Answers to Clemson University Biology Merit Exam
17 April 2015

1. d) Correct. It’s all of them at the same time.

2. a) Correct. Octopuses are the class Cephalopoda of the phylum Mollusca.

3. a) No, that’s the phylum Echinodermata.
   b) Correct. A chiton is class Polyplacophora of the phylum Mollusca.
   c) No, phylum Arthropoda.
   d) No, phylum Annelida.

4. a) No, organism x will probably be more similar to the octopus, but that is not why we say it is more closely related.
   c) Correct. In cladistics, today’s dominant taxonomic technique, the most important question is how long ago two lineages diverged. The recent divergence of x and octopuses convinces taxonomists that they are closely related, no matter how different they are.
   d) No, any two organisms you can name have a common ancestor somewhere. It may be recent (chimpanzees and humans) or it may go as far back as the first cell.

5. a) Correct. The reason we might say that eight legs shows a relationship between spiders and octopuses would be if they inherited this characteristic from an ancestor with eight legs. But this is not true. Spiders and octopuses have no recent common ancestor with eight legs. They developed eight legs independently. So to say that all organisms with eight legs are related makes no more sense than saying that all organisms that weigh between one and two pounds are related.

6. a) No. This would have to be the Cambrian period, about 500 million years ago.
   b) Correct…the Carboniferous period, about 300 million years ago.
   c) No. This sounds like the Jurassic or Cretaceous, about 150 million years ago.
   d) No. This would have to be more recent than 65 million years ago.

7. d) Correct. Modern man originated roughly 200,000 years ago. 300 million years is 1,500 times as long ago.

8. c) Correct. 90 cm = 35.4 inches, almost 3 feet.

9. a) Correct. Contracting the circular muscles squeezes the fluid in the tentacles and makes the tentacle extend. Contracting the longitudinal muscles on one side causes it to bend. Then contracting all the longitudinal muscles causes it to shorten. The other answers have these steps out of order or they do counterproductive things like trying to extend and shorten the tentacle at the same time.

10. a) Correct. Meat is mostly protein.

11. b) Correct. Look at the correct answer. The peptide bond is indicated by the arrow:

\[
\begin{align*}
\text{NH}_2 & \quad \text{O} \\
\text{CH}_3 & \quad \text{CH} & \text{NH} \quad \text{CH}_2 & \text{C} & \text{OH} \\
\end{align*}
\]
The bond shown is where the carbonyl group of the left amino acid joins the amino group of the right amino acid. None of the other answers show this bond.

12. a) Correct. The stomach starts digestion of proteins with pepsin.

13. c) Correct. The CH₃ on the left end of the molecule is the R group of the left amino acid. One of the hydrogens on the third carbon from the right end is the R group on the right amino acid. This dipeptide is alanine joined to glycine.

14. d) Correct. Both a CH₃ and an H would be considered nonpolar R groups.

15. b) Correct. The amino group is to the left, and the right end ends with the carboxyl group.

16. a) Correct…or a condensation reaction.
   b) No, hydrolysis breaks a peptide bond.

17. c) Correct. Proteins are synthesized on ribosomes.

18. a) No, a purine is joined to a pyrimidine at every base pair in DNA. This ratio would always be 1:1.
   b) No. G is always attached to C. 1:1 ratio also.
   c) No. A is always attached to T. 1:1 ratio.
   d) Correct. Theoretically, DNA could have all C-G base pairs or all A-T base pairs. So the A:C ratio could differ in different species.

19. a) No. An octopus in a den will have most of its skin surface blocked by the den walls pressing in from each side.
   b) Correct. The octopus’ skin can exchange with the environment, overall oxygen demand is low, and so the skin can supply a larger part of it.
   c) and d). No. The skin is limited in how much oxygen uptake it can do. If the octopus is exercising and oxygen demand is high, the oxygen taken up through the skin will be dwarfed by the oxygen coming in through the gills.

20. d) Correct. The oxygen uptake will be high because the oxygen gradient between the water and venous blood will be steep, much water is going over the gills so the oxygen content of the gills high, and exercise is making the blood circulate so fast that it is rapidly bringing oxygen to oxygen-depleted muscles.

21. c) Correct. The systemic heart pumps to the body just as the left ventricle pumps through the aorta to the body.

22. a) Correct. The exhausted octopus will have lots of CO₂ (making carbonic acid) plus lactic acid in its blood.

23. a) No. This reaction does not change the pH, and is not a consequence of fatigue.
   b) Correct. This is a roundabout way of saying that the octopus is carrying out lactic acid fermentation.
   c) You don’t reduce FADH₂, you oxidize it.
   d) No, this reaction doesn’t change pH either, and is not a consequence of fatigue.

24. c) Correct. The retina is at the very back of the eye.

25. b) Correct. This means “color bearer.”
d) No. Octopuses have photophores, but these are luminescent spots, not skin colors.

26. a) Correct. ADP will go down and ATP will go up because the octopus is recovering its resting energy balance. The hard one to understand is that NADH will go down and NAD\(^+\) will go up. If the octopus is undergoing aerobic respiration, oxygen will start oxidizing NADH again. The reason that fermentation starts is that NADH is too high and NAD\(^+\) has disappeared. Once aerobic respiration is restored, NAD\(^+\) will reappear and be available for aerobic respiration.

27. b) Correct. The octopus has adopted the “low-budget” strategy of being inactive most of the time, and using fermentation to finance any sudden exertion. Its aerobic capabilities are feeble. The human has the strategy of having a heart and circulatory system that can supply oxygen for a high level of activity. The human requires more food per gram than the octopus, but also has greater aerobic performance and ability to recover from fatigue.

28. d) Yes, all of them. It is harder to pump a viscous fluid than a thin fluid. So, if the octopus wants to maintain the same blood flow, it’s going to need a more powerful heart. And congestive heart failure in humans often comes from years of the heart having to pump blood against high blood pressure.

29. c) Correct. The more concentrated octopus tissues would suck in water from the dilute environment.

30. b) Correct. Photosystems are in the grana (which is made of thylakoids) and carbon fixation by “rubisco” is in the stroma. Both of these are in the chloroplasts.

31. a) Correct.

32. a) No, this means bearing live young.
   b) No, this means bearing young more than once.
   c) Correct. Another example of a semelparous animal is a Pacific salmon.
   d) No. This means laying eggs, which the octopus does, but that has nothing to do with breeding once and then dying.

33. a) Correct. If the young cannot care for themselves, the mother better be around to do it. All the other conditions select for semelparity.

34. d) Correct. All of these are remarkable capabilities, but d) is the most impressive because it shows that the octopus has flexible behavior. For flimsy shells, the octopus just crushes the shell with its beak. For medium shells, it pulls the valves apart with its arms. And for the thickest shells, it slowly rasps a hole in the shell and then injects toxic saliva. These techniques are so different and so appropriate that they are the best evidence of intelligence.

35. a) and b) have nothing to do with neural integration.
   c) Correct. Summing of inputs allows individual neurons to “decide” whether or not to fire, depending on the input they get from surrounding neurons.
   d) No. This is remarkable (and literally creepy), but it is actually a sign that the octopus nervous system is less advanced and less centralized than ours.

36. b) Correct. DNA repair enzymes are important, but they assure genetic stability, not diversity. The other phenomena are well-known methods for increasing genetic diversity.
37. d) Correct. The number of different chromosome combinations for a human is $2^{23}$; for the octopus it would be $2^{28}$. This is $2^5 = 32$ times more combinations for the octopus.

38. a) Correct. If the mother has allele variants A and B and the father had variants C and D, there can be a maximum or four band sizes on the whole gel (A, B, C, and D). Of course, if the mother had A and A and the father B and B, there would be only two, but I asked for the maximum number of different band sizes that two parents could provide.

39. a) If there’s only one band size, all offspring are either DD or all are dd, so how could there be two sucker sizes?  
   b) There’s nothing to indicate sex linkage. And if there’s only one allele in the offspring, how could there be three sucker sizes?  
   c) Correct. The presence of two different band sizes on the gel implies that we have both D and d in the offspring. But if there are three sucker sizes, it must be incomplete dominance where DD, Dd, and dd have different sucker sizes.  
   d) No. If it’s a case of complete dominance, there could be only two sucker sizes, not three.

40. d) Correct. This is complicated, but basically this system cuts any allele at a particular locus that is not the allele that the researcher wants and then uses the preferred (uncut) allele to repair the cut. Therefore, it ends up replacing all the alleles at that locus with alleles introduced by the researcher. This is very much in the scientific news right now.