

6. If species distributions were limited exclusively by temperature, one would expect that:

- A) Ectotherms would have larger geographic ranges than endotherms. ✓
- B) Abundance should be high at the edge of their range and decrease towards the centre. ✓
- C) Abundance should be low at the edge of their range and increase towards the centre. ✓
- D) Endotherms would have larger geographic ranges than ectotherms. ✗
- E) Ectotherms in very specialized habitats would have the largest geographic ranges.

7. Which of the following statements related to non-shivering thermogenesis by brown fat is true?

- A) Low blood flow to brown fat ensures the ADP generated from the oxidation of substrates is not lost through circulation to the extremities.
- B) Uncouples oxidative phosphorylation, and the energy is dissipated as heat rather than producing ATP. ✓
- C) Decreased numbers of mitochondria reduce the efficiency of ADP formation.
- D) Oxidation of substrates occurs without the formation of ADP from ATP.
- E) Increased numbers of mitochondria facilitate the breakdown of substrates to ADP which subsequently drive metabolic processes which contribute to thermogenesis. ✓

8. What do reptiles, monkeys, and brown bears have in common?

- A) They're all polyphyletic. ✓
- B) They're all paraphyletic. ✗
- C) They're all paleophyletic. ✓
- D) They're all poikilophyletic. ✓
- E) They're all periphyletic. ✓

9. Which of the following statements is false about the Cambrian explosion?

- A) It took place around 550 million years ago. ✓
- B) It involved the origin of all major animal and plant groups. ✗
- C) It was preceded by a worldwide glaciation known as "Snowball Earth". ✓
- D) It was closely linked to continental drift. ✗
- E) It was geologically rapid but nonetheless took tens of millions of years. ✓

10. Choose the answer that most accurately completes the following statement:

Plant nutrients in Arctic soils, particularly nitrogen, are available to plants with roots at i) _____, largely because of ii) _____.

- A) i. low rates, ii. extensive symbiotic fixation.
- B) i. high rates, ii. fast microbial decomposition.
- C) i. constant rates, ii. decay of humic layers constrained by low temperatures.
- D) i. high rates, ii. mineralization rates of organic matter constrained by low temperatures.
- E) i. low rates, ii. slow microbial decomposition.

PART TWO – COMPREHENSION

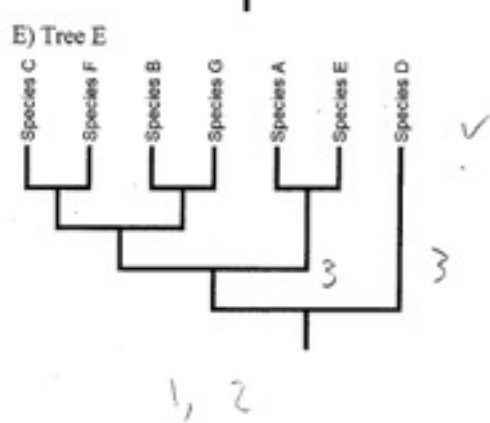
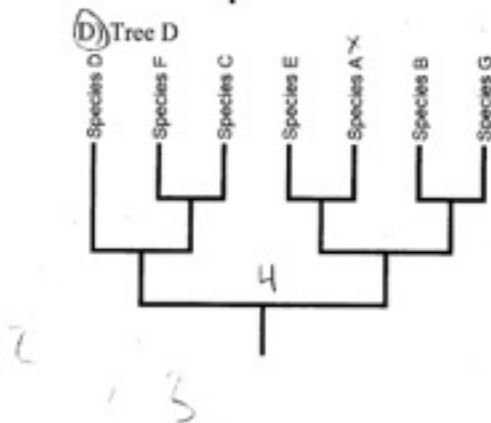
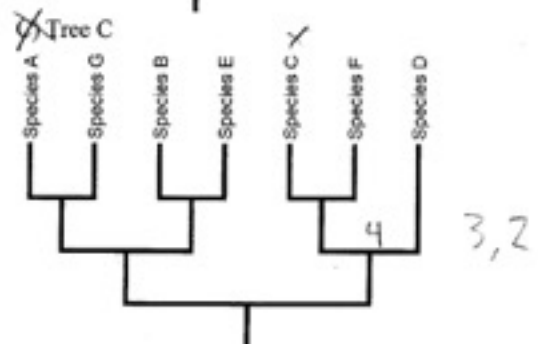
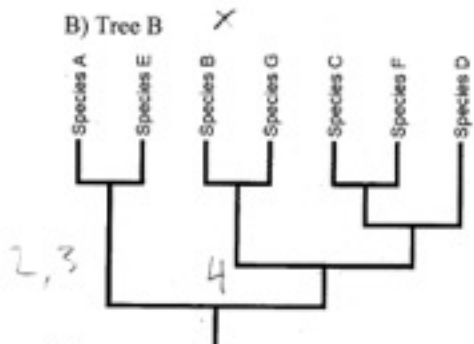
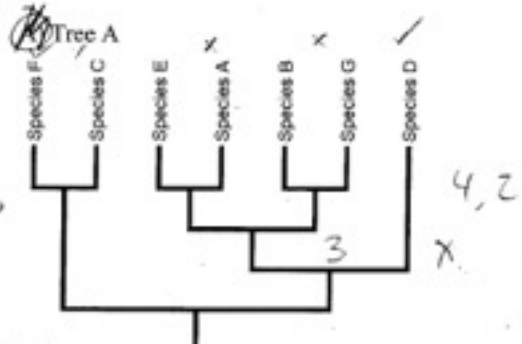
10 questions, 1 mark each

You have conducted an analysis of DNA samples from seven species in order to reconstruct their evolutionary relationships. The results are listed in the box below.

11. Which of the following tree topologies depicts your results?

Results:

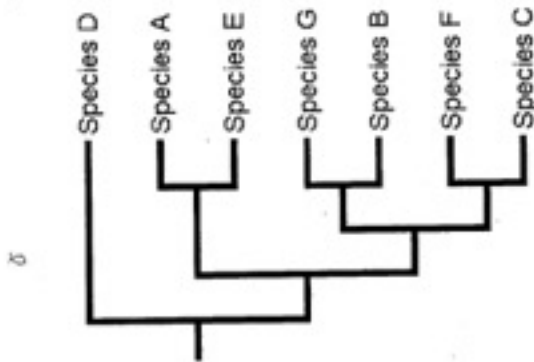
- Species A is sister to species E.
- Species G is sister to species B.
- Species F is sister to Species C.
- Species D is the outgroup to the clade containing Species C and Species F.
- Species A and Species B both share only one common ancestor with Species C.



12. Of the previous phylogenetic trees, which one depicts the closest evolutionary relationship between Species A and Species D?

- A) Tree A
- B) Tree B
- C) Tree C
- D) Tree D
- E) Tree E

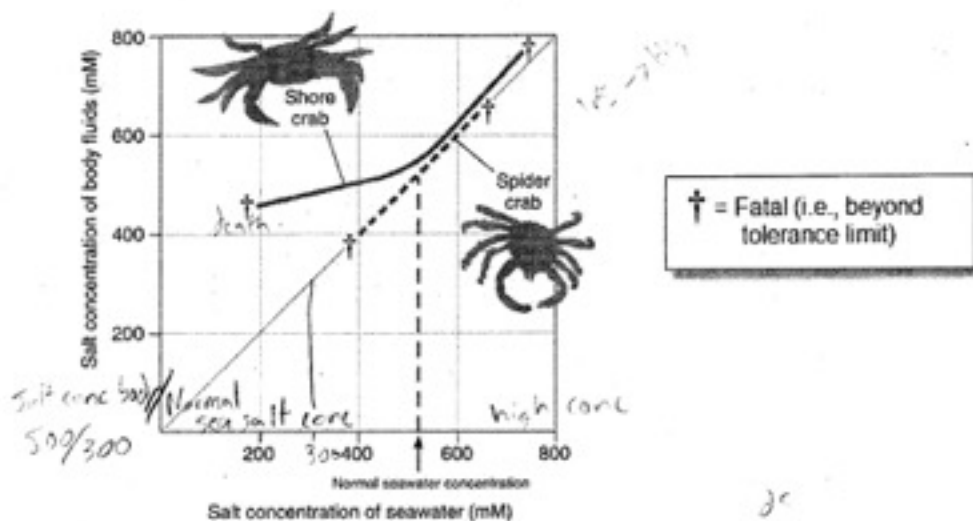
Consider this phylogeny:



13. Which of the previous trees has the same topology as this tree?

- A) Tree A
- B) Tree B
- C) Tree C
- D) Tree D
- E) Tree E

Questions 14-17 refer to the following figure:



14. Which of the following statements is true about this graph?

- A) Spider crabs have a wider tolerance to changes in water salt concentration than shore crabs do. ✗
- B) If both crabs were placed in water with a salt concentration of 300mM, only the shore crab would survive. ✓
- C) If both crabs were placed in water with a salt concentration of 600mM, only the spider crab would survive. ✗
- D) If both crabs were placed in water with a salt concentration of 800mM, only the shore crab would survive. ✗
- E) If both crabs were placed in water with a salt concentration of 400mM, both would have a body fluid salt concentration of 400mM.

15. Spider crabs live in the marine ecosystem only and are:

- A) Osmoregulators that can excrete water and conserve salts. ✓
- B) Osmoregulators that can excrete salts and conserve water. ✗
- C) Osmoconformers because they can expend energy to control internal salt concentration. ✗
- D) Osmoconformers because their fluids always have the same salt concentration as the external environment. ✓
- E) Both A and B.

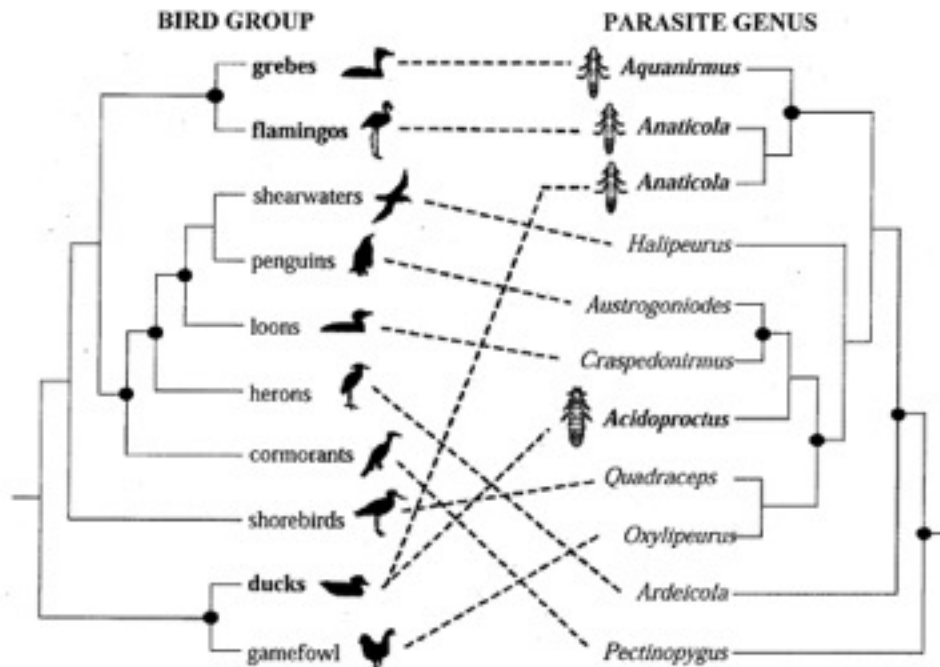
16. Shore crabs live in tidal pools and are:

- A) Osmoregulators that can excrete water and conserve salts. ✓
- B) Osmoregulators that can excrete salts and conserve water.
- C) Osmoconformers because they can expend energy to control internal salt concentration.
- D) Osmoconformers because their fluids always have the same salt concentration as the external environment. ✗
- E) Both A and B.

17. Which of the following statements is most likely to be true about these crabs?

- A) Spider crabs and shore crabs both evolved recently from a freshwater crab ancestor. ?
- B) Spider crabs and their recent ancestors rarely encountered low salt concentrations. ✓
- C) Shore crabs and their recent ancestors rarely encountered low salt concentrations. ✗ ✓
- D) Spider crabs and their recent ancestors rarely encountered salt concentrations higher than normal sea water.
- E) Shore crabs and their recent ancestors rarely encountered salt concentrations higher than normal sea water. ✓

Questions 18-20 refer to the following figures depicting phylogenetic relationships between different groups of birds and their lice parasites.



18. Which of the following statements about this figure is true?

- A) There are no examples of host switching in this figure. ✗
- B) There are no examples of co-speciation in this figure. ✗
- C) There are examples of both host switching and co-speciation in this figure. ✓
- D) Host switching by parasites has involved only closely related groups of host birds.
- E) The most primitive birds (ducks and gamefowl) also have the most primitive parasites.

19. Which hypothesis would you reject as an explanation for the patterns in this figure?

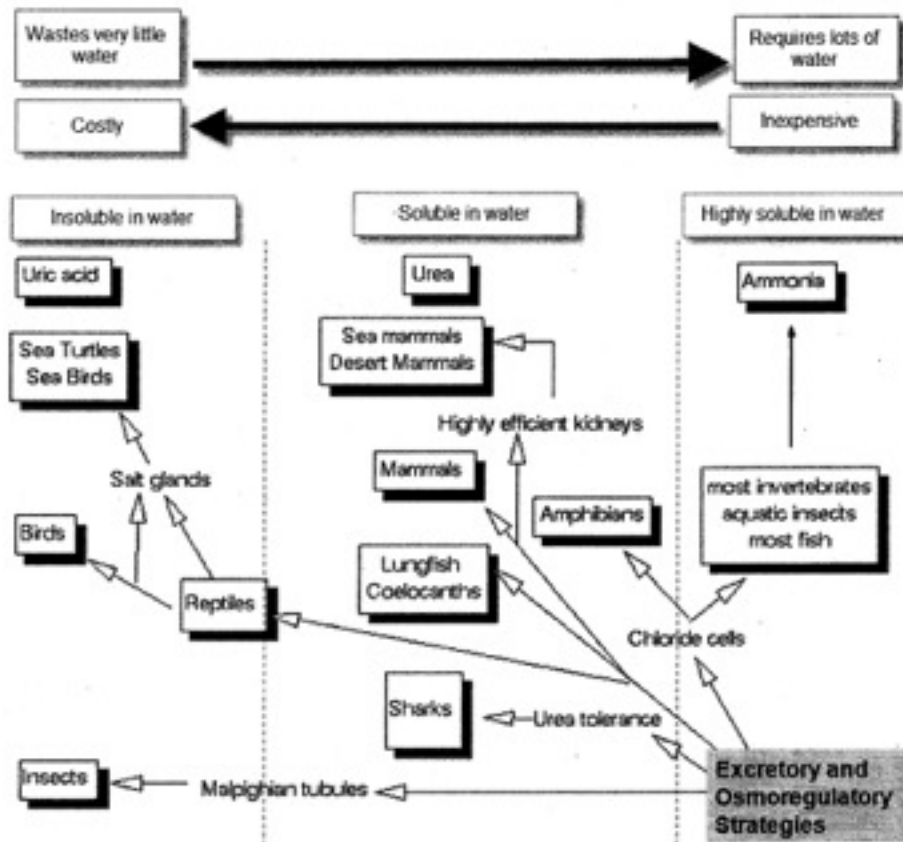
- A) Lice are very specific in which kind of birds' blood they can eat. ✗
- B) These bird groups come into physical contact with each other on occasion. ✓
- C) These bird groups may use the same nest sites at different times. ✓
- D) Lice eggs may be able to survive for some time in the water and then stick to passing birds. ✓
- E) At least some lice genera are quite host-specific. ✓

20. Phylogenetically speaking, which parasites appear to have made the biggest "jump" in host-switching?

- (A) *Anaticola* ✓
- (B) *Acidoproctus* x ✓
- (C) *Austrogoniodes* x ✓
- (D) A and B are equal. ✓
- (E) A, B, and C are equal.

PART THREE – APPLICATION
15 questions, 1 mark each

The following figure summarizes the major strategies of osmoregulation and nitrogenous waste excretion in animals.



21. Choose the answer that most accurately completes the following statement:

Reptiles living in the desert typically excrete nitrogenous wastes as i) _____, largely because it is ii) _____.

- A) i. urea, ii. insoluble and excreted with very little water. ? ←
- B) i. urea, ii. inexpensive to produce when water is limited. ✗
- C) i. uric acid, ii. insoluble and excreted with very little water. ✓
- D) i. uric acid, ii. inexpensive to produce when water is limited.
- E) i. ammonia, ii. highly concentrated in low volumes of water. ✓

22. Which of the following is plausible as an explanation for the fact that not all animals excrete urea?

- A) It is more adaptive to excrete ammonia instead in very dry environments.
- B) It is more adaptive to excrete uric acid instead in marine environments. ✗
- C) Urea excretion requires complex kidneys, which have only evolved in mammals. ✓
- D) Urea excretion is impossible for mammals like whales and seals that live in the water. ✗
- E) Urea excretion is unnecessarily costly in aquatic environments where a less costly alternative is possible. ✗

23. Which of the following statements is most likely to be true?

- A) Aquatic insects have much larger Malpighian tubules than terrestrial insects. ?
- B) Salt glands evolved once in the common ancestor of turtles and birds. ?
- C) Sea mammals are descended from desert mammals. ✗
- D) Highly efficient kidneys in sea mammals and desert mammals represent convergent evolution. ✗
- E) Aquatic birds like penguins excrete ammonia as their main form of nitrogenous waste. ?

Consider the following groups of organisms and their traits:

- i) Earthworm: Annelid, terrestrial (moist habitats and soil), eats decaying organic matter.
- ii) Leech: Annelid, aquatic (freshwater), eats vertebrate blood.
- iii) Polychaete: Annelid, aquatic (marine), eats small invertebrates.
- iv) Slug: Mollusc, terrestrial (moist habitats and soil), eats plant material.
- v) Snail: Mollusc, aquatic (freshwater), eats plant material.

24. Which of these animals are most likely to excrete urea?

- A) i and iii
- B) i and iv ←
- C) ii and v
- D) iii and iv
- E) iii and v

25. Which of these animals probably faces the largest challenge with regard to regulating salt concentration?

- A) The earthworm, because soil is much more saline than sea water. ✗
- B) The leech, because it lives in low salt concentration water but feeds on high salt blood. ?
- C) The polychaete, because its body fluids must remain much more dilute than sea water. ✓
- D) The slug, because too much water is absorbed through its permeable skin. ✗
- E) The snail, because its shell fills with low salt concentration water. ✗

A researcher at Igloolik Station in the mid-Arctic has been recording the number of voles in the area for the past 10 years. Beginning 5 years ago, she noticed a sharp decline in the most common species in the Arctic tundra, Species A, as well as the arrival of another species, Species B, which is normally found only in boreal forests to the south. Here are her recorded data:

	Igloolik Station (Mid Arctic, Tundra)	
	Species A	Species B
Year 1	150	None observed
Year 2	145	None observed
Year 3	147	None observed
Year 4	140	None observed
Year 5	145	None observed
Year 6	95	10
Year 7	84	20
Year 8	71	32
Year 9	62	45
Year 10	52	55

26. Which of the following hypotheses would you reject as a possible explanation of the data from Igloolik Station?

- A) Species B has invaded the tundra and is outcompeting Species A. ✓
- B) Individuals of Species A have emigrated north of Igloolik Station. ✓
- C) Species A is declining for an unknown reason, which opens habitat for Species B. ✓
- D) Dense populations resulted in a localized outbreak of a disease specific to Species A. ✓
- E) A new pollutant appeared in the area that greatly affects vole reproduction. ✗

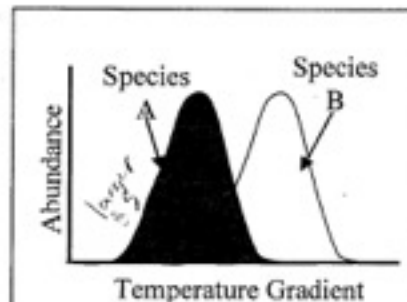
Being a careful researcher, she is not quick to jump to conclusions and contacts her colleagues at Yellowknife Station (Low Arctic) and Devon Station (High Arctic) to obtain their records from the same period.

	Yellowknife Station (Low Arctic, Boreal)		Devon Station (High Arctic, Tundra)	
	Species A	Species B	Species A	Species B
Year 1	None observed	150	122	None observed
Year 2	None observed	170	131	None observed
Year 3	None observed	190	119	None observed
Year 4	None observed	210	128	None observed
Year 5	None observed	220	134	None observed
Year 6	None observed	225	81	None observed
Year 7	None observed	240	65	None observed
Year 8	None observed	260	52	None observed
Year 9	None observed	273	41	None observed
Year 10	None observed	281	33	None observed

27. Which of the following hypotheses remains plausible in light of these additional data from two more research stations?

- A) Species B has invaded the tundra and is outcompeting Species A. ✗
- B) Individuals of Species A have emigrated north of Igloodik Station. ✗
- C) Species A is declining for an unknown reason, which opens habitat for Species B. ✓
- D) Dense populations resulted in a localized outbreak of a disease specific to Species A. ✓
- E) A new pollutant appeared in the area that greatly affects vole reproduction. ✗

Finally, she decides to conduct a transplant experiment by moving individuals of Species B from a boreal forest in the low Arctic to a tundra site in the high Arctic. Upon returning to the site and assessing the number of voles and the temperature where they were found, she observed the following pattern.



28. A close examination of the two species of voles suggests that they differ in some traits. Which of the following is likely to be true?

- A) Species A has a smaller body size. ✗
- B) Species B has a smaller surface area to volume ratio. ✓
- C) Species B has more fat stores. ✗
- D) Species A has thicker fur. ✓
- E) Species B has whiter fur. ✗

29. What kind of interactions might you expect between Species A and Species B at the experimental transplant site?

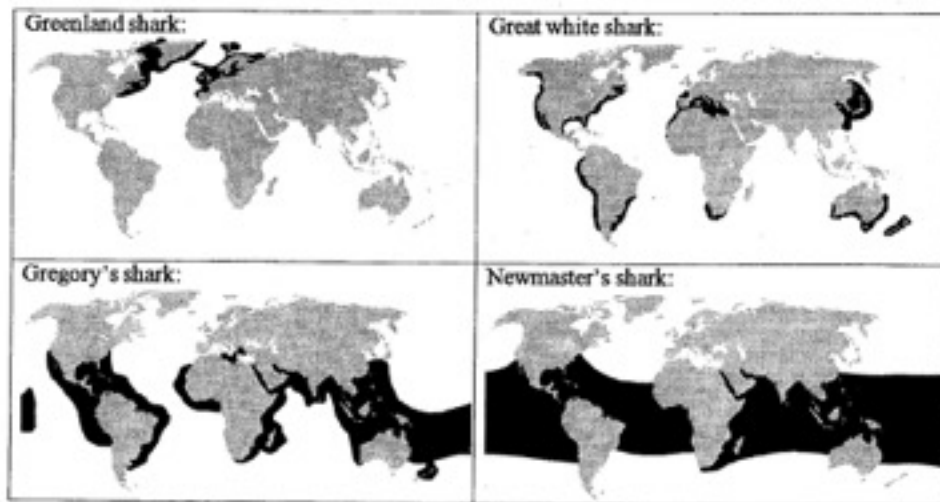
- A) Commensalism. ✗ help
- B) Predation. ✗ kill
- C) Competition. ✗ will
- D) Mutualism. ✓ ✓
- E) Ammensalism. ? under

30. Which of the following is the most likely long-term outcome of this interaction?

- A) ~~B)~~ Species A and Species B will specialize on separate microhabitats. ✓
- B) ~~C)~~ Species A will become much more abundant than Species B. ✗
- C) ~~D)~~ Species B will become much more abundant than Species A. ✗
- D) ~~E)~~ Species A will be extirpated. ✗
- E) ~~F)~~ Species B will be extirpated. ✗

In 2006, a large shark was reported in the St. Lawrence river in Québec. This turned out to be a Greenland shark (*Somniosus microcephalus*), which is normally found in much colder northern Atlantic waters. It is one of the few shark species that occurs in the Arctic. Below are some of this shark's traits, along with those of three other species of sharks. Distribution maps are also provided for each shark species. Use the information provided in the table and figures to answer the questions below.

	Greenland shark	Great white shark	Gregory's shark	Newmaster's shark
Range	North Atlantic, near Greenland, occasionally at mouths of rivers farther south.	Warm coastal surface waters in all major oceans.	Atlantic ocean, river mouths, coastal regions, occasionally deep water.	Tropical and warm temperate oceans.
Size	1000kg	1000kg	150kg	20,000kg
Diet	Mostly fish.	Fish, whales, seals, sea birds.	Slow-moving fish, large crustaceans.	Filter-feeder of plankton.
Activity level	Very sluggish.	Very active.	Active.	Inefficient swimmer.
Reproduction	Internal fertilization and live birth.	Internal fertilization and live birth.	External fertilization of large numbers of eggs.	Internal fertilization and live birth.
Thermoregulation	Very cold tolerant, remains in deep water unless surface is near freezing.	Able to generate heat from muscles and keep heat in blood with special vessels.	Strictly poikilothermic.	Strictly poikilothermic.
Lifespan	200 years	30 years	10 years	70 years
Maximum swimming depth	2100m	1200m	250m	700m
Nitrogenous wastes	Very high urea content in flesh.	Tolerant of urea.	Ammonia excreted via gills.	Tolerant of urea.
Blood salt concentration	550mM	550mM	550mM	550mM



(Black indicates species distribution)

31. Which of the following hypotheses would you consider plausible regarding the current absence of Great white sharks in the Arctic?

- A) They would be outcompeted by polar bears, which also hunt seals. ✗
- B) They can generate heat, but only by swimming vigorously and this is not possible in very cold water. ✗
- C) Their range does not extend near enough to the Arctic for them to ever access the region. ?
- D) There is not enough oxygen in Arctic seas for such active sharks. ✓
- E) They are too large to tolerate cold water. ✗

32. Which of the following statements is true regarding the information provided about the sharks?

- A) At least two of the shark species are able to regulate their blood salt concentrations. ✗
- B) Body size is the major determinant of northern range limits in these sharks. ✓
- C) Large sharks must eat large prey. ✓
- D) Sharks living in coastal regions are incapable of swimming in deep water. ✗
- E) There is probably far less gene flow in Newmaster's shark than in the Great white shark. ✗

33. Which of the following traits of Newmaster's shark would probably be harmful in the Arctic?

- A) Its mode of reproduction. ✓
- B) Its body size. ✗
- C) Its dietary preference. ✗
- D) Its thermoregulatory properties. ✓
- E) Its swimming style. ✗

34. Which of the following traits of Gregory's shark would probably be beneficial in the Arctic?

- A) Its mode of reproduction. γ
- B) Its body size. \checkmark
- C) Its dietary preference. \wedge
- D) Its thermoregulatory properties. \times
- E) Its swimming style. \times

35. Given all of the information at your disposal, which of the following predictions would you consider to be the most plausible if global temperatures continue to rise?

- A) The Great white shark will become more abundant in Canadian waters. \checkmark
- B) Gregory's shark will become abundant in Canadian waters. \times
- C) Newmaster's shark will become abundant in Canadian waters. \checkmark
- D) The Greenland shark will become more abundant in Canadian waters. \times
- E) The Greenland shark will move to Antarctica. \checkmark

BONUS QUESTION

36. If you had a time machine, how far back would you have to travel to meet a Neanderthal?

- A) 300 years
- B) 3,000 years
- C) 30,000 years
- D) 300,000 years
- E) 3,000,000 years

*what the flying
coins?*

HAVE A GREAT HOLIDAY!
