11 Exercise solutions – Sequence profiles

1. **PPM (Position probability matrix)**

   PWM (position weight matrix) is a popular method to find sequenced patterns. It can be generated from PPM (position probability matrix) and PFM (position frequency matrix).

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   Seq1 CAA
   Seq2 CAG
   Seq3 GAC
   Seq4 ATT
   ```

   (a) Create a PFM from Seq1, Seq2, Seq3, and Seq4.

	1	2	3
A	1	3	1
G	1	0	1
C	2	0	1
T	0	1	1

   (b) Create a PPM from Seq1, Seq2, Seq3, and Seq4.

	1	2	3
A	0.25	0.75	0.25
G	0.25	0	0.25
C	0.5	0	0.25
T	0	0.25	0.25

2. **Sequence profile**

   A sequence profile is similar to PWM, but it uses a scoring scheme. Use the following definitions to calculate the profile values.

   $$Prof_{ra} : \frac{1}{m_r} \sum_{b \in M} R_{ba} F_{rb}$$

   F_{rb} : The number of occurrences of b at position r

   R_{ba} : Pairwise score between b and a

   m_r : The number of residues without gaps at position r

   Scoring matrix:

	A	G	C	T
A	2	1	-3	-2
G	1	3	-2	-1
C	-3	-2	4	1
T	-2	-1	1	2

MSA

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Seq1 GT
Seq2 -G
Seq3 CA
```

(a) Calculate the profile values of position 1.

A1: $(1/2) \times ((2 \times 0) + (1 \times 1) + (-3 \times 1) + (-2 \times 0)) = -1$

G1: $(1/2) \times ((1 \times 0) + (3 \times 1) + (-2 \times 1) + (-1 \times 0)) = 1/2$

C1: $(1/2) \times ((-3 \times 0) + (-2 \times 1) + (4 \times 1) + (1 \times 0)) = 1$

T1: $(1/2) \times ((-2 \times 0) + (-1 \times 1) + (1 \times 1) + (2 \times 0)) = 0$

(b) Calculate the profile values of position 2.

A2: $(1/3) \times ((2 \times 1) + (1 \times 1) + (-3 \times 0) + (-2 \times 1)) = 1/3$

G2: $(1/3) \times ((1 \times 1) + (3 \times 1) + (-2 \times 0) + (-1 \times 1)) = 1$

C2: $(1/3) \times ((-3 \times 1) + (-2 \times 1) + (4 \times 0) + (1 \times 1)) = -4/3$

T2: $(1/3) \times ((-2 \times 1) + (-1 \times 1) + (1 \times 0) + (2 \times 1)) = -1/3$

(c) Make a profile matrix.

	1	2
A	-1	1/3
G	1/2	1
C	1	-4/3
T	0	-1/3

3. **Profile search**

A sequence profile can take gap penalties into account. Calculate the score of the alignment between the DNA profile below and a DNA segment.

A DNA profile of length 4

	A	G	C	T	Gap
1	5	-5	-2	-1	10
2	-2	3	4	-7	10
3	1	2	1	-1	5
4	-3	3	-2	7	10

- P1, P2, P3, P4: profile blocks at positions 1 - 4
- Gap penalty (for segments): 4

(a) Profile search on segment D1

Profile:	P1	P2	P3	P4
D1:	A	C	G	T

Solution: $5 + 4 + 1 + 7 = 17$

(b) Profile search on segment D2

Profile:	P1	P2	-	P3	P4
D2:	A	C	C	G	T

Solution: $5 + 4 + (-5) + 2 + 7 = 13$

(c) Profile search on segment D3

Profile:	P1	P2	P3	P4
D3:	A	-	G	T

Solution: $5 + (-4) + 2 + 7 = 10$

(d) Profile search on segment D4

Profile:	P1	P2	-	P3	P4
D4:	-	A	C	G	T

Solution: $(-4) + (-2) + (-10) + 2 + 7 = -7$