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Question 1

a)

```
DP Matrix
 [[ 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]]
The optimal path score: 9
The optimal alignment:
ATCAGAGTA
||  ||||
TTC--AGTA
```

b)Yes, there are 3 different optimally aligned sequences.

c)

```
 [[ 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]]
ATCAGAGTA
||  ||||
TTC--AGTA
ATCAGAGTA
|||  |||
TTCA--GTA
ATCAGAGTA
||||  ||
TTCAG--TA
The optimal path score is  9
```

To get all the optimally aligned sequences we have to use recursive backtracking instead of iteration and store all the paths in a list.

Question 2

```
DP Matrix
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
The optimal alignment:
TCAGAGTA
||  ||||
TC--AGTA
The optimal path score is  10  at ( 9 , 7 )
```

Question 3
Changes required in the program in order to perform local rather than global pairwise sequence alignment:
1) We initialise the matrix with zero instead of gap value.
2) For scoring the matrix, we can put negative values. Thus, while using max function, we add another value, i.e., 0.
3) While tracing back we stop when we reach value 0 in the matrix.

Question 4

a)

```
DP Matrix
[[  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]]
The optimal path score is  7
All possible alignments:
ATCAGAGTA
|| ||||
TTC--AGTA
ATCAGAGTA
||| |||
TTCA--GTA
ATCAGAGTA
|||| ||
TTCAG--TA
```

b)

```
DP Matrix
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
The optimal alignment:
AGTA
||||
AGTA
The optimal path score is  8  at ( 9 , 7 )
```

Yes, there will be changes in optimal path and scores in both questions.
In global alignment our optimal score is reduced to 7 and in local alignment it is reduced to 8.