Midterm Practice Exam

Spring 2021

March 4, 2021

1. Given the table below which was created using the Smith-Waterman algorithm for local alignment, (a) identify the local alignment score, and (b) perform trace-back to find the optimal alignment.

		T	T	A	C	T	G	T	G	T
	0	0	0	0	0	0	0	0	0	0
C	0	0	0	0	↖5	←4.5	←4	←3.5	←3	←2.5
A	0	0	0	↖5	←↑4.5	↖←↑4	↖←↑3.5	↖←↑3	↖←↑2.5	↖←↑2
C	0	0	0	↑4.5	↖10	←9.5	←9	←8.5	←8	←7.5
C	0	0	0	↑4	↖↑9.5	↖←↑9	↖←↑8.5	↖←↑8	↖←↑7.5	↖←↑7
C	0	0	0	↑3.5	↖↑9	↖←↑8.5	↖←↑8	↖←↑7.5	↖←↑7	↖←↑6.5
C	0	0	0	↑3	↖↑8.5	↖←↑8	↖←↑7.5	↖←↑7	↖←↑6.5	↖←↑6
T	0	↖5	↖5	←4.5	↑7.5	↖13.5	←13	↖←12.5	←12	↖←11.5
G	0	↑4.5	↑4.5	↖←↑4	↑7	↑13	↖18.5	←18	↖←17.5	←17
T	0	↖5	↖9.5	←9	←8.5	↑12.5	↑18	↖23.5	←23	↖←22.5
G	0	↑4.5	↑9	↖←↑8.5	↖←↑8	↑12	↖↑17.5	↑23	↖28.5	←28

Optimal Local Alignment Score:

Optimal Local Alignment (note not all of the spaced will be used)

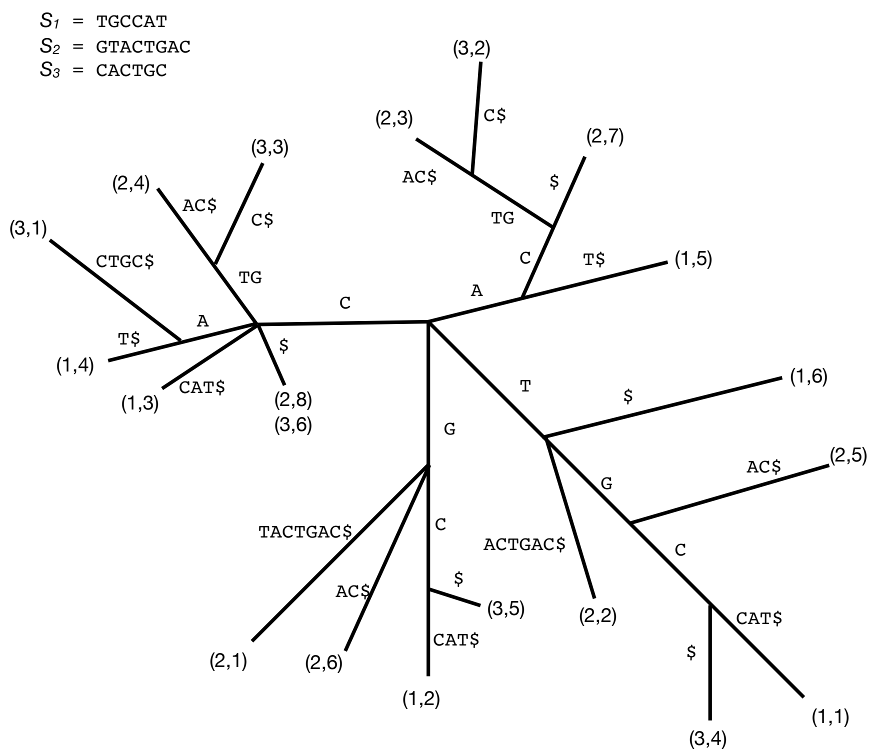
2. Given the Needleman-Wunsch table below, find the optimal global alignment for the two sequences.

		T	T	A	C	T	G	T	G	T
	0	←-0.5	←-1	←-1.5	←-2	←-2.5	←-3	←-3.5	←-4	←-4.5
C	↑-0.5	↖←↑-1	↖←↑-1.5	↖←↑-2	↖3.5	←3	←2.5	←2	←1.5	←1
A	↑-1	↖←↑-1.5	↖←↑-2	↖3.5	←↑3	↖←↑2.5	↖←↑2	↖←↑1.5	↖←↑1	↖←↑0.5
C	↑-1.5	↖←↑-2	↖←↑-2.5	↑3	↖8.5	←8	←7.5	←7	←6.5	←6
C	↑-2	↖←↑-2.5	↖←↑-3	↑2.5	↖↑8	↖←↑7.5	↖←↑7	↖←↑6.5	↖←↑6	↖←↑5.5
C	↑-2.5	↖←↑-3	↖←↑-3.5	↑2	↖↑7.5	↖←↑7	↖←↑6.5	↖←↑6	↖←↑5.5	↖←↑5
C	↑-3	↖←↑-3.5	↖←↑-4	↑1.5	↖↑7	↖←↑6.5	↖←↑6	↖←↑5.5	↖←↑5	↖←↑4.5
T	↑-3.5	↖2	↖←1.5	←↑1	↑6.5	↖12	←11.5	↖←11	←10.5	↖←10
G	↑-4	↑1.5	↖←↑1	↖←↑0.5	↑6	↑11.5	↖17	←16.5	↖←16	←15.5
T	↑-4.5	↖↑1	↖6.5	←6	←↑5.5	↖↑11	↑16.5	↖22	←21.5	↖←21
G	↑-5	↑0.5	↑6	↖←↑5.5	↖←↑5	↑10.5	↖↑16	↑21.5	↖27	←26.5

Optimal Global Alignment (note not all of the spaced will be used)

3. (a) Compute the Z-Values for `ACTAACTAAC`. (b) how are the values of $Z_2, Z_3, ...Z_{i-1}$ used in computing Z_i. (c) what does the value of Z_i mean?

4. From the suffix tree below: (a) determine if the string ACTG is in the input set of sequences, and explain your reasoning; and (b) find the longest common substring between the set of sequences, and explain your reasoning.



5. What is the sum-of-pairs score of the following multiple sequence alignment using the global scoring with affine scoring model with the following parameters:

match	10
mismatch	-3
indel	-1
gap	-3

```
ACCTGCC
-C-TGCA
AGCGGCA
ACCT--A
```

6. Given the pairwise alignments between the 4 sequences, and using sequence B as the star-center, create the multiple alignment using the center-star method.

A: `GATG-TGCCG`	B: `CCTGCT-GCAG`	B: `CCTGCT-GCAG`
B: `CCTGCTGCAG`	C: `CC-GCTAGCAG`	D: `CCTG-TAG--G`

7. How would we modify the Smith-Waterman algorithm if we wanted to find a disjoint set of substrings of S to align to a substring of T.

   For example when aligning $S =$`GGAGCGGCTTGG` with $T =$`AAAACCTTTT`, an optimal alignment would align $S[3..5] \cdot S[8..10]$ to $T[3...8]$:

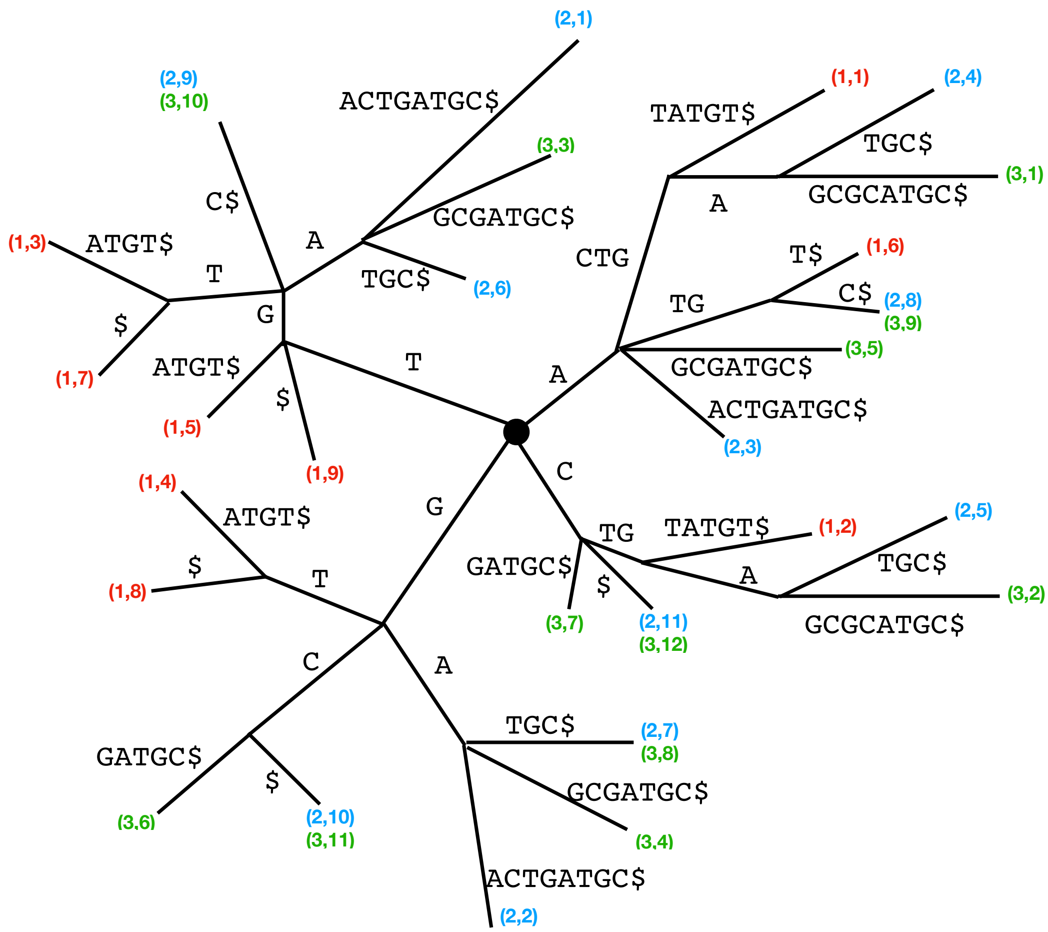
   ```
   AGCCTT
   AACCTT.
   ```

   The concept can be though of as "skipping" $S[6..7]$ when computing the optimal local alignment. Note that the $\cdot$ operator is for concatenation.

8. (2 point) Given the following partially completed computation of the Z-value algorithm, compute the rest of the values using the $O(n)$ time algorithm we discussed in class. Describe how you arrived at each value.

	C	G	T	C	G	T	A	C	G	T	C	G	A	C
i	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Z_i	-	0	0	3	0	0	0	5						

9. (3 points) From the suffix tree below: (a) determine if the string `ACTG` is in the input set of sequences, and explain your reasoning; (b) find the longest substring that occurs in all of the sequences ***twice***, and explain your reasoning; (c) list the missing suffix links.



10. (2 points) How would we modify the Needleman-Wunsch algorithm if we wanted to allow for any character in S to be repeated aligned as many times as we want in place.

    For example when aligning $S =$`AGA` with $T =$`GGGGGA`, an optimal alignment would repeat the `G` in S 5 times to give the alignment:

    ```
    AGGGGGA
    -GGGGGA
    ```

    In reality, the middle `G` is is being aligned with all of the `G`s in T.