

Question 1:

(a) [[0, -1, -2, -3, -4, -5, -6, -7],
[-1, -1, -2, -3, -1, -2, -3, -4],
[-2, 1, 1, 0, -1, -2, 0, -1],
[-3, 0, 0, 3, 2, 1, 0, -1],
[-4, -1, -1, 2, 5, 4, 3, 2],
[-5, -2, -2, 1, 4, 7, 6, 5],
[-6, -3, -3, 0, 3, 6, 6, 8],
[-7, -4, -4, -1, 2, 5, 5, 7],
[-8, -5, -2, -2, 1, 4, 7, 6],
[-9, -6, -3, -3, 0, 3, 6, 9]]

(b) Yes, there indeed is more than one possibility of optimally aligning the given sequences.

(c) All optimal alignments with their scores are:

[TTC--AGTA], Score:9

[TTCA--GTA], Score:9

[TTCAG--TA], Score:9

Question 2:

(a) [[0, 0, 0, 0, 0, 0, 0, 0],
[0, 0, 0, 0, 2, 1, 0, 2],
[0, 2, 2, 1, 1, 1, 3, 2],
[0, 1, 1, 4, 3, 2, 2, 2],
[0, 0, 0, 3, 6, 5, 4, 4],
[0, 0, 0, 2, 5, 8, 7, 6],
[0, 0, 0, 1, 4, 7, 7, 9],
[0, 0, 0, 0, 3, 6, 6, 8],
[0, 2, 2, 1, 2, 5, 8, 7],
[0, 1, 1, 1, 3, 4, 7, 10]]

(b) All the alignments obtained are:

[TC--AGTA], Score:10

[TCA--GTA], Score:10

[TCAG--TA], Score:10

Question 3:

In Global Alignment, there is no limit for the minimum value of an element in the bidimensional array as well as there are gap penalties in the first row and column. Whereas in Local Alignment, the minimum value of an element in the bidimensional array is 0, and there are no gap penalties in the first row and column of the array, so the values in the first row and column are 0. This was achieved in the program by changing the max function and making it `arr[i][j] = max(diagonalScore, leftScore, upScore, 0)`

So now, before entering the value in the `arr[i][j]`, the max function also compares it with 0 too, and if the other values are negative, 0 is the maximum and is added to `arr[i][j]`.

Also the function optimal alignment function was called wherever the maximum score of alignment was found in the bi-dimensional array using for-loop.

Question 4:

Yes it will change the results obtained in the Questions 1 & 2.

For the first question, the new result will be:

```
[[0, -2, -4, -6, -8, -10, -12, -14],  
[-2, -1, -3, -5, -4, -6, -8, -10],  
[-4, 0, 1, -1, -3, -5, -4, -6],  
[-6, -2, -1, 3, 1, -1, -3, -5],  
[-8, -4, -3, 1, 5, 3, 1, -1],  
[-10, -6, -5, -1, 3, 7, 5, 3],  
[-12, -8, -7, -3, 1, 5, 6, 7],  
[-14, -10, -9, -5, -1, 3, 4, 5],  
[-16, -12, -8, -7, -3, 1, 5, 3],  
[-18, -14, -10, -9, -5, -1, 3, 7]]
```

All the alignments obtained are:

[TTC--AGTA], Score:7

[TTCA--GTA], Score:7

[TTCAG--TA], Score:7

For the second question, the new result will be:

```
[[0, 0, 0, 0, 0, 0, 0, 0],
 [0, 0, 0, 0, 2, 0, 0, 2],
 [0, 2, 2, 0, 0, 1, 2, 0],
 [0, 0, 1, 4, 2, 0, 0, 1],
 [0, 0, 0, 2, 6, 4, 2, 2],
 [0, 0, 0, 0, 4, 8, 6, 4],
 [0, 0, 0, 0, 2, 6, 7, 8],
 [0, 0, 0, 0, 0, 4, 5, 6],
 [0, 2, 2, 0, 0, 2, 6, 4],
 [0, 0, 1, 1, 2, 0, 4, 8]]
```

All the alignments obtained are:

```
[TCAG-A], Score:8
[TC--AGTA], Score:8
[TCA--GTA], Score:8
[TCAG--TA], Score:8
```

We see these changes in the results because of the fact that the gap penalty changed, this led to change in the first row and column of the Global Alignment part, as well as the scores obtained from the left and up since gap penalties are added to them, so the new gap penalty was -2, so it changed the leftScore and upScore for every comparison and hence altered the values being entered in the arr. It also altered the score for optimal alignment, in question 1 it changed from 9 to 7, and in question 2, it changed from 10 to 8.