Computer Assignment 4

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#Question 1 ## Subtask (a)

```
X <- c("C","A","G","C","C","C","T","A","G","T","T","G","C","C","C","C","C", "C","A","G","A","G","G","C","A"

states = c("GC", "AT")

T = cbind(c(0.80, 0.75), c(0.20, 0.25))
rownames(T) <- c("GC", "AT")
colnames(T) <- c("GC", "AT")

E = cbind(c(0.10, 0.40, 0.40, 0.10), c(0.40, 0.10, 0.10, 0.40))
rownames(E) <- c("A", "C", "G", "T")
colnames(E) <- c("GC", "AT")

hmm <- initHMM(States = states, Symbols = X, transProbs = T, emissionProbs = E)
bw = baumWelch(hmm, X)

bw
```

```
## $hmm
## $hmm$States
## [1] "GC" "AT"
##
## $hmm$Symbols
##  [1] "C" "A" "G" "C" "C" "C" "T" "A" "G" "T" "T" "G" "C" "C" "C" "C" "C" "A" "G"
## [20] "A" "G" "G" "C" "A" "G" "G" "T" "A" "A" "A" "T" "A" "G" "C" "C" "A"
##
## $hmm$startProbs
##  GC  AT
## 0.5 0.5
##
## $hmm$transProbs
##     to
## from        GC        AT
##   GC 0.8260870 0.1739130
##   AT 0.4166667 0.5833333
##
## $hmm$emissionProbs
##       symbols
## states            C            A            G C C C            T A G T T G C C
##     GC 4.457141e-08 4.166666e-01 3.750000e-01 0 0 0 2.083333e-01 0 0 0 0 0 0 0
```

```
##     AT 1.000000e+00 6.086614e-10 1.857827e-14 0 0 0 7.745255e-36 0 0 0 0 0 0 0
##       symbols
## states C C C A G A G G C A G G T A A A T A G C C A
##     GC 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##     AT 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##
##
## $difference
##   [1] 2.506104e+00 1.859027e-01 1.851036e-01 1.321911e-01 7.028590e-02
##   [6] 3.574159e-02 2.644541e-02 2.198550e-02 1.776005e-02 1.421795e-02
##  [11] 1.141354e-02 9.219188e-03 7.496765e-03 6.135352e-03 5.051088e-03
##  [16] 4.181080e-03 3.477986e-03 2.905942e-03 2.437595e-03 2.051922e-03
##  [21] 1.732648e-03 1.467074e-03 1.245212e-03 1.059150e-03 9.025752e-04
##  [26] 7.704098e-04 6.585460e-04 5.636382e-04 4.829457e-04 4.142110e-04
##  [31] 3.555657e-04 3.054558e-04 2.625842e-04 2.258638e-04 1.943805e-04
##  [36] 1.673636e-04 1.441613e-04 1.242211e-04 1.070740e-04 9.232067e-05
##  [41] 7.962077e-05 6.868382e-05 5.926146e-05 5.114120e-05 4.414095e-05
##  [46] 3.810458e-05 3.289812e-05 2.840648e-05 2.453076e-05 2.118592e-05
##  [51] 1.829878e-05 1.580636e-05 1.365441e-05 1.179622e-05 1.019151e-05
##  [56] 8.805583e-06 7.608498e-06 6.574447e-06 5.681165e-06 4.909437e-06
##  [61] 4.242685e-06 3.666599e-06 3.168826e-06 2.738702e-06 2.367017e-06
##  [66] 2.045821e-06 1.768245e-06 1.528359e-06 1.321038e-06 1.141859e-06
##  [71] 9.869961e-07 8.531477e-07 7.374597e-07 6.374662e-07 5.510367e-07
##  [76] 4.763300e-07 4.117553e-07 3.559377e-07 3.076890e-07 2.659824e-07
##  [81] 2.299305e-07 1.987663e-07 1.718270e-07 1.485396e-07 1.284089e-07
##  [86] 1.110068e-07 9.596349e-08 8.295909e-08 7.171724e-08 6.199897e-08
##  [91] 5.359774e-08 4.633508e-08 4.005662e-08 3.462899e-08 2.993685e-08
##  [96] 2.588055e-08 2.237390e-08 1.934241e-08 1.672168e-08 1.445607e-08
```

```
bw$hmm$transProbs
```

```
##     to
## from        GC        AT
##   GC 0.8260870 0.1739130
##   AT 0.4166667 0.5833333
```

```
bw$hmm$emissionProbs
```

```
##       symbols
## states            C            A            G C C C            T A G T T G C C
##     GC 4.457141e-08 4.166666e-01 3.750000e-01 0 0 0 2.083333e-01 0 0 0 0 0 0 0
##     AT 1.000000e+00 6.086614e-10 1.857827e-14 0 0 0 7.745255e-36 0 0 0 0 0 0 0
##       symbols
## states C C C A G A G G C A G G T A A A T A G C C A
##     GC 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##     AT 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

##Subtask (b)

```
newhmm <- initHMM(States = states, Symbols = X, transProbs = bw$hmm$transProbs , emissionProbs = bw$hmm$

viterbi(newhmm, X)
```

```
##  [1] "AT" "GC" "GC" "AT" "AT" "AT" "GC" "GC" "GC" "GC" "GC" "GC" "AT" "AT" "AT"
## [16] "AT" "AT" "GC" "GC" "GC" "GC" "GC" "AT" "GC" "GC" "GC" "GC" "GC" "GC" "GC"
## [31] "GC" "GC" "GC" "AT" "AT" "GC"
```

##Subtask (c)

```
fw = forward(newhmm, X)
bw = backward(newhmm, X)

fw
```

```
##       index
## states          1          2          3          4          5          6
##     GC -17.6193204  -2.444085  -3.615969 -20.733198 -23.166811 -23.705807
##     AT  -0.6931472 -22.451903 -35.810068  -5.365169  -5.904166  -6.443162
##       index
## states          7          8         9        10        11        12        13
##     GC  -8.887247  -9.953771 -11.12566 -12.88533 -14.64500 -15.81688 -32.93411
##     AT -87.828141 -31.856206 -43.31975 -93.72084 -95.48051 -48.01098 -17.56608
##       index
## states        14        15        16        17        18        19        20
##     GC -35.36772 -35.90672 -36.44572 -36.98471 -21.47301 -22.64489 -23.71141
##     AT -18.10508 -18.64407 -19.18307 -19.72207 -41.48082 -54.83899 -45.61385
##       index
## states       21        22        23        24       25        26         27
##     GC -24.8833 -26.05518 -43.17241 -29.55532 -30.7272 -31.89909  -33.65876
##     AT -57.0774 -58.24928 -27.80438 -49.56314 -62.9213 -64.09319 -114.49427
##       index
## states        28        29        30        31        32        33        34
##     GC -34.72528 -35.79181 -36.85833  -38.6180 -39.68453 -40.85641 -57.97364
##     AT -56.62772 -57.69424 -58.76077 -119.4535 -61.58696 -73.05051 -42.60561
##       index
## states        35        36
##     GC -60.40725 -44.89555
##     AT -43.14461 -64.90336
```

```
bw
```

```
##       index
## states         1         2         3         4         5         6         7
##     GC -43.51799 -42.45146 -41.27958 -40.74058 -40.20158 -37.76797 -36.00830
##     AT -44.20240 -43.13587 -40.06937 -39.53038 -38.99138 -38.45238 -36.69271
##       index
## states         8         9        10        11        12        13        14
##     GC -34.94177 -33.76989 -32.01022 -30.25055 -29.07866 -28.53967 -28.00067
##     AT -35.62619 -34.45430 -32.69463 -30.93496 -27.86846 -27.32946 -26.79047
##       index
## states        15        16        17        18        19        20        21
##     GC -27.46167 -26.92268 -24.48906 -23.42254 -22.25066 -21.18413 -20.01225
##     AT -26.25147 -25.71247 -25.17348 -24.10695 -22.93507 -21.86855 -20.69666
##       index
## states        22        23        24        25        26        27        28
##     GC -18.84036 -16.40675 -15.34023 -14.16834 -12.99646 -11.23679 -10.17026
```

```
##     AT -17.63016 -17.09116 -16.02464 -14.85275 -13.68087 -11.92120 -10.85468
##       index
## states        29        30        31        32        33        34        35 36
##     GC -9.103738 -8.037214 -6.277542 -5.211018 -4.039134 -3.500137 -1.066524  0
##     AT -9.788151 -8.721627 -6.961956 -5.895432 -2.828930 -2.289934 -1.750938  0
```

##Subtask d

```
probSeq = fw[1, 36] + fw[2, 36]

probSeq
```

```
## [1] -109.7989
```

##Subtask e

```
posterior(newhmm, X)
```

```
##       index
## states            1            2            3            4            5
##     GC 8.836766e-08 1.000000e+00 1.000000e+00 6.311976e-08 9.491698e-09
##     AT 9.999999e-01 1.031521e-09 3.498365e-14 9.999999e-01 1.000000e+00
##       index
## states            6            7            8            9           10
##     GC 6.311976e-08 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00
##     AT 9.999999e-01 2.625234e-35 1.551159e-10 5.260698e-15 3.947719e-36
##       index
## states           11           12           13           14           15
##     GC 1.000000e+00 1.000000e+00 6.311976e-08 9.491695e-09 9.491693e-09
##     AT 3.947719e-36 3.498365e-14 9.999999e-01 1.000000e+00 1.000000e+00
##       index
## states           16           17           18           19           20
##     GC 9.491695e-09 6.311976e-08 1.000000e+00 1.000000e+00 1.000000e+00
##     AT 1.000000e+00 9.999999e-01 1.031521e-09 5.260698e-15 1.551159e-10
##       index
## states           21           22           23           24           25
##     GC 1.000000e+00 1.000000e+00 4.197463e-07 1.000000e+00 1.000000e+00
##     AT 5.260698e-15 3.498364e-14 9.999996e-01 1.031521e-09 5.260698e-15
##       index
## states           26           27           28           29           30
##     GC 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00 1.000000e+00
##     AT 5.260698e-15 3.947719e-36 1.551159e-10 1.551159e-10 1.551159e-10
##       index
## states           31           32           33           34           35
##     GC 1.000000e+00 1.000000e+00 1.000000e+00 6.311978e-08 6.311978e-08
##     AT 3.947719e-36 1.551159e-10 3.498365e-14 9.999999e-01 9.999999e-01
##       index
## states           36
##     GC 1.000000e+00
##     AT 2.045102e-09
```

##Subtask f

```
### The results from the posterior allow us to see the path the sequence will take
```

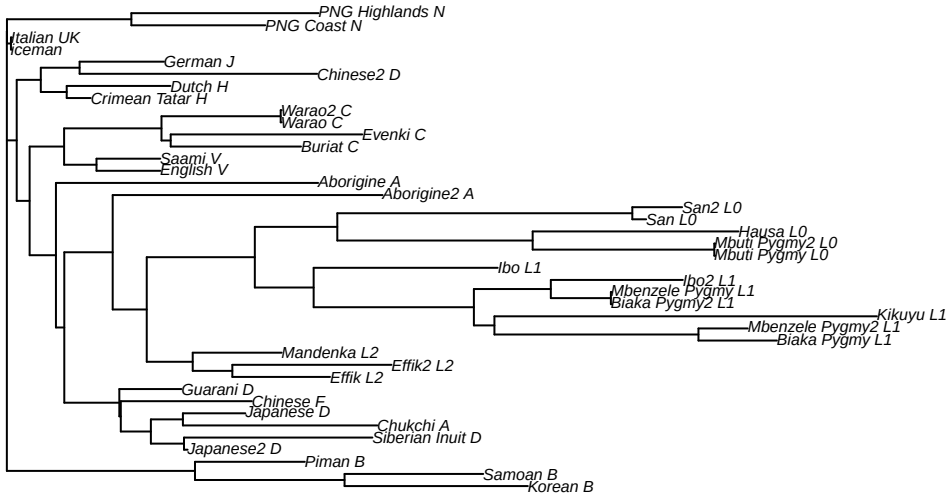
#Question 2 ##Subtask a

```
load("D:/Downloads/iceMan_Phylo.RData")
x <- as.DNAbin(iceMan_phyDat)

dist_a <- dist.dna(x)

tree_a <- NJ(dist_a)

plot(tree_a, cex = 0.5)
```

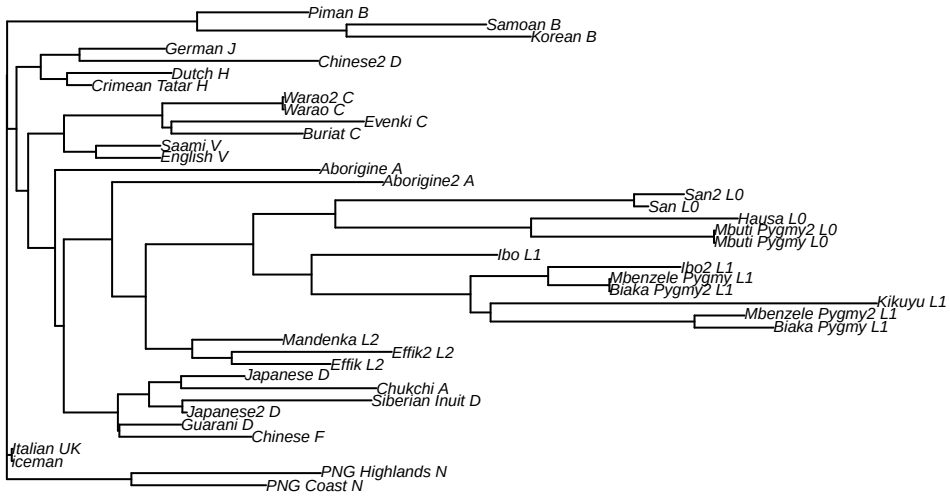


##Subtask b

```
dist_b <- dist.dna(x, model = "JC69")

tree_b <- NJ(dist_b)

plot(tree_b, cex = 0.5)
```

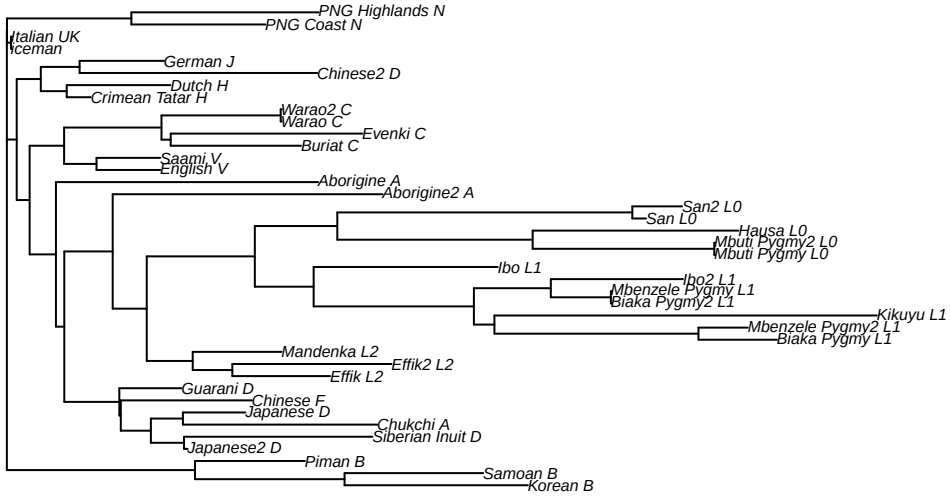


##Subtask c

```
dist_c <- dist.dna(x, model = "K80")

tree_c <- NJ(dist_c)

plot(tree_c, cex = 0.5)
```




```
### The most related modern human population to the Iceman is the Italian UK
```