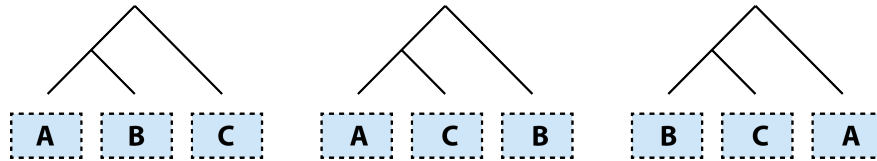# 9 Exercise solutions – Phylogenetic tree

1. **Tree topology**

   A rooted phylogenetic tree can have three topologically different trees when m is 3.

   (a) Fill the labels A, B, or C to satisfy three topologically distinct trees.

   | A | B | C | | A | C | B | | B | C | A |

2. **UPGMA**

   UPGMA is an unweighted version of PGMA (pair-group method using arithmetic mean) for reconstructing a phylogenetic tree. Pairwise sequence alignments are used to calculate the distances among four sequences A, B, C, and D.

	A	B	C	D
A	0	2	7	7
B		0	5	9
C			0	8
D				0

   Below are two examples of the distance calculation that can be used for UPGMA.

   $$d_{(\alpha\beta),\gamma} = \frac{d_{\alpha,\gamma} + d_{\beta,\gamma}}{2}$$

   $$d_{(\alpha\beta\gamma),\delta} = \frac{d_{\alpha,\delta} + d_{\beta,\gamma} + d_{\delta,\gamma}}{3}$$
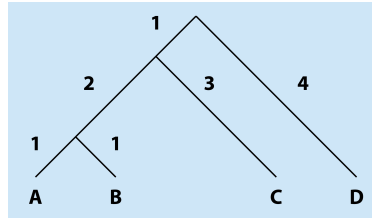
   (a) Identify the first internal node and update the distance matrix.

	(AB)	C	D
(AB)	0	6	8
C		0	8
D			0

   (b) Identify the second internal node and update the distance matrix accordingly.

	(ABC)	D
(ABC)	0	8
D		0

(c) Reconstrut a rooted tree from the calcualted distances.

1

2   3   4

1   1

A   B   C   D

(d) Reconstruct a rooted tree by using UPGMA.

	A	B	C	D
A	0	2	6	8
B		0	6	8
C			0	8
D				0

(e) Calculated the Cavalli-Sforza and Edwards criterion.

$$\sum_{i,j} (M_{i,j} - d_{i,j})^2$$

Solution:

$$\sum_{i,j} (M_{i,j} - d_{i,j})^2 = 2((5-6)^2 + (8-6)^2 + (5-6)^2) = 12$$