

Find the **global alignment** between GATCGTT and TCTGAT with the  $\delta$  values from the table below. As a reminder the recursive formula for global alignment is given.

$\delta$	A	C	T	G	-
A	1.5	-1	-0.75	-1	-0.5
C	-1	1.5	-1	-0.75	-0.5
T	-0.75	-1	1.5	-1	-0.5
G	-1	-0.75	-1	1.5	-0.5
-	-0.5	-0.5	-0.5	-0.5	$-\infty$

$$V(i, j) = \max \begin{cases} V(i-1, j-1) + \delta(S[i], T[j]) & \text{match/mismatch} \\ V(i-1, j) + \delta(S[i], -) & \text{delete} \\ V(i, j-1) + \delta(-, T[j]) & \text{insert} \end{cases}$$

		T	C	T	G	A	T	
G A T C G T T	G	0 L	-0.5 L	-1 L	-1.5 L	-2 L	-2.5 L	-3 L
	A	-0.5 U	-1 D/L/U	-1.25 D	-1.75 L	0 D	-0.5 L	-1 L
	T	-1 U	-1.25 D	-1.75 L/U	-2 D	-0.5 U	1.5 D	1 L
	C	-1.5 U	0.5 D	0 L	-0.25 D	-0.75 L	1 U	3 D
	G	-2 U	0 U	2 D	1.5 L	1 L	0.5 L/U	2.5 U
	T	-2.5 U	-0.5 U	1.5 U	1 D/L/U	3 D	2.5 L	2 L/U
	T	-3 U	-1 D/U	1 U	3 D	2.5 L/U	2.25 D	4 D
	T	-3.5 U	-1.5 D/U	0.5 U	2.5 D/U	2 D/L/U	1.75 D/U	3.75 D

Best score: \_\_\_\_\_ 3.75

Best alignment:

GATC-GAT

--TCTGTT

(0,0)	(1,0)	...	(n,0)
(0,1)	(1,1)	...	(n,1)
:	:		:
(0,m)	(1,m)	...	(n,m)

Find the **local alignment** between CACTUS and REACTSBAD with the  $\sigma$  values that follow the rules below. As a reminder the recursive formula for global alignment is given.

$$V(i, j) = \max \begin{cases} 0 & \text{align empty strings} \\ V(i-1, j-1) + \delta(S[i], T[j]) & \text{match/mismatch} \\ V(i-1, j) + \delta(S[i], -) & \text{delete} \\ V(i, j-1) + \delta(-, T[j]) & \text{insert} \end{cases}$$

$$\begin{aligned} \delta(-, x) &= -1 \text{ for } x \in \Sigma \\ \delta(x, -) &= -1 \text{ for } x \in \Sigma \\ \delta(x, y) &= 2 \text{ for } y = x \\ \delta(x, y) &= -1 \text{ for } y \neq x \end{aligned}$$

		R	E	A	C	T	S	B	A	D
C A C T U S	S	0	0	0	0	0	0	0	0	0
	S	0	0	0	0	2	1	0	0	0
	S	0	0	0	2	1	1	0	0	2
	S	0	0	0	1	4	3	2	1	1
	S	0	0	0	0	3	6	5	4	3
	S	0	0	0	0	2	5	5	4	3
	S	0	0	0	0	1	4	7	6	5

Best score: \_\_\_\_\_7

Best alignment:

ACTUS

ACT-S

(0,0)	(1,0)	...	(n,0)
(0,1)	(1,1)	...	(n,1)
:	:		:
(0,m)	(1,m)	...	(n,m)

Find the **global alignment with affine gap costs** between AGGC and ATTGGGC with the scores. As a reminder the recursive formula for global alignment is given.

$$F(i, j) = \max \begin{cases} F(i-1, j) - b \\ G(i-1, j) - f_{a,b}(1) \end{cases}$$

$$f_{a,b}(i) = \alpha + \beta \cdot i$$

$$E(i, j) = \max \begin{cases} E(i, j-1) - b \\ G(i, j-1) - f_{a,b}(1) \end{cases}$$

$$G(i, j) = \max \begin{cases} G(i-1, j-1) + \delta(S[i], T[j]) \\ E(i, j) \\ F(i, j) \end{cases}$$

F	A	T	T	G	G	G	C	
-∞	-2.5 L	-3 L	-3.5 L	-4 L	-4.5 L	-5 L	-5.5 L	
A	-∞	-5 O	2.5 O	2.0 L	1.5 L	1 L	0.5 L	0 L
G	-∞	-5.5 O	0 O	1.5 O	1 L	4.5 O	4 O/L	3.5 O/L
G	-∞	-6 O	-0.5 O	-1 O	0.5 O	4 O	9.5 O	9 O/L
C	-∞	-6.5 O	-1 O	-1.5 O/L	-2 L	1.5 O	7 O	8.5 O

$$\delta(x, y) = 5 \text{ for } y = x$$

$$\delta(x, y) = -1 \text{ for } y \neq x$$

$$\alpha = 2$$

$$\beta = 0.5$$

Best score: \_\_\_\_\_ 16.5

Best alignment:

A---GGC  
ATTGGGC

G	A	T	T	G	G	G	C	
0	-2.5 L	-3 L	-3.5 L	-4 L	-4.5 L	-5 L	-5.5 L	
A	-2.5 U	5 D	2.5 F	2 F	1.5 F	1 F	0.5 F	0 F
G	-3 U	2.5 E	4 D	1.5 D/F	7 D	6.5 D	6 D	3.5 F
G	-3.5 U	2 E	1.5 D/E	3 D	6.5 D	12 D	11.5 D	9 F
C	-4 U	1.5 E	1 D/E	0.5 D/E	4 E	9.5 E	11 D	16.5 D

E	A	T	T	G	G	G	C	
-∞	-∞	-∞	-∞	-∞	-∞	-∞	-∞	
A	-2.5 U	-5 O	-5.5 O	-6 O	-6.5 O	-7 O	-7.5 O	-8 O
G	-3 U	2.5 O	0 O	-0.5 O	-1 O	-1.5 O	-2 O	-2.5 O
G	-3.5 U	2 U	1.5 O	-1 O/U	4.5 O	4 O	3.5 O	1 O
C	-4 U	1.5 U	1 U	0.5 O	4 O/U	9.5 O	9 O	6.5 O

(0,0)	(1,0)	...	(n,0)
(0,1)	(1,1)	...	(n,1)
:	:		:
(0,m)	(1,m)	...	(n,m)