IB · DP · Biology

🕐 2 hours　　❓ 15 questions

Structured Questions: Paper 2

5.2 Classification & Cladistics

Easy (5 questions)	/34
Medium (5 questions)	/44
Hard (5 questions)	/44
Total Marks	**/122**

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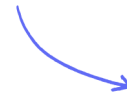
Easy Questions

1 (a) The gray wolf (*Canis lupus*) and the coyote (*Canis latrans*) are both predators occurring across large parts of North America. Coyotes are smaller than gray wolves and its diet consists of a variety of smaller prey animals, such as hares, rodents, birds and reptiles, while gray wolves hunt larger prey such as deer, elk and moose.

State the genus and species name of the gray wolf and the coyote.

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(2 marks)

(b) Organisms are grouped into different taxonomic groups, the largest of which is known as the domain.

Identify the domain to which the gray wolf and coyote belong to.

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(1 mark)

(c) List **two** features of all organisms that belong to the domain identified in part b).

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(2 marks)

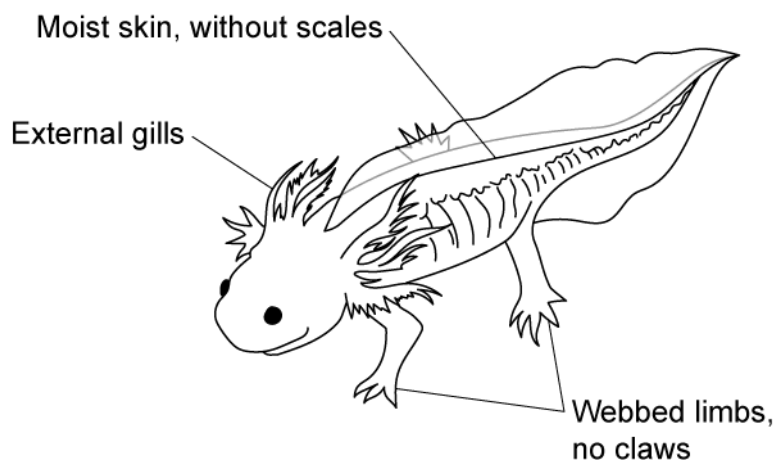**(d)** The grouping of the gray wolf and coyote is an example of natural classification which can be challenging to carry out accurately.

State **one** technological development that has enabled natural classification to be done more accurately.

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(1 mark)

2 (a) Study the following diagram showing some features of specimen **A**.

Use the dichotomous key below to identify the class that specimen **A** belongs to.

1	Four limbs are present...	Go to 2
	Four limbs are absent..	Go to 3
2	External ear flap is absent..	Go to 3
	External ear flap is present...	Mammalia
3	Gills are present..	Go to 4
	Gills are absent, lungs are present..	Go to 5
4	Dorsal fins are present...	Fish
	Dorsal fins are absent..	Go to 6
5	Feathers and a beak are present..	Birds
	Feathers and a beak are absent...	Go to 6
6	Moist, smooth skin...	Amphibian
	Dry, scaly skin..	Reptile

(1 mark)

(b) Specimen **A** is classified by using a natural classification system.

Define the term 'natural classification'.

(2 marks)

(c) Natural classification can be very useful in conducting research in the field of biodiversity.

List **two** advantages of natural classification systems.

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(2 marks)

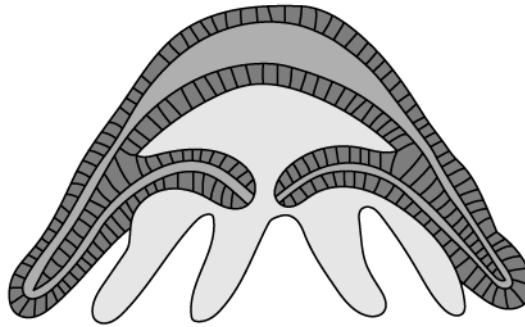**(d)** Sometimes developments in cladistics will lead to the reclassification of organisms.

State **one** example of reclassification.

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(1 mark)

3 (a) The following diagram shows an organism that belongs to the phylum *Cnidaria*.

    (i)   State the type of symmetry that is demonstrated by this organism.

[1]

    (ii)   List **one other** visible feature that is unique to phylum *Cnidaria*.

[1]

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(2 marks)

(b) The phylum *Cnidaria* includes a wide range of different organisms.

List **two** examples of organisms that would belong to this phylum.

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(2 marks)

(c) State the way in which the organism shown in the diagram at part a) would be able to obtain food.

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(1 mark)

4 (a) Study the following cladogram showing the evolutionary relationship between different mammalians.
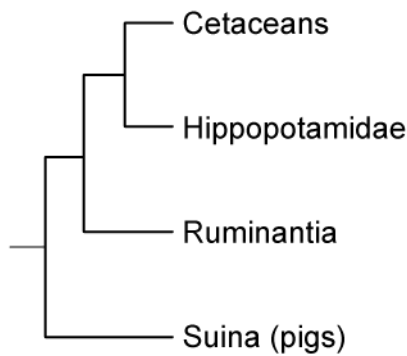
Identify the mammalians that are the most closely related according to this cladogram.

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(1 mark)

(b) State the purpose of the nodes in the cladogram.

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(2 marks)

(c) Identify the mammalian group that were the first to branch off and form an independent group from the others.

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(1 mark)

5 (a) *One mark is available for clarity of communication throughout this question.*

State the conventions that should be used when writing binomial names.

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(3 marks)

(b) Differences in the base sequences of DNA and amino acid sequences of proteins can be used by scientists as a molecular clock.

Outline how differences in the base sequences of DNA can be used as a molecular clock.

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(3 marks)

(c) Coniferophytes are commonly known as conifers and are usually tall trees.

List the main features of Coniferophytes.

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(7 marks)

Medium Questions

1 (a) The common dogwood, *Cornus sanguinea*, is a broadleaved shrub of the family Cornaceae native to Europe and Western Asia. Some of the classification of the common dogwood is shown in the table below.

Kingdom	Plantae
(i)	
Class	Dicotyledonae
(ii)	Cornales
Family	(v)
(iii)	(vi)
(iv)	(vii)

Identify taxa (i)-(vii) from the table above. Note that one box has been left intentionally blank; you do **not** need to identify the taxon from the blank box.

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(2 marks)

(b) *Cornus canadensis* and *Cornus nuttallii* are similar in appearance and are both found across North America.

With the exception of breeding them together, state **two** ways in which scientists could determine that these dogwood varieties are two separate species.

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(2 marks)

(c) The image below shows an illustration of *Cornus canadensis.*

Identify, with a reason, the phylum to which *C. canadensis* belongs.

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(2 marks)

(d) Dogwood species are identified by the use of binomial names such as *Cornus canadensis* and *Cornus nuttallii*.

State the purpose of the binomial system of naming organisms

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(1 mark)

2 (a) Specimen **A** and specimen **B** are similar species of invertebrate.

Scientists wanted to determine whether specimen **A** and **B** are different species of invertebrate, or different forms of the same species.

In order to do this they caught large numbers of each specimen type and measured the body mass and length of each individual before calculating the means and standard deviations (SD). Their results are shown in the table below.

	Specimen A	Specimen B
Mean mass / g (± SD)	0.68 (±0.02)	0.67 (±0.01)
Mean body length / mm (± SD)	21.4 (±0.9)	19.2 (±0.7)

Explain how the standard deviation can help with the interpretation of this data.

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(2 marks)

(b) The scientists hypothesised that the two specimens were different forms of the same invertebrate species.

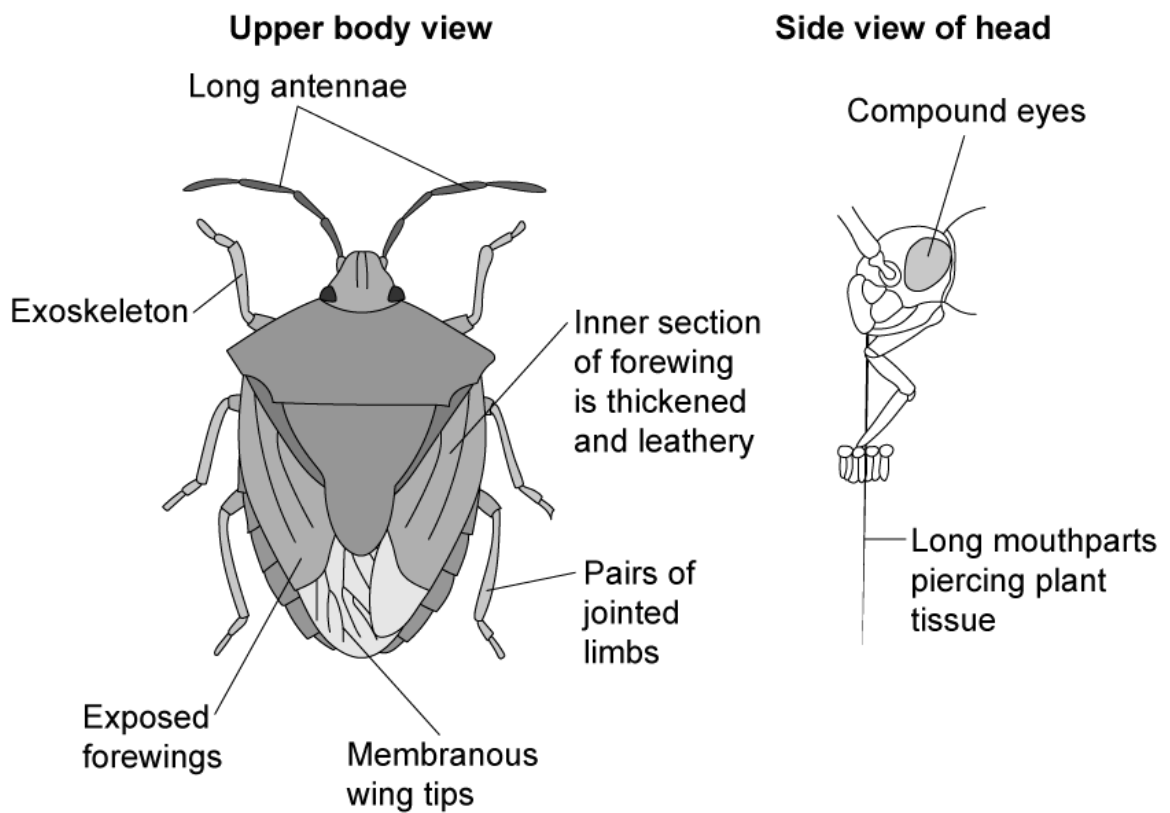Evaluate this hypothesis using the data in the table part (a).

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(3 marks)

(c) The appearance of specimen **A** is shown in the image below.

Upper body view

Long antennae

Exoskeleton

Inner section
of forewing
is thickened
and leathery

Pairs of
jointed
limbs

Exposed
forewings

Membranous
wing tips

Side view of head

Compound eyes

Long mouthparts
piercing plant
tissue

Use the dichotomous key below to deduce the order to which specimen **A** belongs.

1	Hard wing cases cover forewings.	Coleoptera
	Hard wing cases absent.	Go to 2
2	Partially leathery forewings.	Go to 3
	Entirely membranous forewings.	Go to 4
3	Mouthparts adapted for sucking	Hemiptera
	Mouthparts adapted for biting.	Orthoptera
4	Wing pairs of roughly equal size.	Hymenoptera
	One pair of wings much larger than the other..	Diptera

(1 mark)

(d) Use information provided in part (c) to identify, with a reason, the animal phylum to which specimen **A** belongs.

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(2 marks)

3 (a) Cytochrome c is a respiratory protein consisting of roughly 100 amino acids while haemoglobin is a quaternary protein found in red blood cells consisting of over 400 amino acids.

Suggest, with a reason, which of these two proteins is a better choice for use in identifying evolutionary relationships across plantae, fungi and animalia.

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(2 marks)

(b) Explain how biochemical sequence analysis, as opposed to other methods of classification, ensures that natural classification is carried out.

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(1 mark)

(c) Scientists studied the amino acid sequence of cytochrome c in five different animals. The amino acid sequence was compared with **human** cytochrome c and the number of differences to the human sequence were recorded. The results are shown in the table below.

Animal	Number of differences in the amino acid sequence compared with human cytochrome c
Human	0
Dog	11
Duck	11
Turtle	15
Monkey	1
Pig	10

State, with a reason, **one** conclusion that can be reached from the data in the table above about the relationship of humans to other animals.

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(2 marks)

(d) An assistant who looked at the results in the table in part (c) suggested that dogs were more closely related to ducks than to any of the other animals.
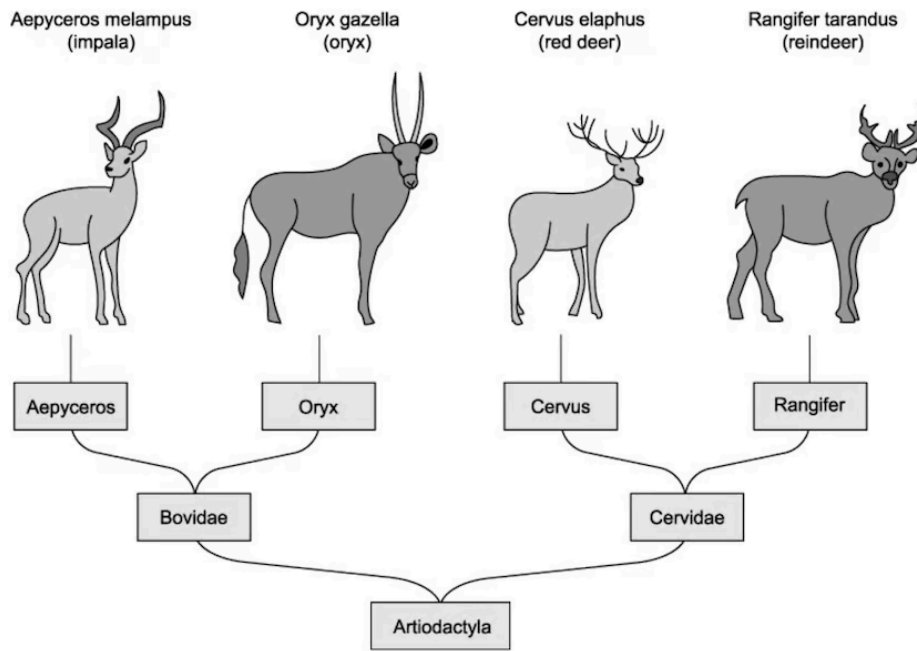
State, with a reason, whether or not the student's suggestion is valid.

(2 marks)

4 (a) The image below shows the classification of some animals with antlers and horns.

State the number of different orders that are present in the image above.

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(1 mark)

(b) Compare and contrast the sciences of taxonomy and cladistics.

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(2 marks)

(c) Deer are members of the suborder (a smaller division within an order) ruminantia, which are themselves members of the order artiodactyla. The relationships between the

artiodactyla are shown on the cladogram below. * denotes a now extinct taxon.
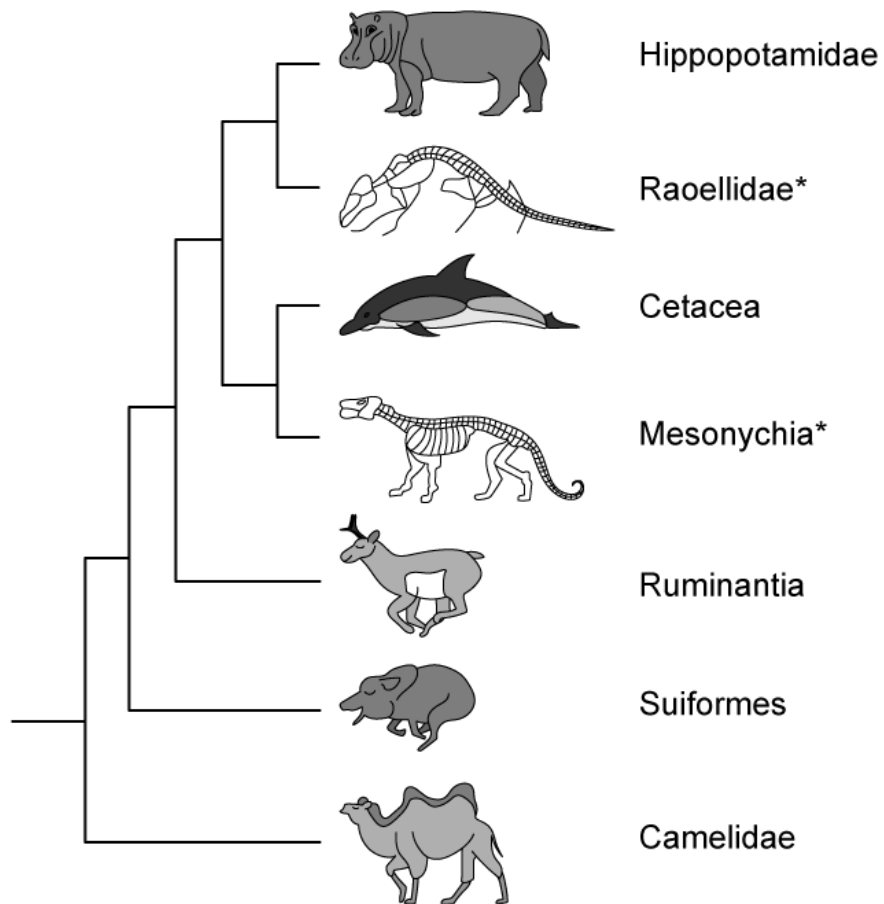
Identify, with a reason, an example of the closest evolutionary relationship shown in the cladogram.

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(2 marks)

(d) A student reading the cladogram in part (c) identified the ruminantia as a clade.

Explain why the student was incorrect in their identification of the ruminantia as a clade.

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(2 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Describe the features of archaea that mean they are classified as a distinct domain in the three domains system of classification.

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(3 marks)

(b) Compare and contrast phylum annelida and phylum platyhelminthes.

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(7 marks)

(c) Outline the reclassification of the scrophulariaceae, or figwort family.

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(5 marks)

Hard Questions

1 (a) *Ailuropoda melanoleuca*, the giant panda, and *Ailurus fulgens*, the red panda, are both native to China. They share the following similarities:

- They live in similar environments
- They both digest bamboo as a primary source of food
- They both have a pseudo-thumb (a sixth digit) used to grip and shred food such as bamboo

The following table shows the differences between a comparable sequence of mitochondrial DNA of the giant panda and the red panda.

Mammal	DNA sequence
Giant panda	ATT GGA GCA GAC TTA
Red panda	ATT GGC ACT GAC CTA

A group of students concluded that the giant panda and the red panda are closely related.

Use the information provided to evaluate this conclusion.

(3 marks)

(b) After careful deliberation, the group of students decided that the giant panda and red panda were, in fact, not closely related.

Suggest an explanation for the existence of a pseudo-thumb in both species.

(2 marks)

(c) The base sequence of a different section of mitochondrial DNA (mtDNA) were analysed to determine the differences between giant panda and red panda DNA. In total, there were eight differences between the mtDNA of the two species.

Mitochondrial DNA is estimated to mutate at a rate of 1.87×10^{-7} mutations site^{-1} year^{-1}. Use the information given to calculate how long ago the giant panda and the red panda evolved from a common ancestor. Show your working and round your answer to three significant figures.

(2 marks)

(d) Explain the difference between a taxon and a clade.

(2 marks)

2 (a) Cetaceans are an order of carnivorous aquatic mammals which include dolphins, whales and porpoises. The following diagram shows two proposals that have been put forward regarding the closest living relative of the cetaceans, represented by diagrams **R** and **S**.
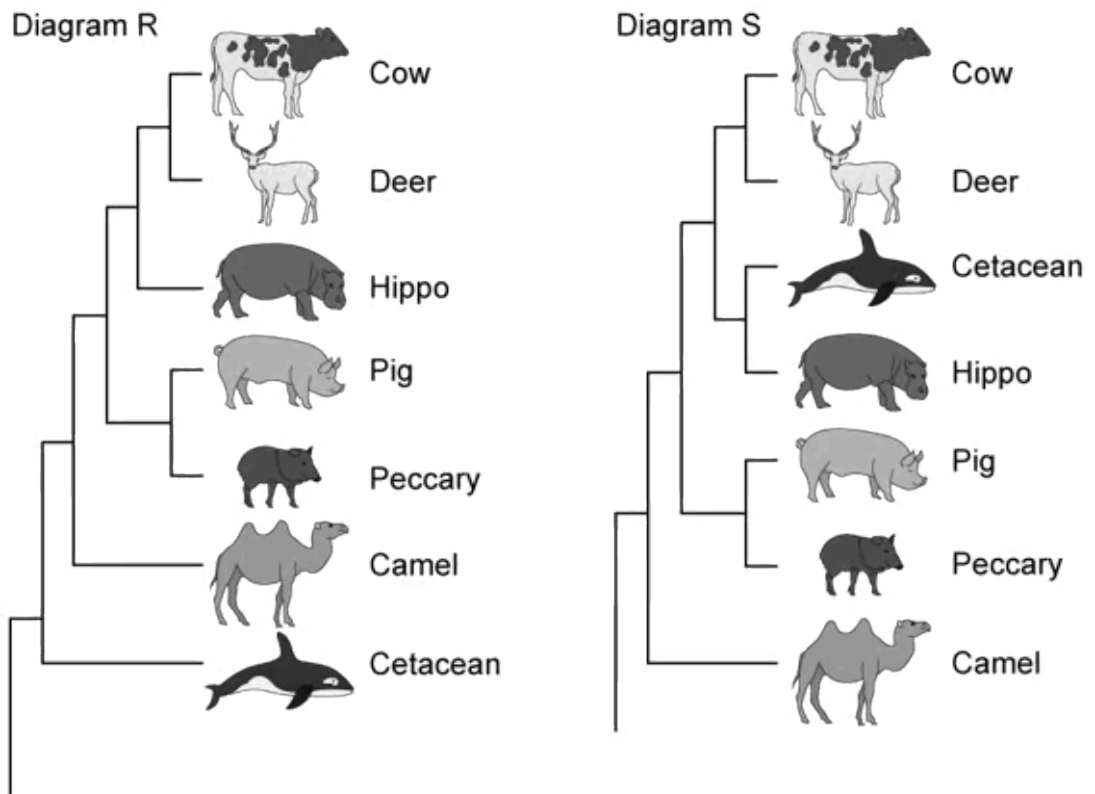
Compare and contrast the information in diagrams **R** and **S**.

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(4 marks)

(b) Casein is a protein found in the milk of most mammals. Scientists investigated the differences in the DNA base sequence of the gene coding for casein in the mammals shown in diagrams **R** and **S**. The following table shows their results.

	Baleen Whale	Sperm Whale	Dolphin	Hippo	Cow	Camel	Deer	Pig
Sperm Whale	3							
Dolphin	3	2						
Hippo	4	3	3					
Cow	9	8	8	8				
Camel	12	11	11	12	14			
Deer	11	10	10	10	4	16		
Pig	11	10	10	11	13	14	13	
Peccary	14	12	13	14	16	16	18	7

Scientists concluded that diagram **S** best represents the currently accepted theory regarding the evolutionary origin of cetacean.

Based on the information provided, evaluate this conclusion.

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(3 marks)

(c) More recently, scientists decided to merge the order *Cetacea* and *Artiodactyla* into a single order called *Cetartiodactyla* based on new sequencing results.

Explain the importance of classifying organisms correctly according to their clade.

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(1 mark)

(d) Based on the information provided in part a), deduce **four other** taxonomic groupings/levels of classification that would be similar for dolphins and whales.

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(1 mark)

3 (a) DNA hybridisation is a technique used to determine the genetic similarity between species. The double stranded DNA of two different species is mixed and then heated until the strands separate. This provides an opportunity for hybridisation between the different DNA strands to occur. The mixture is then cooled in order to allow new hybrid double stranded DNA molecules to form. The greater the degree of hybridisation, the more genetically similar the two species are.

Scientists investigated the genetic similarity between four species of bacteria (**A** to **D**) by allowing their DNA to hybridise with each other. The results of this investigation are shown in the table below.

Bacterial species	DNA-DNA relatedness / % with:			
	Species A	Species B	Species C	Species D
A	100	32	36	24
B	57	100	42	28
C	35	39	100	21
D	26	28	24	100

(i) Identify the species of bacteria that is most closely related to the other bacterial species.

[1]

(ii) Explain your answer at part i).

[1]

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(2 marks)

(b) Scientists concluded that species **D** was the first to branch off from the common ancestor that they all share.

Based on the information provided, comment on this conclusion.

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(c) The group of scientists also investigated the similarity of the protein molecules that make up peptidoglycan in the cell walls of the bacterial species. The amino acid sequence of species **A** was compared to those of species **B** to **D**.

The results are shown in the table below:

| Bacterial species	Percentage similarity
A	100
B	99.4
C	98.7
D	97.8

Based on the information provided and your knowledge of protein synthesis, explain the reason why the bacterial species show such a high level of similarity between the protein molecules, even though there are differences in their DNA.

(1 mark)

4 (a) The following diagram shows a cladogram that indicates the evolutionary relationship of plants. Note that different taxonomic groups are represented in the cladogram.
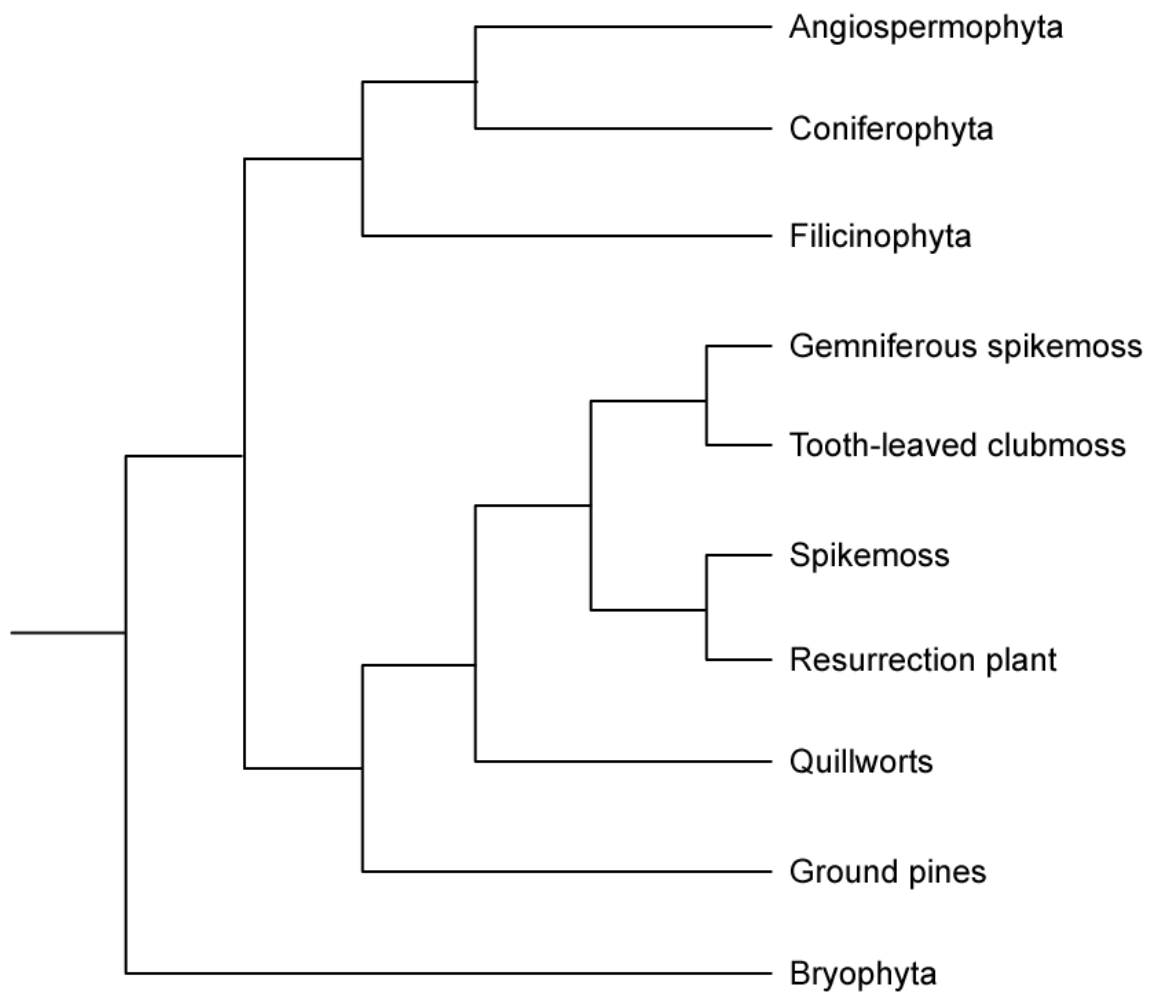
Identify the plant phyla which are the most closely related

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(1 mark)

(b) Bryophyta are found in a variety of environments and are typically very small in size. Filicinophyta are able to grow to much larger sizes than Bryophyta.

Using your knowledge of plant phyla characteristics, explain the difference in size between Bryophyta and Filicinophyta.

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(c) The common names of some plant genera and species were given in this cladogram.

Using the information given in part a), explain how using the common names could cause confusion when studying this cladogram.

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(2 marks)

(d) Gemniferous spikemoss, tooth-leaved clubmoss, spikemoss and the resurrection plant can all be considered members of the same clade.

Explain this statement.

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(1 mark)

5 (a) *One mark is available for clarity of communication throughout this question.*

The binomial naming system is an important tool to facilitate cooperation and collaboration between groups of scientists.

Discuss how the binomial system will facilitate cooperation and collaboration between scientists.

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(3 marks)

(b) Compare and contrast the domain Eubacteria with the domain Eukaryotes.

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(5 marks)

(c) Constructing the evolutionary relationship between organisms based on morphology alone will not always deliver accurate results.

Outline the advancements that have been made in constructing cladograms in the field of cladistics.

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(7 marks)