AP® BIOLOGY
2011 SCORING GUIDELINES (Form B)

Question 4

Phylogeny reflects the evolutionary history of organisms.

(a) **Discuss** TWO mechanisms of speciation that lead to the development of separate species from a common ancestor.
(2 points maximum)

Mechanisms that lead to the development of separate species from a common ancestor (1 point each)

- Geographic isolation (or allopatric speciation) takes place when a population of one species becomes physically separated by some geographic barrier such as a river, mountain range, etc. Long-term isolation of two populations eventually leads to reproductive isolation.
- Sympatric speciation happens when new species arise as a result of reproductive isolation within the population range — for example, because of polyploidy or switching mating behaviors (fruit flies going from hawthorn to apple to lay eggs). Eventually the two populations are unable to interbreed.
- Reproductive isolation by prezygotic barriers, such as habitat, temporal, behavioral, mechanical, or gametic incompatibility.
- Reproductive isolation by postzygotic barriers (e.g., reduced hybrid viability or fertility) leads to speciation.

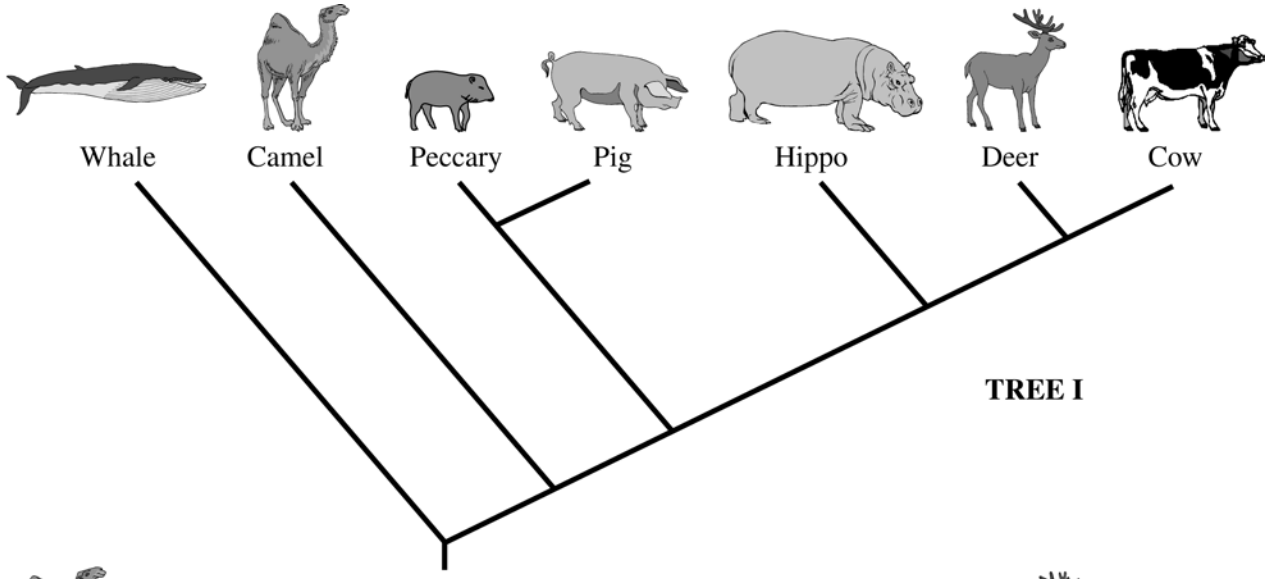
(b) **Explain** THREE methods that have been used to investigate the phylogeny of organisms. **Describe** a strength or weakness of each method.
(6 points maximum)

Response earns 1 point for each method explained and 1 point for either a strength *OR* a weakness.

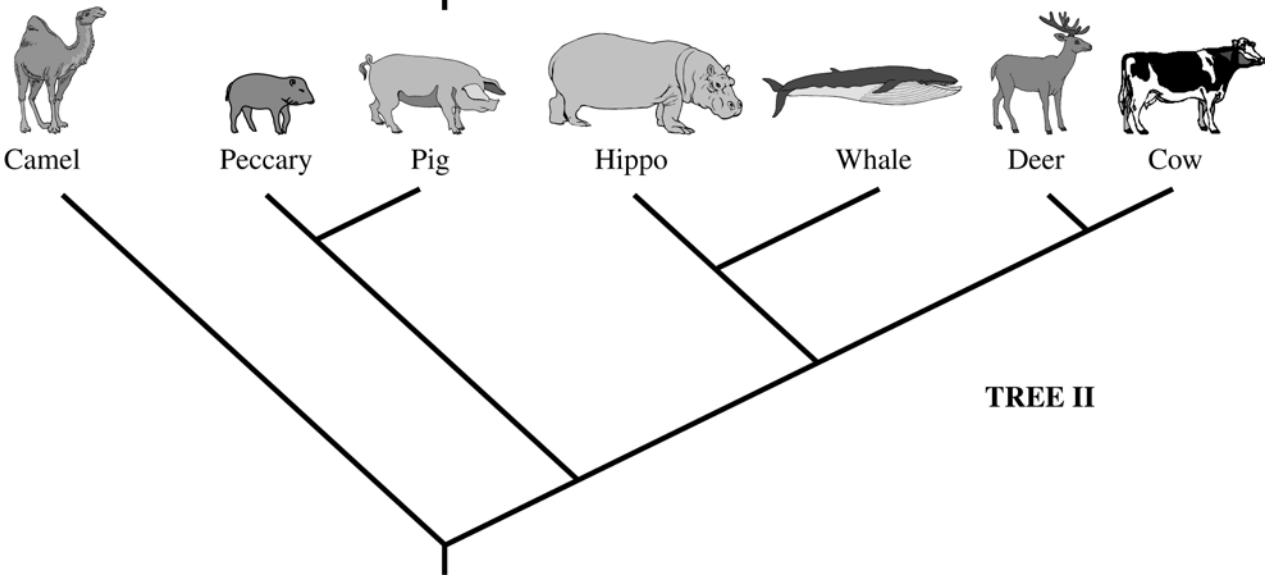
Methods (1 point)	**AND Strengths (1 point)**	**OR Weaknesses (1 point)**
Fossils (paleontology)	Determine time; reveal extinct species.	Not all species leave fossils. Fossil record is incomplete.
Anatomy/morphology	Homologous structures indicate evolutionary relationships.	Analogous structures. Some taxa have little diversity (e.g., bacteria). Some morphology reflects environment or diet.
Embryology/development	Reveals similarities in structures and patterns of development that are not evident in adults.	Similarities between species may be lost in later development.
Molecular traits (amino acid sequence in proteins or base sequence in DNA)	Large numbers of traits. Allow study of evolution between closely related species. Most accurate.	No (or little) data for extinct species. Variation within species blurs differences between species.
Behavioral traits	Some behaviors are genetic (e.g., frog calls).	Behavior maybe culturally transmitted or learned (e.g., bird calls).

Question 4 (continued)

(c) The two phylogenetic trees represent the relationship of whales to six other mammals. All of the organisms shown have a pulley-shaped astragalus bone in the ankle except for the whale.



TREE I



TREE II

AP® BIOLOGY
2011 SCORING GUIDELINES (Form B)

Question 4 (continued)

DATA ON PRESENCE OF SPECIFIC DNA SEQUENCES

+ sequence present
– sequence absent
? undetermined

Locus	1	2	3	4	5	6	7	8	9	10	11	12	13
Cow	–	–	–	–	–	+	+	+	+	+	+	+	–
Deer	–	–	–	–	–	+	?	+	+	+	+	+	–
Whale	+	+	+	+	+	–	?	+	+	–	?	+	–
Hippo	?	–	+	+	+	–	+	+	+	–	?	+	–
Pig	–	–	?	–	–	–	?	–	?	–	–	+	+
Peccary	?	?	?	?	?	?	?	?	?	?	?	?	+
Camel	–	–	–	–	–	–	–	–	–	–	–	–	–

- For each tree, **describe** a monophyletic group, the closest relative to the whale, and the point at which the pulley astragalus was lost or gained.
  (3 points maximum)

  - Correctly identifying a monophyletic group in *BOTH* Tree I and II (a number of correct possibilities) or correctly defining a monophyletic group as a species and all of its descendants. **(1 point)**
  - Correctly identifying the camel as the closest relative to the whale in Tree I *AND* the hippo in Tree II. **(1 point)**
  - Stating that the gain of the pulley astragalus bone in Tree I occurs between the whale and the camel, *OR* that the loss of the bone occurs on the line to whales, *AND* that the loss of the pulley astragalus bone in Tree II occurs between the common ancestor of the hippo and the whale. **(1 point)**

- Based on the principle of parsimony (the simplest explanation is the best) and the genomic information in the table shown, **identify** which tree is the best representation of the evolutionary relationship of these animals, and **justify** your answer.
  (1 point maximum)

Identification of correct tree	**Justifications include but are not limited to**
Tree II	• The camel is the out-group, with none of the 13 sequences. • The peccary and pig have the fewest sequences, but they are similar. • The deer and cow share the same half of the 13 sequences. • The whale and hippo have a similar pattern of DNA sequences.

Note: No point is earned for using the pulley astragalus bone to justify Tree II, nor for discussing common environments, body shapes, or feeding habits.

4A,

4. Phylogeny reflects the evolutionary history of organisms.

(a) **Discuss** TWO mechanisms of speciation that lead to the development of separate species from a common ancestor.

(b) **Explain** THREE methods that have been used to investigate the phylogeny of organisms. **Describe** a strength or weakness of each method.

(c) The two phylogenetic trees represent the relationship of whales to six other mammals. All of the organisms shown have a pulley-shaped astragalus bone in the ankle except for the whale.

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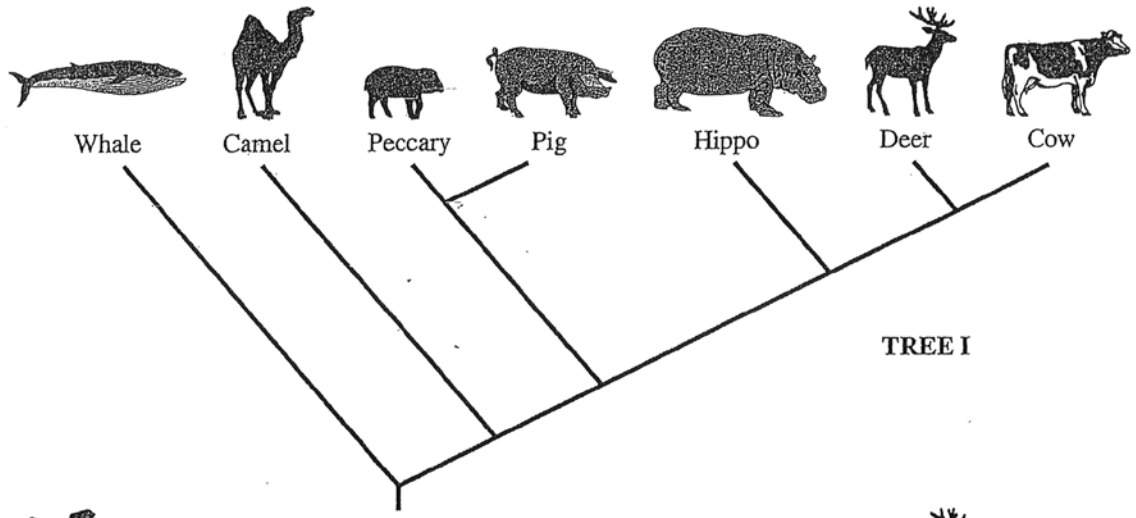
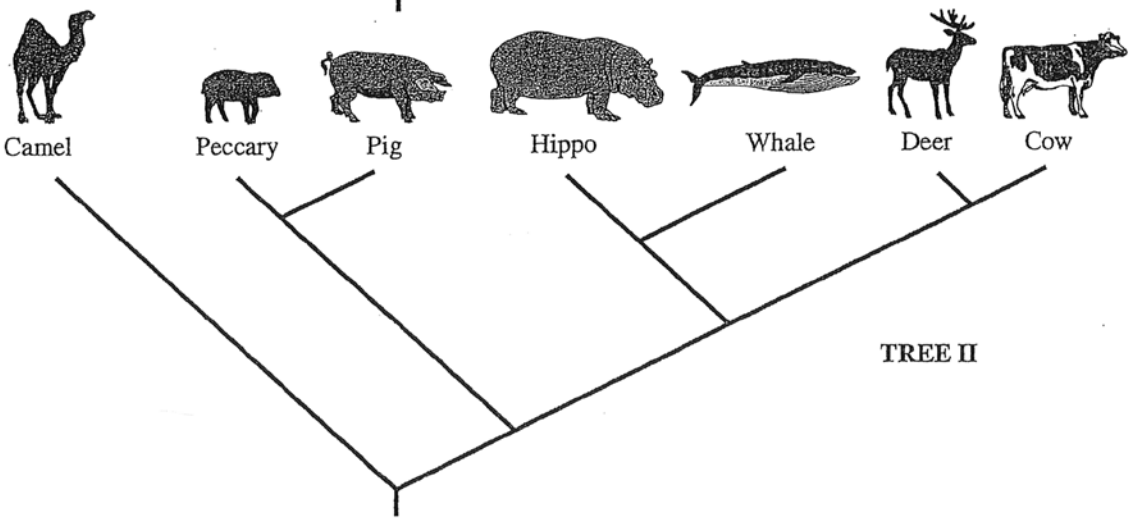


TREE I



TREE II

GO ON TO THE NEXT PAGE.

4A2

DATA ON PRESENCE

OF SPECIFIC DNA SEQUENCES

+ sequence present
– sequence absent
? undetermined

Locus	1	2	3	4	5	6	7	8	9	10	11	12	13
Cow	–	–	–	–	–	+	+	+	+	+	+	+	–
Deer	–	–	–	–	–	+	?	+	+	+	+	+	–
Whale	+	+	+	+	+	–	?	+	+	–	?	+	–
Hippo	?	–	+	+	+	–	+	+	+	–	?	+	–
Pig	–	–	?	–	–	–	?	–	?	–	–	+	+
Peccary	?	?	?	?	?	?	?	?	?	?	?	?	+
Camel	–	–	–	–	–	–	–	–	–	–	–	–	–

a) It is possible that there was a geographic barrier that developed between the organisms of the ~~spec~~ species. This may cause them to adapt differently in order to survive in their environment. Another mechanism of speciation is the adaptation ~~to~~ of a species to its particular ecological niche. The organisms may find themselves having to adapt and evolve in order to survive from a predator or to take advantage of a resource.

b) Comparative Analogy is a method used to study phylogeny. It is the studying of Organism's anatomy to seek similarities between species. A fault in using this method is the case of convergent evolution. Two species may not be related, but they developed simular anatomy of characteristics due to

GO ON TO THE NEXT PAGE.

4A3

being in similar ecological niches. Comparitwe Analogy would not be able to detect this. Another method is looking at DNA sequences. By comparing DNA, scientists can look for similarities and determine the history of the species that way. A strength of this method is that it is very reliable and specific. looking at DNA sequences is something concrete. A third way to study phylogeny is by embryology or the study of the embryos of organisms. Many organisms are very similar in the early stages of life However, there are some differences that occur. looking at these differences can help study and determine the phylogeny of an animal ~~of organism~~. A fault of this would be that you could only use this method for animals that develop ~~from~~ from an embryo.

c) A monophyletic group of tree 1 is the ~~peo~~ peccary and pig and their progenitor. A monophyletic group contains an ancestor and all of its "children". The peccary and pig both evolved from one species as indicated ~~by~~ by tree 1, making it a monophyletic group. The closest relative to the whale in tree 1 is the camel. It is closest to the whale and the diagram indicates that ~~is~~ it has gone through the least changes. Since the whale does not have a pulley astragalus, ~~it~~ it would have been gained at the existence of the camel in tree one. The camel ~~we~~ evolved the earliest after the whale, so it is the first with the pulley astragalus. In tree 2, ~~a pi mo~~ the deer and cow make up a monophyletic

4A

group. The closest relative to the whale would be the hippo in tree 2. This is because they evolved from the same ancestor. They would have the most in common. Their ancestor is different from the other ~~student~~ animals' ancestors. This makes them the closest. The pulley astragal was lost at the whale once it evolved off the ancestor which also produced the hippo.

Tree 2 would be the best representative of the evolutionary relationships ~~betwee~~ among the animals. Taking genomic information into account, the deer and cow, whale and hippo, pig and peccary ~~wei~~ had many sequences in common. The camel however ~~was~~ had no sequences in common with any of the animals. This supports the phylogeny tree number 2.

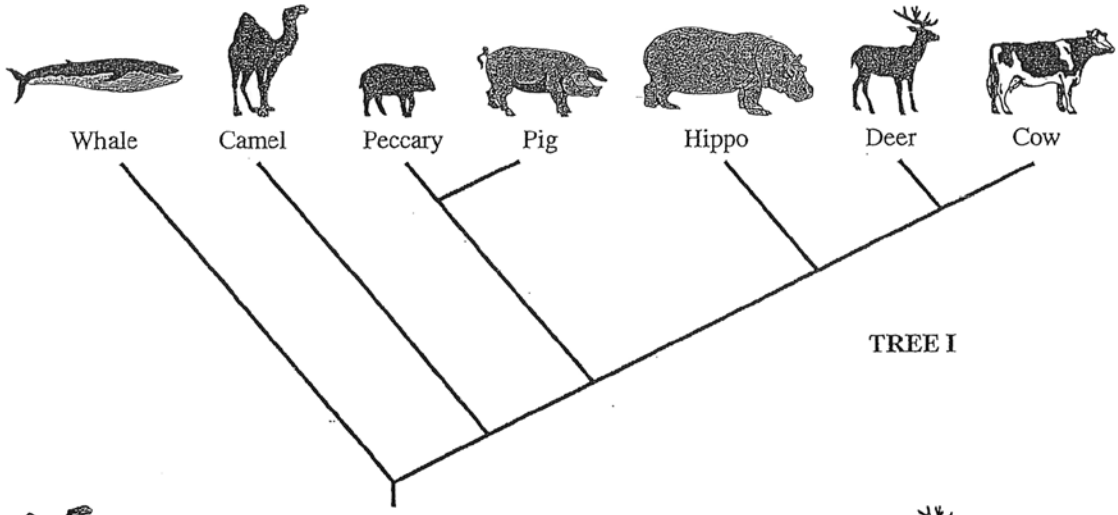
4. Phylogeny reflects the evolutionary history of organisms. 4B,

(a) **Discuss** TWO mechanisms of speciation that lead to the development of separate species from a common ancestor.

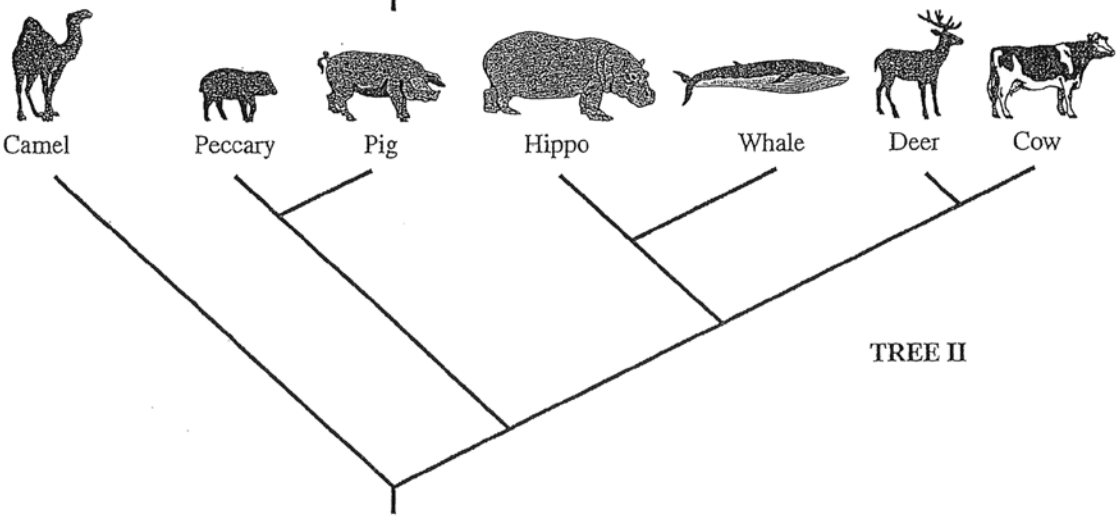
(b) **Explain** THREE methods that have been used to investigate the phylogeny of organisms. **Describe** a strength or weakness of each method.

(c) The two phylogenetic trees represent the relationship of whales to six other mammals. All of the organisms shown have a pulley-shaped astragalus bone in the ankle except for the whale.

- For each tree, **describe** a monophyletic group, the closest relative to the whale, and the point at which the pulley astragalus was lost or gained.
- Based on the principle of parsimony (the simplest explanation is the best) and the genomic information in the table shown, **identify** which tree is the best representation of the evolutionary relationship of these animals, and **justify** your answer.



TREE I



TREE II

GO ON TO THE NEXT PAGE.

4B2

DATA ON PRESENCE

OF SPECIFIC DNA SEQUENCES

+	sequence present
–	sequence absent
?	undetermined

Locus	1	2	3	4	5	6	7	8	9	10	11	12	13
Cow	–	–	–	–	–	+	+	+	+	+	+	+	–
Deer	–	–	–	–	–	+	?	+	+	+	+	+	–
Whale	+	+	+	+	+	–	?	+	+	–	?	+	–
Hippo	?	–	+	+	+	–	+	+	+	–	?	+	–
Pig	–	–	?	–	–	–	?	–	?	–	–	+	+
Peccary	?	?	?	?	?	?	?	?	?	?	?	?	+
Camel	–	–	–	–	–	–	–	–	–	–	–	–	–

Two mechanisms of speciation that lead to the development of separate species from a common ancestor may be geographical isolation which may result from a great natural phenomenon such as a storm. The isolation of the species may lead to adapting to different environments due to the isolation. An example is the finches of Galapagos Islands and their beak sizes which are adapted to different food/seed sizes. Another speciation may be mutation and natu selection in which a particular phenotype is favored by the environment over another.

Three methods used to investigate the phylogeny of organisms include molecular

GO ON TO THE NEXT PAGE.

4B3

comparison (when the sequences of DNA are compared), anatomical comparison which compares the structure of different organisms (such as limbs or the presence of a bone) which can conclude the species having a common ancestor, and embryology when the embryo development of the species are compared. For example, homologous structures may be a clue to a common ancestor and the presence of gill-like structures in many organisms are also indicators of a common ancestor.

In tree one (Tree I), the closest relative to the whale is not described because because the whale is equally connected to the other organisms A monophyletic group in the tree (I) is the [illegible] peccary and the pig. It seems as if the astragalus was lost starting with the camel. In Tree II, a monophyletic group is the hippo and the whale. The closest relative of the whale according to this tree is the hippo. It seems the astragalus was lost with the camel.

Tree two (II) is the best representation of the evolutionary relationship according to the genetic information provided. The whale has 8 sequences in common with the hippo along with the mystery/undetermined characteristic of

4B4

locus 11. On the second tree, this is represented because the whale and the hippo are represented as the closest relatives.

4C.

4. Phylogeny reflects the evolutionary history of organisms.

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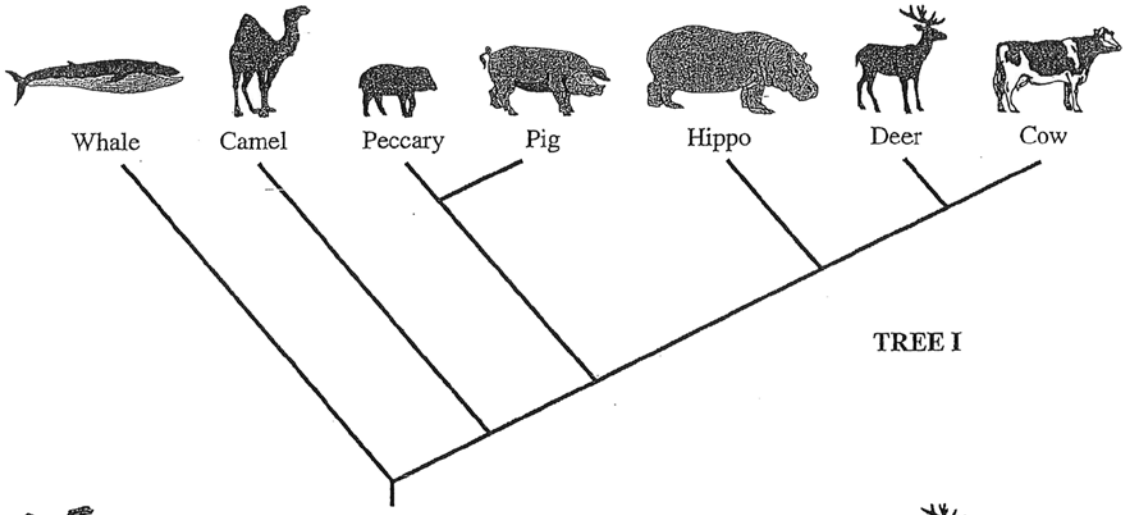
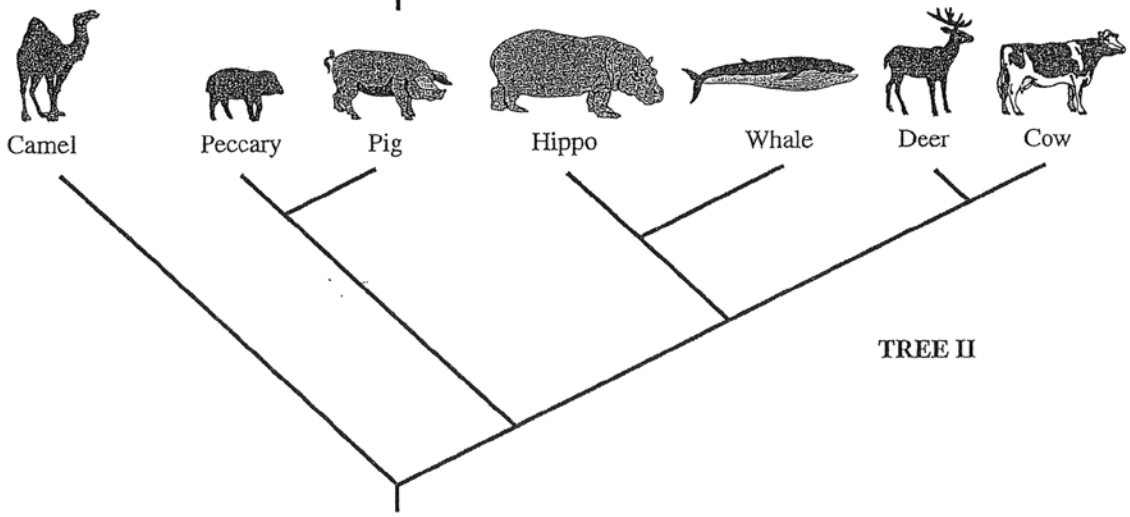


TREE I



TREE II

GO ON TO THE NEXT PAGE.

4 C2

DATA ON PRESENCE

OF SPECIFIC DNA SEQUENCES

+ sequence present
– sequence absent
? undetermined

Locus	1	2	3	4	5	6	7	8	9	10	11	12	13
Cow	–	–	–	–	–	+	+	+	+	+	+	+	–
Deer	–	–	–	–	–	+	?	+	+	+	+	+	–
Whale	+	+	+	+	+	–	?	+	+	–	?	+	–
Hippo	?	–	+	+	+	–	+	+	+	–	?	+	–
Pig	–	–	?	–	–	–	?	–	?	–	–	+	+
Peccary	?	?	?	?	?	?	?	?	?	?	?	?	+
Camel	–	–	–	–	–	–	–	–	–	–	–	–	–

Two mechanisms of speciation are natural selection and evolution. Natural selection is the idea that only the strong survive. This means that each generation must pass on a new trait. For example a longer neck. This would make it easier to reach leaves on the top of the tree. ~~It~~ Each generation is stronger and has new traits it is different from the ancestor. Through evolution a species may change entirely. reptiles are a good example of evolution. The ~~gills~~ lungs allow them to live in water and on land.

One method used to investigate phylogeny of organisms is the fossil record. The downfall of using this record is the age may not be accurately determined. Through the fossil record we can see structural changes

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4C3

ADDITIONAL PAGE FOR ANSWERING QUESTION 4

that a species ~~was~~ went through over time. Another method is the study of DNA. Scientists can see mutations at the cellular level when looking at DNA. Through DNA scientists can determine and even replicate a species. The last method is to look at similar structures called Homologus structures. An example of this is bone structure.

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AP® BIOLOGY
2011 SCORING COMMENTARY (Form B)

Question 4

Sample: 4A
Score: 10

In part (a) 1 point was earned for discussing how a geographic barrier allowed "organisms of the species" to adapt differently.

In part (b) 1 point was earned for explaining the method of comparative anatomy. The response earned a another point for clearly stating the weakness of this method. One point was earned by explaining that DNA sequences could provide information on evolutionary history, and 1 more point was earned for describing the strength of this method as its specificity. One point was also earned for explaining the study of embryos, but no additional point was earned for considering a strength or weakness of this method, as all animals have an embryo.

The response earned the maximum of 4 points in part (c). One point was earned for correctly describing monophyletic groups in Tree I (peccary and pig), and Tree II (deer and cow). Similarly, 1 point was earned for naming the nearest relatives of the whale in Tree I (camel) and Tree II (hippo). Likewise, the response earned 1 point for describing the loss or gain of the pulley astragalus bone in both trees. One point was earned for noting the commonality in DNA sequences for three pairs of species. One additional point could have been earned for noting that the camel has no sequences in common with any of the other animals, but the maximum of 4 points had already been earned in this part.

Sample: 4B
Score: 7

In part (a) the response earned 1 point for the discussion of geographic isolation.

In part (b) 1 point was earned for describing "molecular comparison (when the sequences of DNA are compared)." Another point was earned for describing "anatomical comparison which compares the structure of different organisms," and 1 point was also earned for naming the use of "homologous structures" as a strength of this technique. One more point was earned for describing the "embryo development of the species … compared."

In part (c) 1 point was earned for correctly identifying monophyletic groups in both Tree I and Tree II, and 1 point was earned for a good justification of why Tree II is the best representation of the DNA sequence table.

Sample: 4C
Score: 3

No points were earned in part (a) because the response does not address mechanisms of speciation.

In part (b) the response earned 3 points for explaining the use of "the fossil record," "the study of DNA," and the consideration of "similar structures called Homologus [*sic*] structures" to investigate the phylogeny of organisms.

Part (c) is not attempted.