# Topics

- This week:
  - File input and output
  - OS module and path
  - encoding trees

# Project 3, todo 6

The word “extract” seems to need some lawyering… here is what we want you to do:

- For hiding a “guest picture” in a “host picture”:
  - Get the (i,k) pixel of the host, say red is *aaaabbbb*
  - Get the (i,k) pixel of the guest, say red is *ccccdddd*
  - Combine as (i,k) pixel of the result with red *aaaacccc*
  - Do this for all pixels, for their red, green and blue components
- For recovering the guest picture:
  - Get the (i,k) pixel, say red = *aaaacccc*
  - Make the (i,k) pixel of the result with red *cccc*0000
  - Do this for all pixels, for their red, green and blue components

- Operations:
  - <<
  - >>
  - &
  - |

# Announcements

- Project 4:  First Team Project
  - To be published this Thursday, Oct 18
  - Urgently: Pick a team and register it with us, or let us know you need a team
  - Instructions are on the course wiki under **Projects**
  - Teams should be of size 3
- Mid-semester course evaluations are now open
  - Course home page has details

# Input/Output

- Thus far we have only been able to get input from the user and produce output to the screen
  - Limits the scope of our programs
  - What if we wanted to search in a book?
  - We would have to type the book into our program each time!
- Our output was limited by what we could display to the screen
  - After our program completed the output was gone!

# Files: Multi-line Strings

- A *file* is a sequence of data that is stored in secondary, persistent memory (such as a disk drive).
- Files can contain any data type, but the easiest to work with would be text.
- A text file usually contains more than one line of text.
- Python uses the standard newline character (\n) to mark line breaks.

# Multi-Line Strings

- Hello
  World

  Goodbye 32
- When stored in a file:
  Hello\nWorld\n\nGoodbye 32\n

# Multi-Line Strings

- This is exactly the same thing as embedding \n in print statements.
- Remember, these special characters only affect things when printed. They don’t do anything during evaluation.

# File Processing

- The process of ***opening*** a file involves associating a file on disk with an object in program memory.
- We can manipulate the file by manipulating this object.
  - Read from the file
  - Write to the file

# File Processing

- When done with the file, it needs to be ***closed***. Closing the file causes any outstanding operations and other bookkeeping for the file to be completed.
- In some cases, not properly closing a file could result in data loss.

# File Processing Example

- Reading a file into a word processor
  - File opened for input
  - Contents read into RAM
  - File closed
  - Changes to the file are made to the copy stored in memory, not on the disk.
- Save:
  - Backup copy of file made
  - File opened for output
  - RAM version written to file
  - File closed

# File Processing

- Working with text files in Python
  - Associate a file with a file object using the open function <filevar> = open(<name>, <mode>)
  - Name is a string with the actual file name on the disk. The mode is either ‘r’ or ‘w’ depending on whether we are reading or writing the file.
    - There are also other modes
  - Infile = open("numbers.dat", "r")

# File Methods

- <file>.read() – returns the entire remaining contents of the file as a single (possibly large, multi-line) string
- <file>.readline() – returns the next line of the file. This is all text – up to *and including* the next newline character at the end of the line
- <file>.readlines() – returns a list of the remaining lines in the file. Each list item is a single line including the newline characters.

# File Processing

```
#     Prints a file to the screen.
def main():
    fname = input("Enter filename: ")
    infile = open(fname,'r')
    data = infile.read()
    print(data)
    infile.close()
main()
```

- Prompt the user for a file name
- Open the file for reading
- The file is read as one single string and stored in the variable named *data*

# File Processing

- readline can be used to read the next line from a file, including the trailing newline character

- ```
  infile = open(someFile, "r")
  for i in range(5):
          line = infile.readline()
          print (line[:-1])
  infile.close()
  ```

- This reads the first 5 lines of a file, then closes it

- Slicing is used to strip out the newline characters at the ends of the lines
  ```

# File Processing

- Another way to loop through the contents of a file is to read it in with readlines and then loop through the resulting list.

- ```
  infile = open(someFile, "r")
  for line in infile.readlines():
          # Line processing here
  infile.close()
  ```
  ```

# File Processing

- Python treats the file object itself as a sequence of lines!
- infile = open(someFile, "r")
  for line in infile:
  	# process the line here
  infile.close()

# File Processing

- Opening a file for writing prepares the file to receive data
- If you open an existing file for writing, you wipe out the file's contents. If the named file does not exist, a new one is created.
- Outfile = open("mydata.out", "w")
- Actual writing:
  - print(<expressions>, file=Outfile)
  - Outfile.write(<string>)
  - Print takes multiple arguments; write only one, a string

# Example Program: Batch Usernames

- *Batch* mode processing is where program input and output are done through files (the program is not designed to be interactive)
- Let's create usernames for a computer system where the first and last names come from an input file.

# Helpful String Method

- One of these methods is *split*. This will split a string into substrings based on spaces.

```
>>> "Hello string methods!".split()

['Hello', 'string', 'methods!']
```

# Another String Method

- Split can be used on characters other than space, by supplying the character as a parameter.

```
>>> "32,24,25,57".split(",")

['32', '24', '25', '57']

>>>
```

# CQ: How many?

What does the following program print?

```
S = "a,b,,d,e"
print(len(S.split(",")))
```

A. 8

B. 5

C. 4

# Example Program: Batch Usernames

```
# userfile.py
#    Program to create a file of usernames in batch mode.

def main():
    print ("This program creates a file of usernames from a")
    print ("file of names.")

    # get the file names
    infileName = input("What file are the names in? ")
    outfileName = input("What file should the usernames go in? ")

    # open the files
    infile = open(infileName, 'r')
    outfile = open(outfileName, 'w')
```

# Example Program: Batch Usernames

```
# process each line of the input file
   for line in infile:
       # get the first and last names from line
       first, last = line.split()
       # create a username
       uname = (first[0]+last[:7]).lower()
       # write it to the output file
       outfile.write(uname+”\n”)

   # close both files
   infile.close()
   outfile.close()
   print("Usernames have been written to", outfileName)
```

# Example Program: Batch Usernames

- Things to note:
  - It's not unusual for programs to have multiple files open for reading and writing at the same time.
  - The <string>.lower() method is used to convert the names into all lower case, in the event the names are mixed upper and lower case.
  - We manually added a newline "\n" after each name, this ensures each id is on a separate line
    - What happens if we do not do this?
- When we split the string we were "parsing"

# Methods on Files

- object.method() syntax: this time files are our object
  - Example:  file = open(“myfile”, “w”)
- file.read()  -- reads the file as one string
- file.readlines() – reads the file as a list of strings
- file.readline() – reads one line from the file
- file.write() – allows you to write a string to a file
- file.close() – closes a file

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# Example: Writing to a File

```
def formLetter(gender ,lastName,city):
    file = open("formLetter.txt",”w")
    file.write("Dear ")
    if gender =="F":
        file.write("Ms. "+lastName+":\n")
    if gender =="M":
        file.write("Mr. "+lastName+":\n")
    file.write("I am writing to remind you of the offer ")
    file.write("that we sent to you last week. Everyone in ")
    file.write(city+" knows what an exceptional offer this is!")
    file.write("Sincerely ,\n")
    file.write("I.M. Acrook, Attorney at Law")
    file.close()
```

# Example: result

>>> formLetter("M","Guzdial","Decatur”)

**Dear Mr. Guzdial:**

**I am writing to remind you of the offer that we sent to you last week. Everyone in Decatur knows what an exceptional offer this is!**

**Sincerely,**

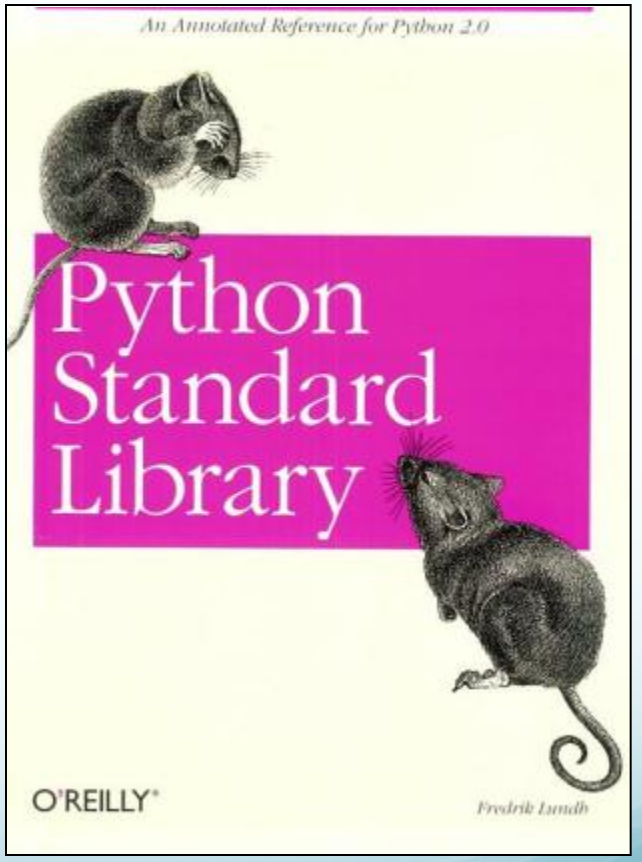
**I.M. Acrook, Attorney at Law**

# File Output is Important

- Allows your programs to produce results that are viewable by other programs
- Allows you to retain computed results after a program terminates

# Python's Standard Library

- Python has an extensive *library* of modules that come with it.
- The Python standard library includes modules that allow us to access the Internet, deal with time, generate random numbers, and…access files in a directory.



# Accessing pieces of a module

- We access the additional capabilities of a module using dot notation, after we *import* the module.
- How do you know what code is there?
  - Check the online documentation.
  - There are books like *Python Standard Library* that describe the modules and provide examples.

# The OS Module

- The OS module provides an interface to the underlying operating system
  - Allows your program to request resources/actions to be performed on your program's behalf
- os.chdir(path) – changes the current working directory
- os.listdir(path) – returns a list of all entries in the directory specified by path
- os.curdir – returns what directory the program is executing in (i.e. the current directory)

# The OS Path submodule

- Once you import os – import os – you can also use the path module
- os.path.isfile(path) – returns true if the path specified is a file, returns false otherwise
  - Use this method to perform a check to see if the user provided input for a valid file

# Example: error checking

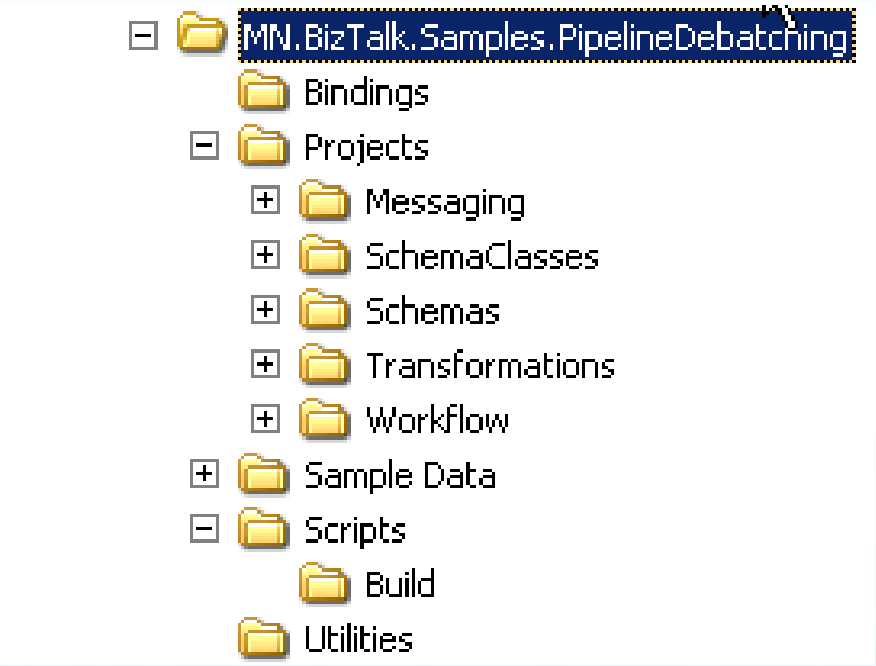
```
import os
def chkPath():
    path = input("type a file name: ")
    if os.path.isfile(path):
        return True,path
    else:
        return False,path
def main():
    chk = True
    while chk:
        chk,file = chkPath()
        if chk: print('file', file, 'exists')
        else: print('file', file,'does not exist')

main()
```

# Trees

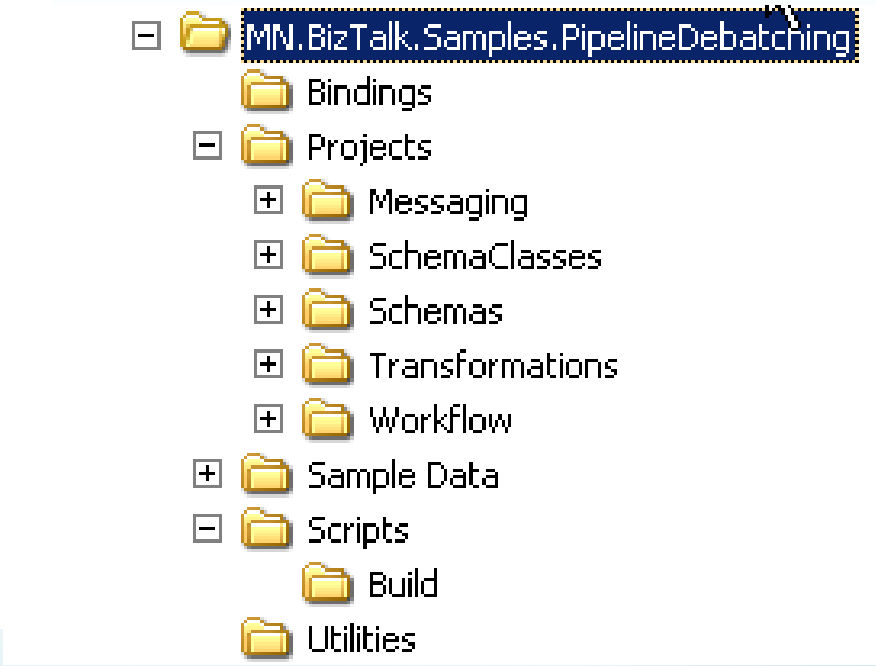
- Tree data structure
- Encoding and access
- Some uses and operations

# Example: Directory trees



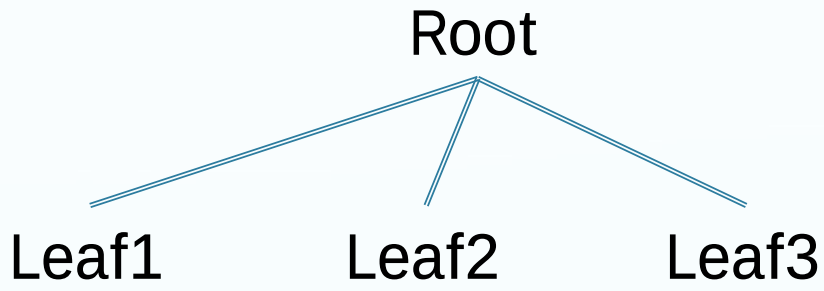
# We call this structure a tree

Root



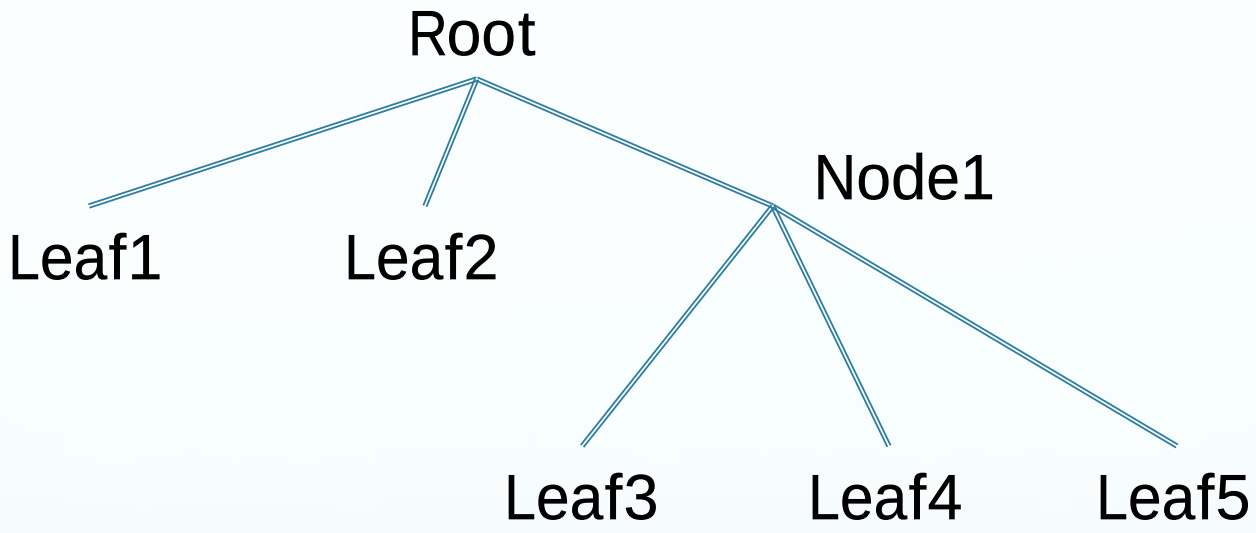

Root

# How might we encode such a structure?



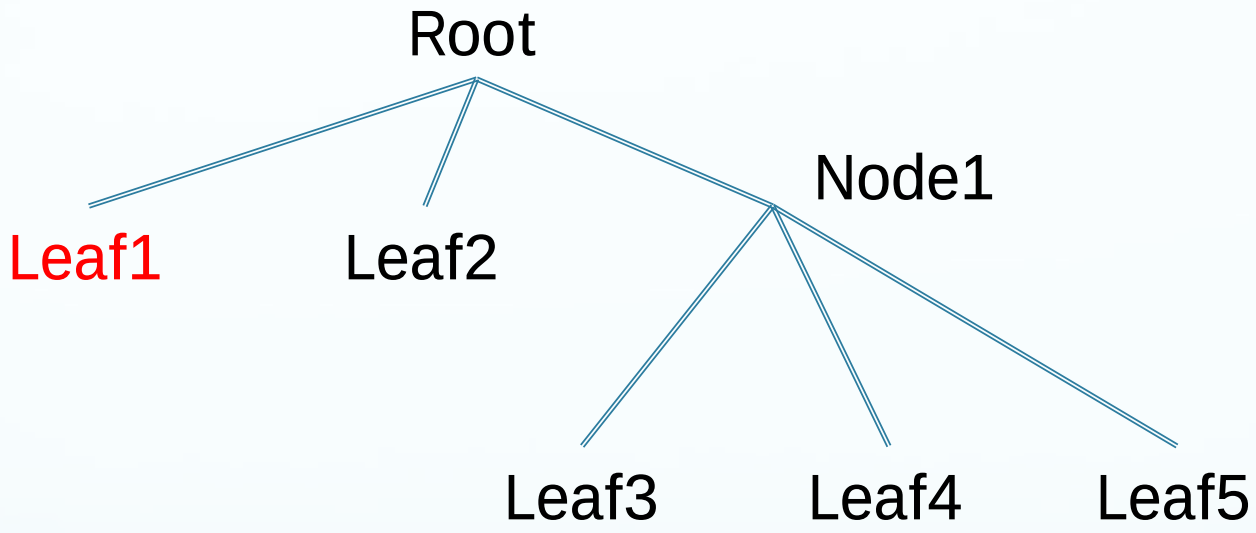

Tree = [‘Root’, ‘Leaf1’, ‘Leaf2’, ‘Leaf3’]

# Trees can be more complex




Tree = [‘Root’, ‘Leaf1’, ‘Leaf2’, [‘Node1’, ‘Leaf3’, ‘Leaf4’, ‘Leaf5’]]

# Trees can be more complex

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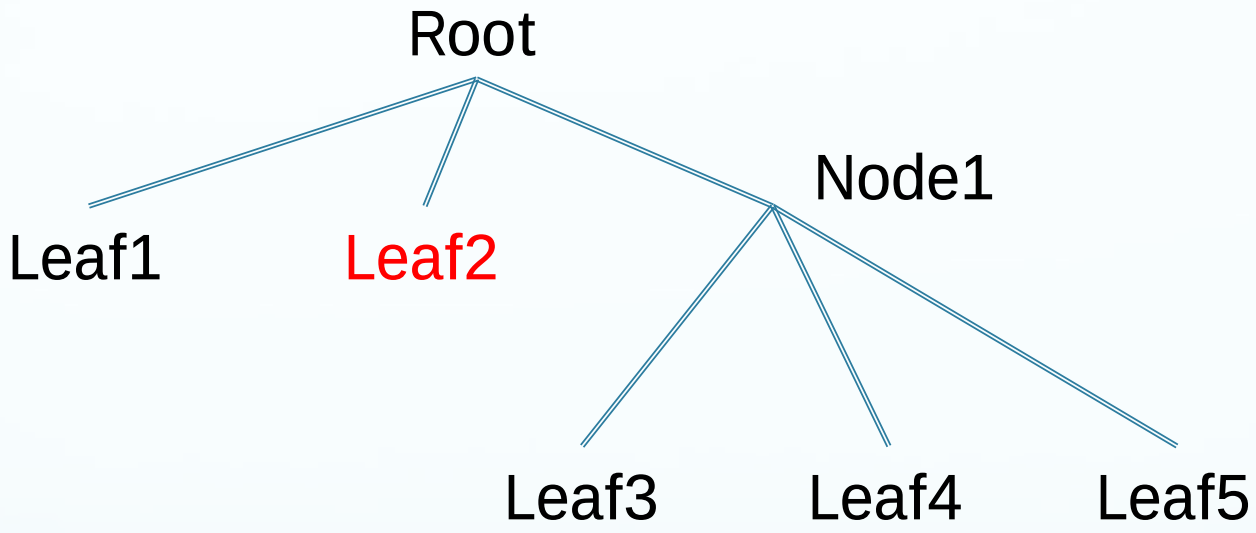


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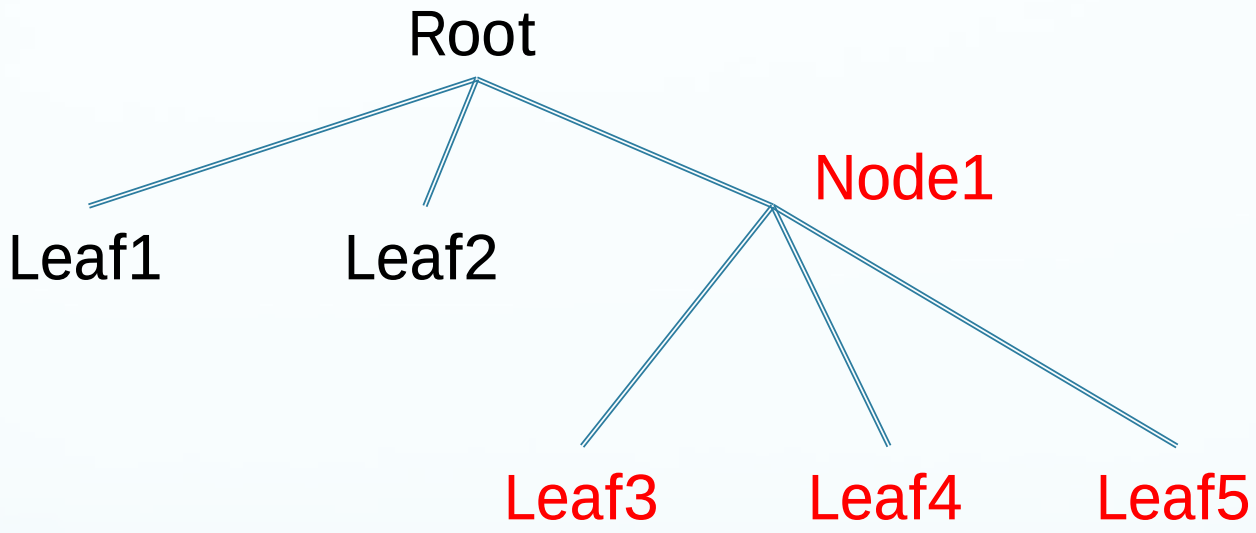
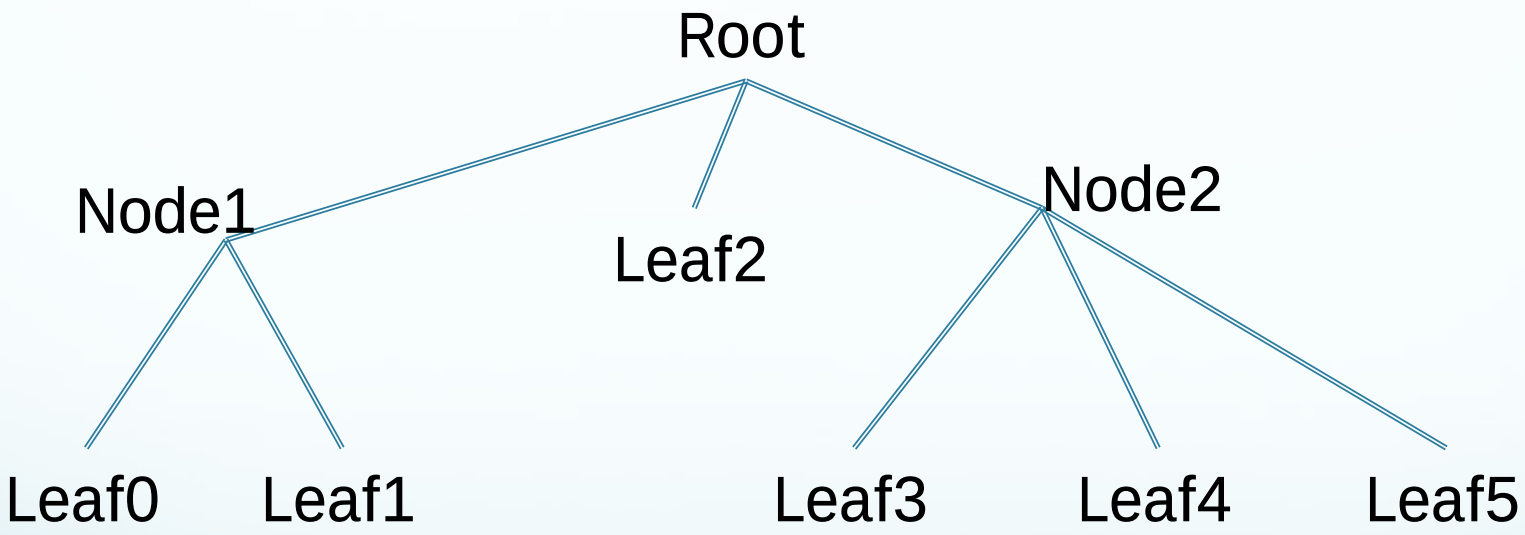


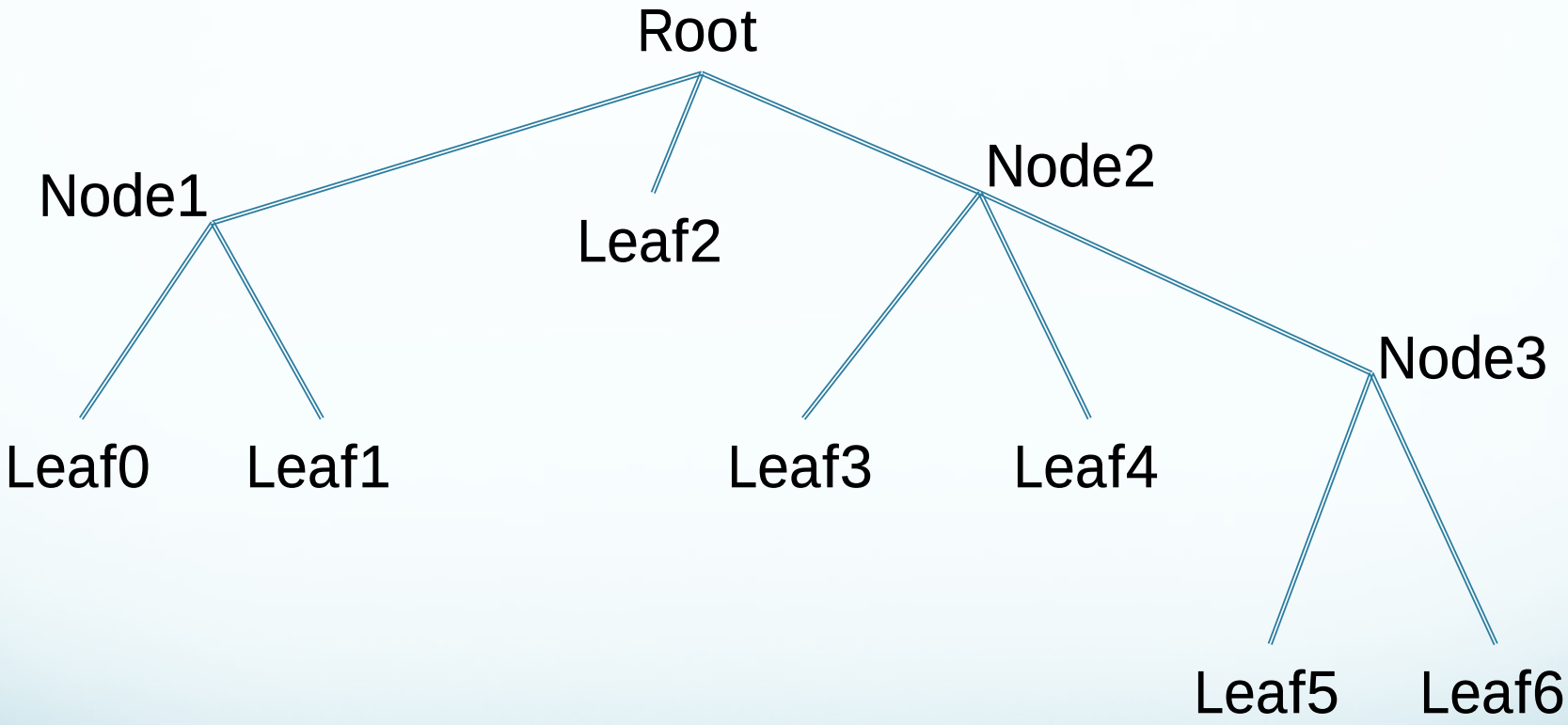

Tree = [‘Root’, ‘Leaf1’, ‘Leaf2’, [‘Node1’, ‘Leaf3’, ‘Leaf4’, ‘Leaf5’]]

# Trees can be more complex




Tree = [‘Root’, [‘Node1’, ‘Leaf0’,‘Leaf1’], ‘Leaf2’, [‘Node2’, ‘Leaf3’, ‘Leaf4’, ‘Leaf5’]]

# Trees can be more complex

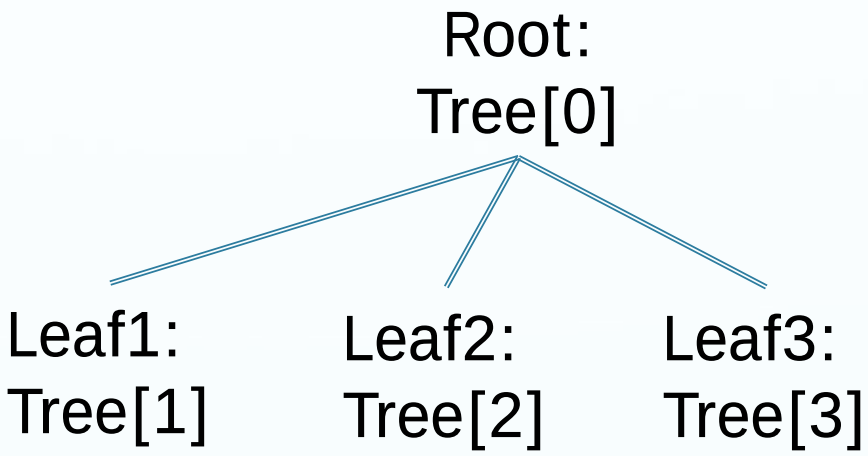



```
Tree = ['Root', ['Node1', 'Leaf0', 'Leaf1'],
                 'Leaf2',
                ['Node2', 'Leaf3', 'Leaf4', ['Node3', 'Leaf5', 'Leaf6']]]
```

# What is the intuition

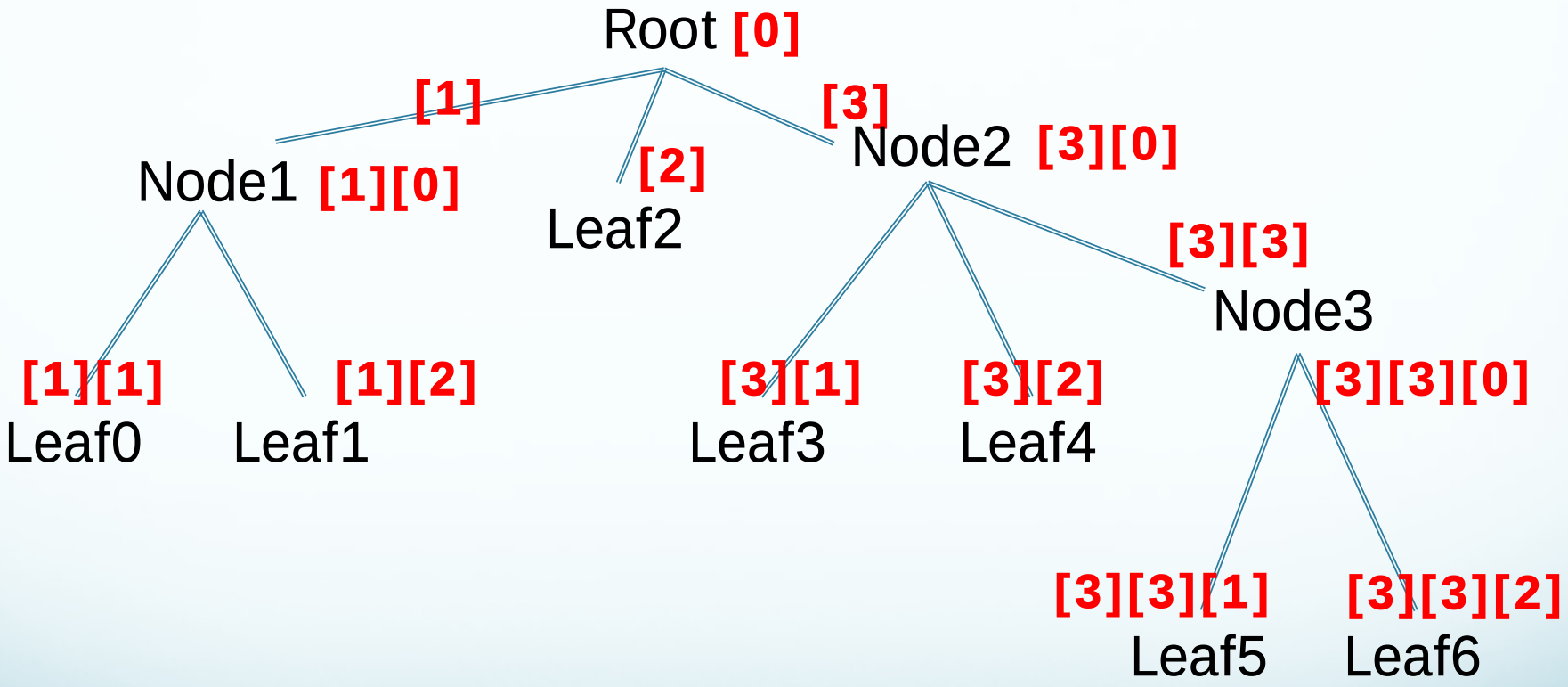
- Each sub list encodes a ‘node’ of the tree plus the ‘branches’ of the tree
- We can think of each sub list as a ‘subtree’ rooted in the node in the leading element position
- We can use indices (the bracket notation [ ]) to select out elements or subtrees

# How can we select out the leaves?



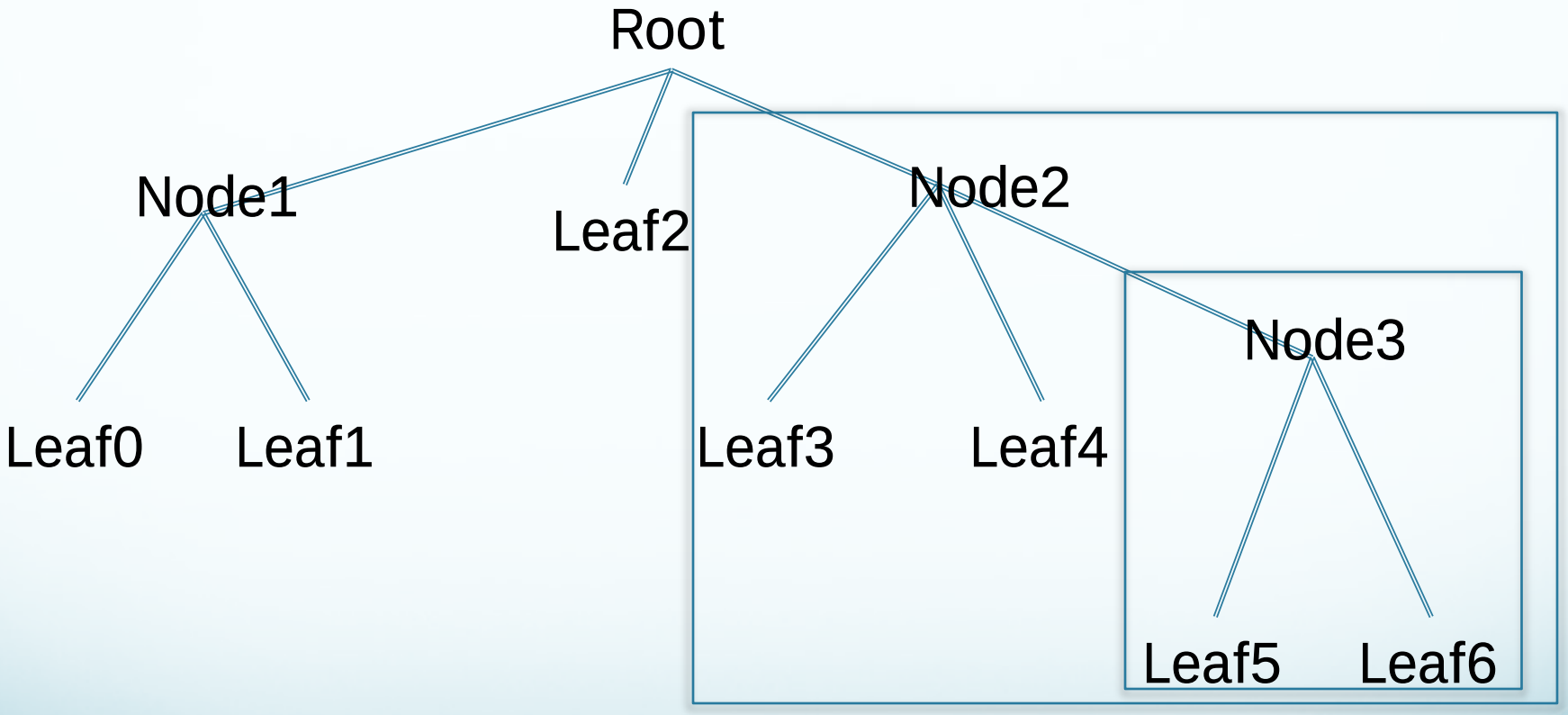

Tree = [‘Root’, ‘Leaf1’, ‘Leaf2’, ‘Leaf3’]

# Indices allow us to “traverse” the tree



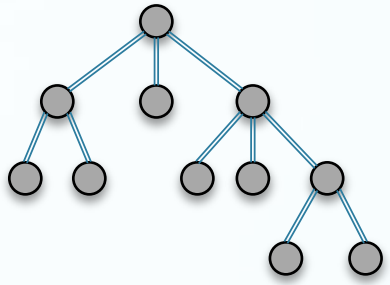

Tree = [‘Root’, [‘Node1’, ‘Leaf0’, ‘Leaf1’],
‘Leaf2’,
[‘Node2’, ‘Leaf3’, ‘Leaf4’, [‘Node3’, ‘Leaf5’, ‘Leaf6’]]]

# Indices allow us to “traverse” the tree




Tree[3] = [‘Node2’, ‘Leaf3’, ‘Leaf4’, [‘Node3’, ‘Leaf5’, ‘Leaf6’]]
Tree[3][3] = [‘Node3’, ‘Leaf5’, ‘Leaf6’]

# Indices allow us to “traverse” the tree






Tree[3][0] = ‘Node2’
Tree[3][1] = ‘Leaf3’
Tree[3][2] = ‘Leaf4’
Tree[3][3] = [‘Node3’, ‘Leaf5’, ‘Leaf6’]
Tree[3][3][0] = ‘Node3’
Tree[3][3][1] = ‘Leaf5’

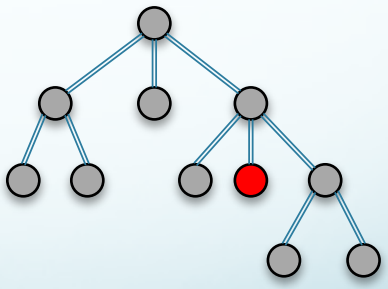
# CQ: How do we select ‘Leaf4’ from the Tree?

```
Tree = [‘Root’, [‘Node1’, ‘Leaf0’, ‘Leaf1’],
                ‘Leaf2’,
                [‘Node2’, ‘Leaf3’, ‘Leaf4’, [‘Node3’, ‘Leaf5’, ‘Leaf6’]]]
```

A: Tree[4][3]

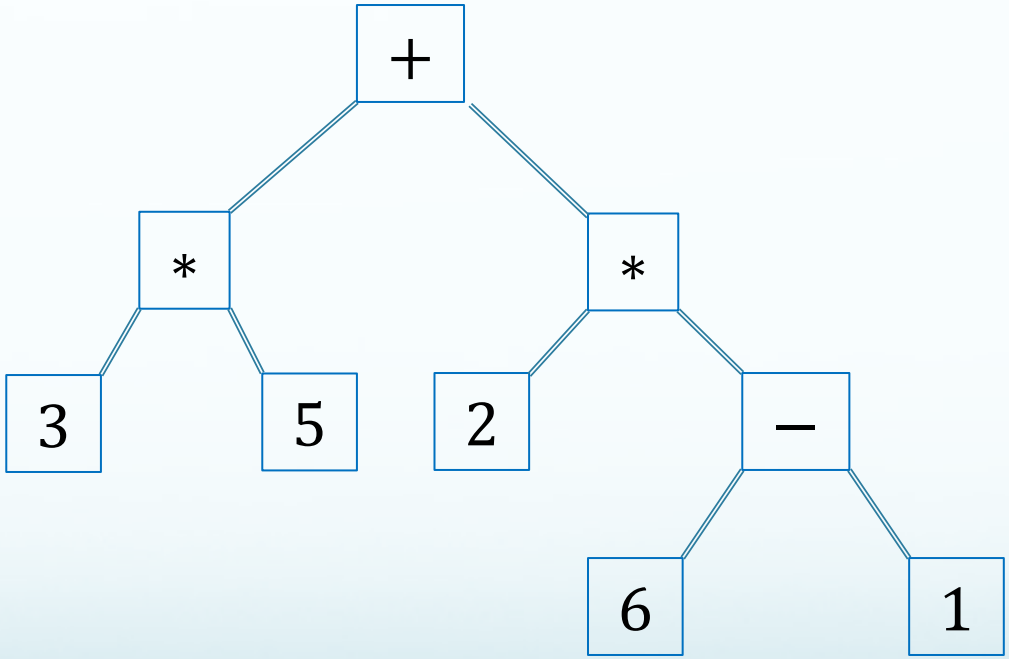
B: Tree[3][2]

C: Tree[8]



# Example: Expressions

$$E = 3 * 5 + 2 * (6 - 1)$$




[+, [*, 3, 5], [*, 2, [-, 6, 1]]]

# Operations on Trees

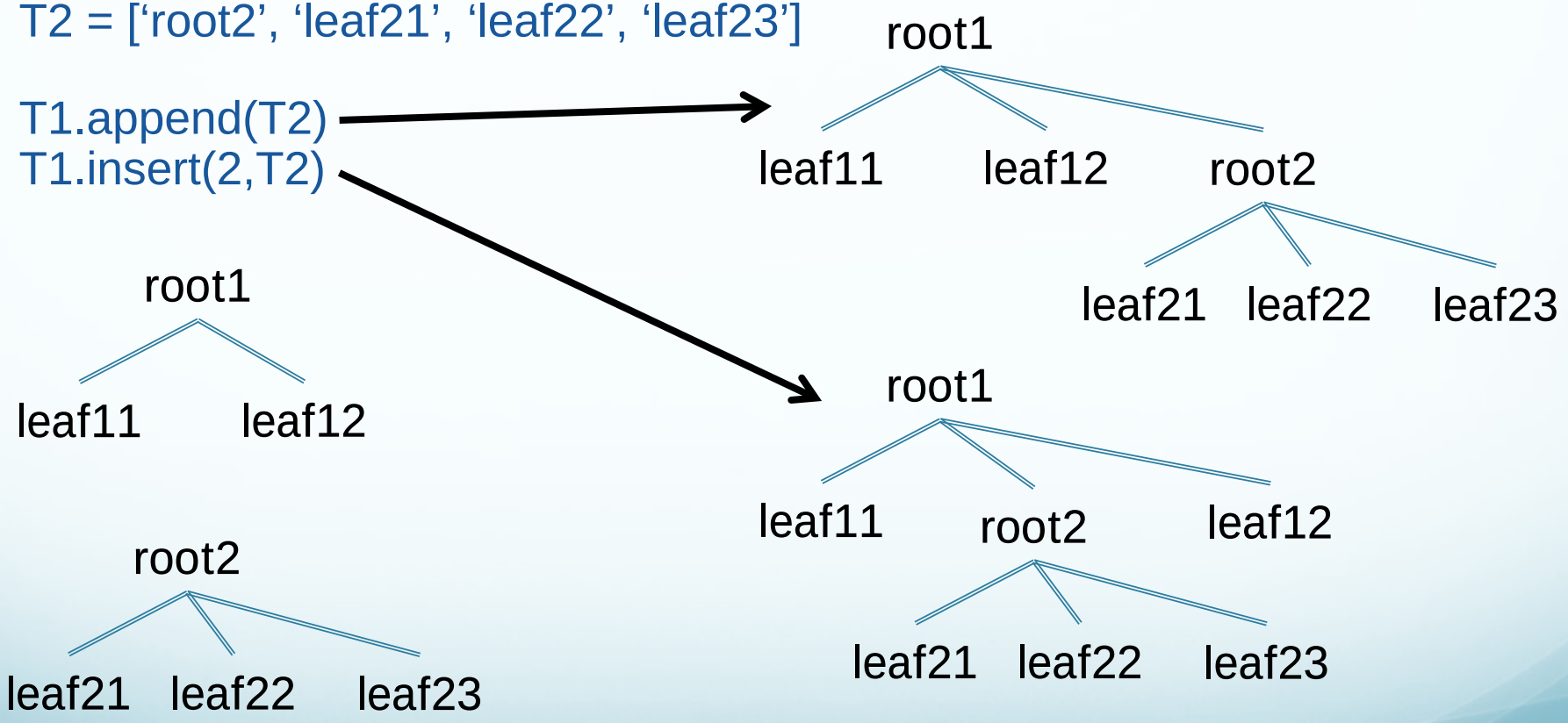
- Trees, since they are encoded via lists, support the same operations that lists support.
  But what do they mean?

- From a ‘tree’ perspective:
  - We can make one tree subtree of another (substitution or extension)
  - We can replace a subtree with a leaf (evaluation)
  - We can drop a subtree (pruning)
  - We can visit each tree node in some order (e.g., depth-first traversal, preorder traversal, etc.)

# T2 as subtree of T1 (Extension)

T1 = [‘root1’, ‘leaf11’, ‘leaf12’]
T2 = [‘root2’, ‘leaf21’, ‘leaf22’, ‘leaf23’]

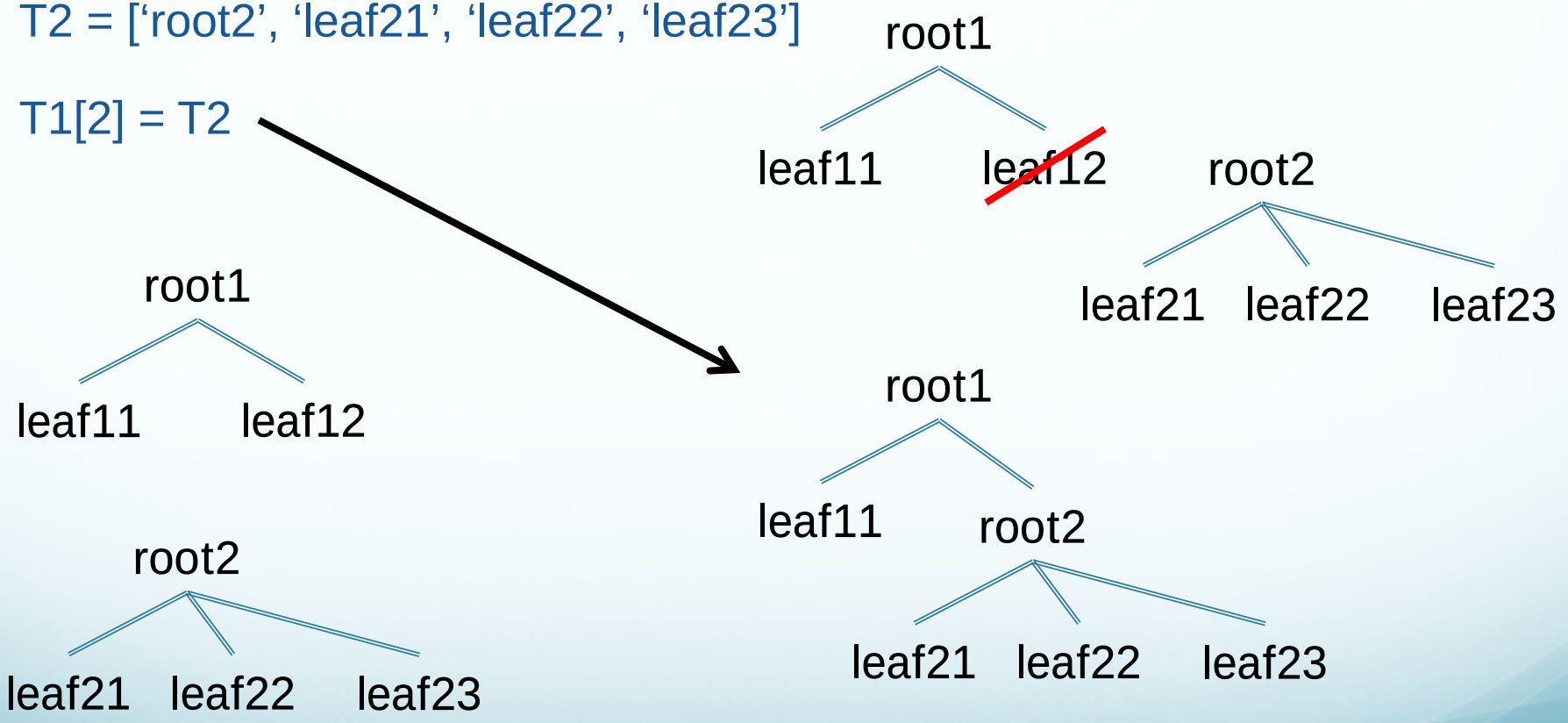
T1.append(T2)
T1.insert(2,T2)



# T2 as subtree of T1 (Substitution)

T1 = [‘root1’, ‘leaf11’, ‘leaf12’]
T2 = [‘root2’, ‘leaf21’, ‘leaf22’, ‘leaf23’]

T1[2] = T2

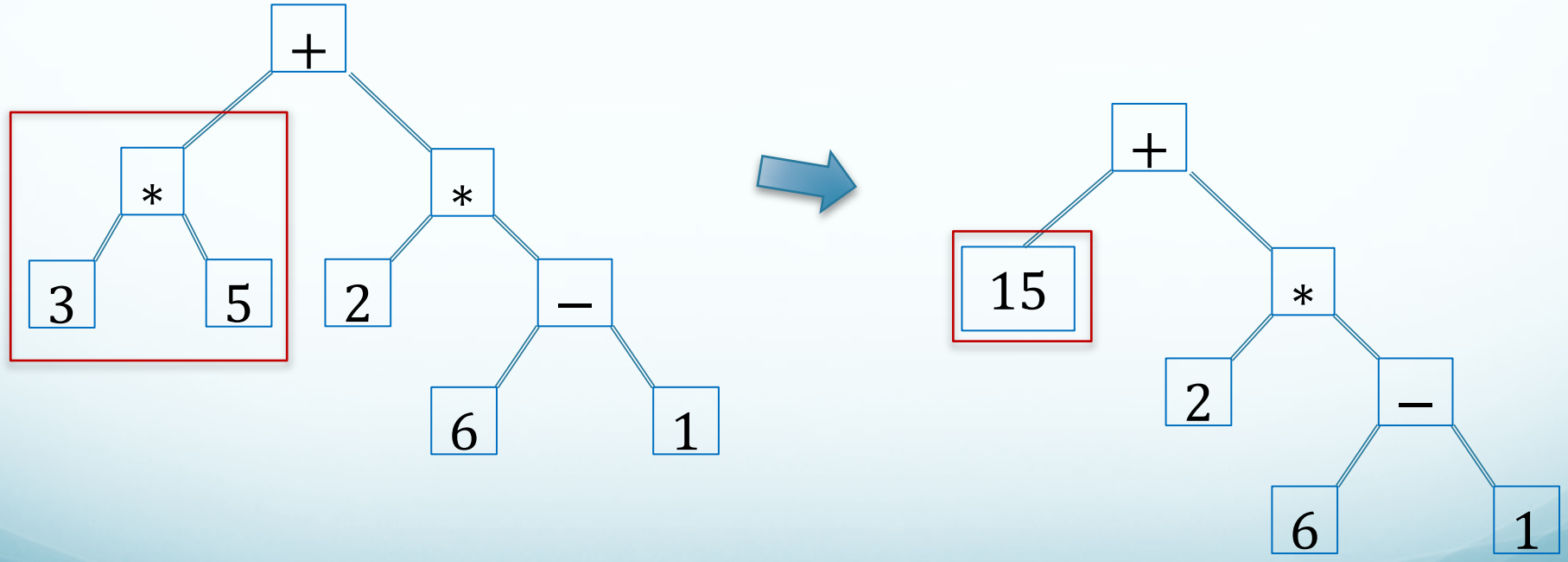


# Tree Evaluation

Requires a notion of evaluating a list. Typical list structure

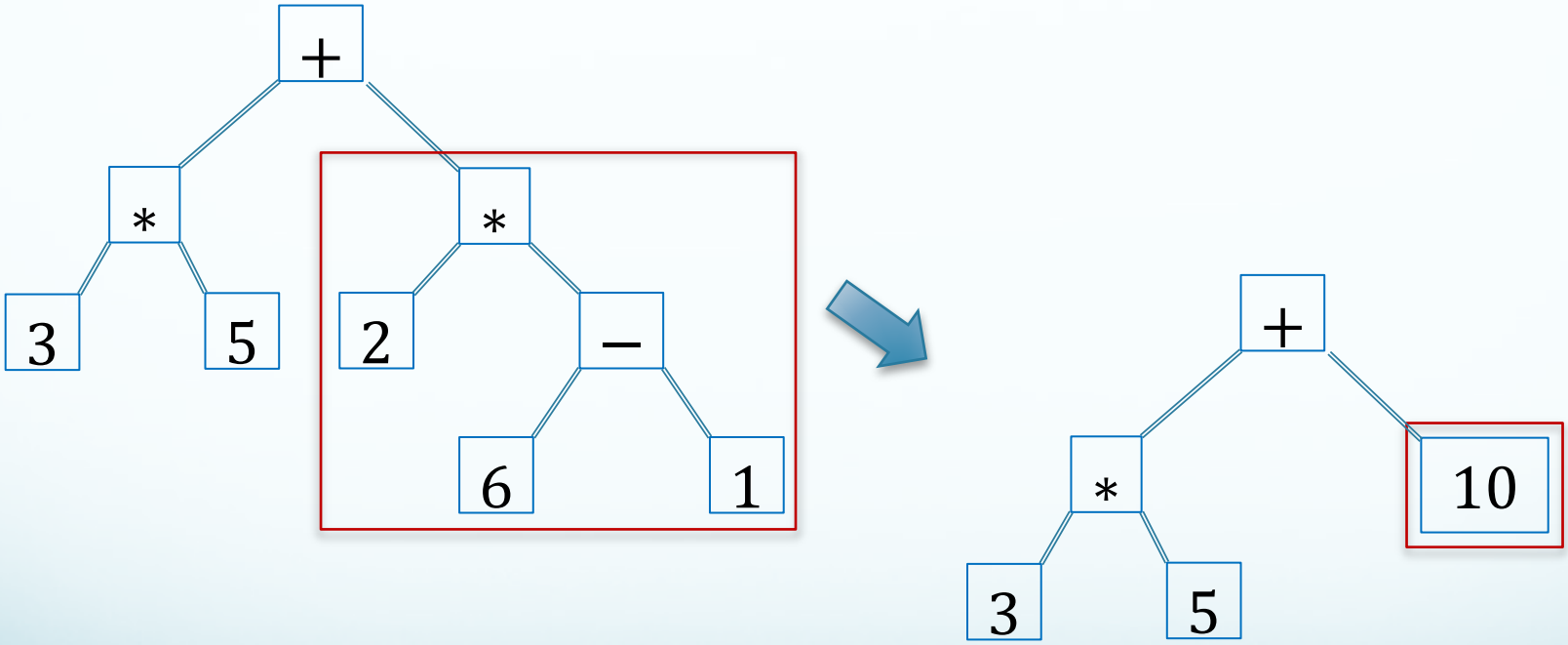
[operation, operand, …, operand] → operand

where operands are compatible with the operation



# Tree Evaluation

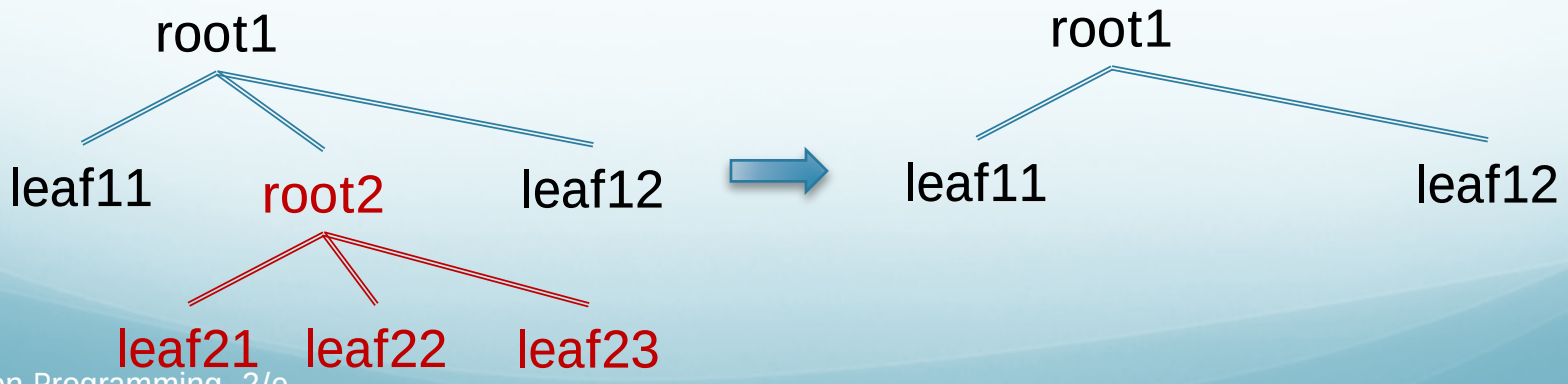
Iterable recursively



# Tree pruning

- Example: Computer Chess
  - Tree records possible moves and responses to some depth (around 6)
  - Each subtree is graded by how desirable its result configuration is. Undesirable choices are dropped

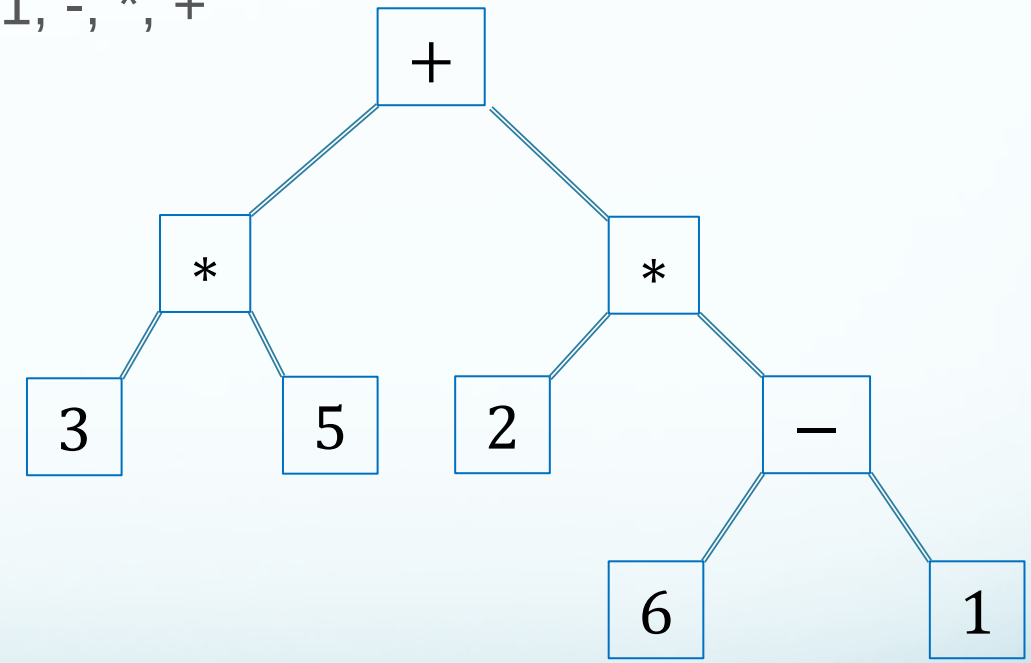
T = [‘root1’, ‘leaf1’, [‘root2’, ‘leaf21’, ‘leaf22’, ‘leaf23]’, ‘leaf12’]
del T[2]



# Tree Traversals

Preorder: +, *, 3, 5, *, 2, -, 6, 1

Post order: 3, 5, *, 2, 6, 1, -, *, +




[+, [*, 3, 5], [*, 2, [-, 6, 1]]]

# Why are trees important?

- They are a fundamental structure in computer science
- They enable us to *search* very quickly, for instance
  - We will revisit trees later in the course
- What have we covered so far that is simple:
  - We can encode a tree as a list of lists
  - Given this encoding, we can select elements like for complex lists, using the index mechanism [ ]
- What is more intricate:
  - Tree constructions and operations arising form the application

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