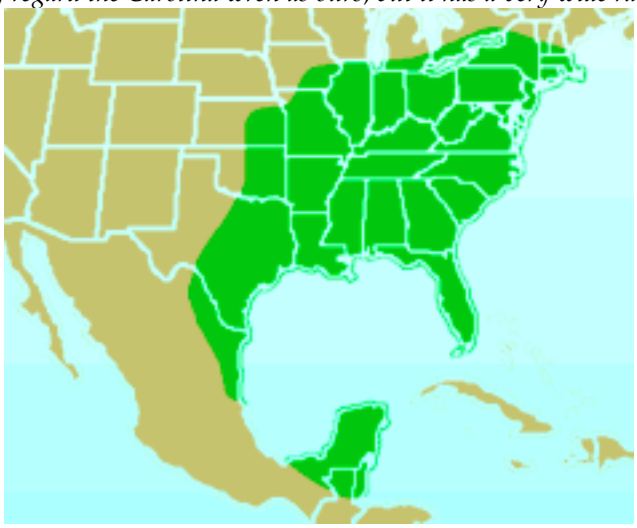
a) Yes, both are correct.
b) No, the first way is right but the second way is wrong,
c) No, the second way is right but the first way is wrong.
d) No, both ways are wrong.

By the way, "ludovicianus" means "of Louisiana."

*5. The wrens belong to the family Troglodytidae. We think the family Troglodytidae originated in the early Tertiary period. If you could go back to the early Tertiary period, you would expect to see

a) dinosaurs walking through great forests of pines and cycads.
b) modern kinds of invertebrates and fish, early mammals, and a world dominated by flowering plants.
c) mammals and many kinds of birds on land, but only invertebrates in the oceans.
d) Neandertal man and modern man competing in Ice Age Europe and Middle East.

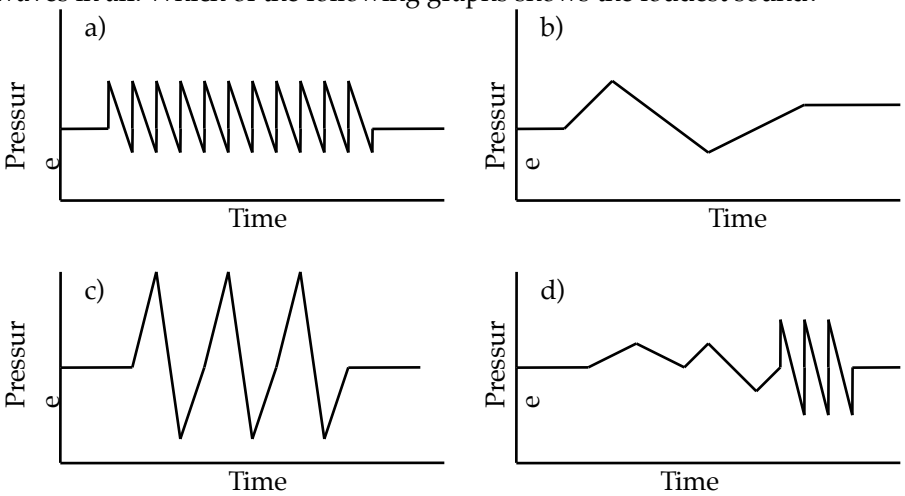
We in South Carolina may regard the Carolina wren as ours, but it has a very wide range, from Mexico to Canada:



*6. Carolina wrens are relatively small birds, although they are considered large wrens. They weigh about 20 g. About how many Carolina wrens would it take to equal the weight of a 150 pound human?

a) 610 b) 720 c) 1300 d) 3400

#7. Wrens may be small, but they are said to have the loudest songs of any bird of their size. Sounds are caused by pressure waves in air. Which of the following graphs shows the loudest sound?



The Carolina wren's song is described as "tea kettle, tea kettle, tea kettle." And while southern humans are reputed to speak more slowly than northern humans, with wrens it's the opposite--northern birds sing more slowly.

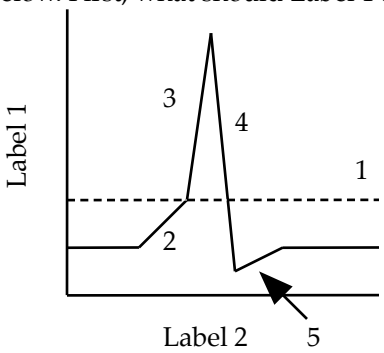
*8. A wren hears another wren's song. The wren's brain know how loud the sound is by the ... of the arriving action potentials.

a) frequency b) size c) direction d) polarity

*9. The brain neurons that will interpret the wren's song will be excited into an action potential when

a) a neurotransmitter opens potassium gates. b) a neurotransmitter opens sodium gates.
c) a neuron membrane hyperpolarizes. d) a G protein is synthesized.

*10. A wren action potential is shown below. First, what should Label 1 and Label 2 be?



a) "Sodium Concentration" and "Time"
b) "Sodium Concentration" and "Membrane Potential"
c) "Potassium Concentration" and "Sodium Concentration"
d) "Membrane Potential" and "Time"

#11. Now, which answer below correctly associates an action potential event with the corresponding part of the graph above?

a) 3 ... potassium rushes out of neuron b) 5 ... threshold potential
c) 2 ... graded potential d) 4 ... sodium rushes into neuron

#12. The major food of Carolina wrens is insects, which they find in leaf litter or on tree trunks. They may even eat lizards and tree frogs. These prey are located visually. If wren vision is like human vision, then the light reflecting off an insect encounters eye structures in the order

a) sclera, cones, lens, rods.
b) rods, cones, lens, choroid coat.
c) lens, cornea, iris, pupil.
d) cornea, lens, retina, choroid coat.

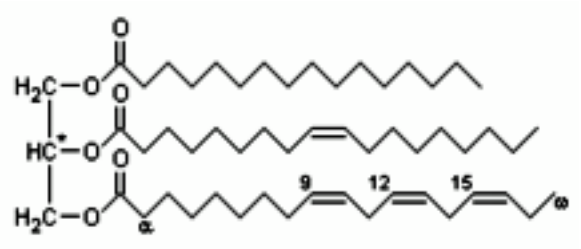
13. If a Carolina wren eats an insect, it will first encounter the insect's exoskeleton, consisting mostly of the molecule

a) cellulose. b) chitin. c) lecithin. d) glycogen.

14. Birds have no teeth, but still they can eat hard, crunchy food like insects because they have an internal grinding organ called a

a) syrinx. b) crop c) gizzard. d) cloaca.

15. A Carolina wren eats an insect that has a lot of the molecule shown below.



In humans, this molecule would be first be digested into ... in the

a) peptides ... stomach.
b) fatty acids and glycerol ... duodenum.
c) cholesterol and phospholipid ... small intestine.
d) monosaccharides ... small intestine.

#16. The enzyme that attacks the food molecule above is specialized to

a) carry out dehydration synthesis.
b) hydrolyze peptide bonds.
c) hydrolyze phosphodiester bonds.
d) hydrolyze ester bonds.

17. Sometimes protein structure is explained by an analogy with a "Slinky" spring toy. In this analogy, protein ... structure would be

a) primary ... the straight wire that will form the spring of the Slinky.
b) secondary ... the spiral, spring shape in the wire.
c) tertiary ... a complex, 3-D shape into which the Slinky is twisted.
d) <u>All</u> of these.

#18. The order of nucleotides in DNA most directly codes for protein ... structure.

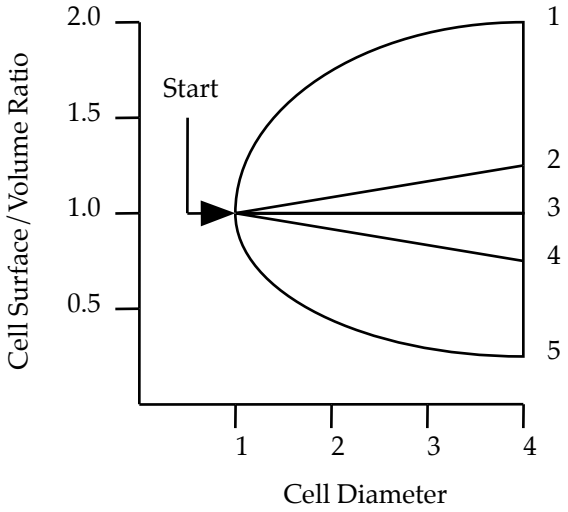
a) primary b) secondary c) tertiary d) quaternary

*19. A particular amino acid in an enzyme is coded for by the DNA codon GCG. This is the "template" DNA. The complementary DNA at that point will be called non-template DNA. We will also find the sequence GCG in the

a) mRNA codon transcribed from the template DNA.
b) tRNA anticodon and non-template DNA.
c) tRNA anticodon.
d) mRNA codon and tRNA anticodon.

20. The gut cells that absorb the products of digestion above have an adaptation that helps them absorb more efficiently; they have
a) microvilli. b) lysosomes. c) MTOCs. d) a central vacuole.

*21. Absorption brings up the question of surface to volume ratio. Say that the gut cell above increased in size while keeping the same shape. We'll call the present diameter of the cell and the present surface/volume ratio both 1.0. Which curve on the graph below shows best what would happen to the cell's surface/volume ratio as the cell increases in diameter?



a) 1 b) 2 c) 4 d) 5

22. If S = surface area and V = volume, cells generally do better when they have a
a) large V. b) large S/V ratio. c) small S. d) <u>All</u> of these.

#23. Plant cells tend to be much larger than animal cells, but they don't suffer as much from surface/volume ratio problems. The most direct reason for this is that they have
a) cell walls. b) mitochondria. c) centrioles. d) central vacuoles.

*24. You're looking at the plant cell above with a microscope, and when you're using your 4x scanning objective, the cell extends across 20% of the field of view. If you switch objectives to 10x, the cell will extend across ... of the field of view.
a) 50% b) 20% c) 8% d) Can't be determined.

#25. Getting back to the wren who ate the insect, the products of the molecule's digestion are picked up by veins serving the wren's digestive tract. The wren's heart is structured like a human heart, so the products of digestion reaching the heart would first enter the
a) left atrium. b) right atrium. c) left ventricle. d) right ventricle.

26. After leaving the heart, the the products of digestion will go to the ... first.
a) lungs b) muscles c) liver d) gut

#27. You would expect that a small, active bird like a wren would have a ... heart rate, ... blood pressure, and ... body temperature than a human
a) lower ... lower ... lower b) faster ... higher ... higher
c) faster ... lower ... higher d) faster ... lower ... lower

Dr. Kosinski once worked in a Biology Department that kept a cage full of parakeets. Occasionally, they'd let a particular one out of the cage and it would fly down to the end of the hall over the heads of amazed students, turn around in the air, and fly back, right into its cage. When it arrived it was very out of breath. The people who took care of it said it didn't get enough exercise. I had never thought about out-of-shape birds before.

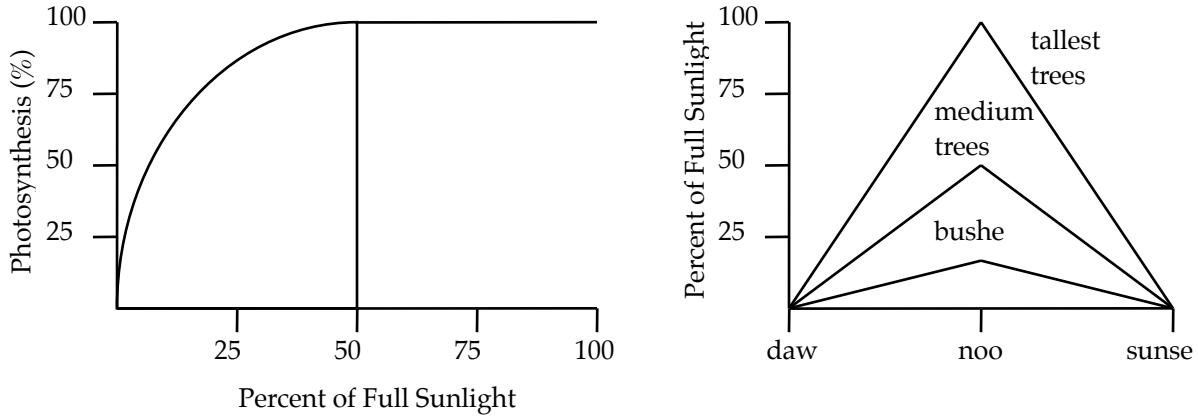
28. Parakeets and wrens need oxygen mainly because it
    a) is a high-energy molecule.
    b) activates enzymes
    c) is incorporated into ATP.
    d) serves as a final electron acceptor.

#29. Even after the parakeet arrived in its cage, it was still breathing hard. Why did flying make the parakeet out of breath?
    a) Flying raised CO_2 concentrations in its blood, and it was breathing hard to bring its blood pH down.
    b) Its circulatory system could not supply enough oxygen for the exercise, and its muscles used anaerobic respiration and built up lactic acid.
    c) Glucose in the muscles had been exhausted, and oxygen is necessary to restore the glucose concentrations by breaking down glycogen.
    d) Lack of oxygen causes hydrogen ions to be unable to flow from the outer compartment of the mitochondria into the matrix to make ATP. Breathing hard brings in oxygen and restores the correct shape of ATP synthase.

*30. Human lungs breathe in and then breathe out. Because the lungs can't be flushed completely with fresh air and there's always some stale air in them, the air in human lungs only has 2/3 of the oxygen concentration of outside air. Wren lungs use a series of air sacs to maintain a one-way flow of air through the lungs at all times and can completely flush them with fresh air. Because of this, wrens can get more oxygen from the air than humans can because their gas exchange system ... than the human system.
    a) maintains a steeper diffusion gradient
    b) has a smaller diffusion distance
    c) has a larger diffusion area
    d) has less of a diffusion barrier.

#31. The German name for the wren is "Zaunkonig," or "King of the Hedges," and wrens do forage for insects in dense foliage. If a wren is perched on a small branch with his feet encircling the branch, the plant tissue he is touching with his feet is ... . On the other hand, the reason the branch can support the wren's weight is that it consists mostly of
    a) xylem ... phloem.
    b) pith ... cortex.
    c) cork ... xylem.
    d) mesophyll ... phloem.

*32. In the dense undergrowth where the wren's bushes are, the light is dim. Higher up are the crowns of some medium-height trees, and they get more light. Finally, the tallest trees rise well above the others, and they get the most light of all. The response of all the plants to light is as shown on the left graph below; the amount of light each layer gets per day is shown on the right graph. Note that the light curve experienced by the layers is a triangle, although a more flattened triangle for the lower layers.



At the *average* light intensity for their level during the daylight hours, what percent of maximum photosynthesis would the tallest trees have? What percent would the bushes have?

a) 75% and 9% b) 50% and 9% c) 50% and 5% d) 100% and 60%

#33. In the winter, Carolina wrens sometimes eat berries. The soft tissue that surrounds the seed inside a berry comes from

a) ovary wall. b) anthers. c) endosperm. d) the embryo.

#34. Of course, female wrens lay eggs. This makes them

a) viparous. b) oviparous. c) viviparous. d) ovoviviparous.

*35. The number of chromosomes in a mature wren egg (before it is fertilized) is 15. These 15 chromosomes have

a) only one copy of each allele. b) 30 molecules of DNA.
c) 30 chromatids. d) <u>All</u> of these.

#36. Earlier in its development, the egg underwent meiosis. It arrived at its present number of chromosomes in

a) telophase II. b) prophase II. c) anaphase II. d) telophase I.

*37. Carolina wrens have a white streak called a "supercilium" above their eye, and it may extend well behind the eye:

A family of wrens is found in which the supercilium is short, just extending over the eye. In the table below, this will be called "short" and the normal supercilium will be called "long." Several different matings turn out like this. In the last line, the short offspring of the long x short mating are used.

Mating	Offspring
long x long	all long (1)
short x short	all short (2)
long x short	all short (3)
long x short (3)	1/2 long, 1/2 short

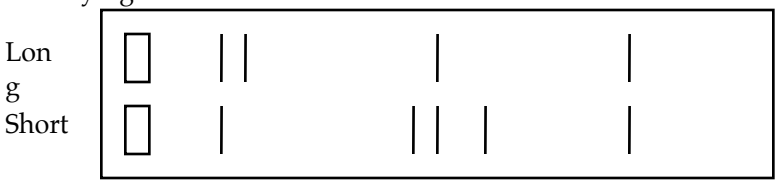
The data above are consistent with the theory that ... . If this theory is correct, if the short (3) offspring are mated with <u>each other</u>, the offspring of that cross will be

a) supercilium length is sex-linked ... all long.
b) "long" is controlled by a dominant, autosomal allele and "short" is recessive ... 3/4 long and 1/4 short.
c) "short" is controlled by a dominant, autosomal allele and "long" is recessive ... 3/4 short and 1/4 long.
d) "short" is controlled by a dominant, autosomal allele and "long" is recessive ... all short.

*38. The supercilium length is one of the characteristics the wrens use to make sure they are mating with an individual of the right species. Although the short supercilium wrens are just as vigorous as the "normal" wrens and perfectly fertile, they do not attract many mating overtures from the normal wrens. The "short" wrens tend to mate with each other. Does this situation violate Hardy-Weinberg equilibrium?

a) Yes, because the "short" wrens will not have as many offspring.
b) Yes, because mating is not random.
c) No, because the "short" wrens have just as many offspring as the normal ones.
d) No, because the normal wrens could easily experience the mutation that originated the short supercilium.

*39. A researcher sequences the DNA of both the short and normal wrens and finds that a single nucleotide has changed in the short DNA. However, this small change has produced a big change in a wren RFLP that the researcher has been studying:



As soon as he sees this gel, the researcher knows that the single nucleotide change that turned the long allele into the short allele has

a) created a new restriction site.
b) destroyed a restriction site.
c) activated an inactive gene.
d) disabled an active gene.

*40. This has little to do with Carolina wrens, but in the past two weeks there has been a discovery of a new species of human ancestor that has received a lot of press coverage. This new species is
a) *Ardipithecus bergensis.*
b) *Homo ergaster.*
c) *Homo archaea.*
d) *Australopithecus sediba.*