

Homework 5 - Hierarchies; Higher-Order Functions

(195 Points)

Due: Tuesday, October 5 at 11pm

Read the Expectations on Homework posted on Canvas.

Assignment Goals

- To make sure you can write data definitions for hierarchies.
- To make sure you can write programs over hierarchies.
- To make sure you can use `map` and `filter` to simplify the development of certain list problems.

The Assignment

There are two parts to this assignment. In Part 1, you will define data and functions for a hierarchy. In Part 2, you will use `map` and `filter` to re-write some of the list functions we developed a couple of weeks ago.

Part 1:

A river system can be represented as a hierarchy. For example, a list of some of the tributaries that feed into the Missouri River includes the Jefferson, Sun, Yellowstone, Madison, and Gallatin Rivers. The Jefferson, in turn, is fed by the Beaverhead and Big Hole rivers. The Yellowstone is fed by the Gardner, Shields, and Boulder rivers, and so on. In this set of exercises you will create a data definition for a river and its tributaries, and write programs that answer questions about the quality of the water in the rivers.

Assume that for each river, measurements of the river's pH and DO (dissolved oxygen) levels are available. Such measurements are taken at the confluence of the rivers (the point at which the tributaries converge). pH levels can range from 0 (most acidic) to 14 (most alkaline). The normal range for bodies of water are 6.5 - 8.5. DO is measured in milligrams per liter (mg/L). DO levels are dependent on many factors, including water temperature, salinity, atmospheric pressure, aeration, and bacterial levels. Dissolved oxygen levels can range from less than 1 mg/L to more than 20 mg/L depending on how all of these factors interact.

1. **(10 Points)** Provide data definitions for a river system. For each **river** in the hierarchy, you should record the following information: the **name** of the river, the pH (**ph**) of the water, the DO (**do**) in mg/L, and a list of the **tributaries** (rivers) that feed into the river. The name of your struct should be **river**. Make sure you define the fields for a river in the order given in the description.
2. **(5 Points)** Provide an example of a river system that starts with a single river and consists of at least two levels in the hierarchy below that. You may use the example given above for the Missouri River, if you wish. (You may make up numbers for pH and DO - for these exercises we're not concerned about the accuracy of the information, just that you can provide a correct model for the information.)
3. **(10 Points)** Provide the templates for your function definitions, i.e. `river-fcn` and `list-of-river-fcn`.
4. **(30 Points)** Develop a function `list-acidic-rivers` that consumes a river system and produces a list of string. The function returns a list of the names of rivers in the system that have a pH level lower than 6.5.
5. **(30 Points)** Develop a function `unhealthy?` that consumes a river system and produces a boolean. The function returns true if any river in the system has a pH below 6.5 or over 8.5 or a DO under 6ppm.
6. **(30 Points)** Acid rain can lower the pH of water in a river system. Develop a function `lower-all-ph` that consumes a river system and produces a river system. The river system that is produced is the same as the original, except that the pH of all the rivers in the system have been lowered by 0.3.
7. **(30 Points)** Write a function `find-subsystem` that consumes the name of a river and a river system and produces either a river system or `#false`. The function returns the portion of the original river system that has the named river as its root. If there is no river in the system with the given name, the function returns false.

Part 2: In Homework 3 we developed several functions that were designed to process a list of menu items in a restaurant. As you solve the following problems, you may use this set of data definitions from Homework 3:

```
(define-struct menu-item (name kind vegetarian? quantity price))
;; a MenuItem is a (make-menu-item String String Boolean Natural Number)
;; interp:
;;      MenuItem represents an item for an electronic menu system in a restaurant,
where
;;      name is the name of the menu item
;;      kind indicates whether the item is a beverage, entree, appetizer, dessert
;;      vegetarian? is true if the item is vegetarian
;;      qty is the number of that item that has been ordered
;;      price is the cost of a single item

;; an Order (ListOfMenu-item) is either
;; empty, or
;; (cons MenuItem Order)
```

Start by copying and pasting the data definitions for MenuItem and ListOfMenuItem (Order) to your DrRacket Definitions window.

8. **(20 Points)** Using map and/or filter (or other higher-order functions), define a new function dollar-menu-items with the following signature and purpose:
;; dollar-menu-items: ListOfMenuItem -> ListOfString
;; consumes a list of menu items and produces a list of the names of all the items with prices of \$1 or less
9. **(15 Points)** Using map and/or filter (or other higher-order functions), define the function all-same-kind? that has the following signature and purpose:
;; all-same-kind?: ListOfMenuItem String -> Boolean
;; consumes a ListOfMenuItem and a kind of food and produces true if every item is of that kind
10. **(15 Points)** Using map and/or filter (or other higher-order functions), redefine the function list-expensive-vegetarian that you wrote for Homework 3, that has the following signature and purpose:
;; list-expensive-vegetarian: ListOfMenuItem Number -> ListOfMenuItem
;; consumes a list of menu items and returns a list of those vegetarian items that exceed the given amount

What to Turn In

The rubric the graders will use for Homework 5 is posted below this assignment on Canvas.
Programs must run in order to receive credit. Note that code that is commented out will not be graded.

Using Canvas, turn in a single file containing all code and documentation for this assignment.

Name your file according to the naming conventions posts in the Assignments block on Canvas.

Make sure your name(s) and login(s)--for both partners, if applicable--appear at the top of the file in a comment.