7.1 Classification and cladistics

Name: _____ Class: _____ Date: _____ **Total: 24 marks**

KEY WORDS taxon • domain • clade • cladogram • molecular clock • parsimony

Objective

Build the skills to answer exam questions on **classification and cladistics** : the hierarchy of taxa, the three domains, clades, cladograms and molecular clocks.

You must be able to:

- list the taxonomic ranks and explain why classification should follow evolutionary relationships
- describe the three domains and the evidence for them
- construct and interpret cladograms, using base or amino acid sequences
- explain molecular clocks and why groups are sometimes reclassified

1 Key knowledge and worked examples

Classification and cladistics

Ranks (taxa): domain → kingdom → phylum → class → order → family → genus → species. A good classification groups organisms by **common ancestry**, so it can **predict** features of a newly found member.

Three domains (from ribosomal RNA sequences): **Bacteria**, **Archaea** and **Eukarya**. Archaea look like bacteria (no nucleus) but their rRNA, membrane lipids and some enzymes are closer to eukaryotes. Viruses are not in any domain.

Clade: a common ancestor and **all** of its descendants. A **cladogram** shows clades: each **node** is a common ancestor; the **root** is the oldest ancestor. Fewer sequence differences → more recent common ancestor (closer relatives). Choose the tree with the fewest changes (**parsimony**).

Molecular clock: mutations build up at a roughly steady rate, so the number of differences estimates the time since two species split. Limits: the rate differs between genes and between groups.

Reclassification: when DNA evidence shows a family is not a clade, species are moved, e.g. the old figwort family was split into several families.

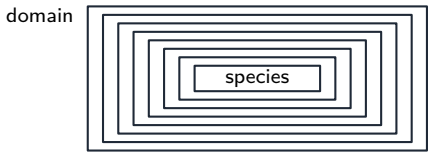
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Worked example. Cytochrome c differences from humans: rhesus monkey 1, horse 12, yeast 44. The **monkey** is the closest relative; yeast split off earliest.

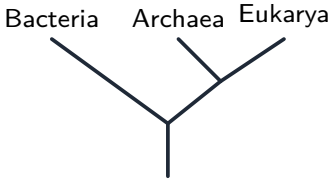
Answer shapes: "nodes show common ancestors"; "fewer differences, more recent split".

2 Practice

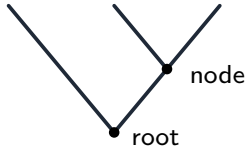
2.1 List the taxonomic ranks from domain to species, in order. [2]



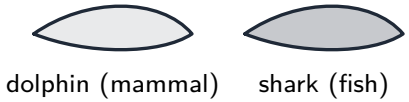
2.2 Explain why the Archaea are placed in a separate domain from the Bacteria. [3]



2.3 State what is meant by a clade, and what a node in a cladogram represents. [3]



2.4 Explain why a classification based on common ancestry is more useful than one based on appearance. [2]



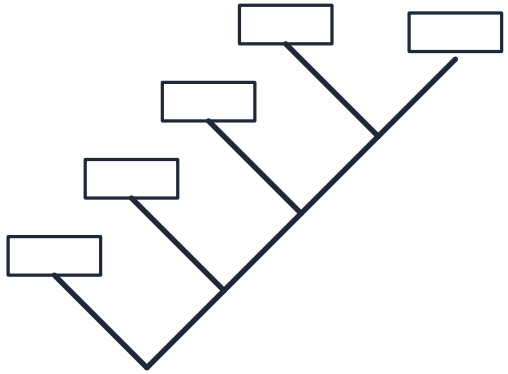
2.5 State one reason why a molecular clock gives only an estimate of when two species split. [2]



3 Exam-style questions

3.1 The table shows the number of amino acid differences in cytochrome c between humans and four other organisms.

organism	differences from human
rhesus monkey	1
dog	11
chicken	13
yeast	44



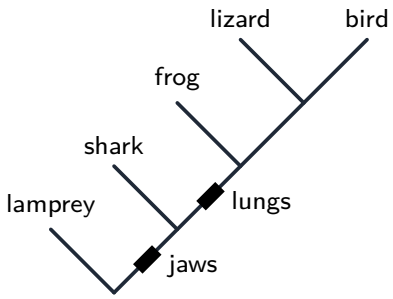
(a) State which organism is most closely related to humans, and give a reason. [2]

(b) Use the data to place the five organisms on the cladogram, from the root outwards. [2]

(c) Explain how cytochrome c differences can act as a molecular clock. [2]

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3.2 The cladogram shows five groups of animals.



(a) State the feature shared by all groups except the lamprey. [1]

(b) Name the group most closely related to birds. [1]

(c) State one group that, with its common ancestor, does **not** form a clade. Explain why. [2]

(d) Suggest why scientists now prefer DNA sequences to anatomy when drawing cladograms. [2]

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