Part I: Short answer (25 points)

1. On Oct. 23, scientists reported sequencing the DNA of a 45,000 year old Neanderthal. If they used an isotope with a half-life of 15,000 years to determine the Neanderthal’s age, about what % of the original amount of $^{14}C$ remains in the bone? Show your work in the space at right for full credit. (3 pts)

2. List the five lines of evidence for evolution, then speculate on a sample observation that might provide evidence that birds are actually a type of reptile (10 points).

<table>
<thead>
<tr>
<th>Line of evidence</th>
<th>Sample observation that might show that birds are reptiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
</tbody>
</table>

3. a. In a movie, we saw lizards living among the large leaves of the forest canopy. Describe an example of a mutation that their habitat might favor. Be sure to explain the effect of the mutation on the lizard’s phenotype and how it would enhance reproductive success (directly or indirectly). (4 points)

b. Explain how multiple species of lizards might evolve on an island with a variety of habitats. Use mutations, competition, natural selection, and reproductive barriers in your answer (4 pts).

4. Angiosperms and mammals originated on land, yet water lilies and whales live in water. Describe a feature that you predict they’d share with their land-based ancestors, and describe how that feature might have been shaped by selective forces in water (4 points).

<table>
<thead>
<tr>
<th>This feature retained from ancestors on land …</th>
<th>Water lilies</th>
<th>Whales</th>
</tr>
</thead>
</table>

| Has been shaped in this way by selective forces in water |             |        |
Part II: 75 points (38 questions; each question except the last one is worth 2 points)

True-false (mark A for true, B for false):

1. Bacteria and fungi occupy different domains, but both groups have members that can cause disease, have commercial and industrial uses, or play vital roles in ecosystems.
2. Gymnosperms and flowering plants both produce pollen and seeds, but gymnosperms are nonvascular plants and angiosperms have xylem and phloem.
3. The modern evolutionary synthesis integrated research on genes and mutations with research showing that species have changed over billions of years.
4. Humans have existed for about half of Earth’s history.

Multiple choice / matching:

5. Consult the diagram at right. Which of the following is incorrectly matched with its function?
   a. 1 = attract pollinators
   b. 2 = produces pollen
   c. 3 = receives pollen
   d. 4 = becomes stalk of fruit
   e. 5 = contains egg that will become embryo after fertilization

6. A lizard’s foot and a human’s foot each have five toes. It is therefore reasonable to suppose that:
   a. “five toes” is a characteristic inherited from the last common ancestor of lizards and humans.
   b. lizard toes are homologous to human toes.
   c. lizards and humans are two members of the same clade.
   d. the environment does not select against having five toes.
   e. All of the above are reasonable conclusions.

7. Which of the following qualifies as an evolutionary change (according to the biological definition)?
   a. Fewer people have vitamin deficiencies in 2014 than in 1914, thanks to vitamin-fortified foods.
   b. More women are blond (thanks to hair dye) in 2014 than in 1914.
   c. Skin cells acquire genetic mutations throughout a person’s life.
   d. The ability to produce enzymes that digest lactose (milk sugar) past infancy is more common now than it was thousands of years ago, thanks to the domestication of dairy-producing cattle.
   e. All of the above are examples of evolutionary changes.

For the next two questions, mark your scantron as follows (answers may be used more than once or not at all):

Mark “a” if the first item occurred BEFORE the second
Mark “b” if the first item occurred AFTER the second
Mark “c” if the two items occurred at the same time

8. O₂ accumulated in Earth’s atmosphere … origin of cyanobacteria
9. Origin of reptiles … plants moved onto land
10. $^{14}$C is a radioactive isotope sometimes used in radiometric dating. A Neanderthal fossil dated at 70,000 years old would have ___ $^{14}$C in it as compared to a fossil dated at 45,000 years old.
   a. more    b. less    c. the same amount of

11. Neanderthals looked somewhat different from modern humans, with a heavy brow ridge, shorter legs and arms, large hands and fingers, and curved arm bones. If you could pick a gene to compare in modern humans vs. Neanderthals and wanted to choose a gene that was most likely to have a lot of differences between the two groups, it would make the most sense to pick a gene related to:
   a. photosynthesis
   b. respiration
   c. upright walking
   d. limb length
   e. number of digits

12. Researchers have discovered that modern humans coexisted with Neanderthals in Europe for about 5000 years. Researchers debate whether they belonged to the same or different species. According to the biological species concept, which of the following would be evidence that they belonged to the same species?
   a. Similar appearances of modern humans and Neanderthals.
   b. DNA with at least 75% similarity.
   c. Evidence of a family unit consisting of a modern human grandfather, a Neanderthal grandmother, several adult children, and grandchildren.
   d. Fossils showing that modern humans and Neanderthals shared a common ancestor in Africa.
   e. Evidence that both modern humans and Neanderthals practiced agriculture.

13. A human’s skull does not have a ridge along the top, but a chimpanzee’s does. That ridge is a clue that chimpanzees:
   a. have larger, stronger jaw muscles than humans.
   b. eat more meat than a human.
   c. walk on all fours (not upright like a human).
   d. have more vestigial structures than a human.
   e. are products of the founder effect.

14. In one of your hand-written pop quizzes, I asked you to explain the connection between the increasing use of herbicide (Roundup) and the growing number of weed species that are Roundup-resistant. Which of the following explanations is the most consistent with how natural selection works?
   a. “Over time the species realizes it’s dying and needs the more adaptable weeds to reproduce.”
   b. “The adaptations allow the plants to become resistant.”
   c. “The more Roundup that is used, the more an individual plant can adapt to it.”
   d. “In order to keep from going extinct, each plant generates the mutations it needs to survive when Roundup is used.”
   e. “The weeds that weren’t resistant to it died, leaving resistant weeds to reproduce.”
15. In the lizards movie, the researchers used DNA evidence to generate the evolutionary tree at right. It shows that:
   a. all lizards from around the world share a common ancestor.
   b. lizards occupying the same island are more closely related to each other than they are to lizards on other islands.
   c. Puerto Rican lizards descended from Cuban lizards.
   d. grass-bush anoles are always more closely related to canopy anoles than they are to other types of anoles.

16. Why do the offspring of sexually reproducing species have more variation than the offspring of asexual ones?
   a. Because mutations only occur during sexual reproduction.
   b. Because meiosis scrambles genes each time it happens, so no two siblings are alike (except for twins).
   c. Because sexual reproduction produces more offspring than asexual reproduction.
   d. Because sexual selection multiplies the number of sexes in the population.

17. The best way to tell archaea from bacteria is to:
   a. look at their cells; archaea are eukaryotes and bacteria are prokaryotes.
   b. look at their cells; archaea are prokaryotes and bacteria are eukaryotes.
   c. look at their nuclei; the nucleus of an archaean contains DNA but that of a bacterium does not.
   d. look at their chloroplasts; those of an archaean have different pigments from those of a bacterium.
   e. sequence their DNA; the differences between archaea and bacteria cannot be seen with a microscope.

18. In lecture, someone brought up the rumor that the Chinese government forced two extremely tall people to marry and have a child, who grew up into super-tall former basketball player Yao Ming. If that’s really how it happened, that would be an example of:
   a. sexual selection
   b. artificial selection
   c. natural selection
   d. unnatural selection
   e. speciation

19. How many of the following characteristics apply to BOTH seedless vascular plants and angiosperms?

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Seedless Vascular Plants</th>
<th>Angiosperms</th>
</tr>
</thead>
<tbody>
<tr>
<td>autotroph</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>vascular tissue</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>pollen</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>fruits</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>cuticle</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>lignin</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>swimming sperm</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>flowers</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>eukaryotic</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>seeds</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>blastula</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

   a. 12  b. 10  c. 8  d. 6  e. 4
20. Some animals in different phyla have similar common names. Which of the following such animal pairs are the most closely related?
   a. Vinegar eel (roundworm you saw in lab) and a real eel (a type of bony fish)
   b. Cuttlefish (the color-changing squid you saw in lecture) and a real fish
   c. Sea monkey (the brine shrimp you fed to another animal in lab) and a real monkey
   d. Starfish (sea star) and a real fish
   e. Lion fish and a real lion

21. Wallace’s line is an imaginary line that passes through a group of islands in Asia. On the east side of the line, the mammals resemble those of Australia, and on the west side of the line, they resemble those of Asia. A deep ocean trench that always remains flooded, regardless of sea level, accounts for the difference. Which of the following statements about Wallace’s line is likely to be true?
   a. The trench is a long-term barrier that has prevented mammals on each side of the line from migrating to the other side.
   b. Natural selection does not apply to species living on islands.
   c. The trench is preventing continental drift from occurring in this region of the world.
   d. The climates on each side of the line must be so different that species from one side cannot survive on the other side.

22. Which of the following must have happened before the first cell actually formed?
   a. endosymbiosis
   b. colonies became truly multicellular organisms
   c. muscle tissue and nervous tissue formed
   d. All of the above are correct.
   e. None of the above is correct.

23. In the illustration at right, panel X shows a human accidentally crushing part of a population of bugs. Panel Y shows a bird selectively eating the dark beetles. Panel X is illustrating ___, and panel Y is illustrating ___.
   a. artificial selection … natural selection
   b. natural selection … artificial selection
   c. genetic drift … natural selection
   d. natural selection … genetic drift

24. Sharks, frogs, turtles, chickens, and cats all have ___
   a. jaws
   b. amniotic eggs
   c. placenta
   d. lungs
   e. All of the above are correct.
25. Kristin M. sent me photos of sunflowers, pine trees, lobsters, bees, snail shells, and her cat. These organisms represent ___ domain(s) and ___ kingdom(s).
   a. 1 … 2  b. 2 … 3  c. 2 … 1  d. 3 … 3  e. 3 … 2

26. What happens to a population if conditions change and no individuals have the allele combination required to survive and produce offspring?
   a. In general, individuals will find a way to adapt to the new conditions.
   b. The species will go on as before, but it will not be as successful as it would have been.
   c. The population will go extinct.
   d. In general, asexual reproduction will become more common in the population.
   e. The population will learn to cope with the new conditions, and it will be stronger as a result.

27. Sexual selection means that a:
   a. person gets to choose what gender he or she is assigned.
   b. plant can “choose” whether to use the male or female parts of its flowers.
   c. cnidarian can “choose” whether to reproduce sexually or asexually.
   d. characteristic can be unique to one sex because the other sex prefers that trait.
   e. moss can “choose” whether it will use swimming sperm or pollen in reproduction.

28. Many people mistakenly believe that fungi are simple plants. Which of the following is evidence that they actually form separate clades?
   a. Plants are eukaryotes; fungi are prokaryotes.
   b. Plant cells have a cell wall; fungal cells don’t.
   c. Plant cells have chloroplasts and mitochondria; fungal cells have mitochondria but not chloroplasts.
   d. Plants package embryos into pollen; fungi package embryos into spores.
   e. Plants use their roots to digest organic matter externally; fungi use their hyphae to digest organic matter internally.

29. A sloth, a human, and a platypus are all mammals. A platypus lays eggs; a sloth belongs to the same clade of mammals as humans. Consider the following characteristics.
   I) Amniote
   II) Monotreme
   III) Placenta
   IV) Mammary glands
   V) Postanal tail
   VI) Hair/fur

Which of the following statements is correct?
   a. II and VI are true for a sloth, but neither is true for a platypus.
   b. III is true for a sloth but not for a platypus.
   c. I, II, III, IV, V, and VI are true for a platypus but not for a sloth.
   d. I, II, III, IV, V, and VI are all true for both.
   e. V is true for both a platypus and for a sloth, but not true for birds and other reptiles.

30. You discover a new animal while you are on vacation in Chile. The animal’s skin is dry and has scales. It has a hinged jaw, lungs, and no legs. What have you discovered?
   a. A snake (legless reptile)
   b. A caecilian (legless amphibian)
   c. An earthworm
   d. Need more information; it could be a, b, or c.
   e. Need more information; it could be a or b.
31. How many of the items in the following list are classified as protists and are heterotrophs?

- moss
- amoeba
- Paramecium
- sponge
- dinoflagellates
- mushroom
- kelp
- slime mold
- red alga
- yeast
- green alga
- E. coli bacteria

a. one  
b. two  
c. three  
d. four  
e. five

Fill out the table below, then answer questions 32-35.

<table>
<thead>
<tr>
<th>Bilateral symmetry</th>
<th>Annelids</th>
<th>Roundworms</th>
<th>Flatworms</th>
<th>Echinoderms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete digestive tract</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastrula stage</td>
<td>Y1</td>
<td>Y2</td>
<td>Y3</td>
<td>Y4</td>
</tr>
<tr>
<td>Segmented</td>
<td>Z1</td>
<td>Z2</td>
<td>Z3</td>
<td>Z4</td>
</tr>
</tbody>
</table>

32. What goes in the space marked W?
   a. Yes (adults only)  
b. Yes (larvae only)  
c. No

33. What goes in the space marked X?
   a. Yes (mouth and anus)  
b. Yes (mouth only)  
c. Yes (anus only)  
d. No

34. What goes in the third row?
   a. Y1, Y2, Y4 = yes; Y3 = no  
b. Y1, Y2, Y3, Y4 = yes  
c. Y1, Y2, Y3, Y4 = yes  
d. Y1, Y4 = yes; Y2, Y3 = no  
e. Y2, Y3 = no; Y1, Y4 = yes

35. What goes in the fourth row?
   a. Z1, Z2, Z3, Z4 = yes  
b. Z2, Z3 = yes; Z1, Z4 = no  
c. Z1 = yes; Z2, Z3, Z4 = no  
d. Z1, Z4 = yes; Z2, Z3 = no  
e. Z3 = yes; Z1, Z2, Z4 = no

36. Which of the following statements is FALSE?
   a. Sponges are the simplest animals; they have no gastrula or true tissues.  
b. Cnidarians are carnivores with radial symmetry, an incomplete digestive tract, and stinging cells.  
c. Arthropods and roundworms have bilateral symmetry and a complete digestive tract; they must molt before they can grow.  
d. Mollusks live on land (snails) or in the ocean (sea stars and sand dollars).  
e. Chordates have a post-anal tail and a dorsal nerve cord.

37. According to the evolutionary tree at right, does a group consisting only of bony fishes form a clade?
   a. Yes  
b. No

38. What color is your test form?
   a. blue  
b. yellow