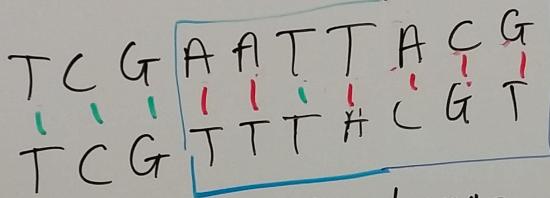


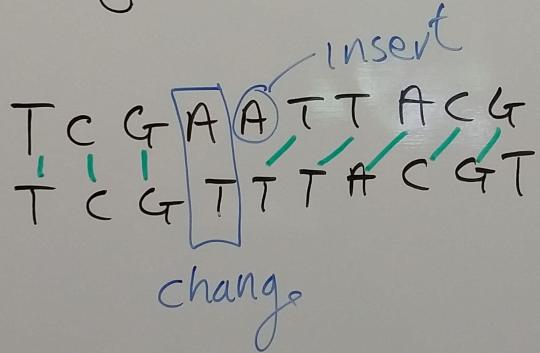
(1)

## DNA Alignment

miss  
match



match



relate  
- w.r.t.  
evolutionary  
operation

+ Delete a base  
(A, G, C, T)

→ Insert a base

+ change a base  
 $A \rightarrow C$   
 $G \rightarrow T$

②

Given: two strings  
lengths      A,    B  
                    n,    m

Find: sequence of substitution, insert  
                    delete operators  
                    that  $A \rightarrow B$

Such That: minimal sequence

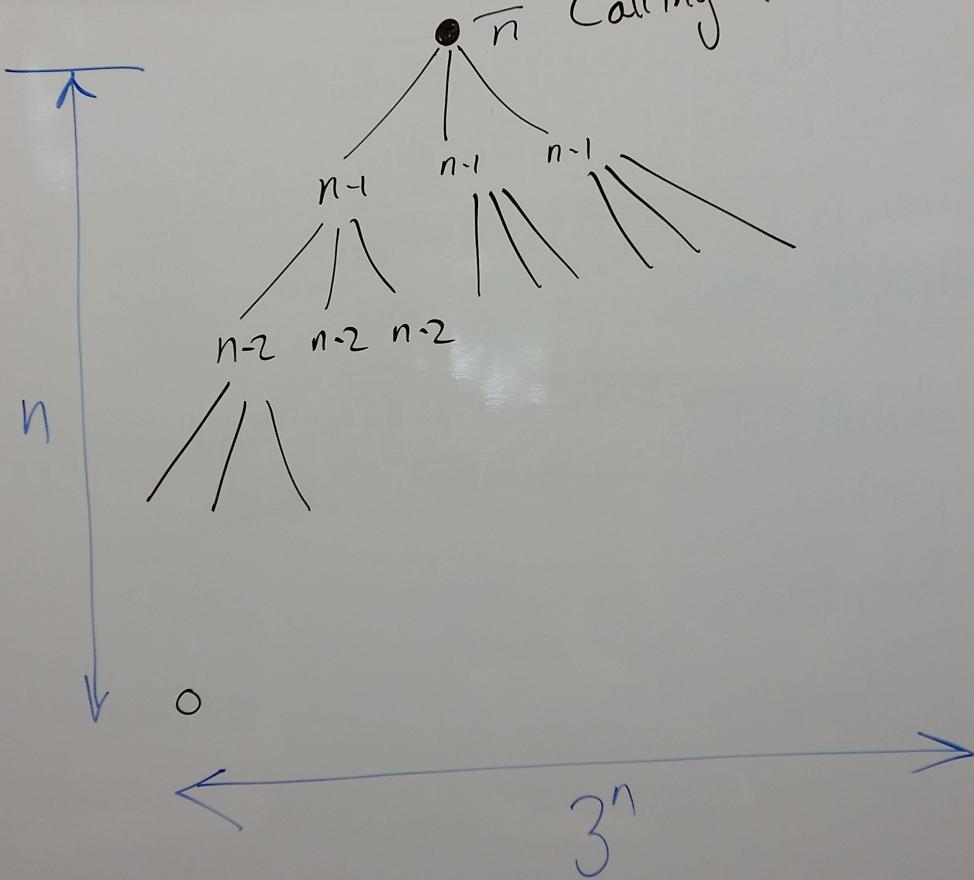
③ count of number of operators  
 INT Def Align '(i, j) // initial call (n, m)  
 // index 0 is the empty string  
 A = "", B = "ACGTT"  
 i=6

```

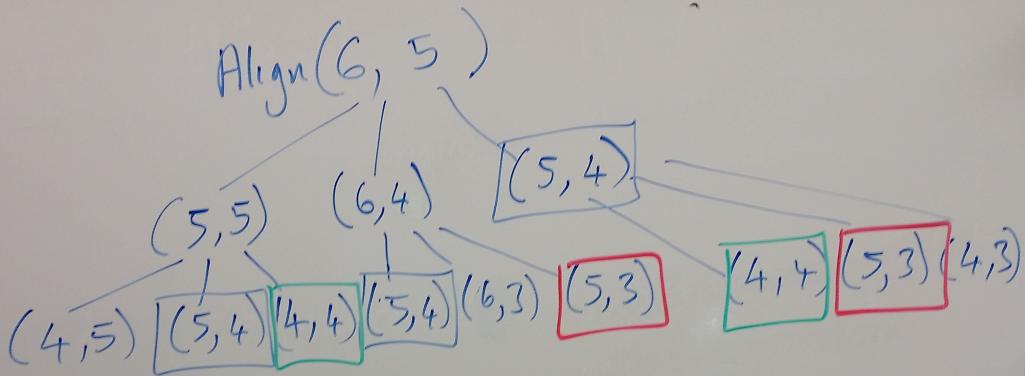
    IF i==0 // empty A
      return j
    IF j==0 // empty B
      return i
    return min (
      Align(i-1, j) + 1,           A = "A G C T T A"
      Align(i, j-1) + 1,           B = "C G T T T"   ↑ j=5
      Align(i-1, j-1) +           A = "A G C T T A"   align T with
      A[i] != B[j] ) Align(i-1, j)   B = "C G T T"     T
                                         A = "A G C T T"
                                         B = "C G T T"
                                         Align(i, j-1)
                                         Align(i-1, j-1)
  
```

④

Analyze Speed / Complexity  
Calling tree



5



Many repeats SAME call

How many UNIQUE calls?

$$\text{Align}(n, m)$$

$$(n+1)(m+1) \leftarrow \text{unique calls}$$

$$10^4 \quad 10^4 \quad 10^8$$

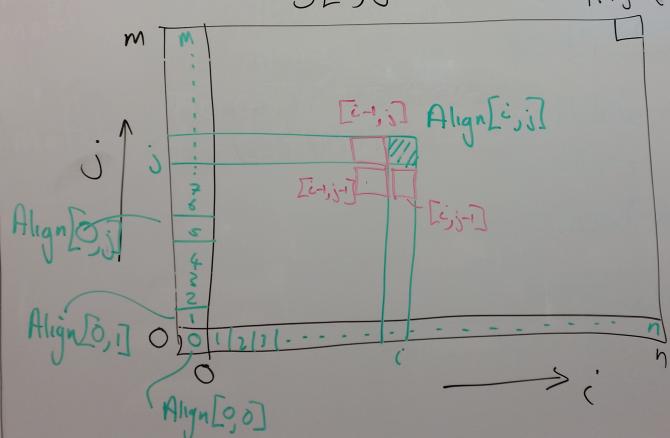
array

6 Dynamic Programming  
"Bellman Equation"

2D array to  
store the solutions to each unique problem

$S[i, j]$   $\text{Align}(n, m)$

$+1,$   
 $] + 1,$   
 $- 1] + A[i] := B[j]$



String A  
String B

A G T T  
" " " "  
- G T G

Delete  
from A

↑ Solu  
this  
arr

A G T T C A  
G T G A A T

8

7

```
S = new int[n+1, m+1] // array
for i in range(0, n+1):
    S[i, 0] = i
for j in range(0, m+1):
    S[0, j] = j
for i in range(1, n+1):
    for j in range(1, m+1):
        S[i, j] = min(S[i-1, j] + 1,
                        S[i, j-1] + 1,
                        S[i-1, j-1] + A[i] != B[j])
return S[n, m]
```

(8)

Alignment Solution 4

String A  
String B

A	G	T	T	C	A	A	T	-
"	"	"			"	"	"	
-	G	T	G	-	A	A	T	C



Delete from A



Delete from B

either match  
substitution

↗ Solution comes for  
this location in the  
array

Trace Back(initial call is  
 $i=n, j=m$ )Def  $TB(i, j)$ IF  $i == 0 \text{ and } j == 0$   
returnIF  $i == 0$   
print ("\_ " " "  $B[j]$ )  
 $TB(i, j-1)$  returnIF  $j == 0$   
print ( $A[i]$  " " "-")  
 $TB(i-1, j)$  returnIF  $S[i, j] == S[i-1, j+1]$   
print ( $A[i]$  " " " $B[j]$ )  
 $TB(i-1, j)$  return

MORE . . .