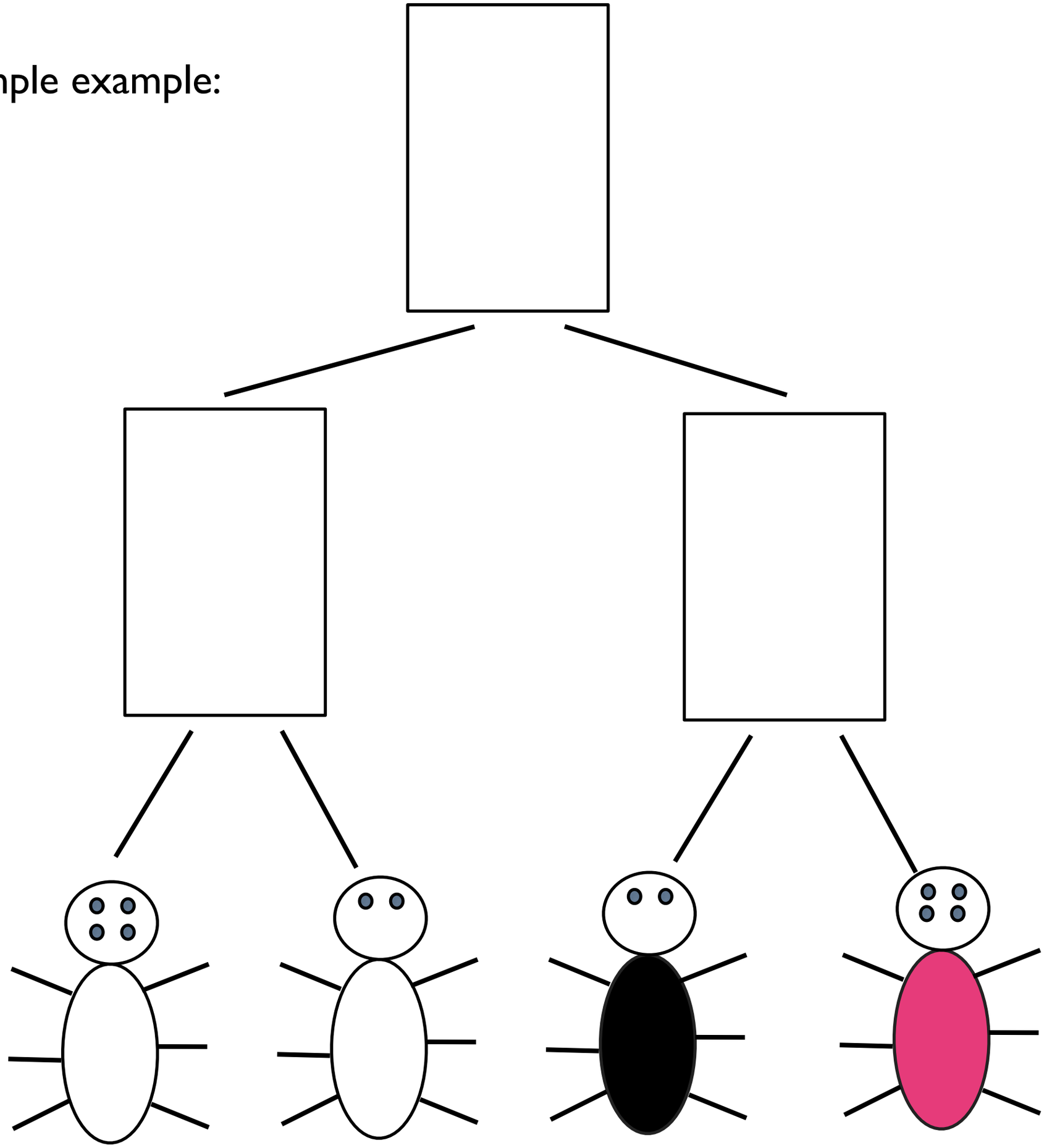
Fitch's Algorithm

CSc106 Fall 2012 Lab

Fitch's Algorithm

- Given a set of known creatures **and**
- An ancestral tree shape
- Find a **most parsimonious** set of ancestors which could explain these creatures
- Solves the **Small Parsimony Problem**
- Can be done in **polynomial time**

A simple example:



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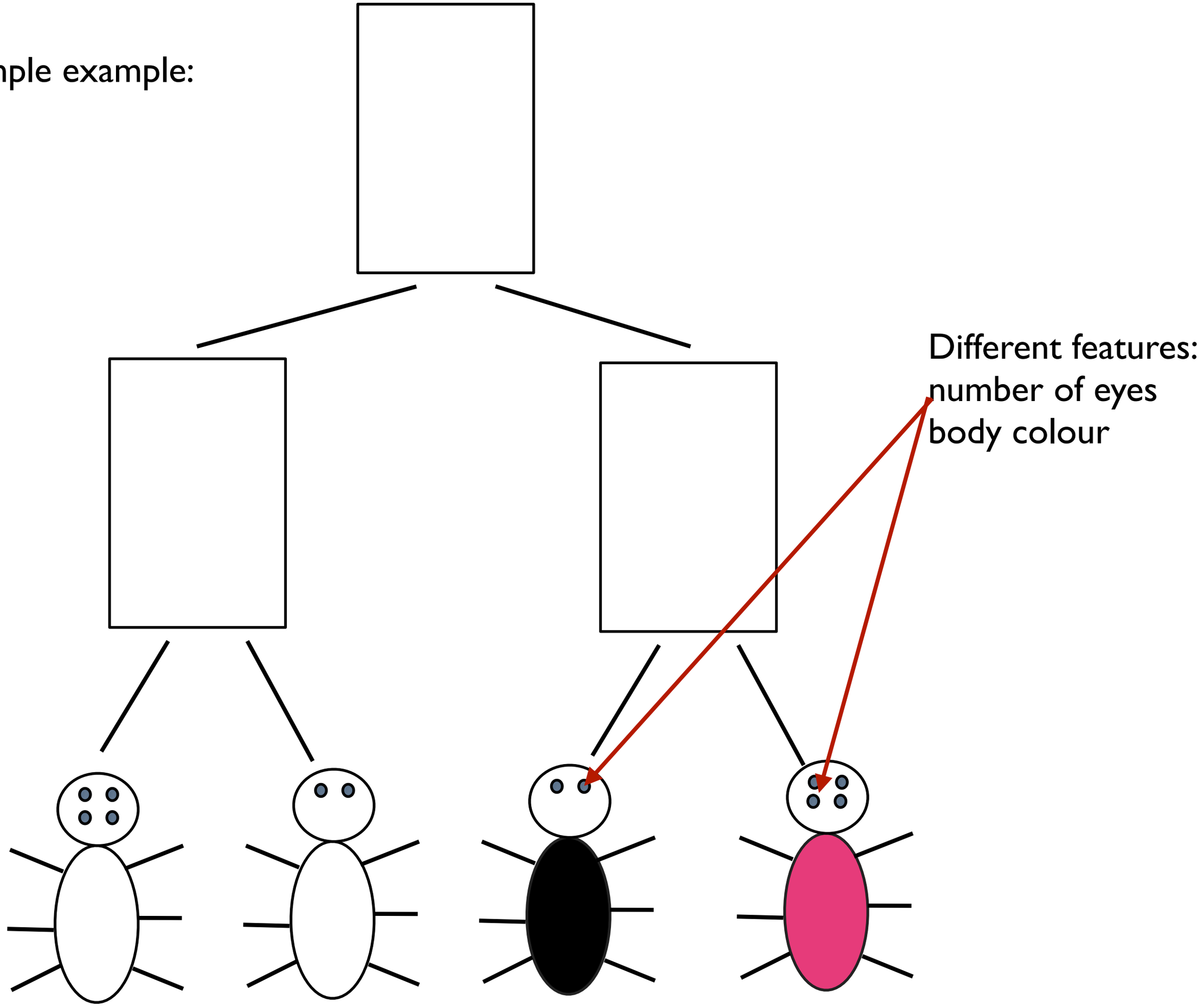

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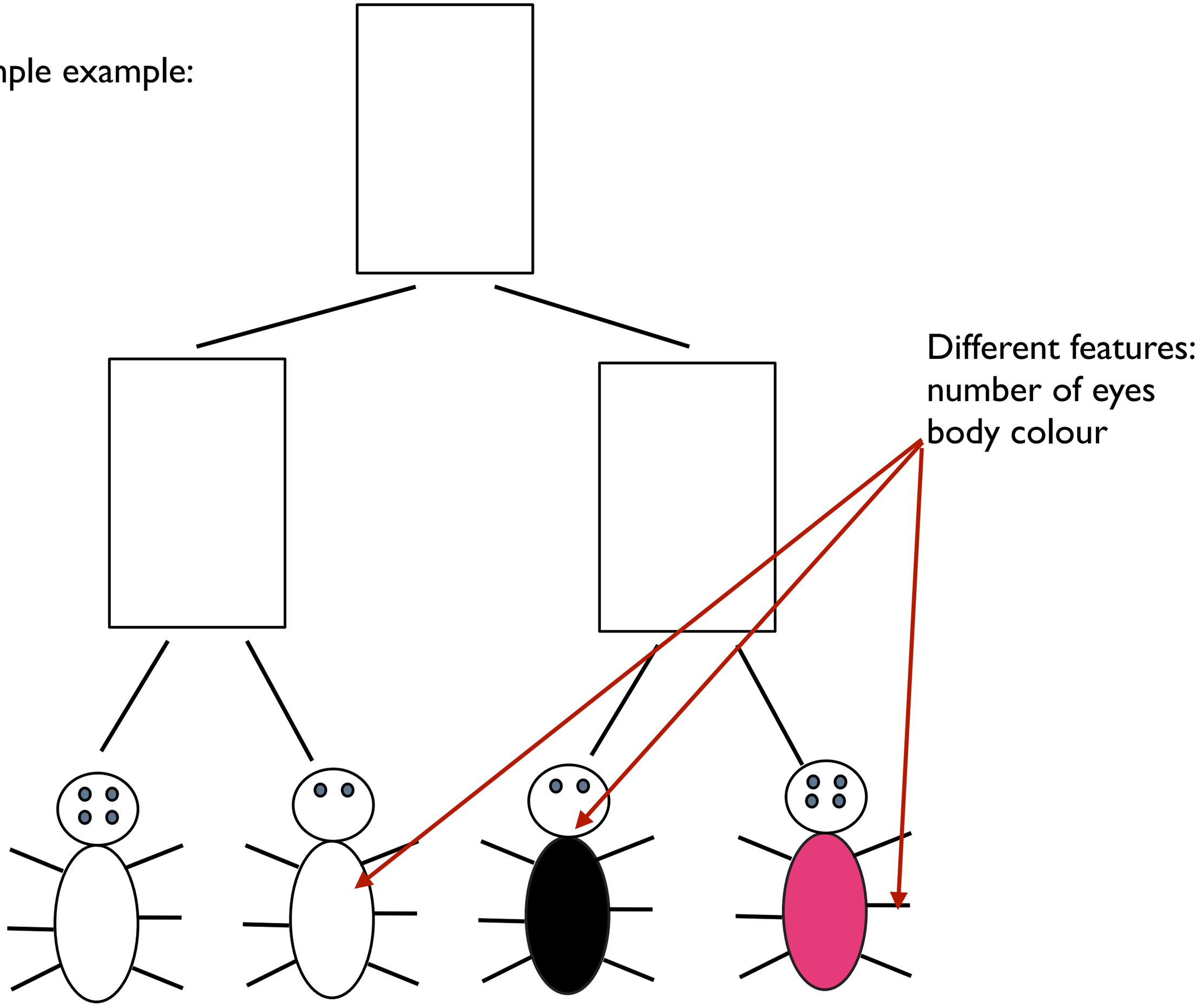
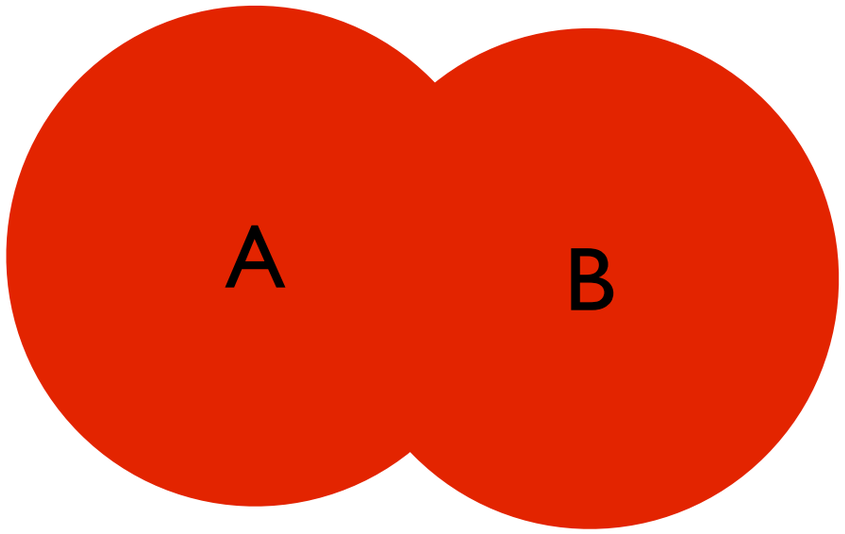


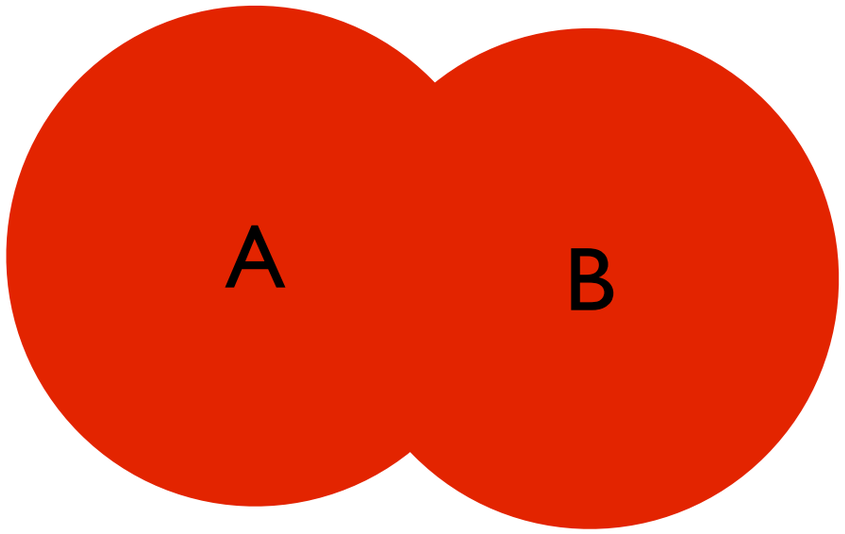
A quick review...

- Recall:
  - ***Union*** of {a,b,c} {b,c,d} is {a,b,c,d}
  - ***Intersection*** of {a,b,c} {b,c,d} is {b,c}
  - ***Postorder*** traversal: visit children before parent
  - ***Preorder*** traversal: visit parent before children
  - Keep left-first branch consistent!

Union and Intersection

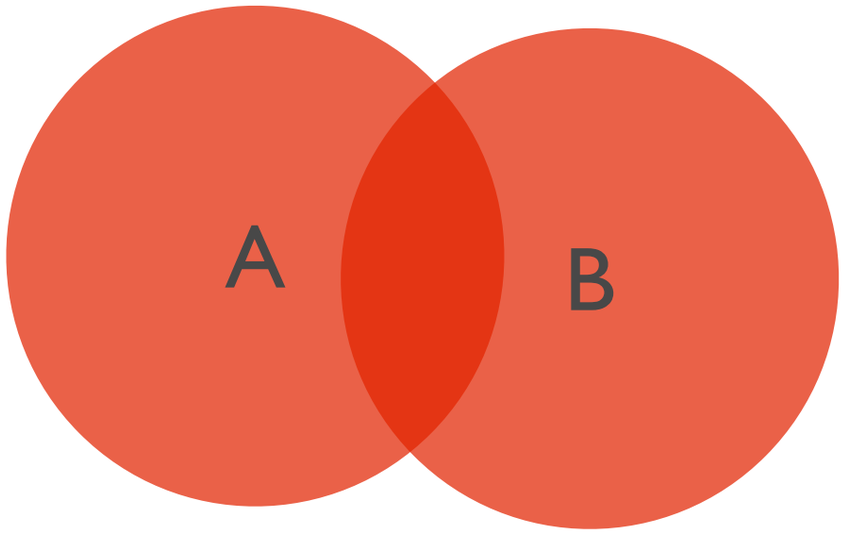


Union and Intersection



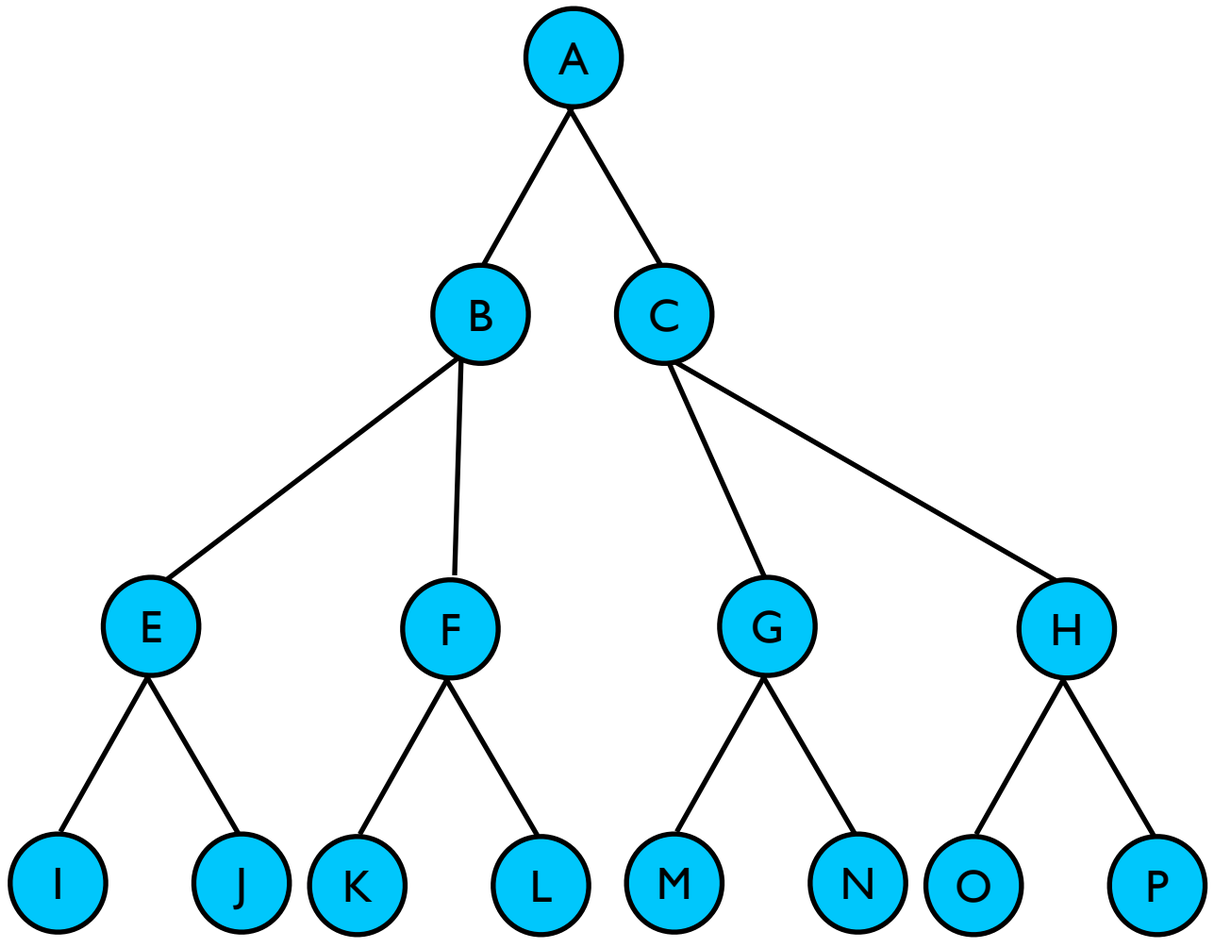
Union: All of A OR B

Union and Intersection

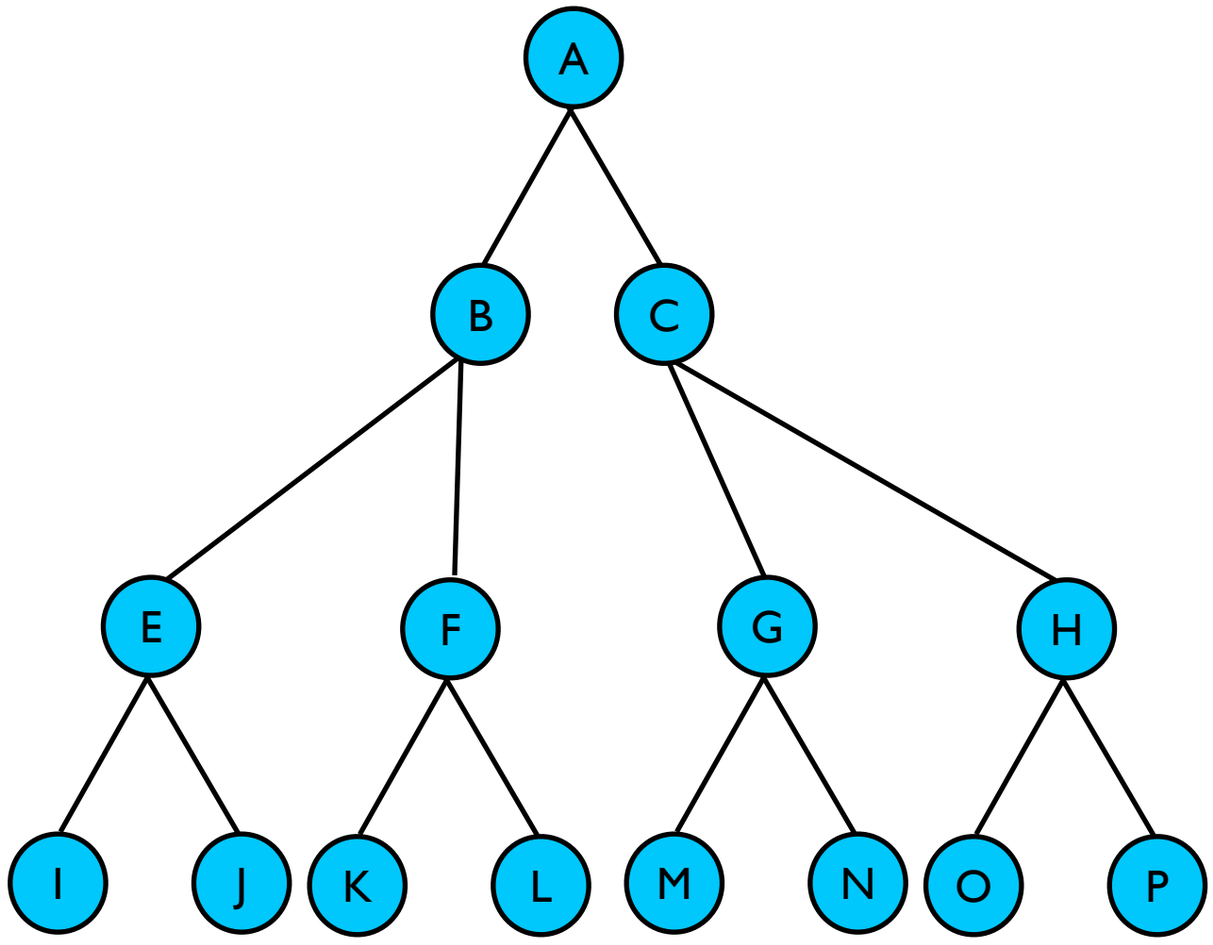


Intersection: Only in A AND B

Tree Traversals

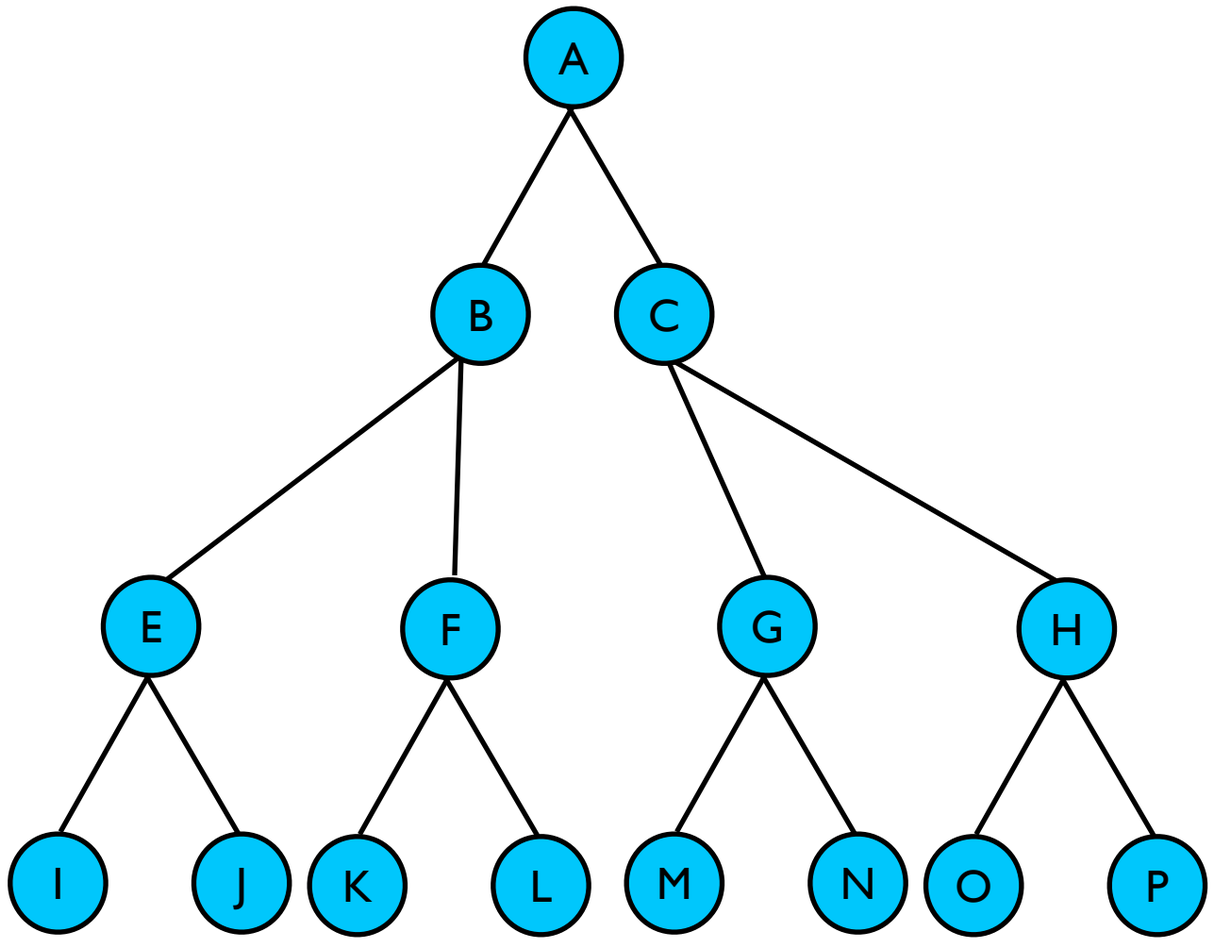


Tree Traversals



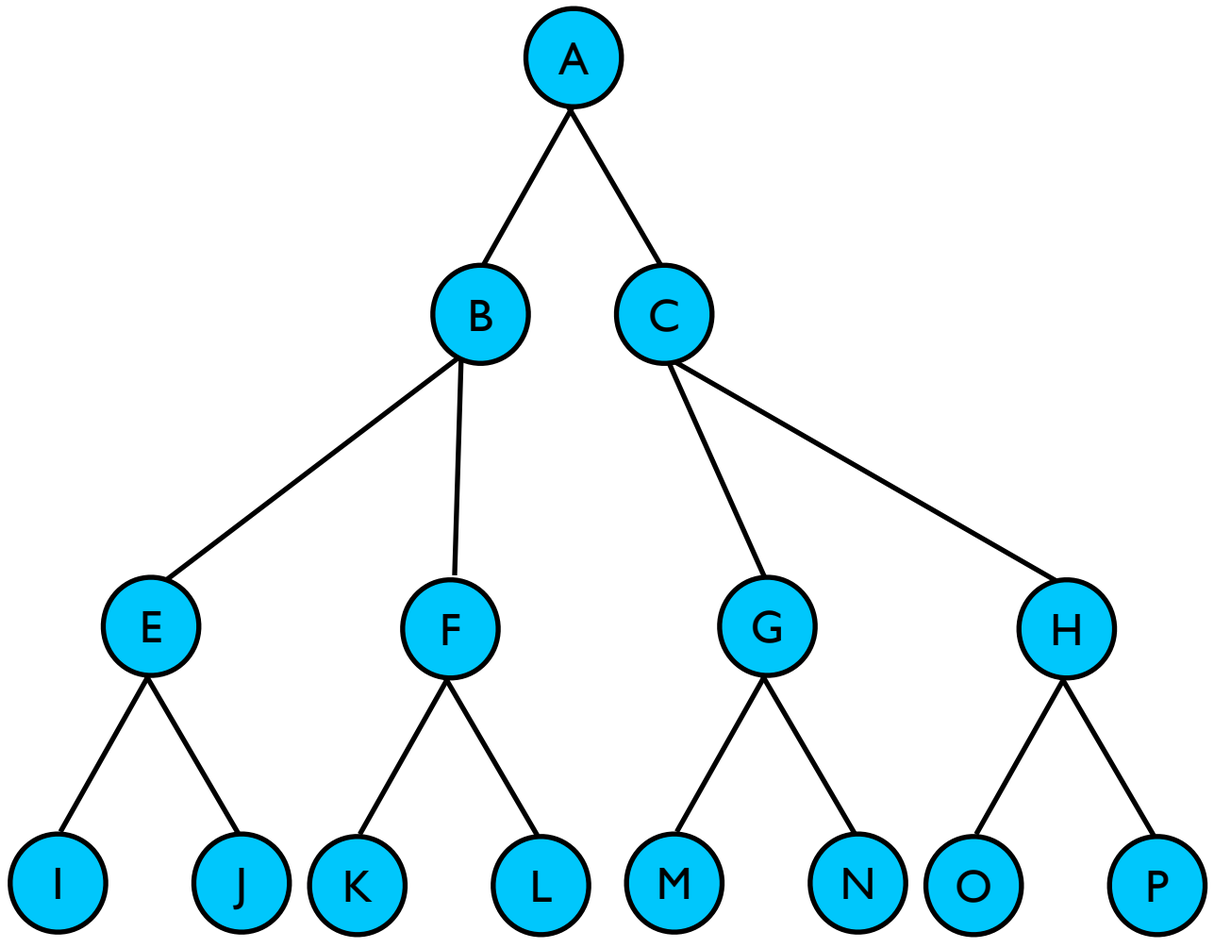
Pre-Order: Parent first, then children...

Tree Traversals



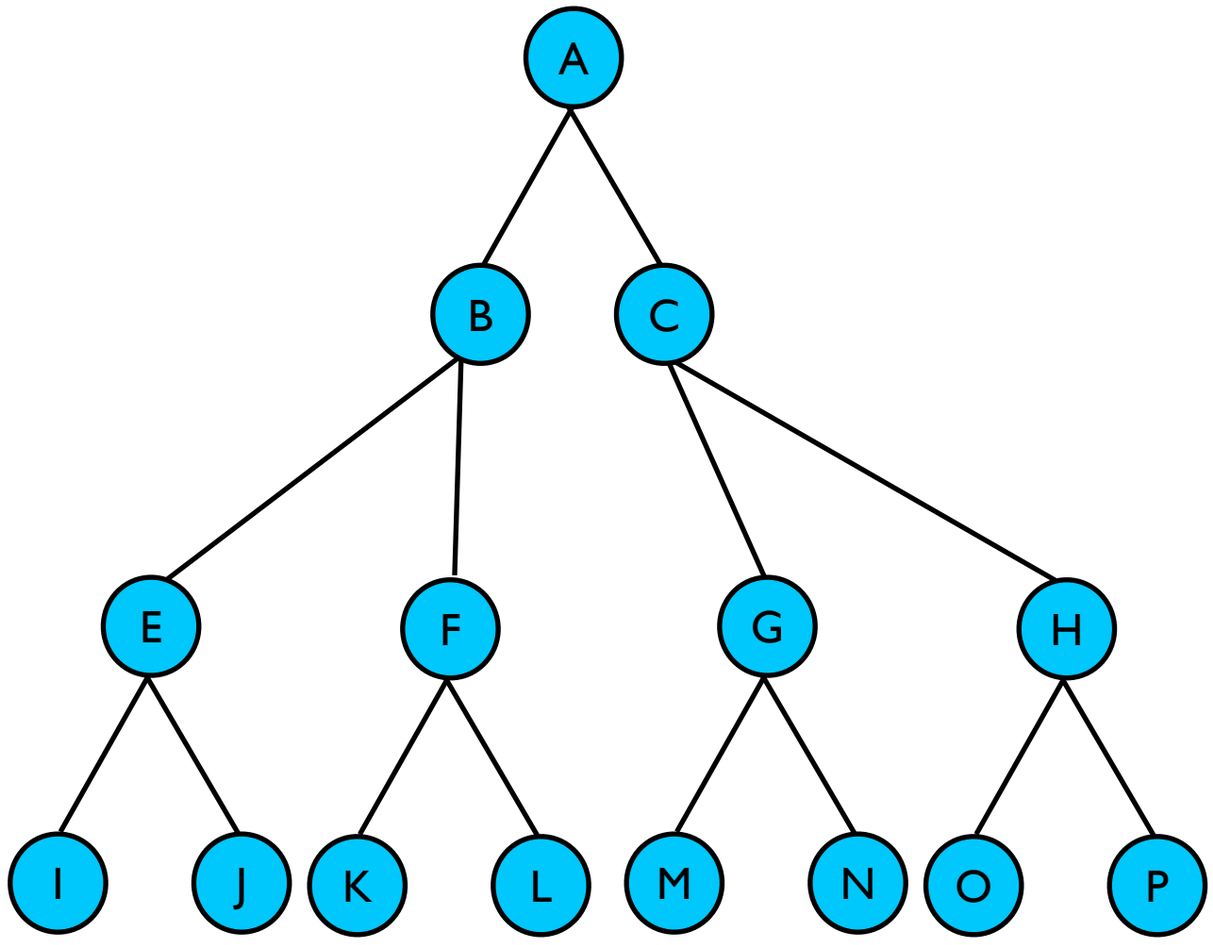
Pre-Order: A, B, E, I, J, F, K, L, C, G, M, N, H, O, P

Tree Traversals



Post-Order: Children first, then parent...

Tree Traversals



Post-Order: I, J, K, L, M, N, O, P, E, F, G, H, B, C, A

Fitch's Algorithm

LABEL TREE

Traverse tree in post-order, for each node:

if (features of the two children *intersect)*

label the parent with *intersection* of its children's features(s)

else

label with the parent with *union* of children's feature(s)

ASSIGN FEATURES

Traverse tree in pre-order, for each node:

if (the node is the root)

for each feature,

choose any label arbitrarily

else

if a feature's label matches the parent's feature

choose that feature

else

pick a feature from labels, arbitrarily

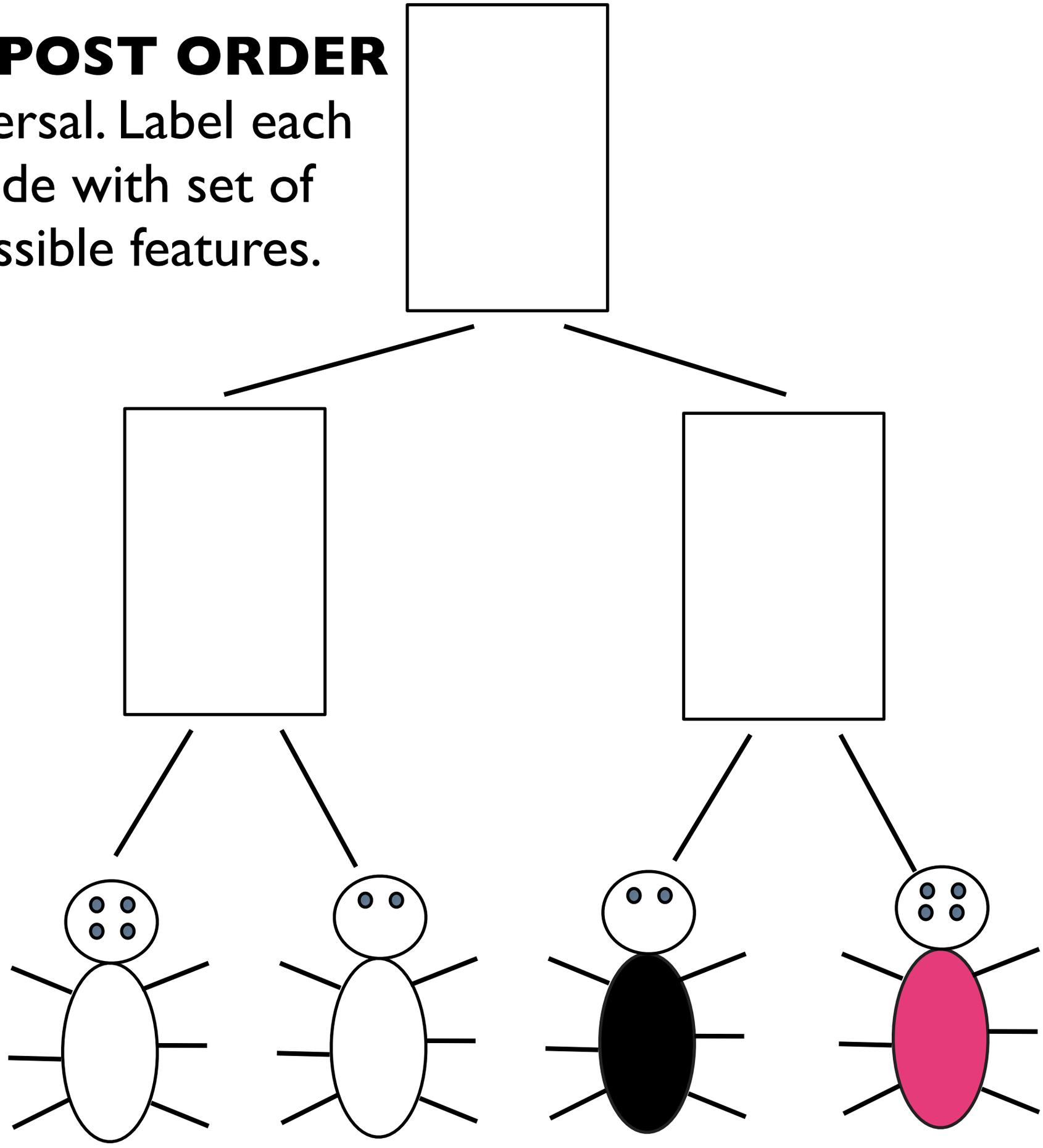
CALCULATE SCORE

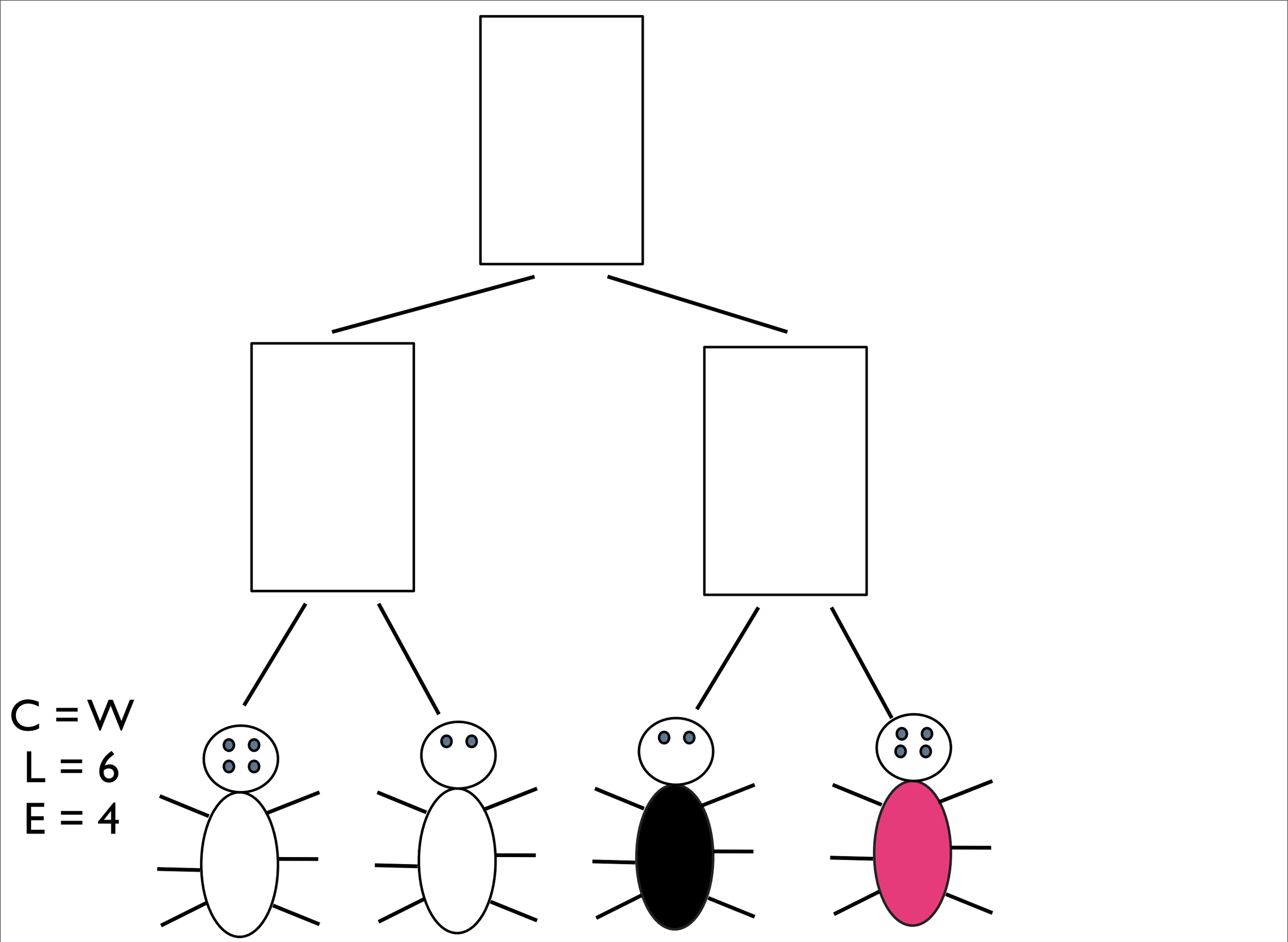
Sum the differences between all child/ancestors

Fitch's Algorithm

- Changes of different features are independent!
- Algorithm described for one feature, but can be done for all features in parallel

Do a **POST ORDER** traversal. Label each node with set of possible features.




C = W
L = 6
E = 4

C = W
L = 6
E = 4

C = W
L = 6
E = 2

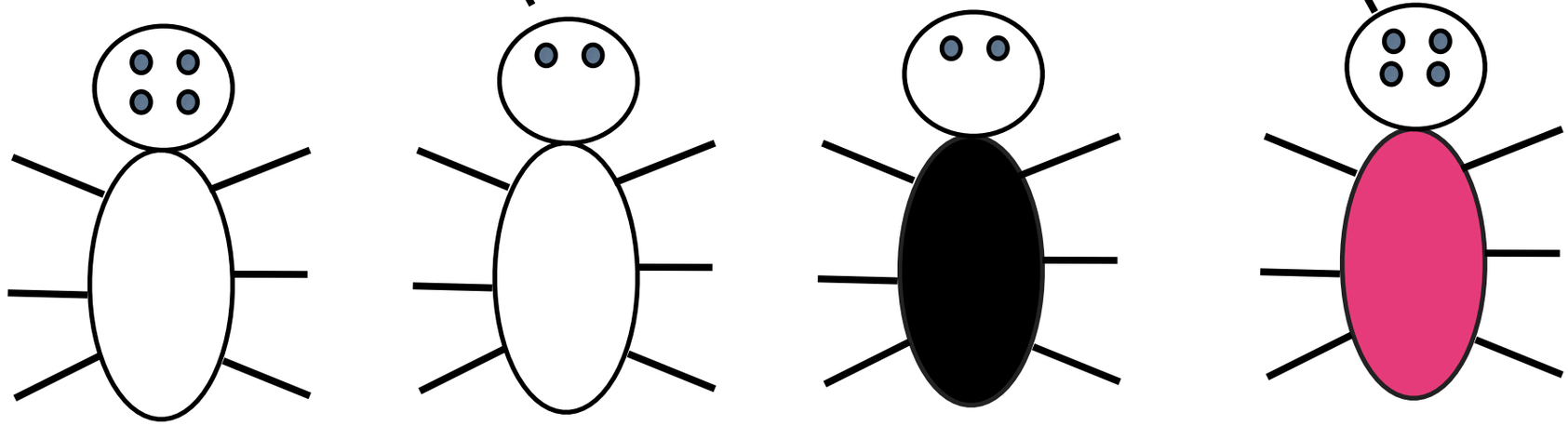
C = W
L = 6
E = {2,4}

C = W
L = 6
E = 2

C = B
L = 6
E = 2

C = P
L = 6
E = 4

C = W
L = 6
E = 4



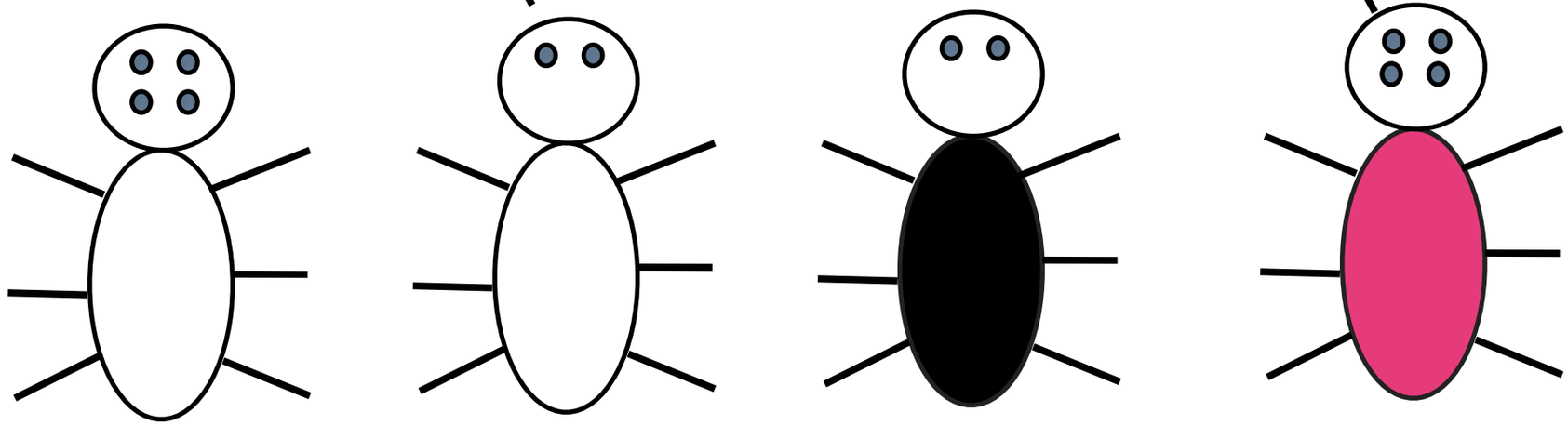
C = W
L = 6
E = {2,4}

C = W
L = 6
E = 2

C = B
L = 6
E = 2

C = P
L = 6
E = 4

C = W
L = 6
E = 4



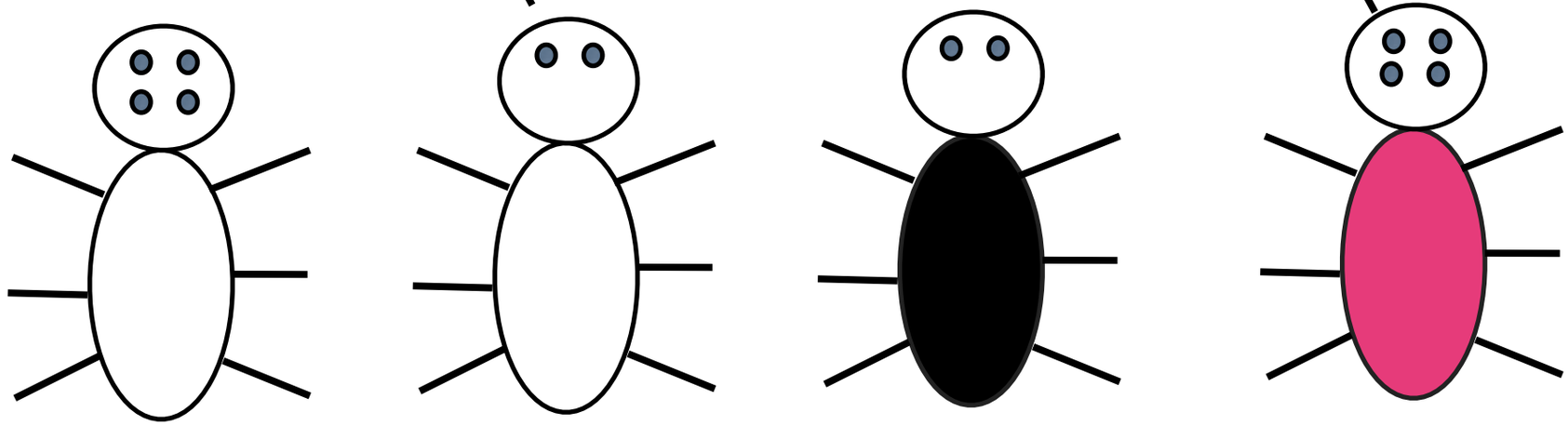
C = W
L = 6
E = {2,4}

C = W
L = 6
E = 2

C = B
L = 6
E = 2

C = P
L = 6
E = 4

C = W
L = 6
E = 4



C = W
L = 6
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C = {B,P}
L = 6
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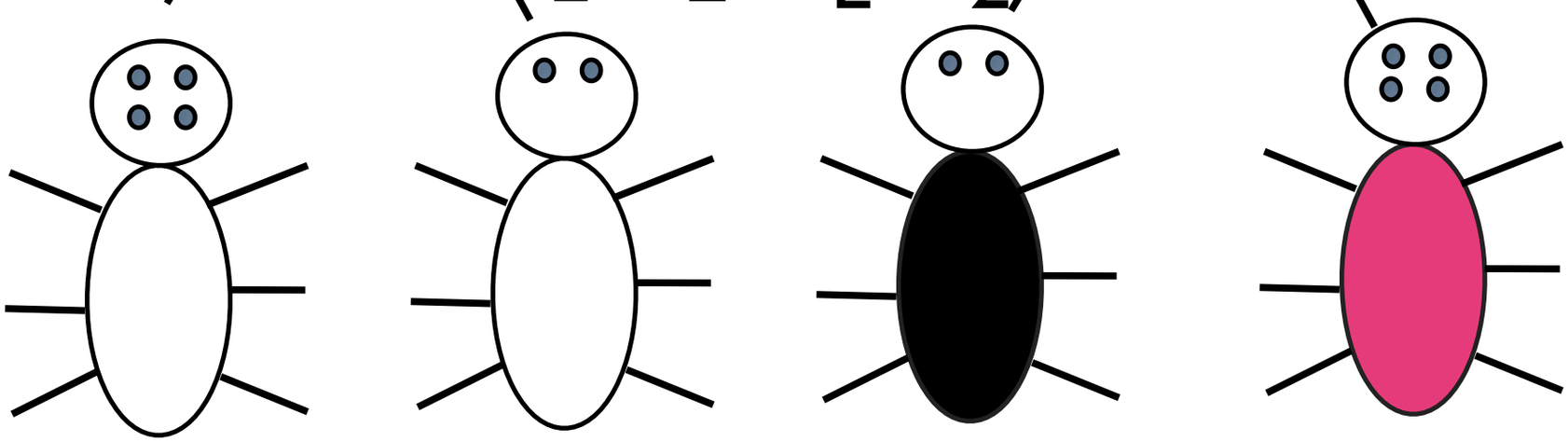
C = W
L = 6
E = 4

C = W
L = 6
E = 2

C = B
L = 6
E = 2

C = P
L = 6
E = 4



C = {B,P,W}
L = 6
E = {2,4}

C = W
L = 6
E = {2,4}

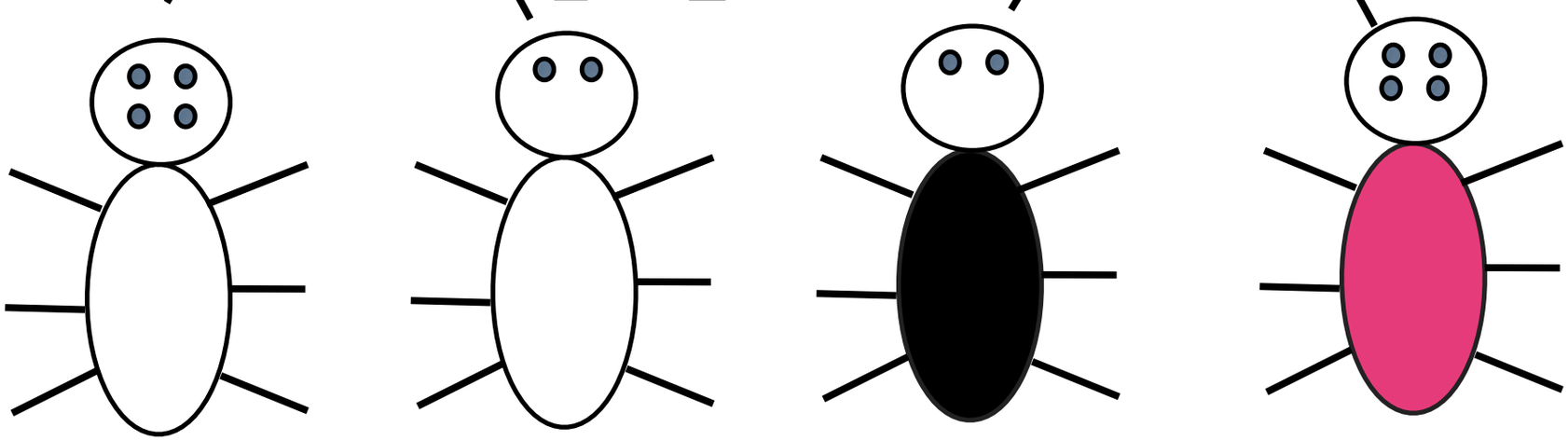
C = {B,P}
L = 6
E = {2,4}

C = W
L = 6
E = 4

C = W
L = 6
E = 2

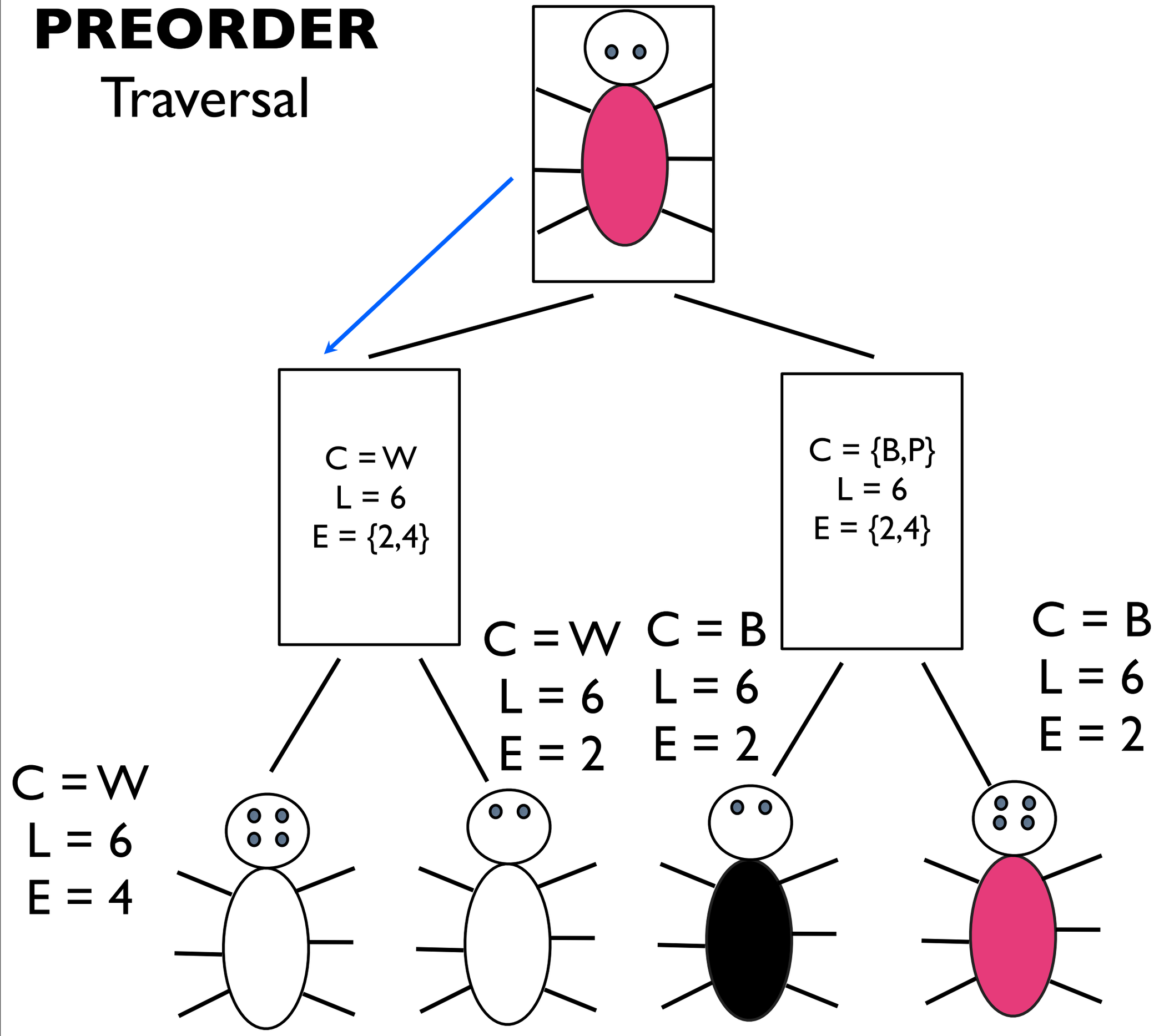
C = B
L = 6
E = 2

C = P
L = 6
E = 4



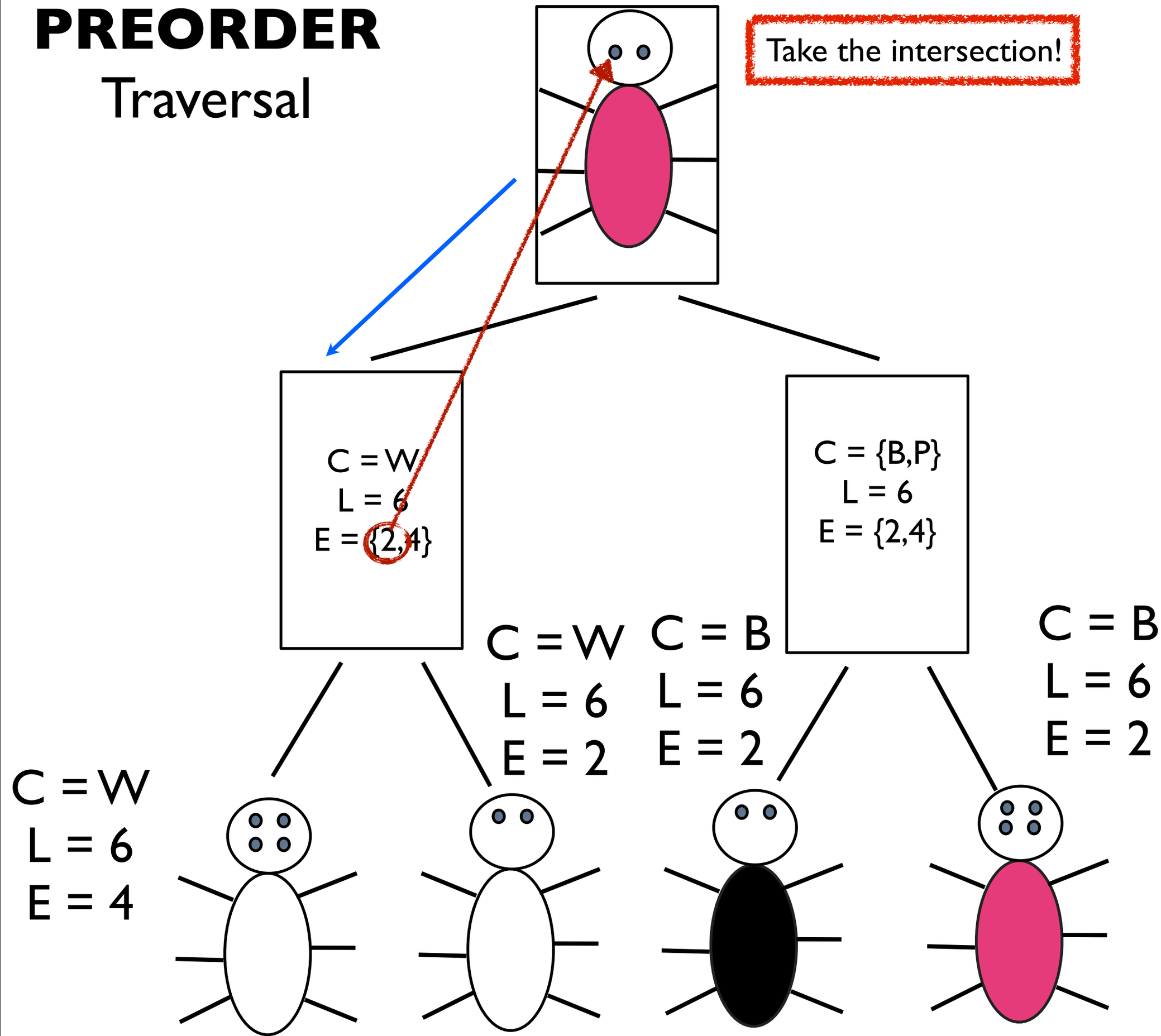
PREORDER

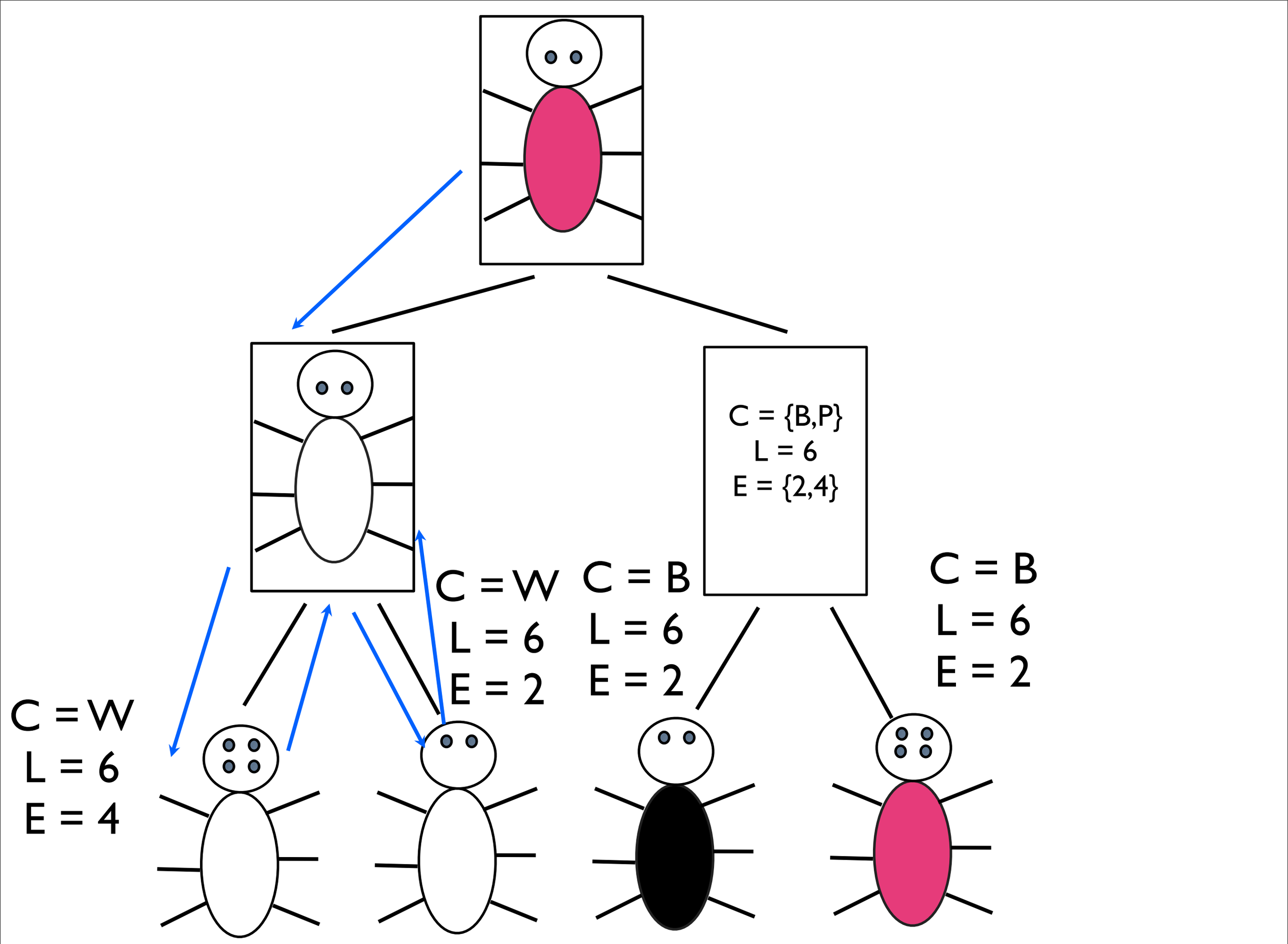
Traversal

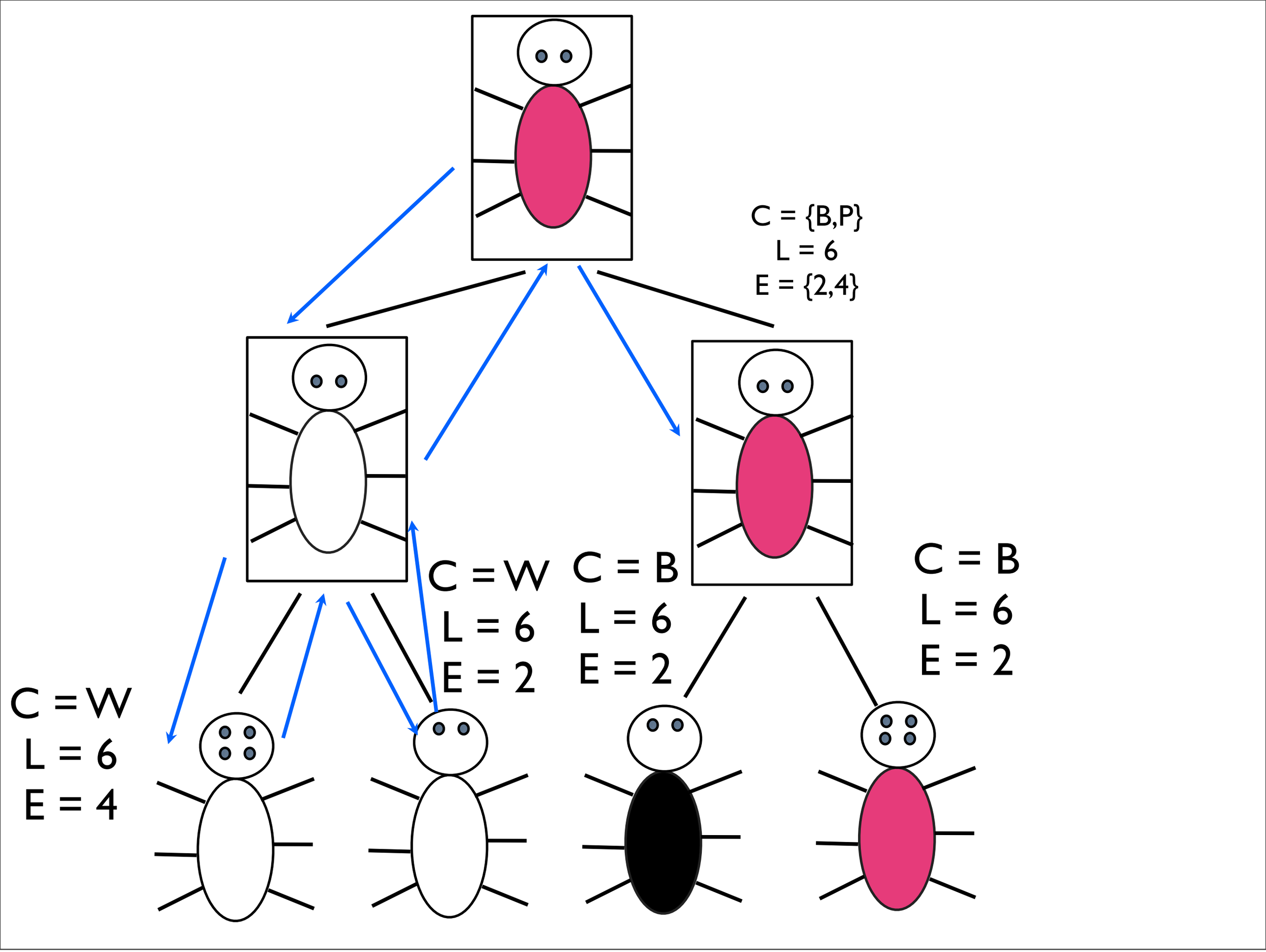


PREORDER

Traversal




C = {B,P}
L = 6
E = {2,4}
C = W
L = 6
E = 4
C = W
L = 6
E = 2
C = B
L = 6
E = 2
C = B
L = 6
E = 2


C = {B,P}
L = 6
E = {2,4}
C = W
L = 6
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C = W
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C = B
L = 6
E = 2
C = B
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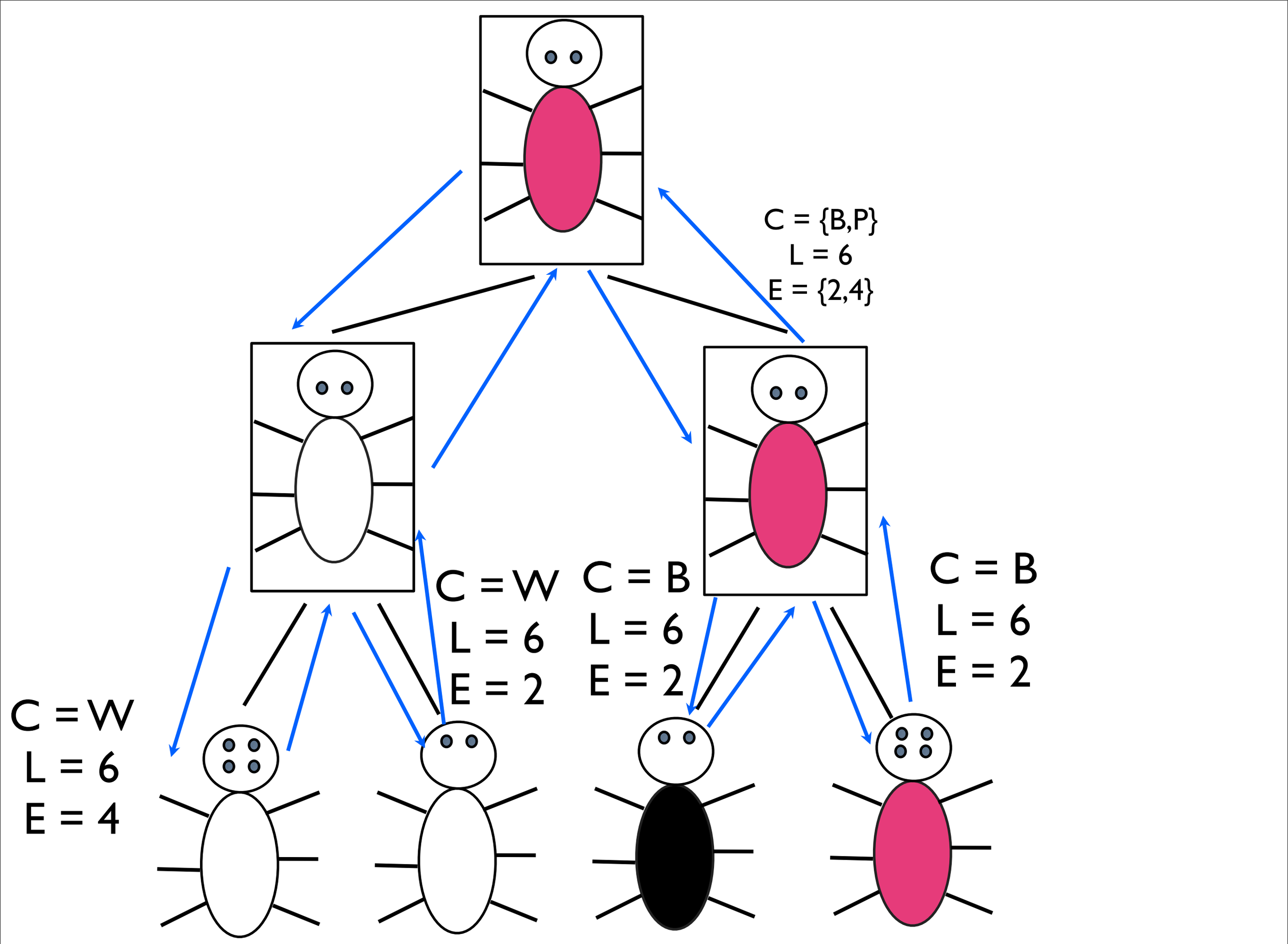
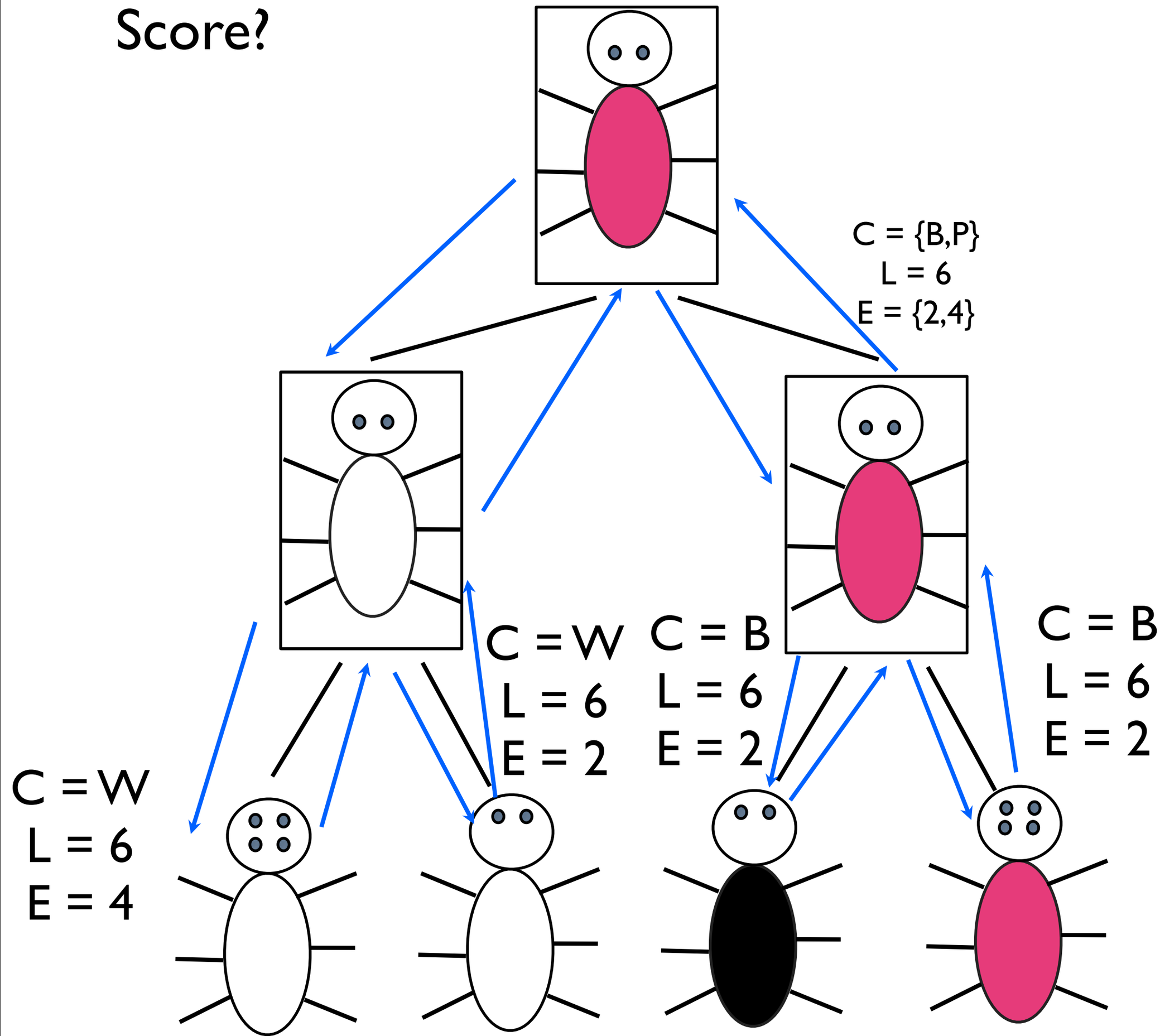
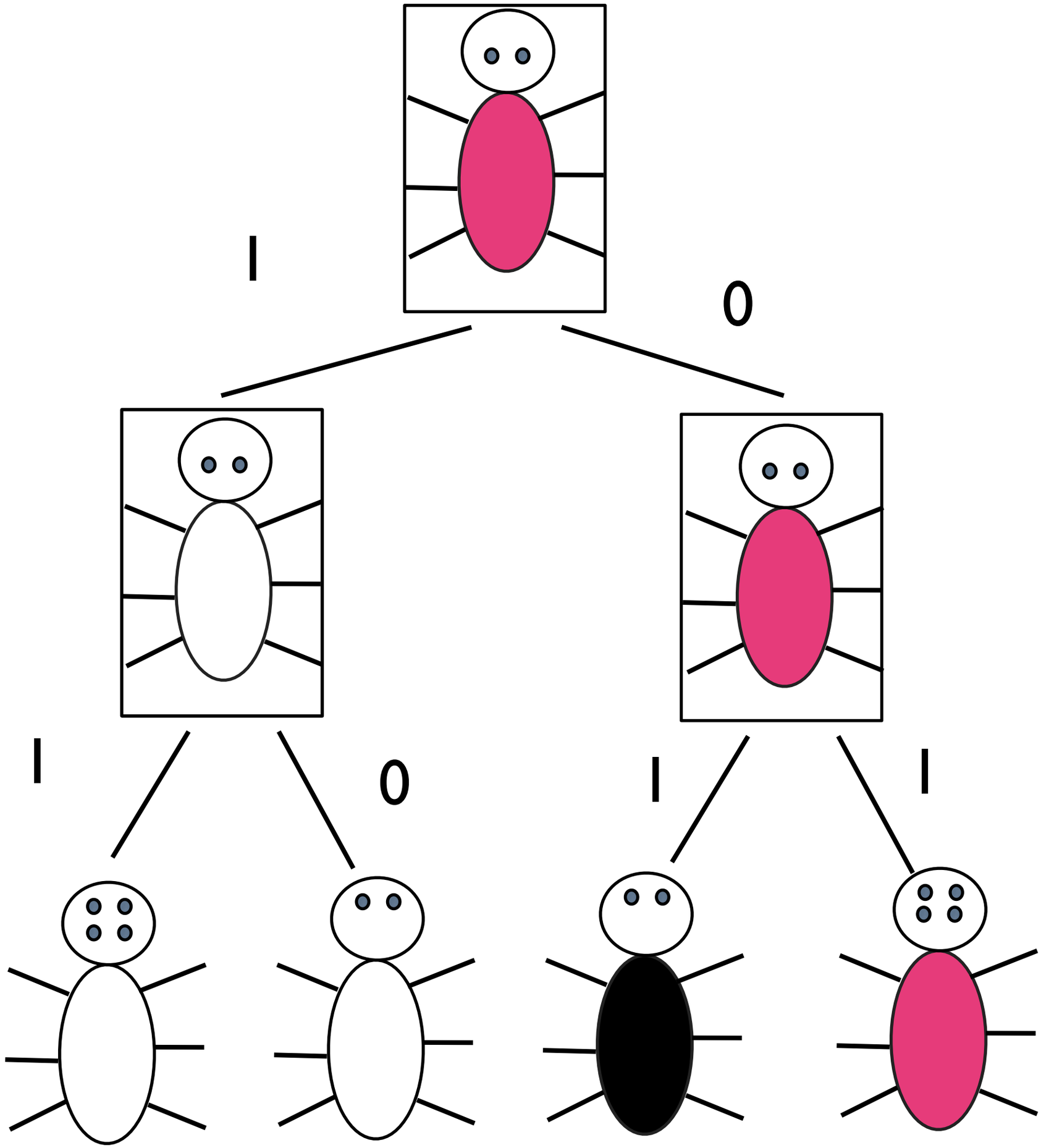
E = 2

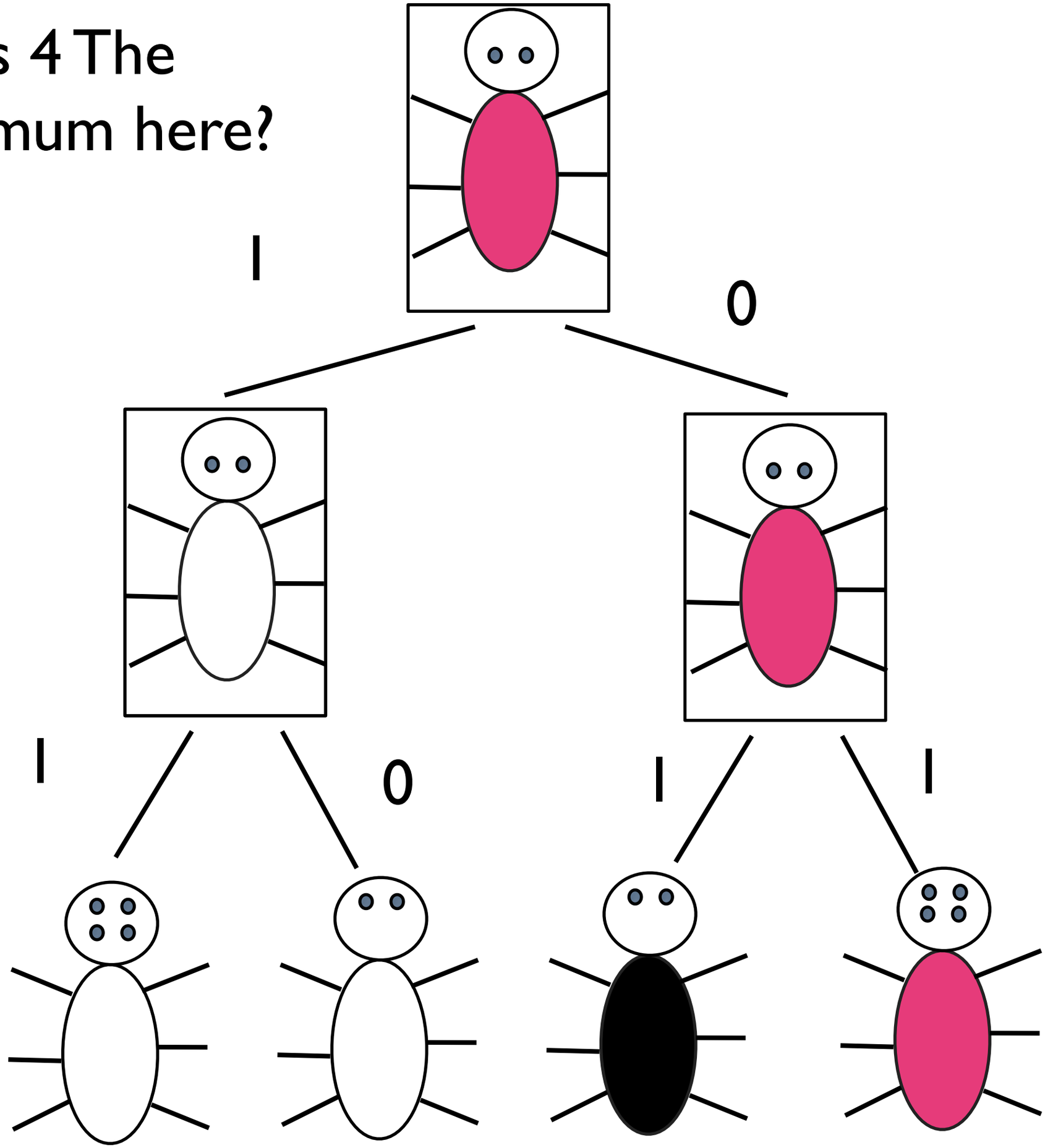

C = {B,P}
L = 6
E = {2,4}
C = W
L = 6
E = 4
C = W
L = 6
E = 2
C = B
L = 6
E = 2
C = B
L = 6
E = 2

Score?

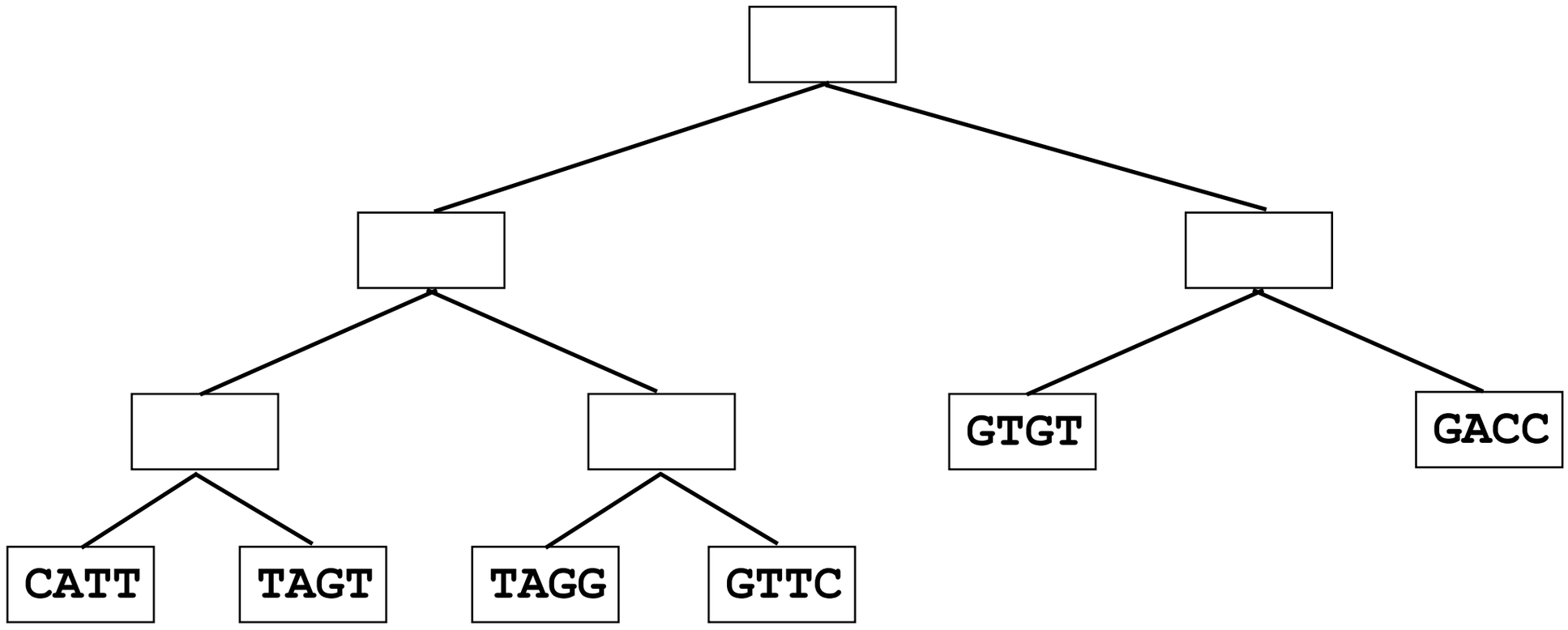



1
0
1
0
1
1

Is 4 The minimum here?

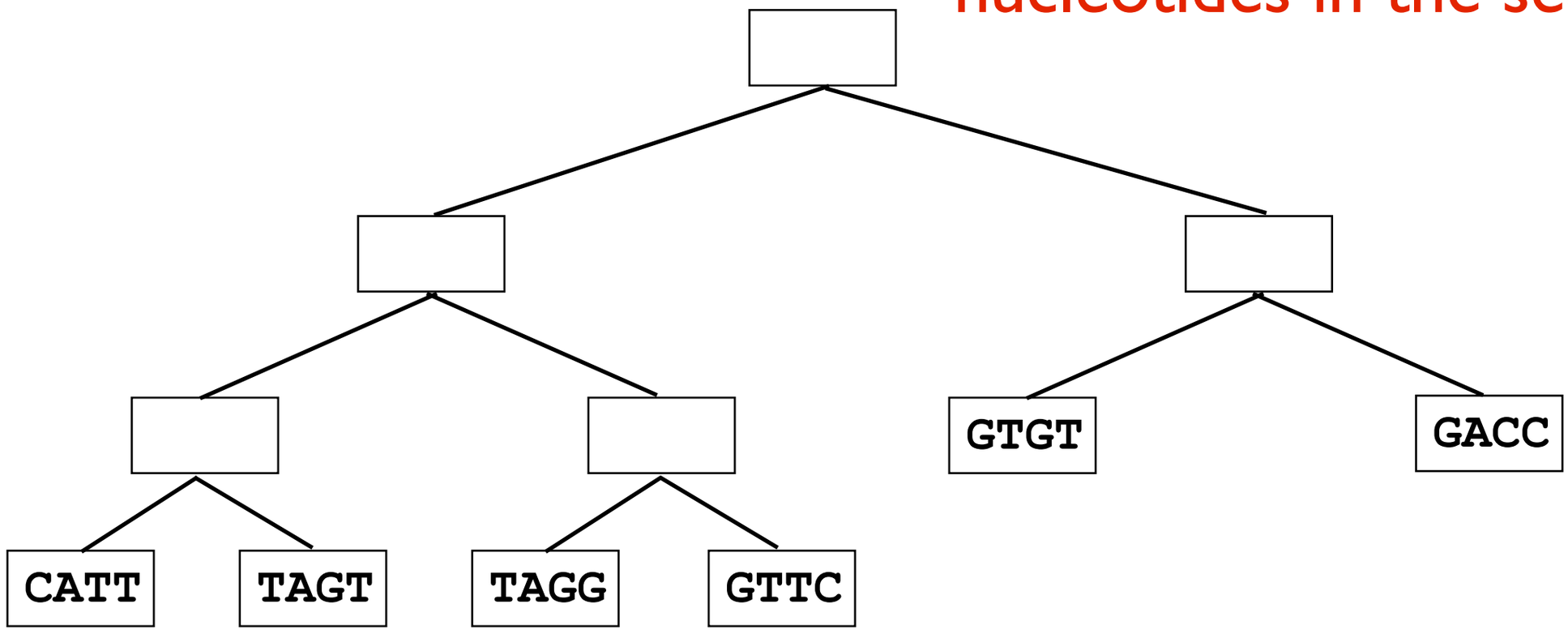


Fitch's on DNA



Fitch's Algorithm on DNA

Features are the 1, 2, 3, 4th nucleotides in the sequence



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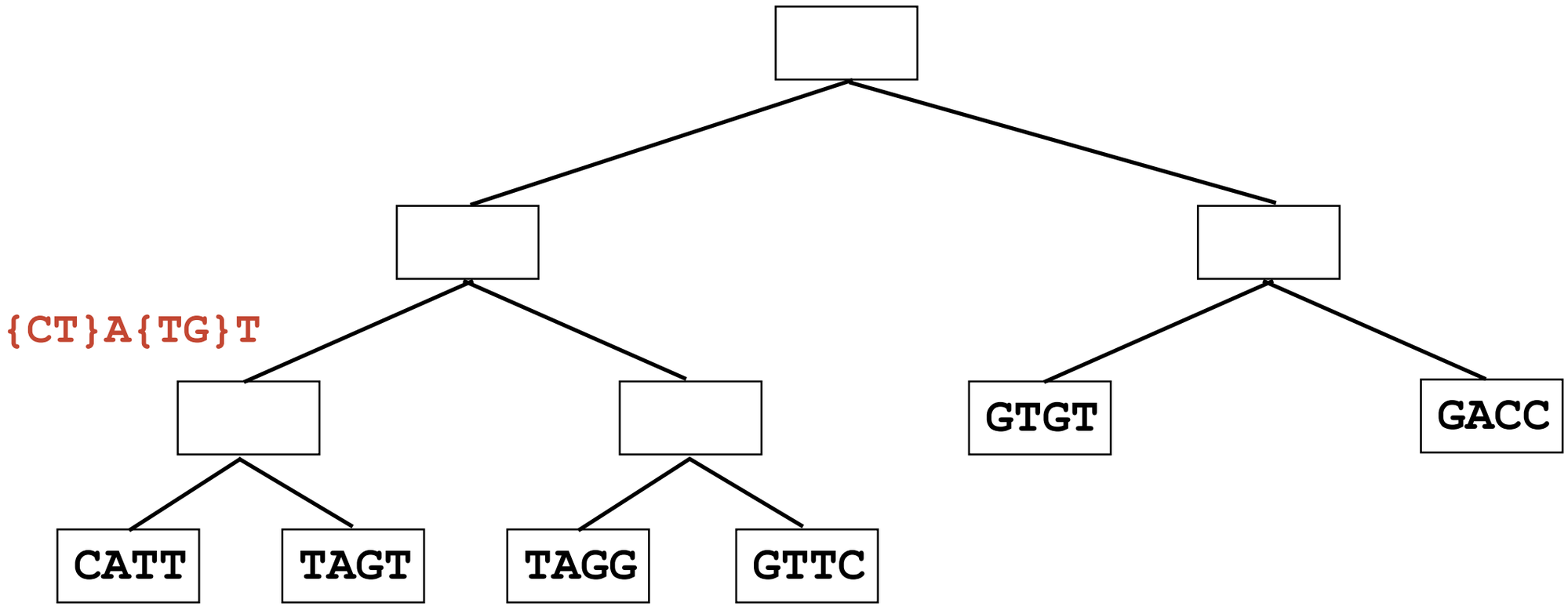

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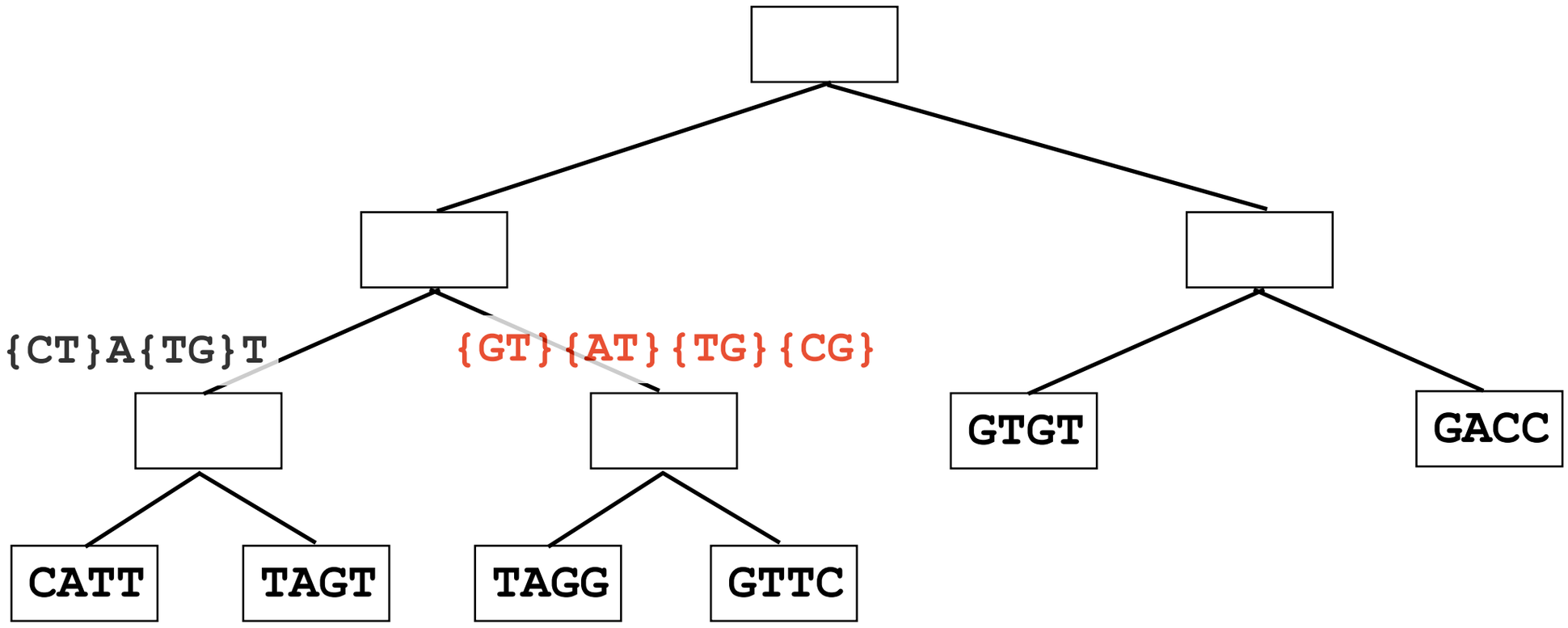

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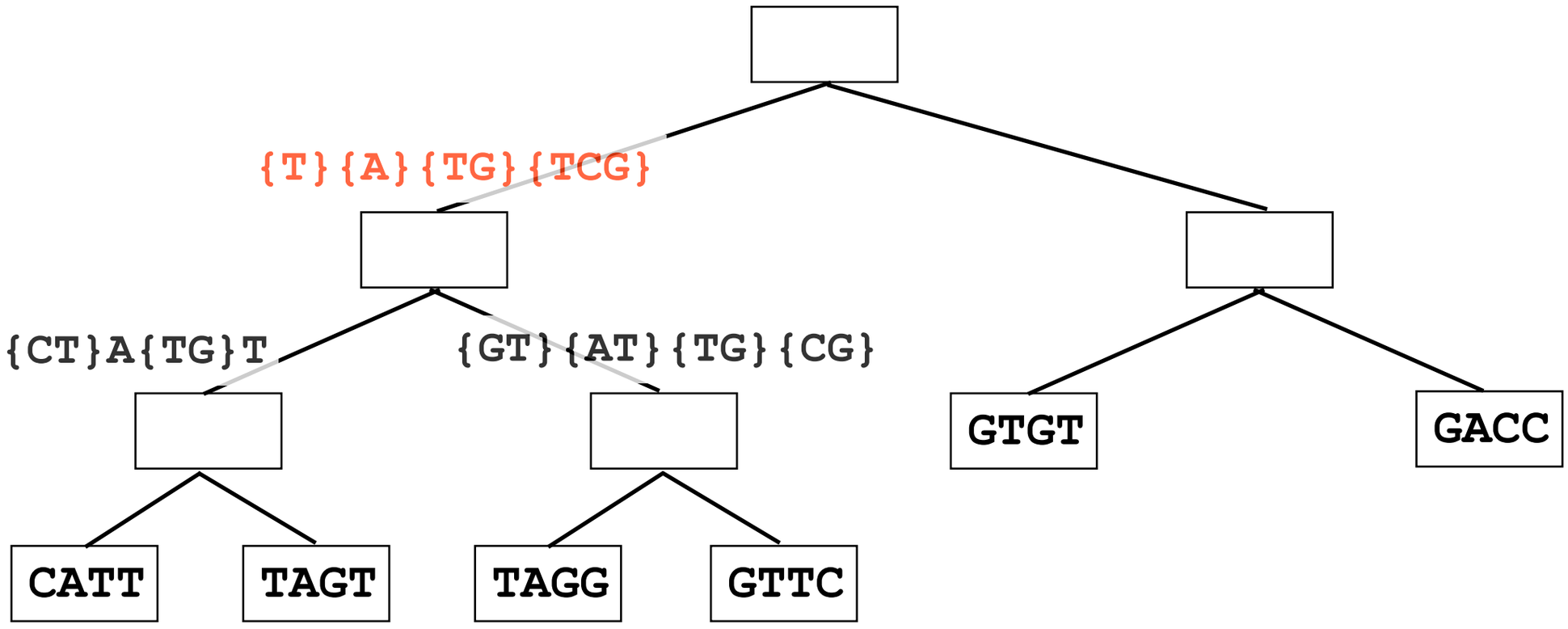
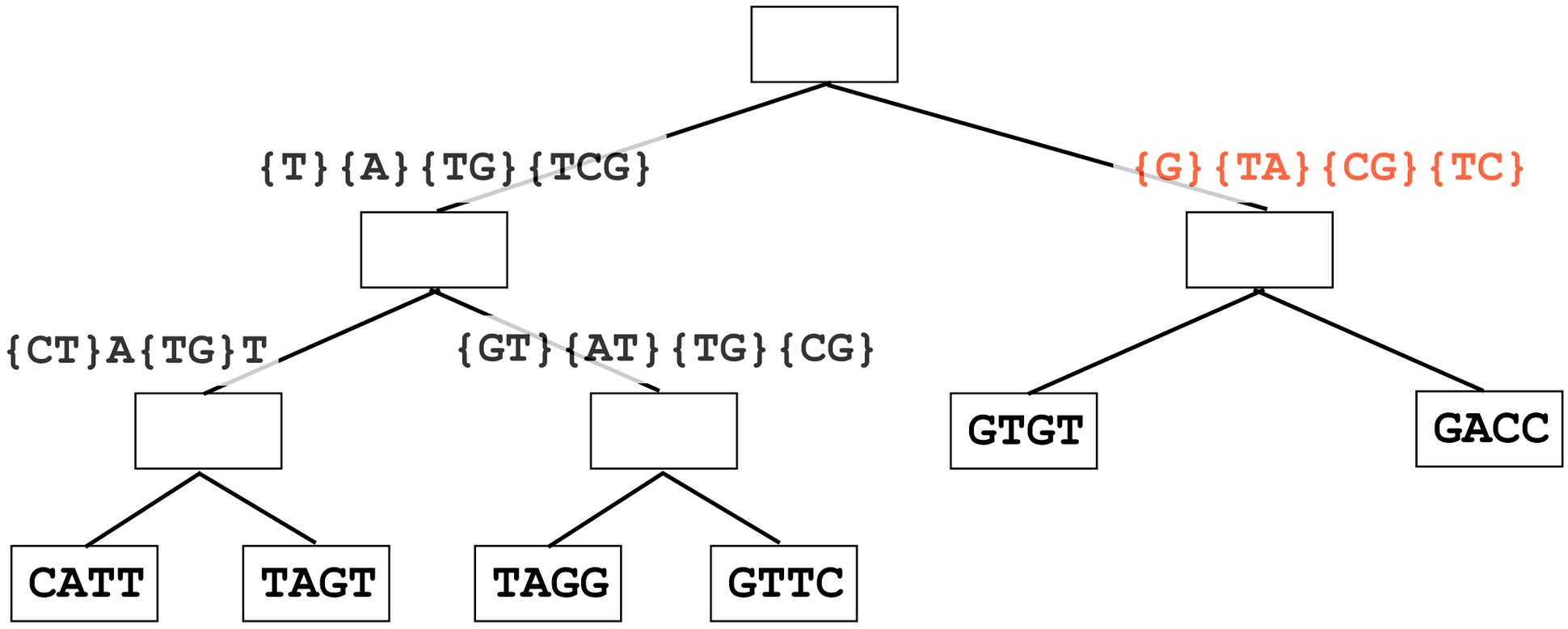


Fitch's on DNA



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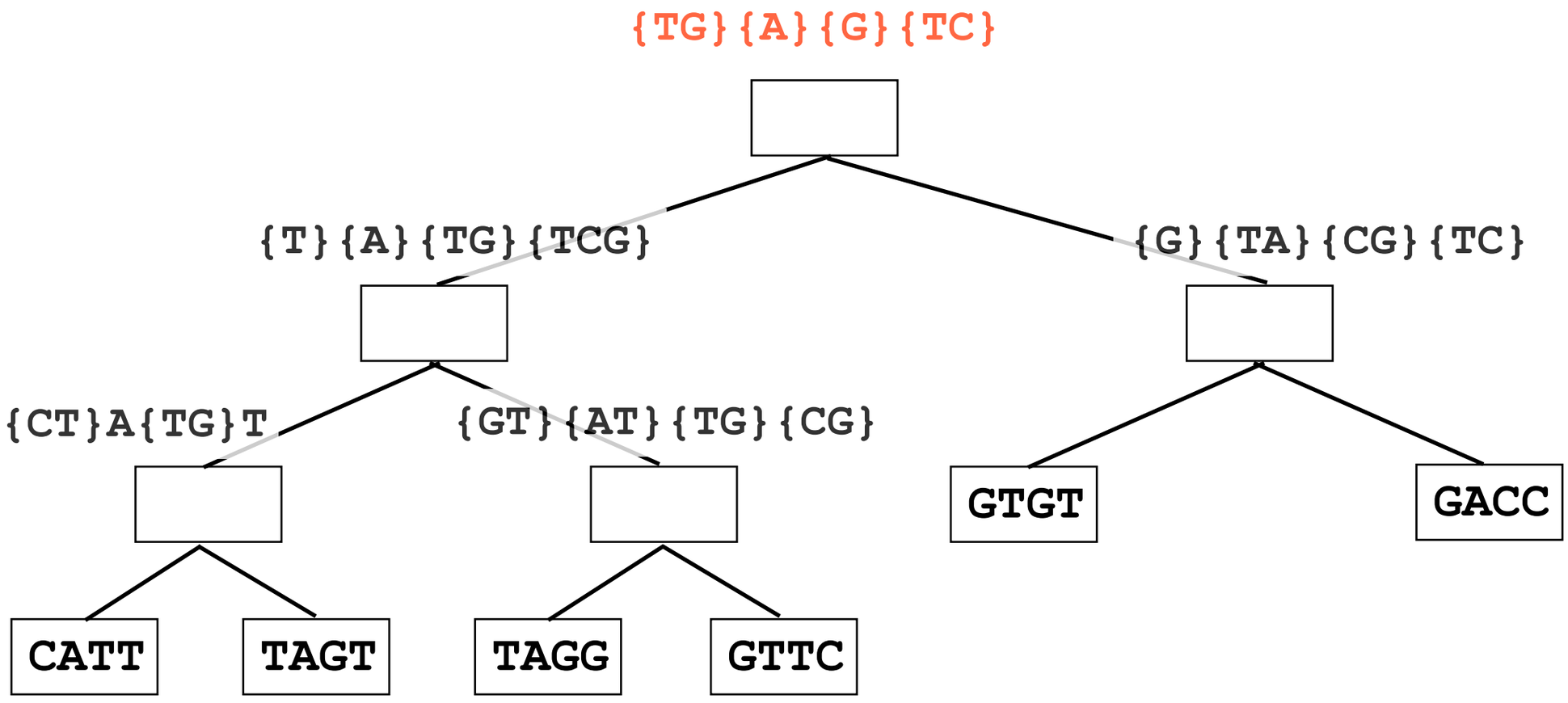

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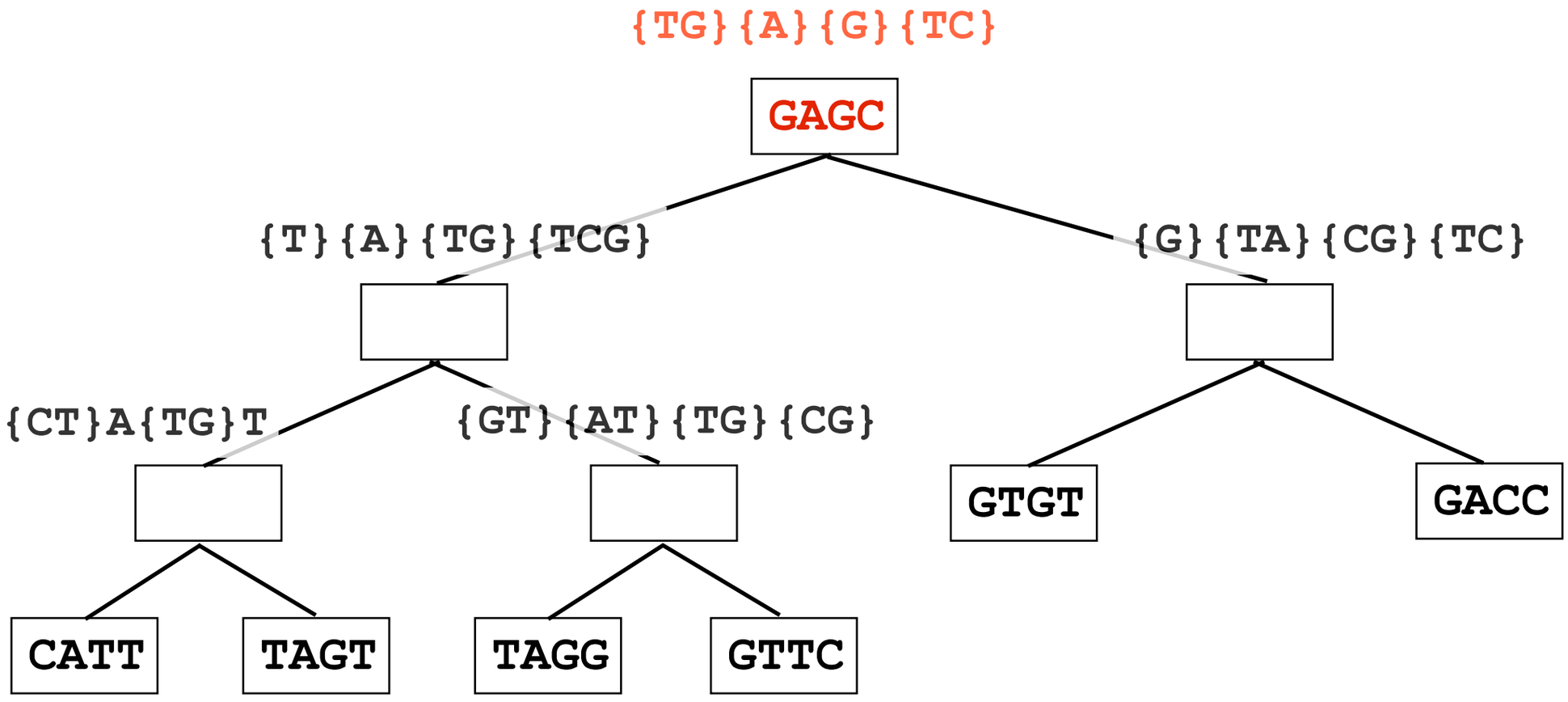
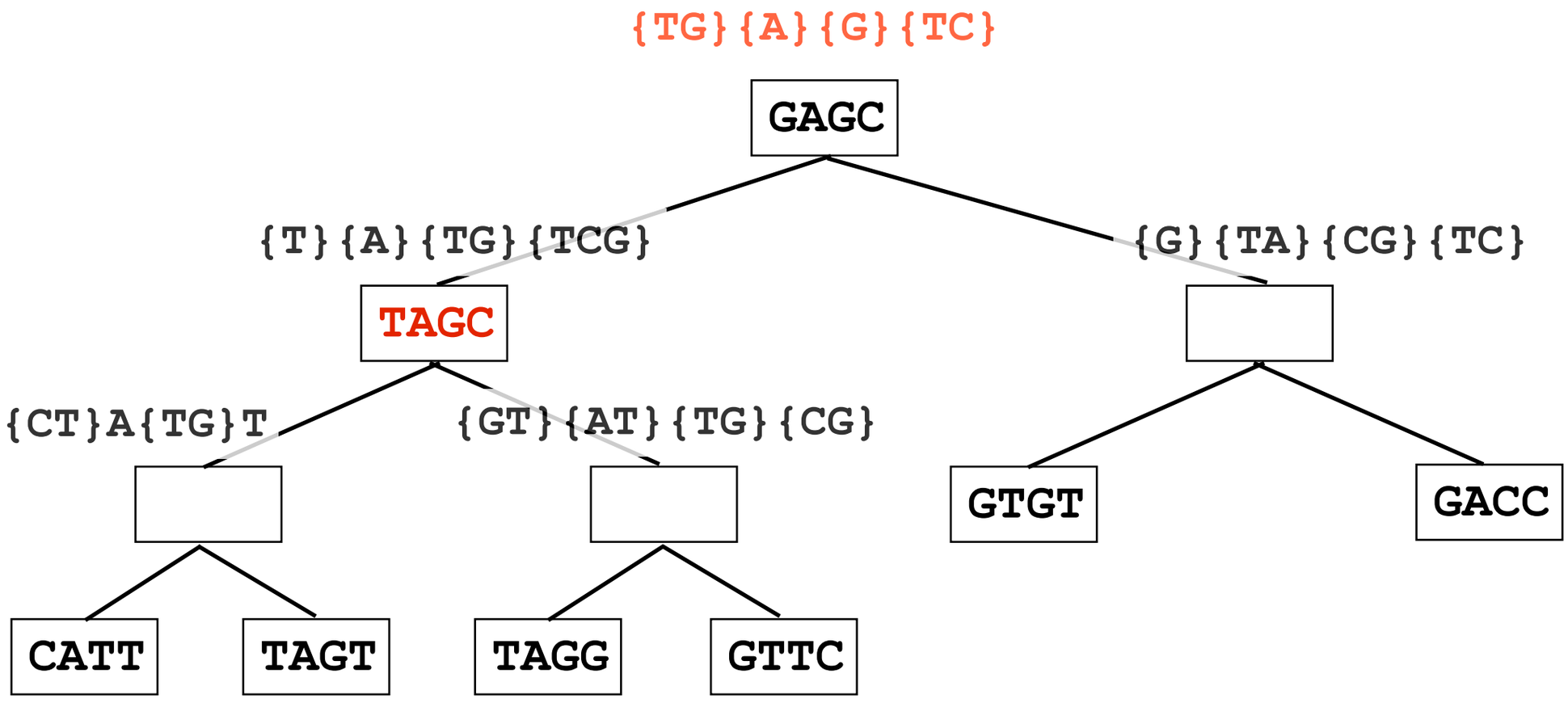
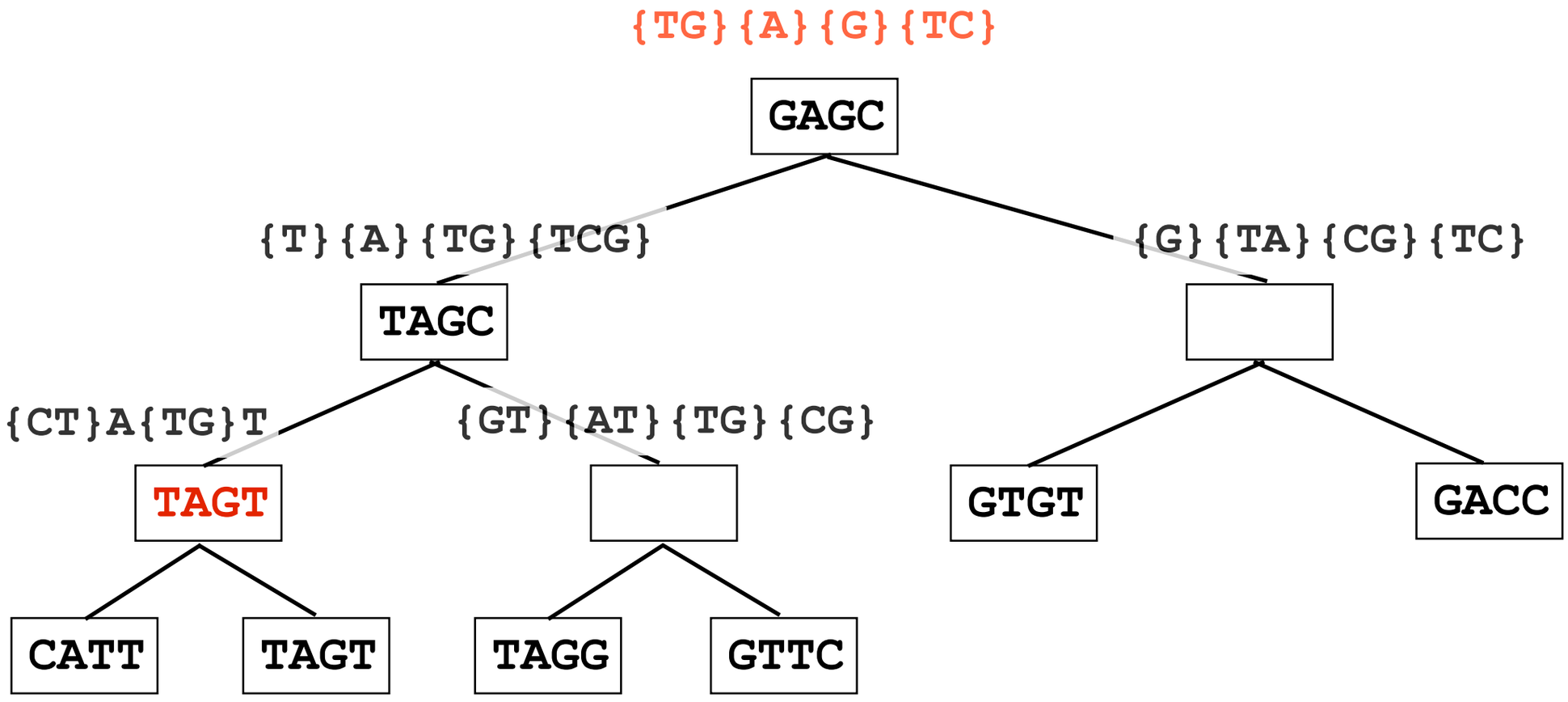


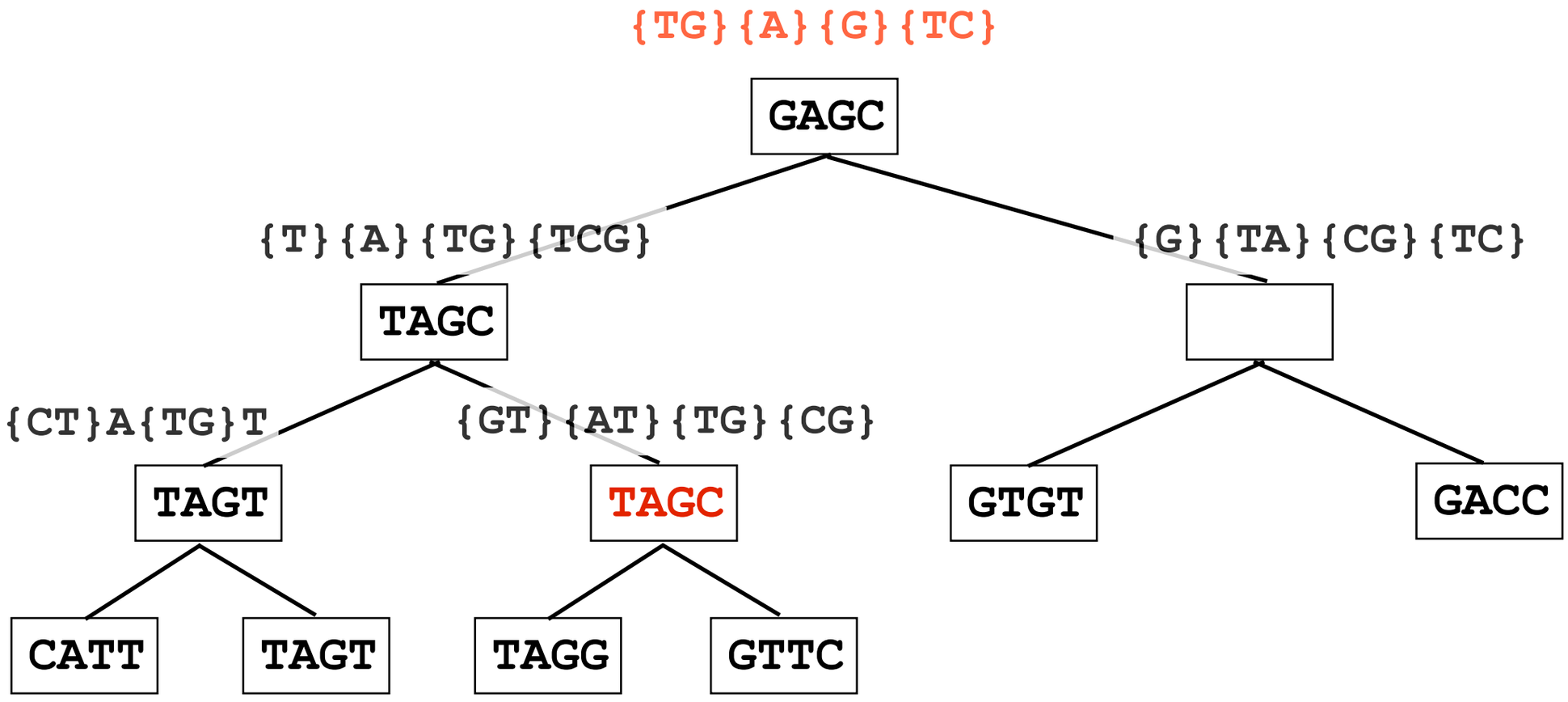
Fitch's on DNA



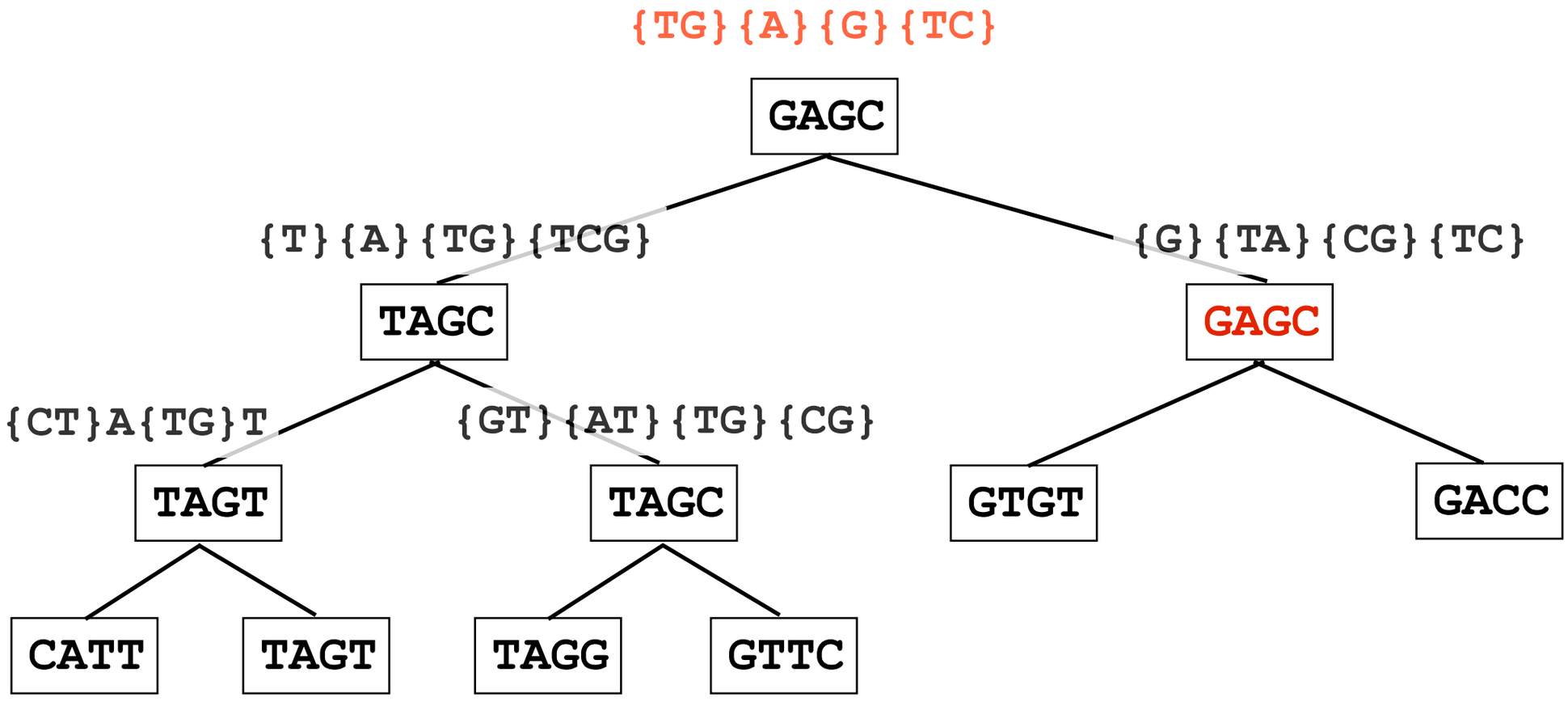
Fitch's on DNA



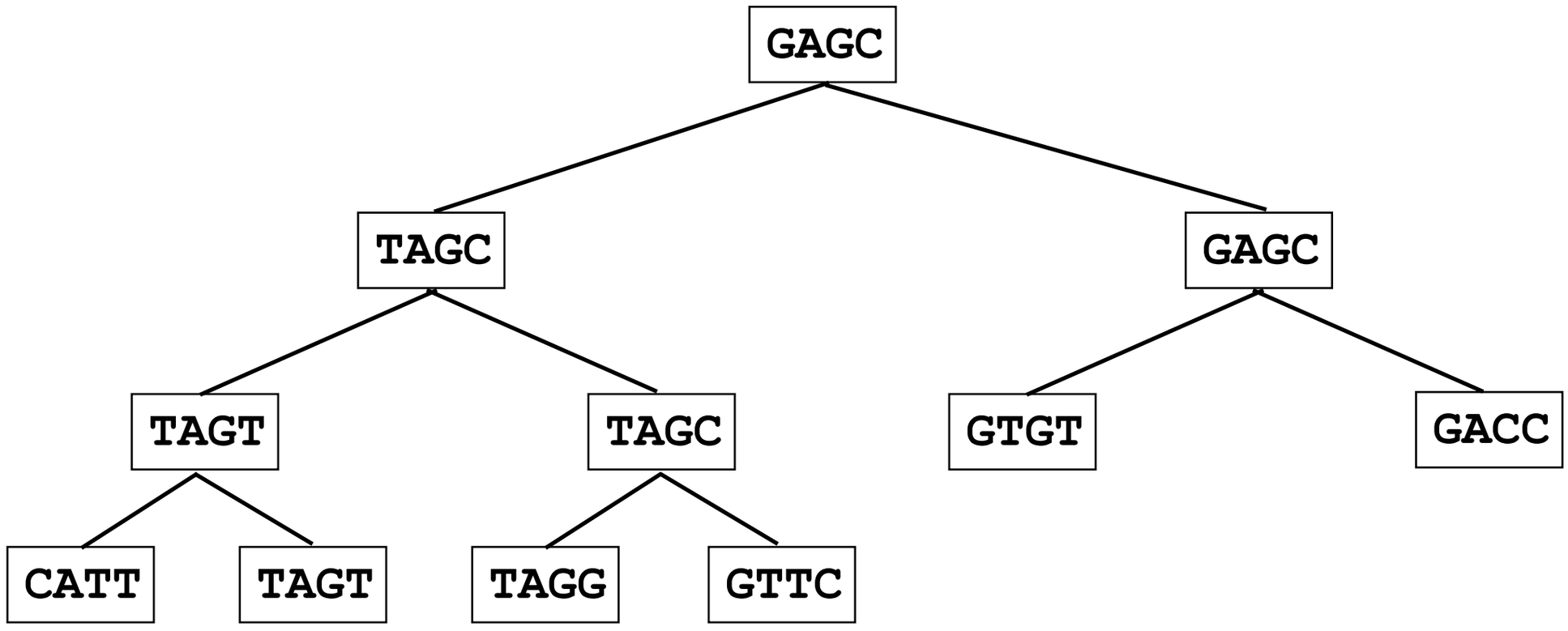
Fitch's on DNA



Fitch's on DNA

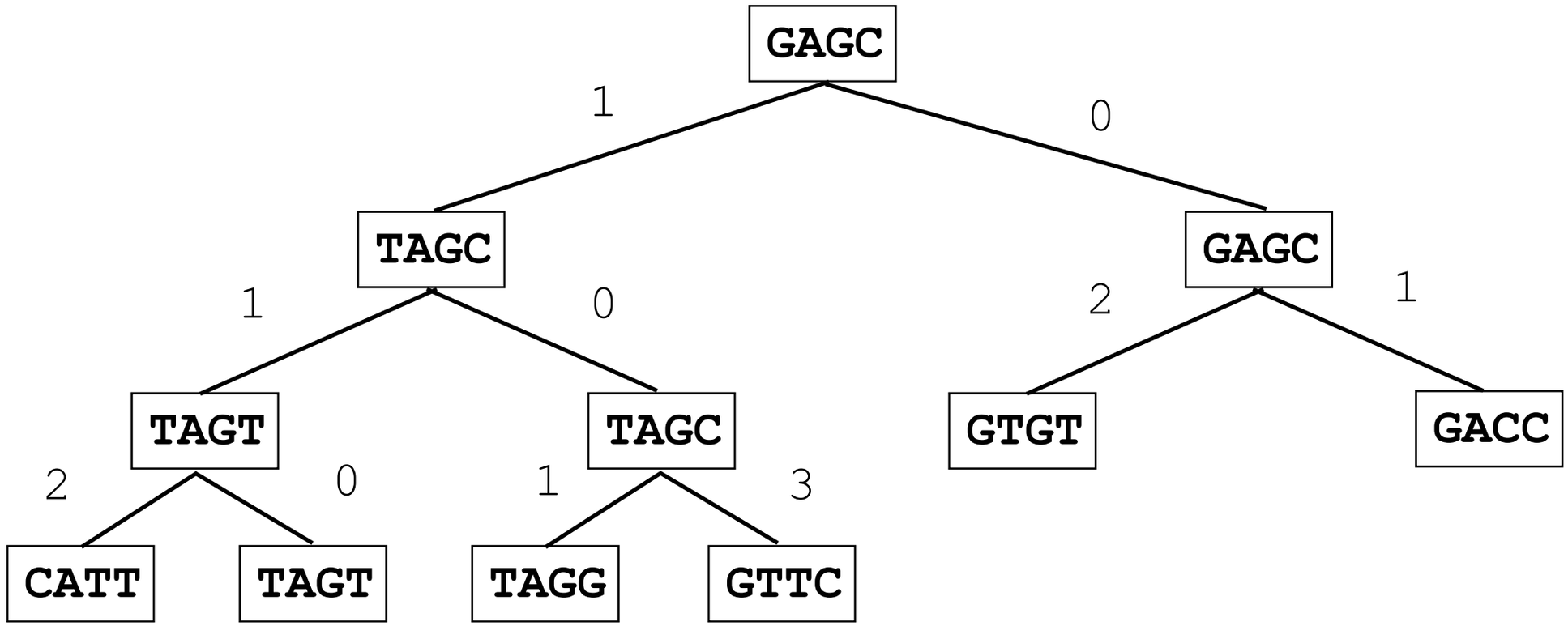


Fitch's on DNA



What is parsimony of this tree?

Fitch's on DNA



The parsimony of this tree is: 11