Recursive Structures & Processes

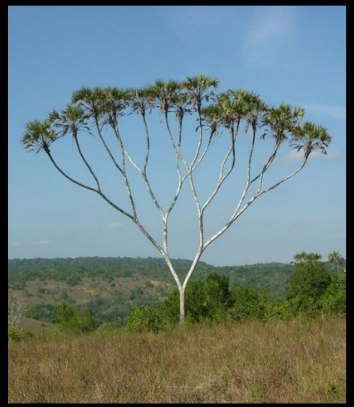
Announcements

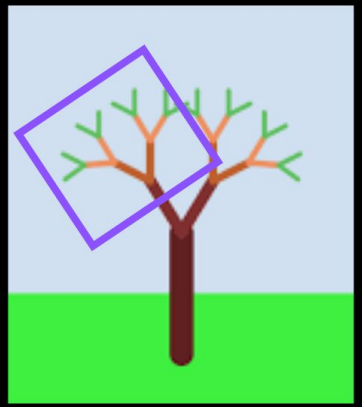
- **LS15: Class Survey** due Tuesday (April 7) at 11:59pm
- **EX07: River Simulation** due Thursday (April 9) at 11:59pm

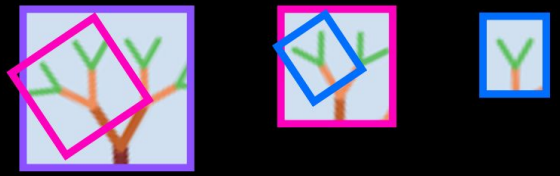
Recursion: defining an operation/object in terms of itself

A real-world phenomenon! Examples:

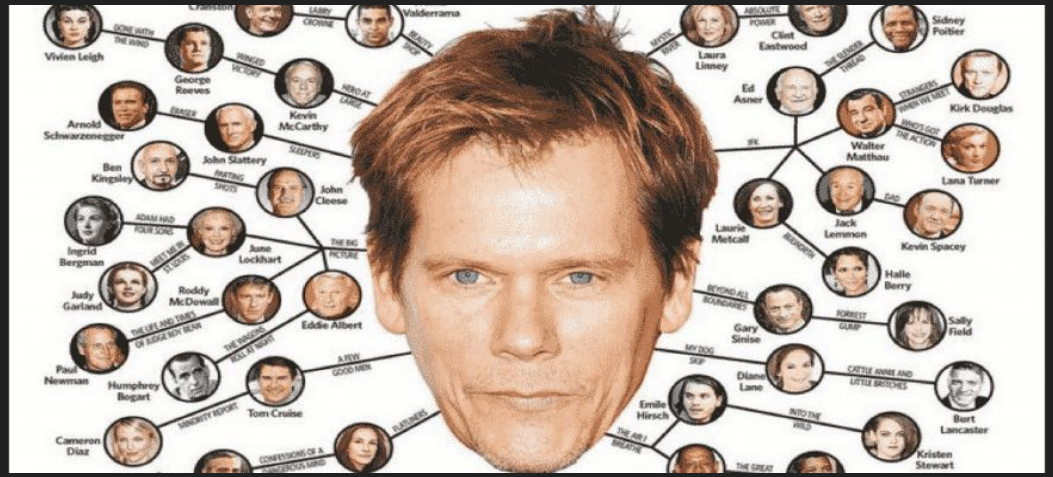
- **You** have **parents**, who have **parents**, who have **parents**, who have **parents**, who…
  … were **early humans**
- A **tree** has **branches**, which have **branches**, which have **branches**, which…
  … have **leaves**





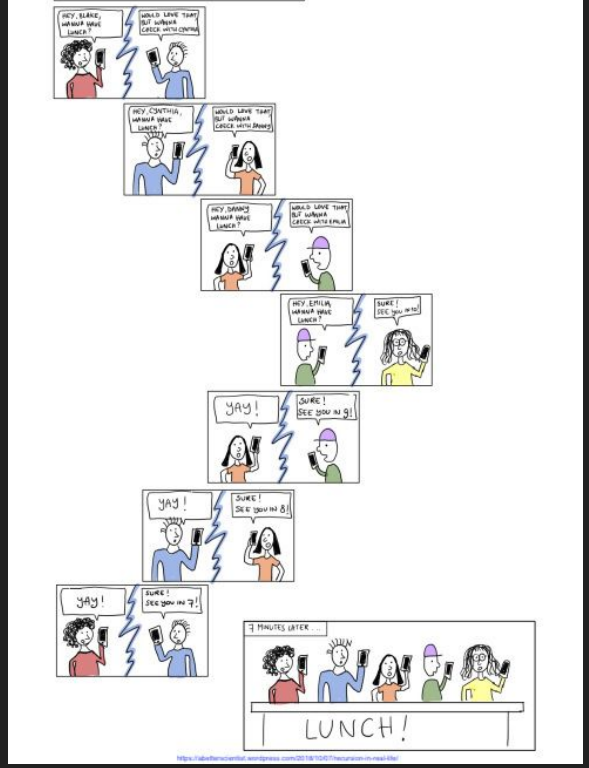


Different recursive structures for different purposes



Six degrees of Kevin Bacon

graph/network



Coordinating plans with individual phone calls

linked list

Anatomy of a Singly-Linked List

Memory diagram

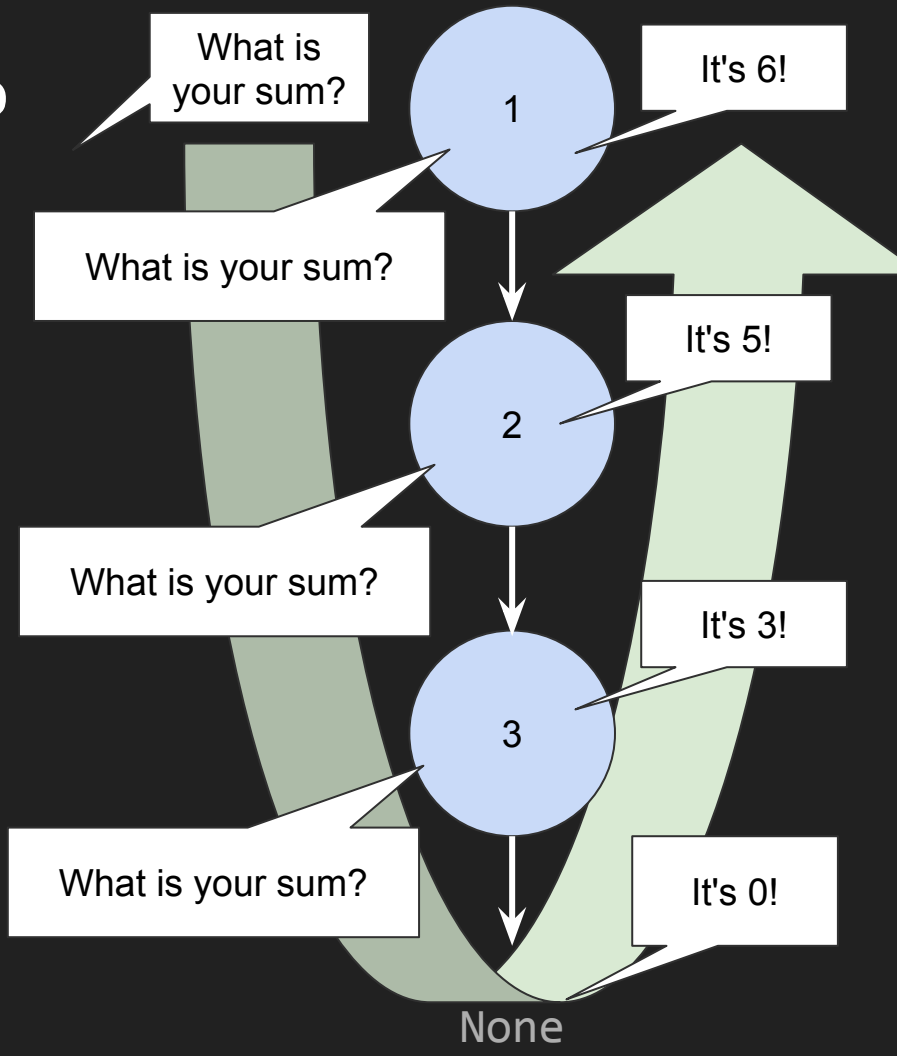
```python
from __future__ import annotations  # Ignore for now!

class Node:
    value: int
    next: Node | None

    def __init__(self, val: int, next: Node | None):
        self.value = val
        self.next = next

# Note: There are no errors!
two: Node = Node(2, None)
one: Node = Node(1, two)
# We'll extend this diagram shortly, leave room
```

A Recursive `sum` Algorithm Demo

1. When you are asked, "what is your sum?"

2. Ask the ***next*** Node, "what is your sum?"
   Wait patiently for an answer!

3. Once the answer is returned back to you, add ***your value to it***, then turn to the person who asked you and give them this answer.



Let's write a recursive function called `sum`!

```python
from __future__ import annotations  # Ignore for now!

class Node:
    value: int
    next: Node | None

    def __init__(self, val: int, next: Node | None):
        self.value = val
        self.next = next

# Note: There are no errors!
two: Node = Node(2, None)
one: Node = Node(1, two)
# We'll extend this diagram shortly, leave room
```

Write a function called `sum` that adds up the `value`s of all `Node`s in the linked list.

Diagramming the `sum` function call

```python
from __future__ import annotations

class Node:
    value: int
    next: Node | None

    def __init__(self, val: int, next: Node | None):
        self.value = val
        self.next = next

# Note: There are no errors!
two: Node = Node(2, None)
one: Node = Node(1, two)

def sum(head: Node | None) -> int:
    if head is None:
        return 0
    else:
        rest: int = sum(head.next)
        return head.value + rest

print(sum(one))
```

For reference: recursive function checklist:

Base case:

- ❏ Does the function have a clear base case?
  - ❏ Ensure the base case returns a result directly (without calling the function again).
- ❏ Will the base case *always* be reached?

Recursive case:

- ❏ Does the function have a recursive case that *progresses toward the base case*?
  - ❏ Does the recursive call have the right arguments? The function should call itself on a simpler or smaller version of the problem.
- ❏ Have you tested your function with multiple cases, including edge cases?