TABLE 27.11. Neighbor-joining example

TABLE 27.11. Neighbo					
	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
Distance matrix	A B C D E B 5 -	$\begin{array}{c ccccc} U_1 & C & D & E \\ C & 3 & & \\ D & 6 & 7 & \\ E & 5 & 6 & 5 & \\ F & 7 & 8 & 9 & 8 \end{array}$	$\begin{array}{c ccccc} U_1 & C & U_2 \\ C & 3 & & \\ U_2 & 3 & 4 & \\ F & 7 & 8 & 6 \end{array}$	$ \begin{array}{c ccc} U_2 & U_3 \\ U_3 & 2 \\ F & 6 & 6 \end{array} $	U ₄ F 5
Step 1					
S calculations $S_x = (\text{sum all } D_x)/(N-2),$ where N is the # of OTUs in the set.	$\begin{array}{l} S_{\rm A} = (5\!+\!4\!+\!7\!+\!6\!+\!8)/4 = 7.5 \\ S_{\rm B} = (5\!+\!7\!+\!10\!+\!9\!+\!11)/4 = 10.5 \\ S_{\rm C} = (4\!+\!7\!+\!7\!+\!6\!+\!8)/4 = 8 \\ S_{\rm D} = (7\!+\!10\!+\!7\!+\!5\!+\!9)/4 = 9.5 \\ S_{\rm E} = (6\!+\!9\!+\!6\!+\!5\!+\!8)/4 = 8.5 \\ S_{\rm F} = (8\!+\!11\!+\!8\!+\!9\!+\!8)/4 = 11 \end{array}$	$\begin{split} S_{U1} &= (3{+}6{+}5{+}7)/3 = 7\\ S_C &= (3{+}7{+}6{=}8)/3 = 8\\ S_D &= (6{+}7{+}5{+}9)/3 = 9\\ S_E &= (5{+}6{+}5{+}8)/3 = 8\\ S_F &= (7{+}8{+}9{+}8)/3 = 10.6 \end{split}$	$\begin{split} S_{\cup 1} &= (3 + 3 + 7)/2 = 6.5\\ S_{\rm C} &= (3 + 4 + 8)/2 = 7.5\\ S_{\cup 2} &= (3 + 4 + 6)/2 = 6.5\\ S_{\rm F} &= (7 + 8 + 6)/2 = 10.5 \end{split}$	$\begin{split} S_{\cup 2} &= (2\!+\!6)/1 = 8\\ S_{\cup 3} &= (2\!+\!6)/1 = 8\\ S_{\rm F} &= (6\!+\!6)/1 = 12 \end{split}$	Because $N - 2 = 0$, we cannot do this calculation.
Step 2					
Calculate pair with smallest (M), where $M_{ij} = D_{ij} - S_i - S_j$.	Smallest are $M_{AB} = 5 - 7.5 - 10.5 = -13$ $M_{DE} = 5 - 9.5 - 8.5 = -13$ Choose one of these (AB here).	Smallest is $M_{CU_1} = 3 - 7 - 8 = -12$ $M_{DE} = 5 - 9 - 8 = -12$ Choose one of these (DE here).	Smallest is $M_{CU_1} = 3 - 6.5 - 7.5 = -11$	Smallest is $M_{U_2F} = 6 - 8 - 12 = -14$ $M_{U_3F} = 6 - 8 - 12 = -14$ $M_{U_2U_3} = 2 - 8 - 8 = -14$ Choose one of these ($M_{U_2U_3}$ here).	
Step 3				2 9	
Create a node (U) that joins pair with lowest M_{ij} such that $S_{IU} = D_{ij}/2 + (S_i - S_j)/2$.	$ \begin{array}{l} U_1 \text{ joins A and B:} \\ S_{\rm AU_1} = D_{\rm AB}/2 + (S_{\rm A} - S_{\rm B})/2 = 1 \\ S_{\rm BU_1} = D_{\rm AB}/2 + (S_{\rm B} - S_{\rm A})/2 = 4 \end{array} $	$U_{2} \text{ joins D and E:} S_{DU_{2}} = D_{DE}/2 + (S_{D} - S_{E})2 = 3 S_{EU_{2}} = D_{DE}/2 + (S_{E} - S_{D})/2 = 2$	$ \begin{array}{l} U_3 \text{ joins C and } U_1: \\ S_{\rm CU_3} = D_{\rm CU_1}/2 + (S_{\rm C} - S_{\rm U_1})/2 = 2 \\ S_{\rm U_1U_3} = D_{\rm CU_1}/2 + (S_{\rm U1} - S_{\rm C})/2 = 1 \end{array} $	$U_4 \text{ joins } U_2 \text{ and } U_3:$ $S_{U_2U_4} = D_{U_2U_3}/2 + (S_{U_2} - S_{U_3})/2 =$ $S_{U_3U_4} = D_{U_2U_3}/2 + (S_{U_3} - S_{U_2})/2 =$	For last pair, connect 1 U_4 and F with branch 1. length = 5.
Step 4					
Join <i>i</i> and <i>j</i> according to S above and make all other taxa in form of a star. Branches in blacl are of unknown length. Branches in red are of known length.	$b = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$	$ \begin{array}{c} C \\ D \\ 3 \\ U_2 \\ U_1 \\ 1 \\ C \\ A \\ B \\ B$	$D_{1} = 0$ $C_{1} = 0$ $C_{2} = 0$ $C_{2} = 0$ $C_{1} = 0$ $C_{2} = 0$ $C_{2} = 0$ $C_{1} = 0$ $C_{2} = 0$ C_{2	$\begin{bmatrix} D & 3 & C & 4 & B \\ & 2 & U_2 & U_3 & 1 \\ & E & 2 & U_4 & 1 \\ & & F & \end{bmatrix}$	$ \begin{array}{c} D & 3 & C & B \\ & & & 2 & U_1^4 & B \\ & & & & E & 2 & U_4^1 & A \\ & & & & & 5 & F \\ \end{array} $
Step 5	F	F	,		Comments
Calculate new distance matrix of all other taxa to U with $D_{xU} = D_{ix} + D_{jx} - D_{ij}$, where <i>i</i> and <i>j</i> are those selected from above.					Note this is the same tree we started with (drawn in unrooted form here).

From http://www.icp.ucl.ac.be/~opperd/private/upgma.html.