Review 5

Recursion

What We Will Do today

- Practice recursive specifications and functions
  - Given a recursive problem definition
    - Determine a proper specification (note preconditions)
  - Given a problem description and specification:
    - Write the recursive base case
    - Write the recursive call
    - Verify that it is correct

Questions?

Important Steps

1. Precise Specification
   - What does the function do?
   - What are the preconditions?
2. Write the base case
   - What is the most basic case?
   - What causes termination of the recursive function?
3. Write the recursive case
   - How do we make progress toward termination?
   - Is your computation correct?

Writing Specifications

Write a specification for a function that:

- Computes the complement of a positive integer.
  i.e. The complement of 12345 is 98765.

- Reduce the positive input integer to a single digit.
  i.e. 472 -> 47+2 = 49 -> 4+9 = 13 -> 1+3 = 4

Writing Specifications

Write a specification for a function that:

- Computes the complement of a positive integer.
  i.e. The complement of 12345 is 98765.

```
"""Returns: complement of n, by replacing each decimal
digit of n by 10-n. ie. the result for 93723 is 17387.
Precondition: n > 0 an int, and no digit of n is 0"""
```

- Reduce the positive input integer to a single digit.
  i.e. 472 -> 47+2 = 49 -> 4+9 = 13 -> 1+3 = 4

```
"""Returns: n reduced to a single digit (summing its digits)
Precondition: n > 0 an int"""
```

Writing Specifications

Write a specification for a function that:

- Compresses a String so that duplicate are replaced with counts i.e. aaabbbbbbccd -> a3b6c2d1

- Converts an integer to a string representation with commas i.e. 5923821 is converted to 5,923,821.

Writing Specifications

Write a specification for a function that:

- Compresses a String so that duplicate are replaced with counts i.e. aaabbbbbbccd -> a3b6c2d1

```
"""Returns: s compressed so that duplicates are replaced with
count of how many occurrences that character has in a row.
Precondition: s a string"""
```

- Converts an integer to a string representation with commas i.e. 5923821 is converted to 5,923,821.

```
"""Returns: String representation of n with commas added
Precondition: n an int (positive or negative)"""
```

Complement of an Integer

```
def complement(int n) {
    """Returns: the complement of n, formed by replacing
    each decimal digit of n by 10-n.
    i.e. the result for the integer 93723 is 17387.
    Precondition: n > 0 and int, and no digit of n is 0"""
    # Base Case



    # Recursive Case
```

Complement of an Integer

```
def complement(int n) {
    """Returns: the complement of n, formed by replacing
    each decimal digit of n by 10-n.
    i.e. the result for the integer 93723 is 17387.
    Precondition: n > 0 and int, and no digit of n is 0"""
    # Base Case
    if n < 10:
        return 10 – n

    # Recursive Case
    return complement(n/10) * 10 + (10 - n%10)
```

Adding Commas to an Integer

```
def add_commas(n):
    """Returns: string representation of n with commas added
    Precondition: n is an int (positive or negative)"""
    # Base case



    # Recursive Case
```

Adding Commas to an Integer

```
def add_commas(n):
    """Returns: string representation of n with commas added
    Precondition: n is an int (positive or negative)"""
    # Base case
    if n < 1000:
        return str(n)
    # Recursive Case
    number = str(n)
    return add_commas(n/1000) + ',' +number[-3:0]
```

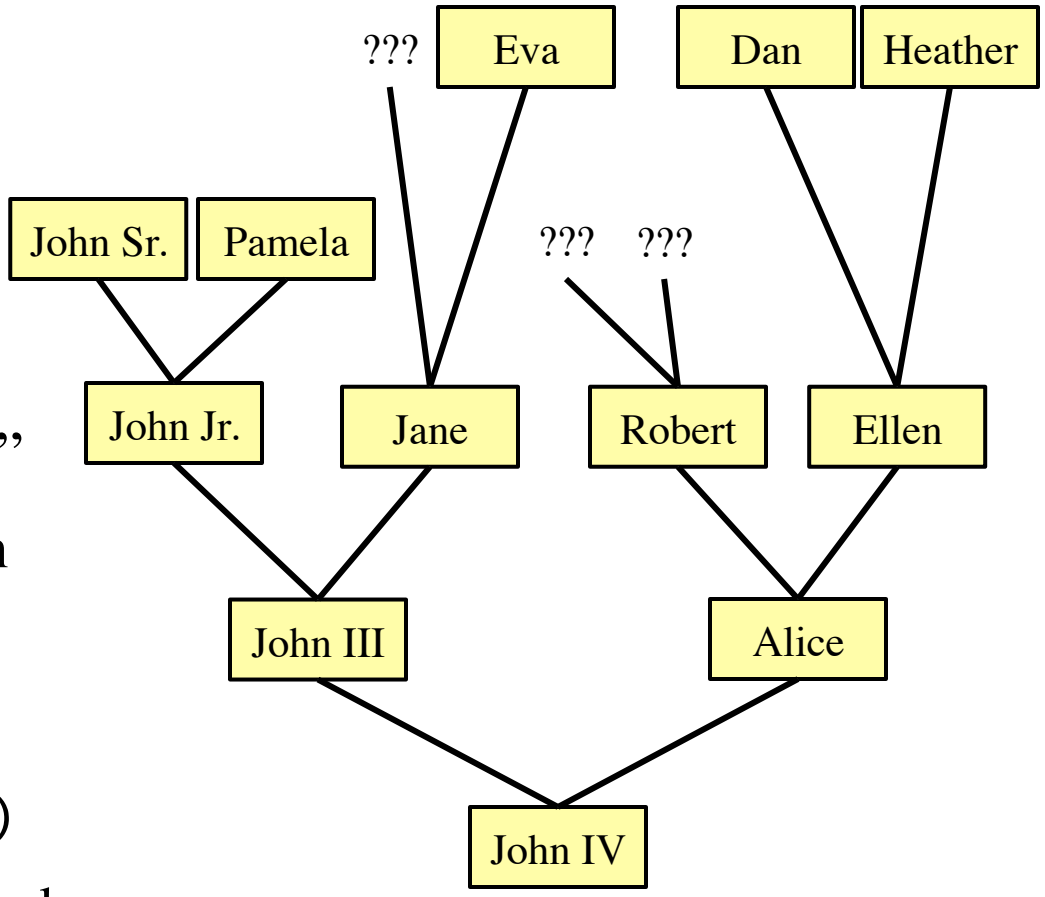
Is something wrong?

Adding Commas to an Integer

```
def add_commas(n):
    """Returns: n with commas added. Precondition: n is an int (positive or negative)"""
    if n < 0:
        return '-' + add_commas_helper(-n)
    else:
        return add_commas_helper(n)


def add_commas_helper(n):
    """Returns: n with commas added.  Precondition: n > 0 is an int"""
    # Base case
    if n < 1000:
        return str(n)
    # Recursive Case
    number = str(n)
    return add_commas_helper(n/1000) + ',' +number[-3:]
```

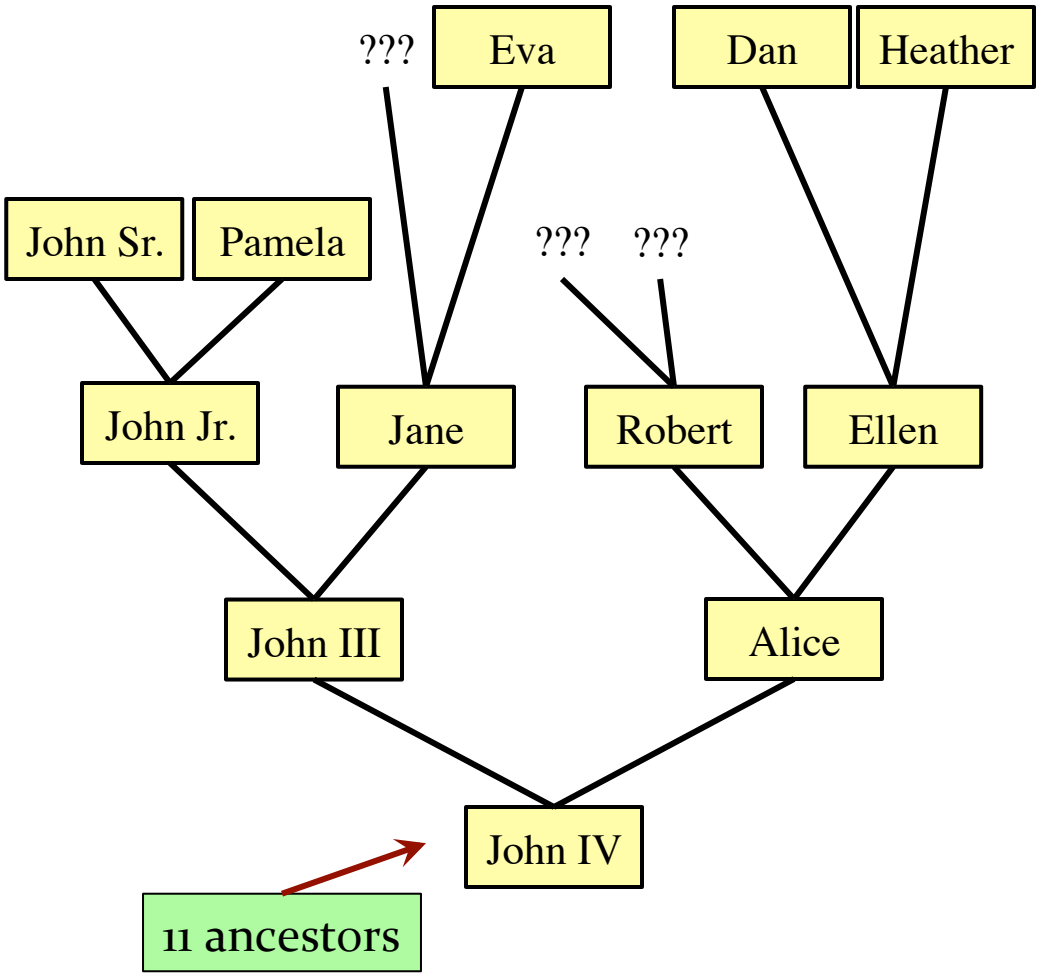
Recursion and Objects

- Class Person (`person.py`)
  - Objects have 3 attributes
  - `name`: String
  - `mom`: Person (or `None`)
  - `dad`: Person (or `None`)
- Represents the "family tree"
  - Goes as far back as known
  - Attributes `mom` and `dad` are `None` if not known
- **Constructor**: `Person(n,m,d)`
  - Or `Person(n)` if no mom, dad



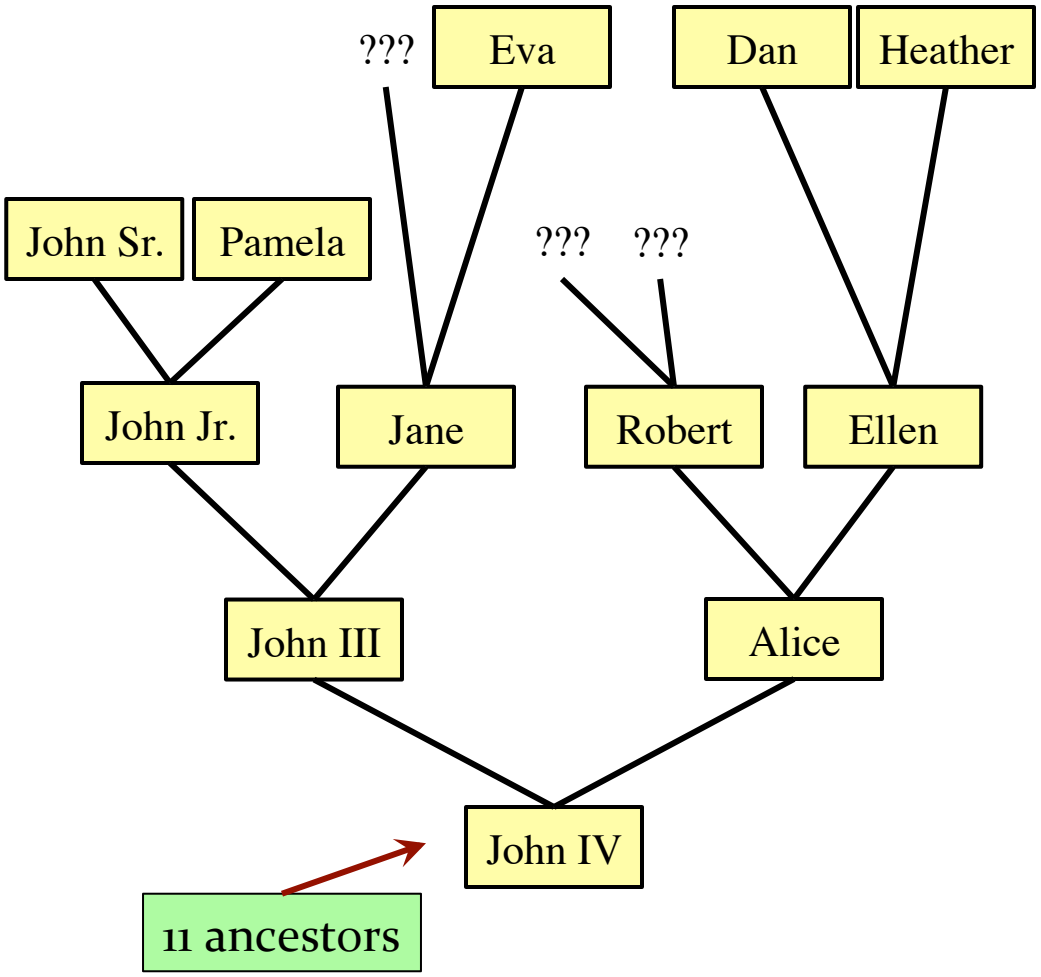
Recursion and Objects

```
def num_ancestors(p):
    """Returns: num of known ancestors
    Pre: p is a Person"""
    # Base case
    # No mom or dad (no ancestors)


    # Recursive step
    # Has mom or dad
    # Count ancestors of each one
    # (plus mom, dad themselves)
    # Add them together
```



Recursion and Objects

```
def num_ancestors(p):
    """Returns: num of known ancestors
    Pre: p is a Person"""
    # Base case
    if p.mom == None and p.dad == None:
        return 0

    # Recursive step
    moms = 0
    if not p.mom == None:
        moms = 1+num_ancestors(p.mom)
    dads = 0
    if not p.dad== None:
        dads = 1+num_ancestors(p.dad)
    return moms+dads
```



Extra Problems

- Given a list, use recursion to determine if it is sorted

- Given a String s, list all the permutations of String s:
  - "XZY" → "XYZ", "XZY", "ZYX", "YXZ", etc

- Use recursion to find the minimum element in a list

One Last Problem

```
class FacebookProfile(object):
    """name [str]: name of this profile
       friends [list of FacebookProfile]: friends list"""
```

We want to answer the question:

- Is this profile at most 6 degrees away from Kevin Bacon?
- In other words, is Kevin Bacon a friend of a friend of a friend of a friend of a friend of a friend?

Specification (Method inside class FacebookProfile):

```
    def sixDegreesOfBacon(self):
        """Returns: True if this FacebookProfile is at most 6
        degrees away from Kevin Bacon; False otherwise"""
```

6-Degrees of Kevin Bacon

```
class FacebookProfile(object):
    ...
    def sixDegreesOfBacon(self):
        """Returns: True if this FacebookProfile is at most 6 degrees away from Kevin Bacon"""
        return _sixDegreesHelper(6)

    def sixDegreesHelper(self,n):
        """Returns: True if this FacebookProfile is at most n degrees away from Kevin Bacon
        Precondition: n > 0 an int"""
        # Base case
        if self.name == 'Kevin Bacon':
            return True
        if n == 0:
            return False
        # Recursive Case
        for f in self.friends:
            if f.sixDegreesHelper(n-1):
                return True
        return False
```

Questions?