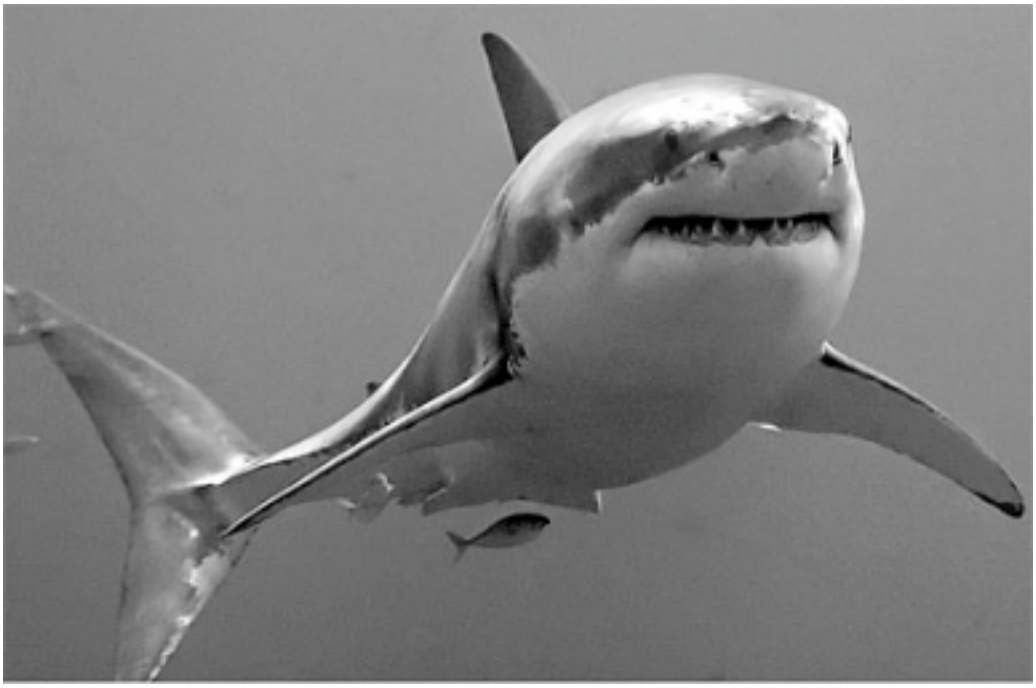
Clemson University Biology Merit Exam
24 April 2009

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 great white shark, the world's largest predatory fish, and the cause of 1/2 to 1/3 of all shark attacks on humans.



1. Humans and great white sharks are related, but distantly. Both humans and great whites are
   a) primates. b) vertebrates. c) mammals. d) <u>All</u> of these.

2. If we know that the great white and another organism belong to the same ..., they must also belong to the same
   a) genus ... family. b) class ... order.
   c) phylum ... class. d) kingdom ... phylum.

3. The species name of the great white shark is correctly printed as
   a) Carcarodon Carcharias. b) carcharodon carcharias.
   c) <u>Carcarodon Carcharias</u>. d) *Carcarodon carcharias*.

   By the way, this name refers to the serrated teeth of the great white. "Carcharodon" means "ragged tooth."

4. There are about 600 species of sharks in the world, and all of them belong to the Class Chondrichthyes. This is defined as the group of fish that
   a) are endothermic (warm-blooded). b) protect their young in a pouch.
   c) have cartilagenous skeletons. d) have both gills and lungs.

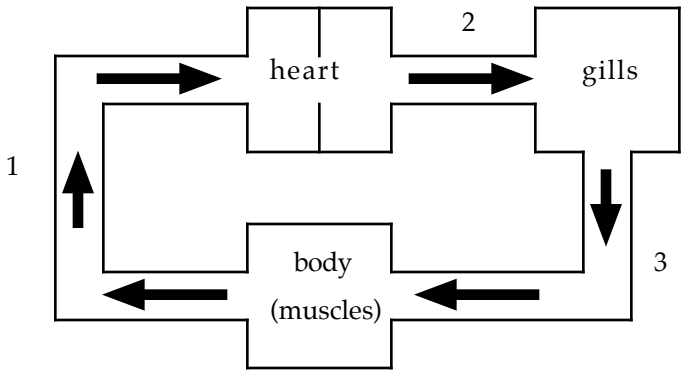
5. As mentioned above, great whites are the world's largest predatory fish. Look at this silhouette of a large great white compared to a school bus!

Although maximum size is a matter of great controversy, it seems that the largest great whites can get up to 6.4 m long and 3270 kg. This is about ... feet long and ... pounds.
a) 32 ... 6300 b) 21 ... 7200 c) 12 ... 3300 d) 50 ... 10200

6. Great whites are found mostly along the coasts of the temperate regions of the world. They require water temperatures between 12° C and 24° C, or an average of 18° C. 18° C is about ... F.
a) 75° b) 81° c) 52° d) 64°

7. If a human were placed in 18° C water, he would attempt to maintain his body temperature by
a) shivering. b) diverting blood to his skin.
c) reducing his secretion of thyroxine. d) <u>All</u> of these.

8. Humans have a great ability to regulate their body temperature, but great white sharks have a partial ability to do so, and can keep their brain up to 14° C warmer than the surrounding water. To explain how they do this, we have to consider their circulatory system. The basic diagram of a great white's circulatory system looks like this:



Ignore the numbers on the diagram for now. The blood goes from the heart to the gills and directly from there to the vessels of the body. The shark heart has only two chambers. Humans have lungs instead of gills, but how is a human circulatory system different from this pattern?
a) Substitute "lungs" for "gills" above and you'd have the human system.
b) The human has a four-chambered heart, but otherwise is the same as the system above.
c) The human has a four-chambered heart and separate pulmonary and systemic circulations.
d) The human has a three-chambered heart and *partially* separate pulmonary and systemic circulations.

9. With regard to blood temperatrue, the major fact is that the great volume of cold water flowing over the gills rapidly cools the blood to the water's temperature. Therefore, any body heat that gets to the gills will be lost. The heart is also cold. However, blood returning to the heart from the exercising muscles is warm. Now look at the numbers on the diagram above. The best way for the shark to conserve heat in its body and avoid losing it to the water flowing over the gills would be to place vessel ... next to vessel
a) 1 ... 3. b) 1 ... 2.

10. This ability to maintain a higher body temperature than the environment is common in some large, "cold-blooded" animals such as big turtles and fish, and was thought to be present in large, aquatic dinosaurs too. However, small fish and turtles rapidly reach the temperature of their environment. Large size allows an animal to conserve heat better because large animals have
    a) a higher metabolic rate per gram.
    b) more efficient circulatory systems.
    c) a larger surface/volume ratio.
    d) a smaller surface/volume ratio.

11. Working muscles are the greatest source of heat in the shark's body. You've probably experienced how exercise can make you feel overheated in just a few minutes. Muscles generate so much heat mainly because
    a) working muscles synthesize glycogen from glucose.
    b) muscle contraction is powered by the exothermic breakdown of actin.
    c) the return of myosin heads to the "cocked" position consumes much ATP.
    d) the conversion of one A band to an I band requires oxidation of four glucose molecules.

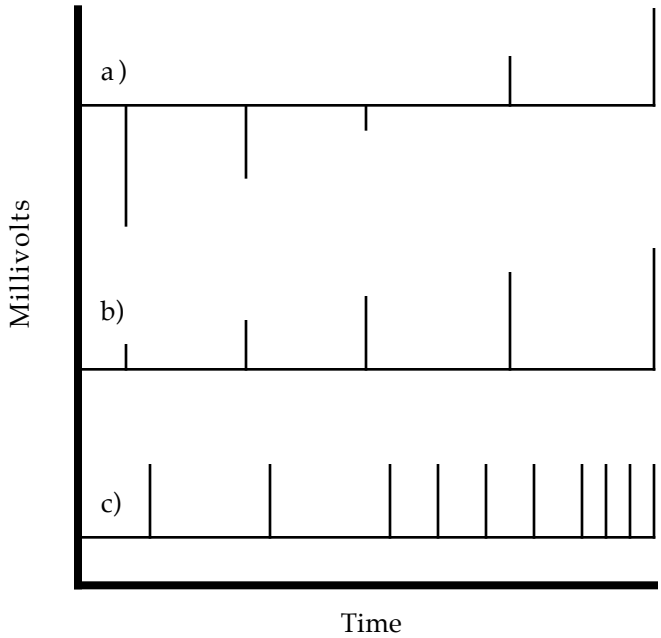
12. In a human heart, the wave of depolarization that starts the heartbeat begins in the
    a) SA node.
    b) sinus venosus.
    c) septum.
    d) AV node.

13. The great white shark heart can beat at a faster pace when the shark is exercising. A human heart beats faster during exercise mostly because
    a) higher CO_2 in the blood directly stimulates the heart muscle.
    b) exercise causes the sympathetic nervous system to secrete epinephrine and norepinephrine.
    c) lower oxygen in the blood increases the conductivity of the AV node.
    d) TSH from the anterior pituitary increases the metabolism of the heart muscle.

14. What is the main reason that it is advantageous that the heart speeds up when exercise starts?
    a) More blood is needed to keep the pH of the exercising muscles from rising.
    b) Exercising muscles need much more oxygen than resting muscles.
    c) Exercise depletes glucose from the liver and more blood flow restores that glucose.
    d) More blood is needed to keep the muscles supplied with lactic acid.

15. During exercise, the shark's gills will remove relatively ... oxygen from the water passing over them because the blood circulating through the gills will have ... oxygen than when the shark is at rest.
    a) more ... more
    b) less ... more
    c) less ... less
    d) more ... less

16. Adult great white sharks commonly hunt large marine animals like tuna, sea turtles, and especially, seals. They sense these prey by several methods. The first perception of the prey will probably be by sense of smell. The great white can detect one drop of blood in 100 L of sea water. If each spike below represents an action potential, which trace below shows the expected output of a single olfactory neuron that is reporting a smell that is getting stronger?



17. The great white also has a sensory organ called the lateral line system that allows it to detect disturbances in the water. The lateral line system runs down the two sides of the shark's body. If it wants to swim to a disturbance, it should turn towards the side with the ... signal and then stop turning when
    a) stronger ... the signals on both sides of the body are equal.
    b) stronger ... the signal on one side of the body disappears.
    c) weaker ... the signals on both sides of the body are equal.
    d) weaker ... the signal on one side of the body disappears.

18. As the shark gets within visual range of the prey, it uses its eyesight. Off California, the peak shark hunting hours are early in the morning because at that time the sun is not shining down into the water but a shark swimming near the bottom can see surface animals (like sea lions) silhouetted against the bright sky. If a shark eye is constructed like a human eye, then incoming light will penetrate or pass its ... first.
    a) retina b) cornea c) iris d) lens

It is thought that some shark attacks on human surfers occur because from below, the silhouette of a surfer paddling on a surfboard looks like the silhouette of a swimming seal.

The eye of the great white appears to be a featureless, black disk, which contributes to the shark's reputation for mindless ferocity.

The shark accelerates upward towards its seal target, reaching speeds of 25 mph. It attempts to hit the seal in the middle of the body and rip out a large bite that will cause the seal to bleed to death. The gruesome picture below shows a seal that died from such an attack.

19. The shark can do such damage because of its teeth. The teeth in the lower jaw pierce and hold the prey, and the teeth in the upper jaw are serrated and saw off a big chunk of meat when the shark shakes its body from side to side. Note the difference between the lower teeth and the upper teeth in the picture below.

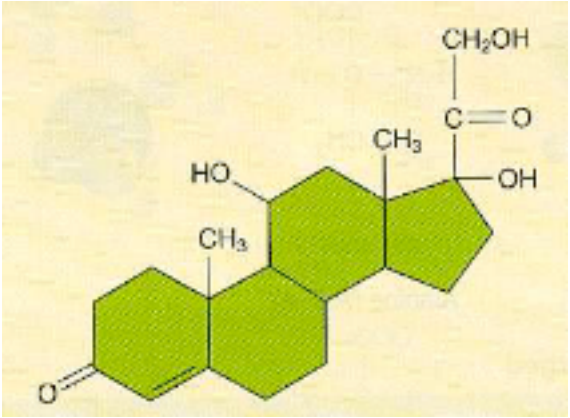
Great whites have about 300 teeth; adult humans have ... teeth.

a) 20 b) 22 c) 26 d) 32

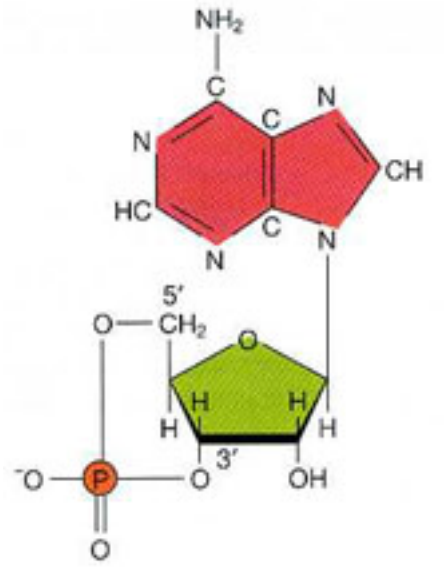
20. One of the reasons sharks prefer prey like seals is that they have a high fat content. Fat is one of the best possible foods if the shark is trying to maximize its food's content of
   a) essential amino acids.
   b) vitamins and minerals.
   c) energy per gram.
   d) enzymes.

21. Which of the following shows a fat molecule?

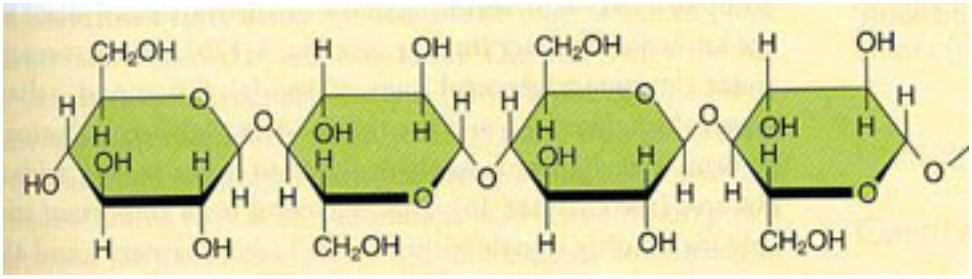
a)



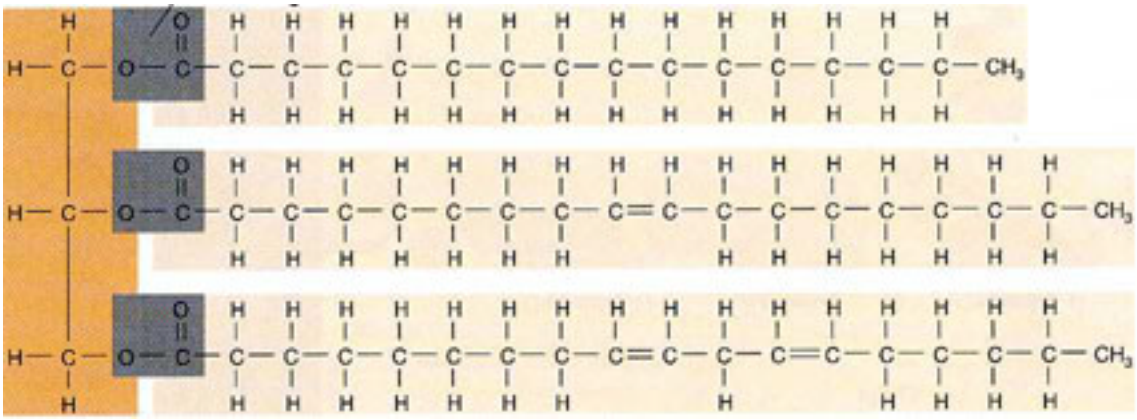
b)



c)



d)

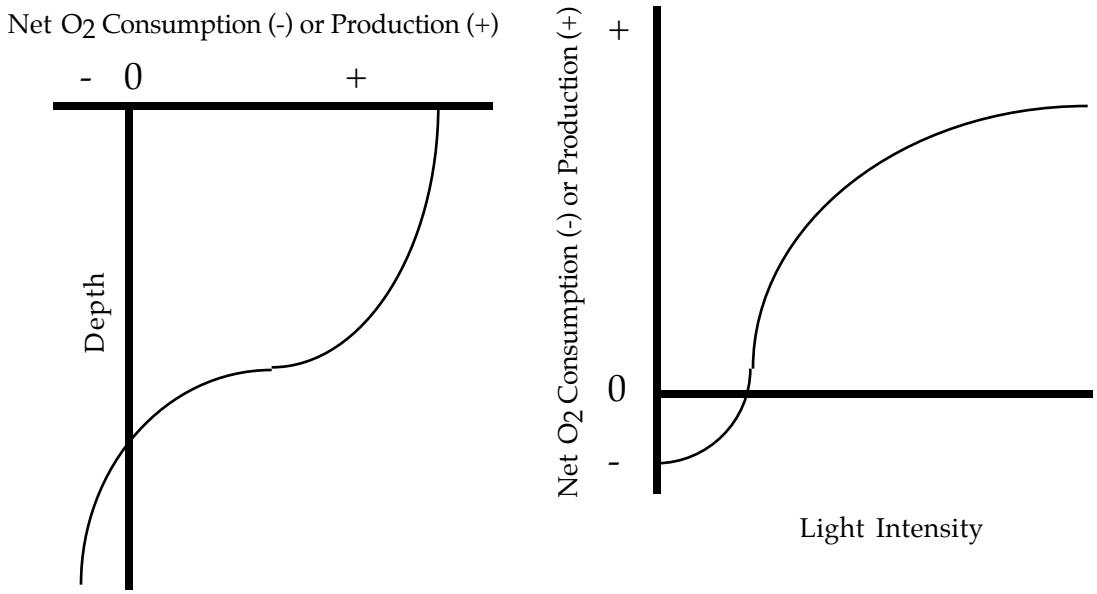


22. If the shark's digestive system is like a human digestive system, which component of the seal flesh that the shark has swallowed will be attacked *first* in its digestive tract? Note: Sharks do not have saliva.
    a) Some of the peptide bonds in the protein would be attacked.
    b) The glycogen would be digested into glucose.
    c) The fat would be emulsified and then hydrolyzed.
    d) Nucleic acids would be broken down.

23. Eventually, large amounts of glucose will be entering the blood of the shark. The *first* step in breaking down this glucose will take place in the ... of the cells and it will involve
    a) mitochondria ... splitting the glucose into two 3-carbon compounds.
    b) glyoxysomes ... stripping all the hydrogen from the glucose.
    c) cytosol ... adding a phosphate group to the glucose.
    d) central vacuole ... stripping all the nitrogen from the glucose.

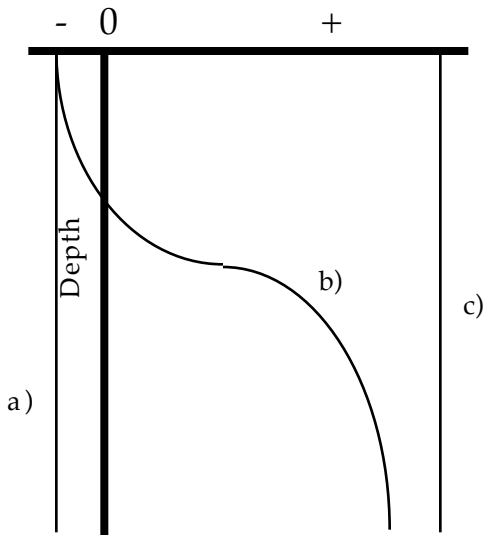
24. The glucose will eventually yield ATP, NADH, and $FADH_2$ molecules. The ATP can be used directly, but the NADH and $FADH_2$ will yield ATP when they are
    a) put through the Krebs cycle.
    b) oxidized by the electron transport system.
    c) reduced in the mitochondrial matrix.
    d) reduced in fermentation.

25. As the shark ate the seal carcass, it was surrounded by millions of photosynthesizing phytoplankton cells. The graph on the left shows the predicted net production or consumption of oxygen by a bottle of these phytoplankon at different depths. The horizontal line at the top is the surface. The graph on the right shows the predicted results if the phytoplankton were subjected to different light intensities in the lab. Are both these graphs reasonable predictions?



    a) Yes. Both are reasonable predictions.
    b) No. The left graph is reasonable, but the right graph is wrong.
    c) No. The right graph is reasonable, but the left graph is wrong.
    d) No. Neither one shows a reasonable prediction.

26. If the left experiment had been run at night, which is the best prediction for the results?



a) Vertical line at left. b) Curve marked b.
c) Vertical line at right. d) No change from the left graph in question 25.

27. The phytoplankton cells above are producing oxygen during photosynthesis because they are
a) carrying out cyclic photophosphorylation.
b) oxidizing NADPH.
c) using water as an electron acceptor.
d) splitting water in order to use its electrons to reduce CO_2.

28. If the phytoplankton are like terrestrial plants, they will be able to use ... wavelengths of light most effectively for photosynthesis.
a) green b) blue and red c) green and yellow d) violet and infrared

29. Great white sharks reproduce using males and females, like humans. However, in 2007, a female bonnethead shark (a small hammerhead about 1 m long) reproduced in a zoo in Omaha by fusing two eggs together. If several offspring were produced (each from a separate pair of eggs), were the offspring genetically identical to each other and were they genetically identical to their mother?
a) Yes and yes. b) Probably not and yes.
c) Yes and probably not. d) Probably not and probably not.

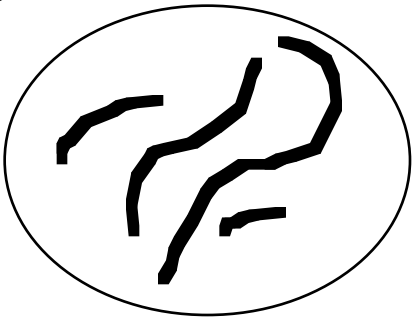
30. At an early stage of embryonic development, the shark embryo is a blastula. Which of the following structures would you be able to find in a blastula?
a) a blastopore b) a blastocoel c) an archenteron d) somites

Do you think you've had a tough youth? Before they are born, great white shark pups attack and eat weaker siblings in the uterus!

31. A body cell of a great white shark has 82 chromosomes. This means that mature great white shark sperm cells have ... chromosomes.
a) 82 b) 41 c) 164 d) 80

32. A great white stomach cell is just about to undergo *mitosis*. This cell will have ... *molecules* of nuclear DNA. A great white cell that will become an egg is just about to start *meiosis*. This cell will have ... *molecules* of nuclear DNA.
a) 82 ... 41 b) 82 ... 82 c) 82 ... 164 d) 164 ... 164

33. The cell below is at some stage of mitosis or meiosis.



This cell appears to be ..., ... homologous pairs, and could be in
a) diploid ... has ... telophase. b) diploid ... does not have ... prophase.
c) haploid ... does not have ... telophase II. d) haploid ... has ... telophase I.

34. Great whites have variable dorsal fins, and often individuals can be recognized by their fins. Both short and tall dorsal fins are seen. Fin height is controlled at one locus, and there are only two possible alleles at this locus. If a shark with a tall fin is mated with a shark with a short fin, some matings produce nothing but tall-finned offspring and some matings produce 1/2 tall-finned offspring and 1/2 short-finned offspring. This happens whether the short-finned shark is male or female. This difference could occur because in the first type of mating ..., but in the second type of mating,
a) the tall-finned shark is homozygous ... the tall-finned shark is heterozygous.
b) the tall-finned shark is heterozygous ... the tall-finned shark is homozygous.
c) the fin height locus is autosomal ... the fin height locus is sex-linked.
d) the "tall" allele is recessive ... the "tall" allele is dominant.

35. Off California, the sharks either have tall fins or short fins, but off Australia, an intermediate fin height is found as well. Assuming that fin height is controlled at one locus in both populations and both populations have only two alleles, what could explain these observations?
a) The frequency of the short allele is higher in Australia.
b) The short allele is dominant in California, but recessive in Australia.
c) The short allele is dominant in Australia, but recessive in California.
d) The tall allele in Australia is incompletely dominant.

36. The protein made by the "short" allele differs by only one amino acid from the protein made by the "tall" allele. What does this tell us about the nucleic acid sequences of the short and tall alleles?
a) The nucleotide sequences might be identical.
b) The allele sequences differ by one nucleotide.
c) The sequences might differ by one, two or three nucleotides, but no more than three.
d) The sequences could differ by more than three nucleotides.

37. A researcher is studying the fin height gene with a DNA microarray. The basic principle used by a DNA microarray is that
    a) any gene with a sequence complementary to the injected RNA will be silenced.
    b) the more active a gene is, the more flourescent cDNA will cling to that spot on the microarray.
    c) the only genes that will show up on the microarray will be those that the restriction enzyme could not cut.
    d) any DNA fragements that end with a radioactive nucleotide will be visible on the microarray.

38. After his microarray study, the scientist studies translation of the fin height protein. The best summary of translation is that
    a) mRNA is constructed by complementary base pairing using DNA as a template.
    b) a new strand of DNA is constructed by complementary base pairing using an old strand as a template.
    c) mRNA serves as a template for ordering complementary tRNAs and their attached amino acids.
    d) introns are excised from pre-mRNA to make a shorter mature mRNA.

39. It used to be thought that great white sharks were territorial, and stayed in certain areas. Now, tagging studies have shown that great whites can travel astounding distances. Some sharks from Baja California journey to an area between California and Hawaii for a part of the year and then return, and a South African great white took a year to swim to Australia and back. What effect will these long migrations have on the ability of the worldwide great white population to remain a single species?
    a) Migration will tend to keep the species intact, but only if the migrating sharks mate at these distant locations.
    b) Migration will maintain the species whether or not the sharks mate on their journeys.
    c) The long migrations will encourage the species to break up into genetically distinct subspecies.
    d) Migration (with or without mating) will not have any effect on the cohesiveness of the great white species.

40. While the sharks originated 350 million years ago, the oldest great white fossils come from about 15 million years ago. What was the biological world like 15 million years ago?
    a) The land was dominanted by slow amphibians, but fierce fish predators ruled the seas.
    b) The dinosaurs were at the peak of their development.
    c) It was the Age of Mammals, but there were no humans yet.
    d) Modern man was dispersing out of Africa and spreading over southern Asia.