

# Exercise sheet 6: BLAST

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## Exercise 1

You are given accession number NM\_000667.3. Use the BLAST web server to find out about the gene that belongs to this accession number (choose nucleotide blast, and the database RefSeq RNA).

**Question 1A** Which gene is it, and in which organism?

**Solution** Gene: Alcohol Dehydrogenase 1A

Organism: *Homo sapiens* (human)

**Question 1B** Which other organisms does it seem to be highly conserved in?

**Solution**

- *Gorilla gorilla*: gorilla
- *Pan troglodytes*: common chimpanzee
- *Pan paniscus*: bonobo
- *Nomascus leucogenys*: northern white-cheeked gibbon
- *Cebus capucinus*: white-headed capuchin

Many more...

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## Exercise 2

We wish to find sequences related to a query sequence of 28 residues in a database of 1 billion residues. Since this sequence belongs to a highly conserved gene family, we decide to use the PAM30 matrix.

**Question 2A** Does this query sequence provide enough information to find significant matches?

**Hint 1: scoring matrices**

BLOSUM	bits/site	PAM	bits/site	Sequence identity
		30	2.57	
		60	2.00	63%
90	1.18	100	1.18	43%
80	0.99	120	0.98	38%
60	0.66	160	0.70	30%
56	0.52	200	0.51	25%
45	0.38	250	0.36	20%

**Hint 2: formulae**

$$\text{Shortest reliable alignment} = \frac{\log_2(mn)}{H^N}$$

**Solution**

$$\text{Shortest reliable alignment} = \frac{\log_2(mn)}{H^N} = \frac{\log_2(28 \cdot 10^9)}{2,57} \simeq 14 \text{ residues}$$

In that case, the query is long enough, since the minimum query length is 14 residues.

**Question 2B** Our supervisor has asked us to find homologous sequences of a gene which belongs to a highly diverged gene family. In that case, we decide to use the PAM250 matrix, since it provides the best sensitivity. What are the implications of using PAM250 instead of PAM30, assuming that the query has a similar size?

**Solution** The information content of the matrix PAM250 is much lower than PAM30 (0,36 bits/site vs 2,57 bits/site). It has a direct impact in the information contained in the query. So, let's check if the query contains enough information to find significant matches:

$$\text{Shortest reliable alignment} = \frac{\log_2(mn)}{H^N} = \frac{\log_2(28 \cdot 10^9)}{0,36} \simeq 96 \text{ residues}$$

Since the shortest alignment for which significance can be reliably is greater than the query size, it implies that a query size of 28 residues doesn't provide enough information. In order to solve the problem, we could try to use a longer query sequence, or use a smaller database.

## Exercise 3

You are given a nucleotide query sequence  $q = \text{ATAC}$ , and a nucleotide database sequence  $s = \text{ATAAAACGGGGG}$ . The word-size  $k = 2$ . Use a simple scoring scheme that assigns a score of 2 for a match and a score of  $-1$  for a mismatch.

**Question 3A** Generate all  $k$ -length words of the query sequence.

**Solution**

- $w_1 = AT$
  - $w_2 = TA$
  - $w_3 = AC$
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**Question 3B** List all possible words for the first  $k$ -length word (AT) that have a score of at least  $T_1 = 1$ .

**Solution**

- $s(AA) = 1$
  - $s(AC) = 1$
  - $s(AG) = 1$
  - $s(AT) = 4$
  - $s(CT) = 1$
  - $s(GT) = 1$
  - $s(TT) = 1$
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**Question 3C** Scan the database for exact matches for the words from the question 3B.

**Solution**  $AA$  at position 2,3,4.  $AC$  at position 5,  $AT$  at position 0.

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**Question 3D** Extend the exact matches that you found in the question 3C to the left/right and report all MSPs with a score greater than 4.

**Solution AA:**

Pos: 2           ATA  
                   |||  
                   AAA       with score 3

Pos: 3           ATAC  
                   ||||  
                   AAAC       with score 5

Pos: 4           AT  
                   ||  
                   AA       with score 1

AT:

Pos: 0           ATA  
                   |||  
                   AAA       with score 6

AC:

Pos: 5           AT  
                   ||  
                   AC       with score 1

MSPs start in the template at index 0 and 3.

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**Question 3E** What happens if we vary the parameters  $k$  and  $T_1$ ?

**Solution**

- Higher  $T_1$ ,  $k$ : - faster (less seeds), - less sensitive (some hits will be missed)
  - Lower  $T_1$ ,  $k$ : - slower (more seeds), - more sensitive (less hits will be missed)
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**Exercise 4 - Programming assignment**

Programming assignments are available via Github Classroom and contain automatic tests.

We recommend doing these assignments since they will help you to further understand this topic.

Access the Github Classroom link: Programming Assignment: Sheet 06.

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