COMP 204

Functions II

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based on material from Mathieu Blanchette and Carlos Oliver Gonzalez

Quiz 12 password

Getting help

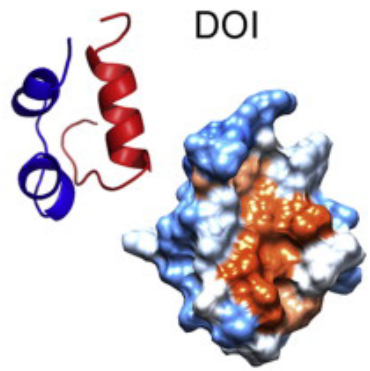
- TAs and I are available to help, and not just for assignments!
- The Computer Science Undergraduate Student (CSUS) association has a help desk where you can drop in with questions any time 10am-5pm in Trottier 3090.

Quiz 11 review: order the functions get executed

```
1  import math  # this imports the math module
2
3  def euclid(xHome, yHome, xAcc, yAcc):
4      return math.sqrt((xHome - xAcc)**2 + (yHome - yAcc)**2)
5
6  def pregnantQuestion():
7      if (input("Are you pregnant? (yes/no) ") == "yes"):
8          print("You must evacuate")
9      else:
10         print("Evacuation is recommended")
11
12 def evaluateRisk(distance):
13     if distance <= 20:
14         print("You must evacuate")
15     elif distance <= 40:
16         pregnantQuestion()
17     else:
18         print("No need to evacuate")
19
20 def evacuateAssessmentMain():
21     xAcc = 20; yAcc = 30
22     xHome = 40; yHome = 50
23     evaluateRisk(float(euclid(xHome, yHome, xAcc, yAcc)))
24
25 evacuateAssessmentMain()
```

Example: Hydrophobic patches

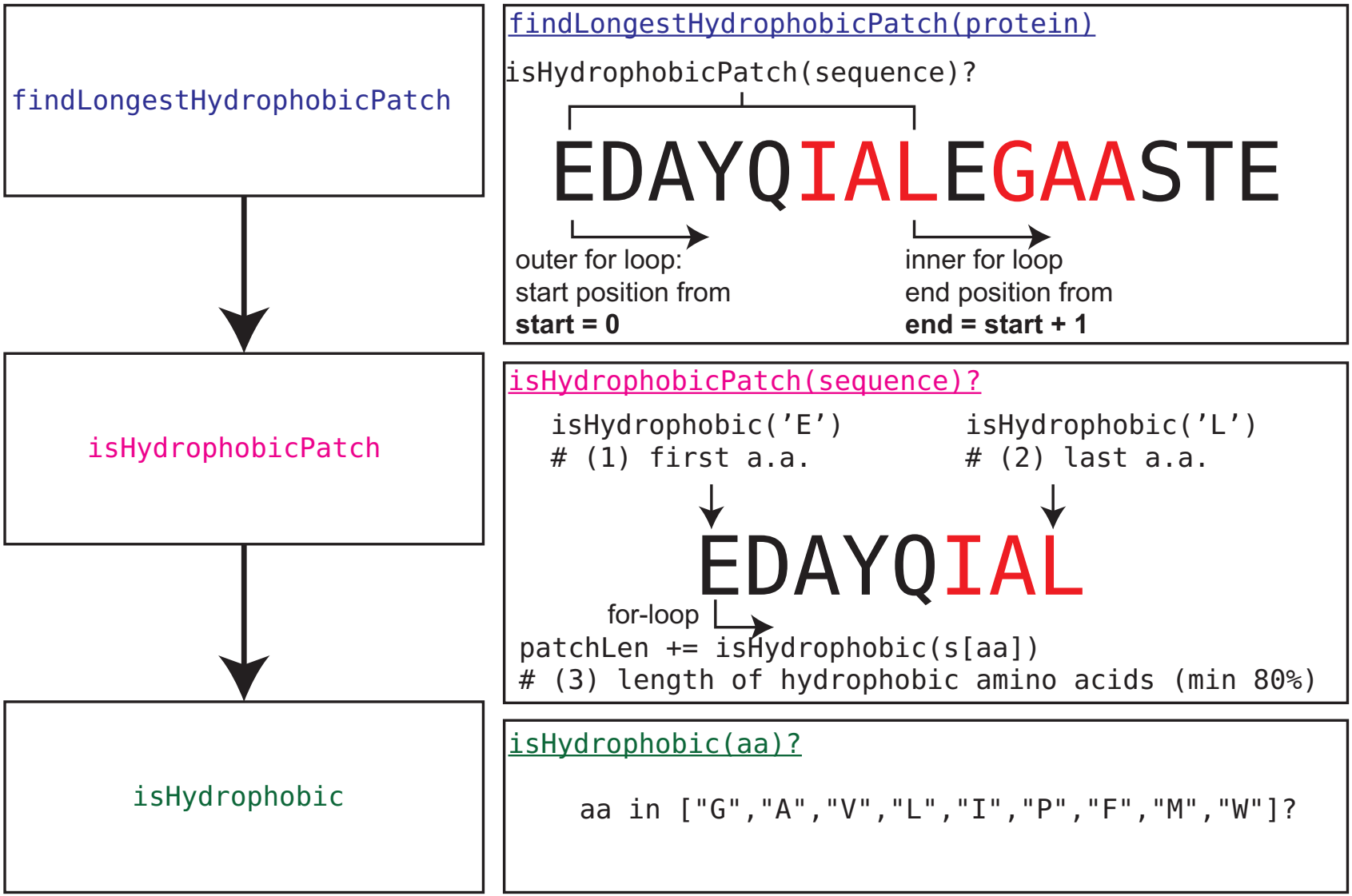
- Protein sequences are made of amino acids.
- Some amino acids (G, A, V, L, I, P, F, M, W) are hydrophobic (i.e. they don't like to interact with water molecules).
- Some proteins contain *hydrophobic patches*, which are portions of the sequence that start and end with an hydrophobic amino acid and where at least 80% of the amino acid are hydrophobic.



- For example, in the sequence EDAYQIALEGAASTE, the longest hydrophobic patch is IALEGAA.

Goal: Write a function that identifies the *longest* hydrophobic patch in a given protein sequence.

Find longest hydrophobic patch by *divide-and-conquer*



Not the most efficient way (discussed a bit later)

Example: Hydrophobic patches

Divide-and-Conquer (bottom up approach): Break it down into small, manageable tasks and start with the lowest tasks

1. Write a function that checks if a given amino acid is hydrophobic
2. Write a function that checks if a given sequence is a hydrophobic patch:
   - Starts and ends with a hydrophobic amino acid
   - Made at 80% or more of amino acids (i.e. count hydrophobic amino acids; see if count is at least 0.8*length)
3. Use nested for or while loop to iterate over all possible start and end points of a candidate patch. Use function above to test if it is a patch. If it is, calculate length and update the variable that keeps track of the longest patch found so far.
4. Report longest patch found

isHydrophobic function

```
1  # This function returns True if aa is a hydrophobic amino
       acid
2  def isHydrophobic(aa):
3      hydrophobic = ["G","A","V","L","I","P","F","M","W"]
4
5      # This checks if aa is equal to an object in the list
       hydrophobic
6      if aa in hydrophobic:
7          return True
8      else:
9          return False
10
11 # This is a shorter way to do the same thing
12 def isHydrophobic2(aa):
13     return (aa in ["G","A","V","L","I","P","F","M","W"])
```

isHydrophobicPatch function

```
# This function tests whether a given sequence
# contains at least 80% of hydrophobic amino acids
def isHydrophobicPatch(sequence):
    # test if sequence starts and ends with a hydrophobic aa
    # If not, it is not a hydrophobic patch, so return False
    if isHydrophobic(sequence[0]) == False or isHydrophobic(
    sequence[-1]) == False:
        return False
    # Count the fraction of hydrophobic amino acids
    hydrophobicCount = 0
    for aa in sequence:
        if isHydrophobic(aa):
            hydrophobicCount += 1
    # See if we have enough hydrophobic amino acids
    if hydrophobicCount >= 0.8 * len(sequence):
        return True
    else:
        return False
```

```
# shorter way to do the same with one boolean expression
def isHydrophobicPatch2(sequence):
    return isHydrophobic(sequence[0]) and \
           isHydrophobic(sequence[-1]) and \
        len([aa for aa in sequence if isHydrophobic(aa)]) >
    0.8*len(sequence)
```

findLongestHydrophobicPatch function

```
# This returns the longest hydrophobic patch found in a sequence
def findLongestHydrophobicPatch(protein):
    longestPatch=""  # the longest patch found so far

    # for every possible starting point
    for start in range(0,len(protein)):

        # and every possible end point
        for end in range(start+1,len(protein)+1):
            # get the sequence
            candidate = protein[start:end]

            # test hydrophobicity
            if isHydrophobicPatch(candidate):

                # if longer than longest seen so far, update
                if len(candidate)>len(longestPatch):
                    longestPatch = candidate

    return longestPatch
```

This is an exhaustive search and not the most efficient algorithm. How do we improve it? How much can we improve?

Recursion version (advanced): `findLongestHydrophobicPatch_recur`

```
1  def findLongestHydrophobicPatch_recur(protein, start, end):
2
3      if start < end and end <= len(protein):
4          if isHydrophobicPatch(protein[start:end]):
5              return protein[start:end]
6          else:
7              patch1 = findLongestHydrophobicPatch_recur(
       protein, start+1, end)
8              patch2 = findLongestHydrophobicPatch_recur(
       protein, start, end-1)
9      else:
10         return ""
11
12     if len(patch1) > len(patch2):
13         return patch1
14     else:
15         return patch2
16
17 # code to test our function
18 protein = input("Enter protein sequence: ")
19 patch = findLongestHydrophobicPatch_recur(protein,0,len(
       protein))
20 print("Longest hydrophobic patch is ",patch)
```

Positional arguments

The functions we have seen so far take as input *positional arguments*.
Arguments are passed in the same order as the function definition
Example:

```
1 def inputInRange(message, minVal, maxVal):
```

Notes:

- Every call to the function *must* provide exactly three objects as arguments
- The order of the arguments matter:
  inputInRange("Enter age", 0, 150)
  is not the same thing as
  inputInRange("Enter age", 150, 0)

Optional arguments

Another way to pass arguments to functions is to use *keyword arguments*. Example:

```
# The function takes two keyword arguments
def inputInRange(message, minVal = 0, maxVal = 100):
    while True: # loops until return statement is executed
        n = int(input(message))
        if n >= minVal and n <= maxVal:
            return n
        else:
            print("Number outside of range",minVal, maxVal)

age = inputInRange("Enter age:")
height = inputInRange("Enter heigth (in cm):",maxVal = 250)
weight= inputInRange("Enter weight:",maxVal=250, minVal=20)
```

Notes:

- Keyword arguments are optional when calling the function. If the caller does not provide them, they are set to their default value specified in the function header.
- Keyword arguments must come *after* positional arguments.
- Keyword arguments can be specified in any order.
- Useful when a function can take a large number of optional

Returning multiple outputs

A function can only return one object. What if a function needs to return multiple pieces of information? Idea: The object returned can be a compound object (list, tuple).

```
1  # This returns a tuple made of the longest hydrophobic patch
2  # found in a sequence, along with its start and end
       positions
3  def findLongestHydrophobicPatch(protein):
4      longestPatch=""
5      for start in range(0,len(protein)):
6          for end in range(start+1,len(protein)):
7              candidate = protein[start:end]
8              if isHydrophobicPatch(candidate):
9                  if len(candidate)>len(longestPatch):
10                     longestPatch = candidate
11                     longestPatchStart = start
12                     longestPatchEnd = end
13     # this returns a tuple
14     return (longestPatch,longestPatchStart,longestPatchEnd)
15
16 # code to test our function
17 protein = input("Enter protein sequence: ")
18 patch, s, e = findLongestHydrophobicPatch(protein)
19 print("Longest hydrophobic patch is ",patch)
20 print("It goes from position",s,"to position",e)
```

Recursion version 2: findLongestHydrophobicPatch_recur2

```
1  def findLongestHydrophobicPatch_recur2(protein, start, end):
2
3      if start < end and end <= len(protein):
4          if isHydrophobicPatch(protein[start:end]):
5              return (protein[start:end], start, end)
6          else:
7              patch1, patch1_start, patch1_end =
       findLongestHydrophobicPatch_recur2(protein, start+1, end
       )
8              patch2, patch2_start, patch2_end =
       findLongestHydrophobicPatch_recur2(protein, start, end
       -1)
9      else:
10         return ("", 0, 0)
11
12     if len(patch1) > len(patch2):
13         return patch1, patch1_start, patch1_end
14     else:
15         return patch2, patch2_start, patch2_end
```

The scope of variables

When inside a function, the only variables that are available are:

- Local variables: The function's arguments, and all the variables defined within that function.
  - When we return from a function, all local variables are discarded.
  - It is possible for a function to have a local variable called x, even if a global variable x already exists. Those are considered two different variables, and only the local version is used.
- Global variables: Those defined outside any function. Their value can be accessed within a function, but not changed.

Notes:

- Avoid referring to global variables within functions. It makes code very confusing.
- It is actually possible for a function to change the value of global variables, but this is rarely a good thing to do, so we will not explain it here.

```
1  def fun1():
2      x=53  # is local to fun1
3      print("Within fun1, x = ",x)
4
5  def fun2(x):
6      x=2  # is local to fun2
7      print("Within fun2, x = ",x)
8
9  def fun3():  # x is not defined within fun3,
10                # so we use the global variable
11     print("Within fun3, x = ",x)
12
13 x=17
14 print("To start, x = ",x)
15 fun1()
16 print("After fun1, x = ",x)
17 fun2(x)
18 print("After fun2, x = ",x)
19 fun3()
20 print("After fun3, x = ",x)
```

Output:
To start, x = 17
Within fun1, x = 53
After fun1, x = 17
Within fun2, x = 2
After fun2, x = 17
Within fun3, x = 17
After fun3, x = 17