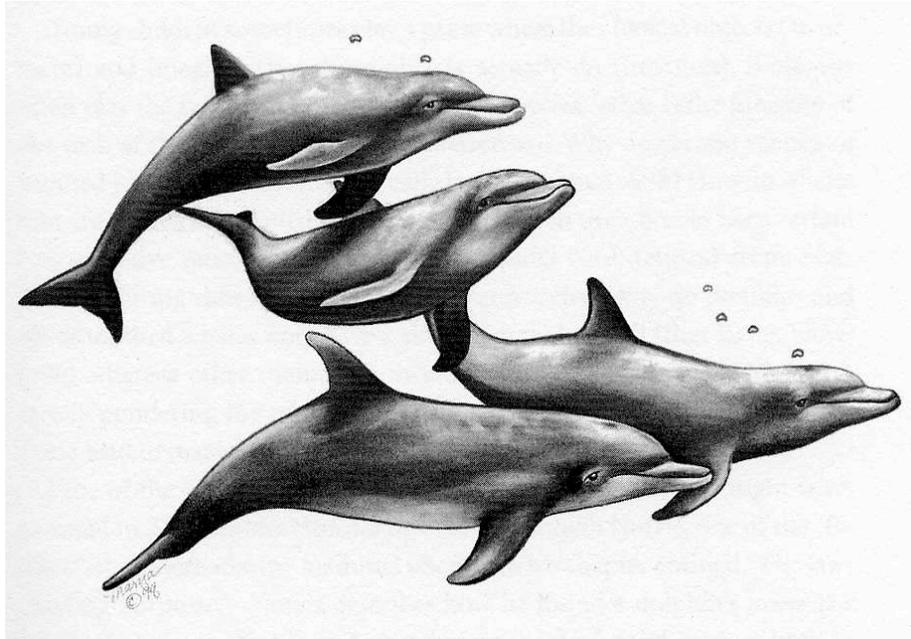


Clemson University Biology Merit Exam  
31 March 2006

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 dolphin, one of the most popular and appealing marine animals:



1. Dolphins are mammals, not fish. This means that dolphins, in contrast to fish,
  - a) breathe air with lungs.
  - b) nurse their young with mammary glands.
  - c) are endothermic (warm-blooded).
  - d) All of these.
2. The dolphins in the picture above are mammals, but there is also a bony fish called a "dolphin":



- Both our mammal dolphins and this bony fish dolphin
- a) have backbones.
  - b) have chitin cell walls.
  - c) have one circular molecule of DNA per cell.
  - d) have cells with large central vacuoles.

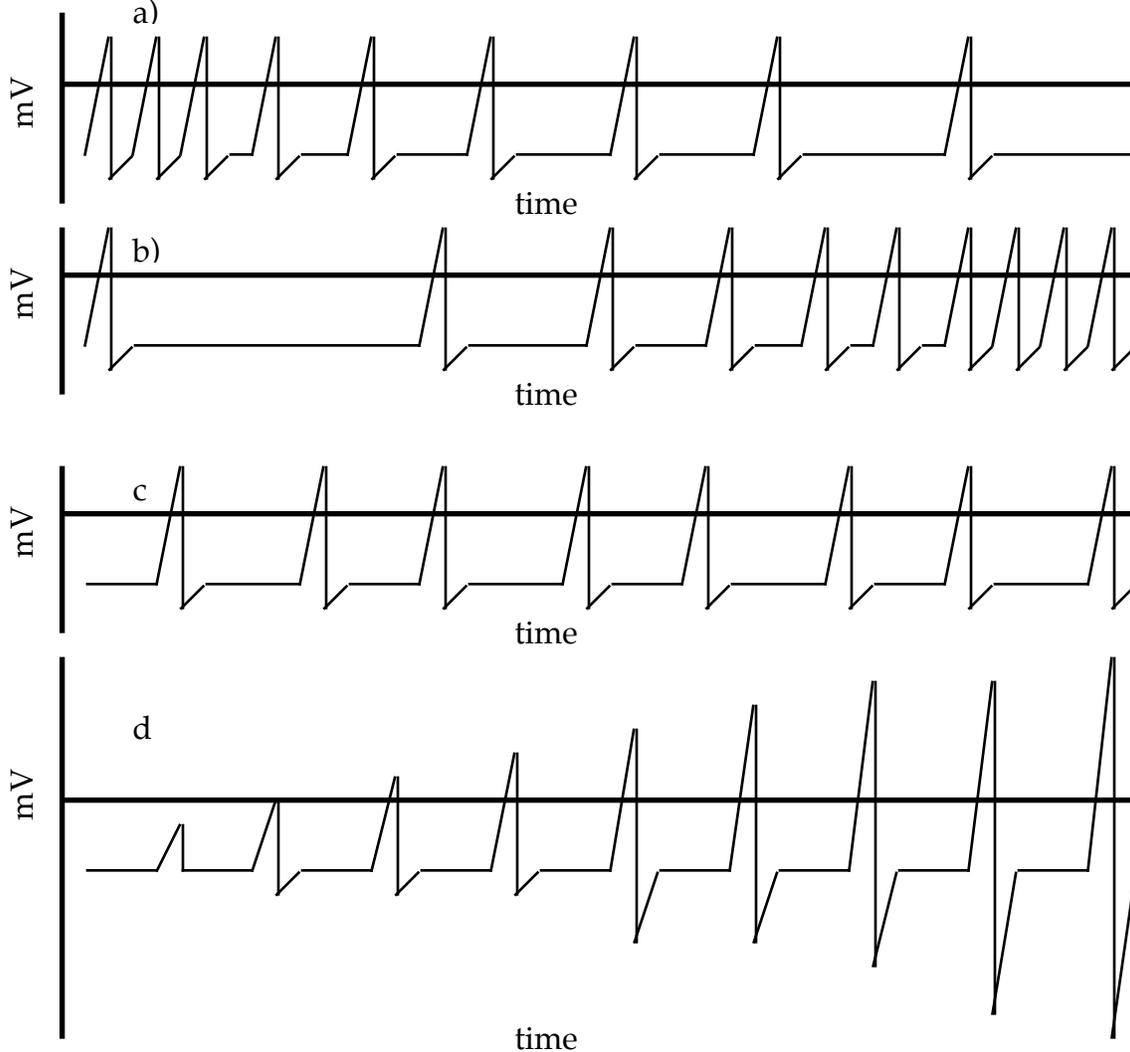


- \*5. Although the dolphin and the shark, for example, came from completely different ancestries, they have a very similar body shape because any animal that needs to move quickly through water has to be streamlined. That is, the similarity in body shape between sharks and dolphins is ..., the result of ... evolution.
- a) analogous ... convergent                      b) analogous ... divergent  
c) homologous ... convergent                      d) homologous ... divergent

*Interesting fact: Molecular evidence indicates that the terrestrial mammal most closely related to the beautiful, graceful dolphin is...the hippo!*

6. There are 34 species of dolphin worldwide. A species is a group of organisms that
- a) have the same evolutionary ancestor.  
b) can interbreed and produce fertile offspring.  
c) share the same habitat.  
d) have DNA that is at least 50% the same.
7. The pictures you have seen so far have shown the most common dolphin off South Carolina, the Atlantic bottlenose dolphin, *Tursiops truncatus*. The practice of identifying organisms with two Latin names originated with
- a) Darwin.                      b) Aristotle.                      c) Lamarck.                      d) Linnaeus.
- #8. We don't think of bottlenose dolphins as remarkably big animals, but the biggest ones can get 15 feet long and weigh 650 pounds. That is, they are about ... m long and weigh about ... kg.
- a) 3.5 ... 495                      b) 4.5 ... 295                      c) 2.7 ... 315                      d) 5.5 ... 160
9. Bottlenose dolphins eat mostly fish and squid. Squid are a member of the phylum
- a) Mollusca.                      b) Chordata.                      c) Arthropoda.                      d) Annelida.
- \*10. Dolphins locate their fish and squid prey by a combination of vision and echolocation. Dolphins have excellent eyes that contain both rods and cones. If dolphin eyes are like human eyes, the rods are mainly responsible for seeing objects ... and the cones are mainly responsible for seeing objects
- a) moving left to right ... moving up and down.  
b) reflecting short wavelengths ... reflecting long wavelengths.  
c) in poor illumination ... in good illumination.  
d) that are straight ahead ... that must be seen with peripheral vision.
- \*11. The dolphin's brain determines that a prey has been sighted when an action potential arrives on the optic nerve. When an action potential starts in a neuron, it will involve the following steps, starting with the resting neuron:
1. Axon hillock reaches -55 mV.
  2. Potassium channels close.
  3. Potassium channels open.
  4. Sodium channels close.
  5. Sodium channels open.
- The correct order of these steps is:
- a) 1 3 2 5 4                      b) 2 3 5 4 1                      c) 5 4 3 2 1                      d) 1 5 4 3 2

- \*12. To echolocate, the dolphin makes a series of clicks that bounce off objects in the water. These echoes are picked up by the dolphin's ears. Of course, the closer the object is, the louder the echoes are. Which graph below shows the expected pattern of action potentials in one neuron of the dolphin's auditory nerve as the dolphin gets closer to its target (a fish)? The horizontal axis represents 0 mV. Assume that the dolphin is producing clicks at a constant rate as it homes in on the fish.



13. Dolphins are renowned for their intelligence, which in both humans and dolphins is based mainly in the brain's  
 a) cerebrum.      b) pons.      c) medulla.      d) cerebellum.

*Interesting fact: When nosing in rough sediments, dolphins may cover their snouts with a piece of sponge, like using a workglove. This means they use tools. They can form general concepts, like being able to recognize an object as a ball no matter what size or color it is. Dolphins can recognize themselves in a mirror. Chimps can do this, but most monkeys cannot. Dolphins also play and may even have a sense of humor. One dolphin repeatedly leaped out of the water and arched over a floating pelican, seemingly just to startle the bird.*

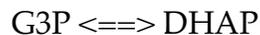
- \*14. When a motor neuron secretes a neurotransmitter onto a muscle, the most direct effect is to cause the affected muscle cells to
- spill calcium ions from their sarcoplasmic reticulum.
  - coil actin into a helix.
  - polymerize myosin into a sarcoplasmic process.
  - phosphorylate tropomyosin.
- \*15. Dolphins normally cruise at 5-7 mph (faster than the fastest Olympic swimmers), but can achieve brief spurts of 20 mph. However, a dolphin swimming that fast will soon tire. If the reason for the fatigue is the same as in a human doing a sprint, muscle fatigue will occur because
- NADH concentration in the muscles rises to toxic levels.
  - most of the muscle glucose is converted to unusable glycogen.
  - high CO<sub>2</sub> concentrations make the muscle too alkaline to contract.
  - glycogen is depleted and lactic acid concentrations rise.

- \*16. The ATP for muscle contraction comes from breakdown of glucose. The overall equation for this reaction under aerobic conditions is



The role of the C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> here is to ...; the role of the O<sub>2</sub> is to

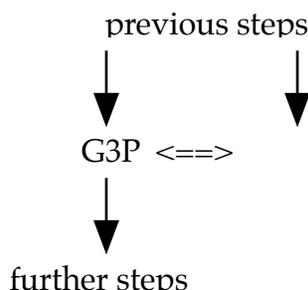
- provide carbon atoms that can be reduced ... keep hydrogen ion concentrations in the mitochondria from rising too high.
  - furnish energetic electrons ... act as a final electron acceptor.
  - serve as an electron acceptor ... serve as an electron donor.
  - provide energy ... store energy until it can be used.
- #17. Of course, the equation above is simplified; the aerobic breakdown of glucose has many steps. The step that yields the majority of the ATP in aerobic respiration is
- fermentation.
  - glycolysis.
  - electron transport.
  - the Krebs cycle.
- \*18. An early step of the breakdown of glucose involves a reaction in which glyceraldehyde-3-phosphate (G3P) and dihydroxyacetone phosphate (DHAP) transform into one another:



Say we put G3P, DHAP, and the enzyme that catalyzes the reaction above into a test tube. If nothing is added to or removed from the reaction mixture, this reaction will continue until G3P and DHAP have reached some characteristic ratio to one another. At this point, the equilibrium point,

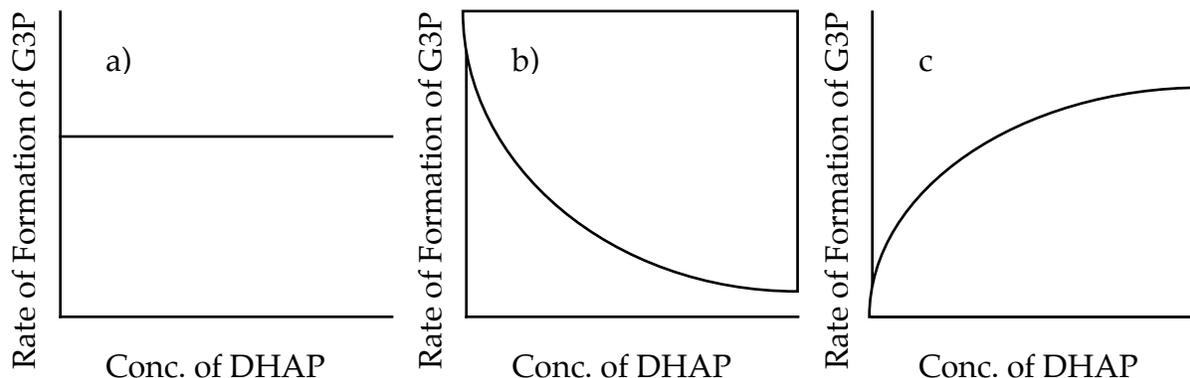
- the number of DHAP molecules transforming into G3P is equal to the number of G3P molecules transforming into DHAP.
- the concentrations of G3P and DHAP must be equal.
- the cell has exactly the ratio of G3P to DHAP that it needs.
- All of these.

- \*19. In the breakdown of glucose, both G3P and DHAP are formed in equal amounts by the first steps of the pathway, but only the G3P continues on to further steps:



We would predict that

- virtually all the G3P formed will be transformed into DHAP.
  - virtually all the DHAP formed will be transformed into G3P.
  - the G3P will be further metabolized, but the DHAP will be left behind.
- #20. The G3P <=> DHAP reaction is catalyzed by an enzyme. This enzyme speeds up the reaction by
- lowering its activation energy.
  - acting as a reducing agent.
  - providing energy to it.
  - making it exergonic.
- \*21. Say we start with a reaction chamber that contains this enzyme plus various concentrations of DHAP, but no G3P. How do we expect that the initial rate of formation of G3P will react to an increase in the DHAP concentration?



- #22. Our dolphin is still homing in on a fish. It turns out to be a mullet, a fish that eats phytoplankton that have settled onto the mud. These phytoplankton are photosynthetic algae. If they are like higher plants on land, this means that they
- use sunlight's energy to excite electrons out of chlorophyll.
  - pass these high-energy electrons to NADPH.
  - use this NADPH (and ATP) to reduce CO<sub>2</sub> to sugar.
  - All of these.
- #23. The Calvin-Benson cycle is described in answer ... in the previous question.
- - 
  - 
  - The Calvin-Benson cycle is not described in any answer of that question.

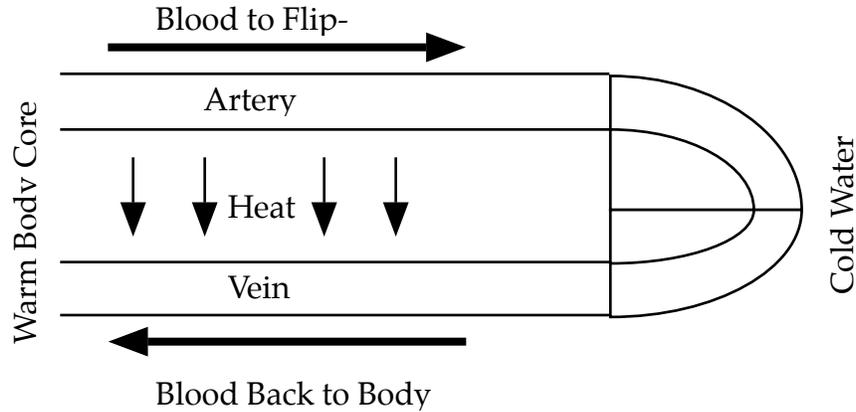
24. Eventually, the dolphin reaches the mullet and catches it in its jaws. Dolphins have conical teeth that are all alike. These teeth can be used to hold food, but not to chew it.



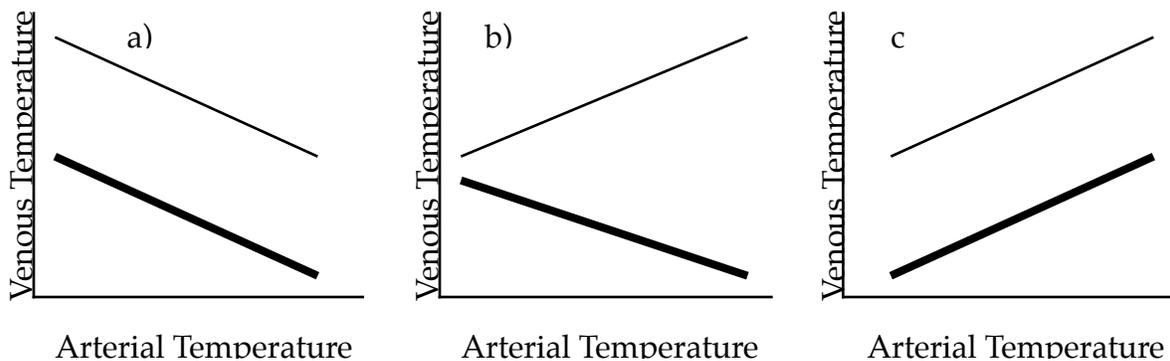
In contrast, humans have several different kinds of teeth. The chisel-like human teeth that are used to shear off pieces of food are the

- a) incisors.                      b) canines.                      c) premolars.                      d) molars.
- #25. The dolphin swallows the mullet whole. Dolphin stomachs have three compartments, and the second one is most similar to our stomach. We would expect that this compartment would
- a) use bile to emulsify fat.  
b) secrete HCl and start digestion of proteins.  
c) split polysaccharides into maltose subunits.  
d) absorb monomers rather than digesting polymers.
- #26. After several hours, the fat and protein in the mullet are starting to be absorbed by the dolphin's intestine. If these foods are completely broken down into monomers, we would expect that they would yield high concentrations of
- a) monosaccharides and disaccharides.  
b) amino acids and nucleotides.  
c) pentose sugars, purines, and pyrimidines.  
d) amino acids, fatty acids, and glycerol.
- #27. The circulatory system of dolphins is similar to that of humans. After the monomers above are absorbed in the intestine, they would be picked up by intestinal capillaries, then go to veins, and then enter the heart in the
- a) right ventricle.                      b) left ventricle.                      c) right atrium.                      d) left atrium.

- \*28. Dolphins in cool water have a big problem with heat loss. Body heat is lost 40x faster to water than to air. Most of the dolphin's body is insulated with a thick layer of fat (blubber) to prevent heat loss, but the flippers and tail flukes are not. Instead, these have a "countercurrent heat exchanger." Arteries entering the cold tissue are placed right next to veins coming back from it. This means that instead of being lost to the outside, the heat in the arterial blood is transferred to the venous blood just as it is reentering the warm body core:



Which graph below shows the relationship between the temperature of the arterial blood and the venous blood in warm water (light line) and cold water (dark line)? In all cases, the water temperature is cooler than that of the arterial blood.



*Interesting fact: Whales are often encrusted with fouling organisms like barnacles, but this doesn't happen with dolphins. One reason may be that the epidermis (outer skin layer) of dolphins is entirely replaced every two days! Thus the outer layer is shed so fast that fouling organisms can never get a foothold.*

- #29. Another big problem for dolphins is osmoregulation. They live in a seawater environment that is about three times as concentrated as their blood. This means that the environment is ... to their cells and the cells will tend to
- a) hypertonic ... shrivel up.
  - b) hypertonic ... swell and burst.
  - c) hypotonic ... shrivel up.
  - d) hypotonic ... swell and burst.
- \*30. Dolphin females have estrous cycles rather than menstrual cycles, but let's talk about the human menstrual cycle for a moment. In humans, the hormones that directly build up the uterine lining are mostly ... before ovulation and ... after ovulation.
- a) FSH ... FSH and LH.
  - b) estrogen ... estrogen and progesterone.
  - c) inhibin ... human chorionic gonadotropin.
  - d) estrogen ... LH and human chorionic gonadotropin.

- #31. A human female begins her menstrual period today. If her cycles are normally 28 days long, her next fertile period will extend from ... days from now until ... days from now.

a) 5 ... 10                      b) 10 ... 21                      c) 16 ... 21                      d) 10 ... 15

*Interesting fact: Dolphin males do not have a scrotum. It is thought that they can keep the temperature of their internal testicles low enough for spermatogenesis by piping cool blood from the heat exchangers directly to the testicles.*

- #32. Many bony fish lay millions of eggs and swim away immediately after laying them. Dolphins have a 12-month gestation period and then deliver a single calf who is one-third as long as the mother. This calf may take milk from the mother for 18 months, and stay with the mother for years, learning to hunt, echolocate, and interact correctly with other dolphins. The calf may not be physically mature until an age of 10-20 years, and may live to an age of 50. Dolphin mortality rates in Sarasota Bay, Florida, average only 1-4% per year. All this implies that dolphins are ... animals, ... humans.

a) r-selected ... like                      b) K-selected ... like  
c) r-selected ... unlike                      d) K-selected ... unlike

- #33. Given the life history characteristics above, if you could catch random dolphins in an area with a stable dolphin population, you would expect to find that

a) the great majority would be young rather than an old or middle-aged.  
b) the great majority would be old rather than a young or middle-aged.  
c) the great majority would be middle-aged rather than young or old.  
d) there would be fairly equal representation of young, middle-aged, and old dolphins.

- #34. There are instances of high dolphin mortality, however. In 1987-1988, there was a massive dolphin dieoff on the East Coast due in part to toxins produced by red tide organisms. Red tides are produced by

a) dinoflagellates.    b) diatoms.                      c) ciliates.                      d) trypanosomes.

35. Dolphin genetics has been studied with mitochondrial DNA. Mitochondria are cellular organelles that mainly function in

a) digestion of worn-out organelles.                      b) structural support of the cell.  
c) heredity.                      d) aerobic metabolism.

36. A section of mitochondrial DNA reads AGCTTA. The complementary strand of DNA would read

a) AGCTTA.                      b) ATTCGA.                      c) TCGAAT.                      d) AGCUUA.

- #37. Restriction enzymes are often used to develop "genetic fingerprints." The feature of restriction enzymes that makes them most useful for this application is that they

a) can withstand high temperatures without denaturing.  
b) cut DNA only at certain base sequences.  
c) add nucleotides to a growing chain but stop when they incorporate a U nucleotide.  
d) can separate DNA into its complementary strands.

