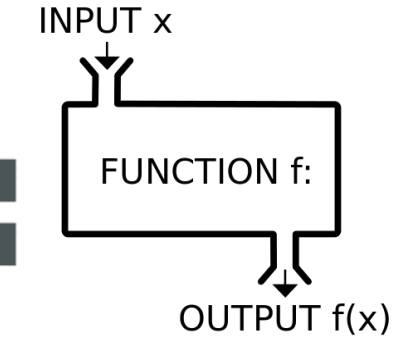
Functional Programming



Lists

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Lists

Lists are the most important data type in functional programming

Learning Targets

You

- understand the structure of lists in Haskell
- know how to create a list and how to access its elements
- can use the available functions which are defined in the prelude
- know how to use hoogle to search for functions

Content

- Definition
- Lists as Models
- Accessing List Elements
- The Structure of Lists
- Pattern Matching on Lists
- Important List Functions
- Higher Order List Functions Preview

Lists

- **A list is a sequence of elements of the same type**
- **List types**
  - If T is a Type then [T] is the type of a list with elements of type T
  - The number of elements contained in a list is not represented by the type
- **List values**
  - Syntax: Enclosed in square brackets and separated by commas

```
[1, 2, 3, 4]                    :: [Integer]
[True, True, False, True]       :: [Bool]
["Milk", "Bread", "Flakes"]     :: [String]
[sum, product]                  :: [(Num a => [a] -> a)]
```

Lists

- **sequence of elements** of the **same** type
- Type: [T] one type for all elements
- Length: The **number of elements** in a
- Lists of the **same type** can have **different lengths**

Tuples

- **finite sequence** of components of **possibly different** type
- Type: $(T_1, T_2, ..., T_n)$ defining the type at each position in the tuple
- Arity: The **number of components** in a tuple
- All tuples of the **same type** have the **same arity**

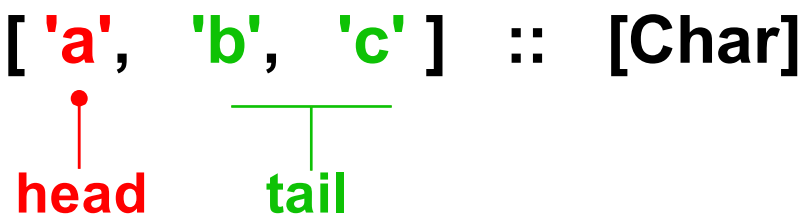
Worksheet: Lists as Models

Key learnings

- **Lists can be utilized to model many different kind of real world data**
- **When the number of elements is not statically determined, you need a list**

Accessing List Elements

- A list of type [T] consists of a head element of type T and a tail of type [T]



- Access the first element of the list

```
head :: [a] -> a
```

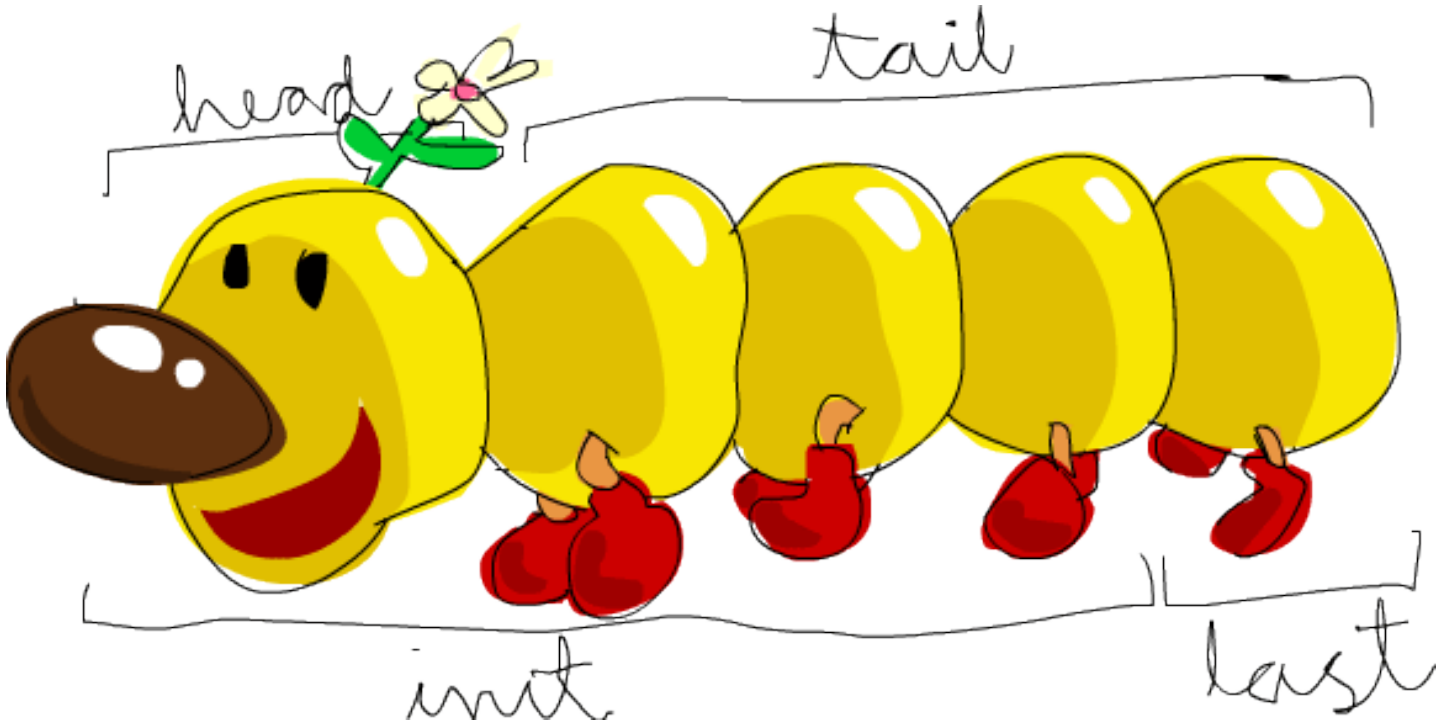
```
head ['a', 'b', 'c'] ~> 'a'
```

- Access the rest of the list

```
tail :: [a] -> [a]
```

```
tail ['a', 'b', 'c'] ~> ['b', 'c']
```

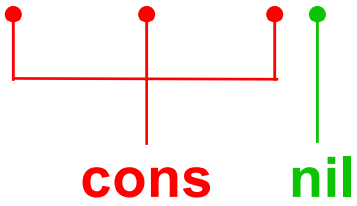
Structure of a list I



http://learnyouahaskell.com/starting-out#an-intro-to-lists

Constructing Lists

- ['a', 'b', 'c'] translates to 'a' : ('b' : ('c' : []))



- The empty list is called nil and is written as []

```
[] :: [a]
```

- cons (:) takes an element and a list and returns a new list with the element as its new head

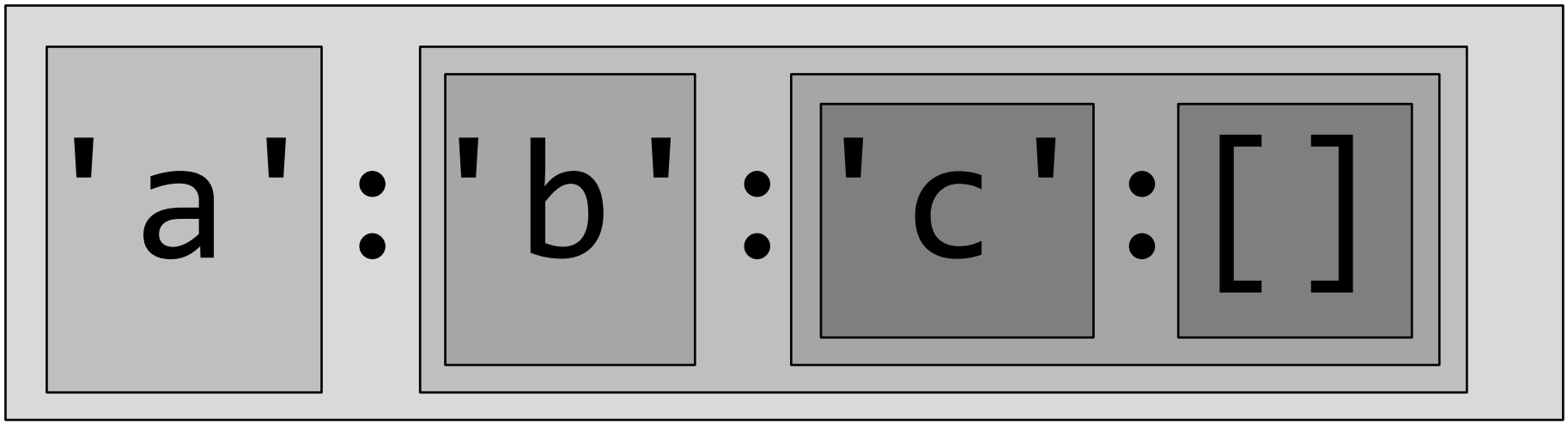
```
(:) :: a -> [a] -> [a]
```

```
'a' : ['b', 'c'] ~> ['a', 'b', 'c']
```

- cons associates to the right

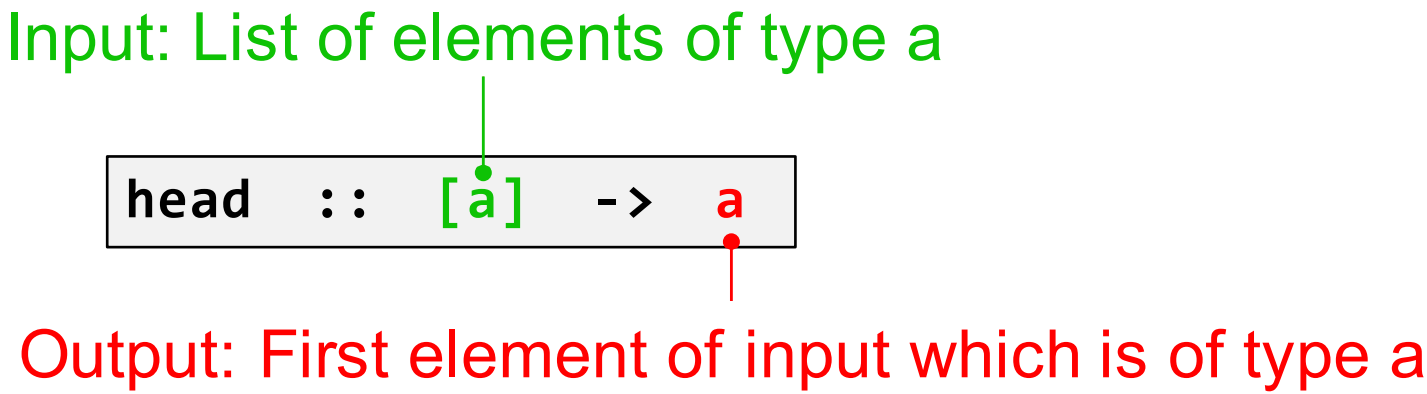
'a' : 'b' : 'c' : [] is interpreted as ('a' : ('b' : ('c' : [])))

Structure of a list II



- **At the end of a finite list is always the empty list [].**

Head in Detail



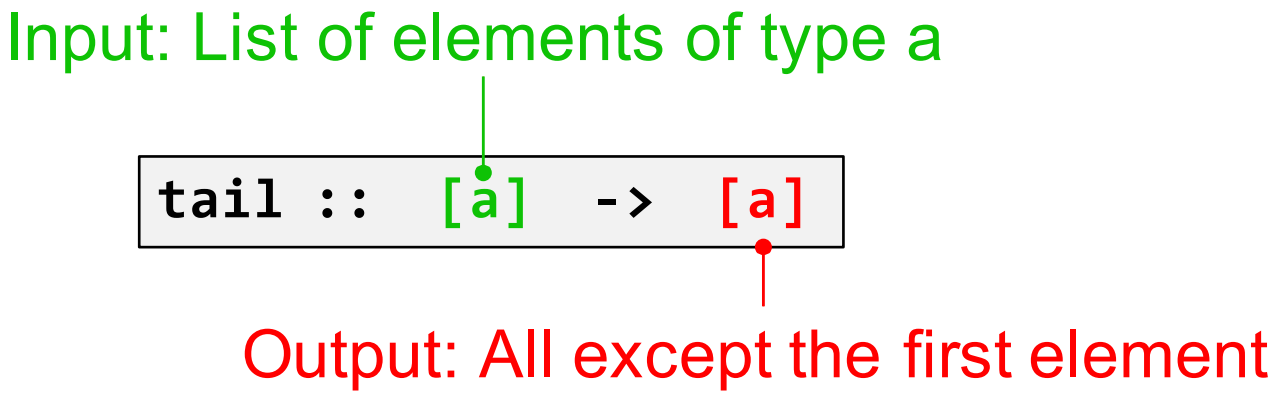
- **head on non-empty list**

```
head [1,2,3] ~> 1
```

- **head on the empty list []**

```
head [] ~> *** Exception: Prelude.head: empty list
```

Tail in Detail



- **tail on non-empty list**

```
tail [1,2,3] ~> [2,3]
```

- **tail on the empty list []**

```
tail []  ~> *** Exception: Prelude.tail: empty list
```

Length of a List

- **Check whether the list is empty or not**

```
null :: [a] -> Bool
```

```
null ['a','b','c'] ~> False
null []            ~> True
```

- **Get the number of elements in the list**

```
length :: [a] -> Int
```

```
length ['a','b','c'] ~> 3
length []            ~> 0
```

- **Before accessing elements of list always check that it is**
  - not null
  - length > 0

to avoid runtime errors

Worksheet: List Deconstruction

Key learnings

Pattern Matching Lists

- **Matching type constructors**
  - One case for the empty list
  - One case for a list with a head element

```
stdMatch :: Show a => [a] -> String
stdMatch []     = "Matched empty list"
stdMatch (x:xs) = "Matched list with head " ++ show x
```

- **The following two functions are equivalent**

```
ml :: Show a => [a] -> String
ml [x]        = "Matched list with one element" ++ show x
ml [x,y]      = "Matched List with two elements"
```

```
ml :: Show a => [a] -> String
ml (x:[])     = "Matched list with one element" ++ show x
ml (x:y:[])   = "Matched List with two elements"
```

String is a List of Characters

- In Haskell the type String is simply an alias for [Char]

```
type String = [Char]
```

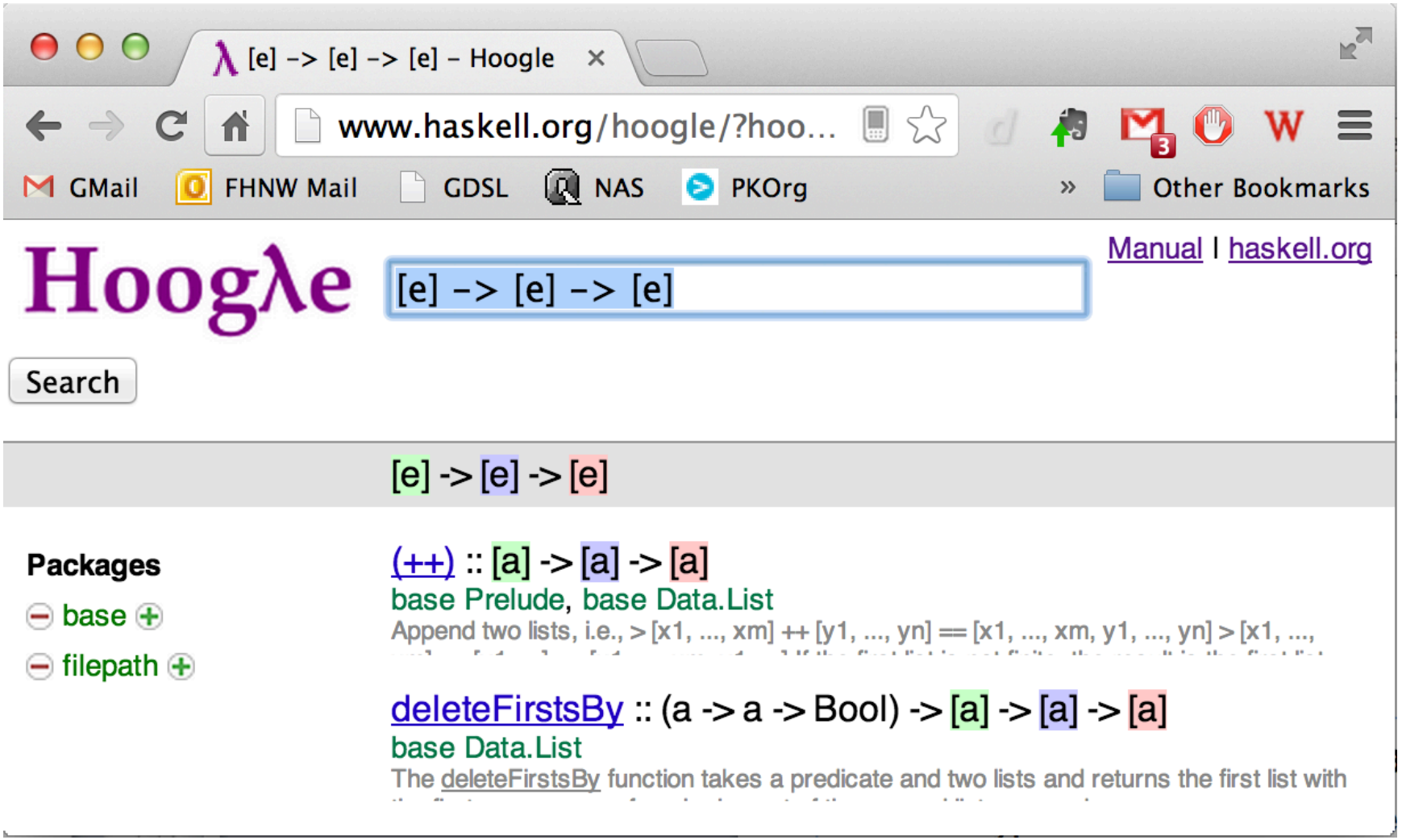
- Which means that the following expressions are all equal

```
"abc" == ['a','b','c'] == 'a':'b':'c':[]
```

- As a consequence: Strings can be processed like any other list

```
head "hello"   ~> 'h'
tail "hello"   ~> "ello"
length "hello" ~> 5
```

List Functions WS



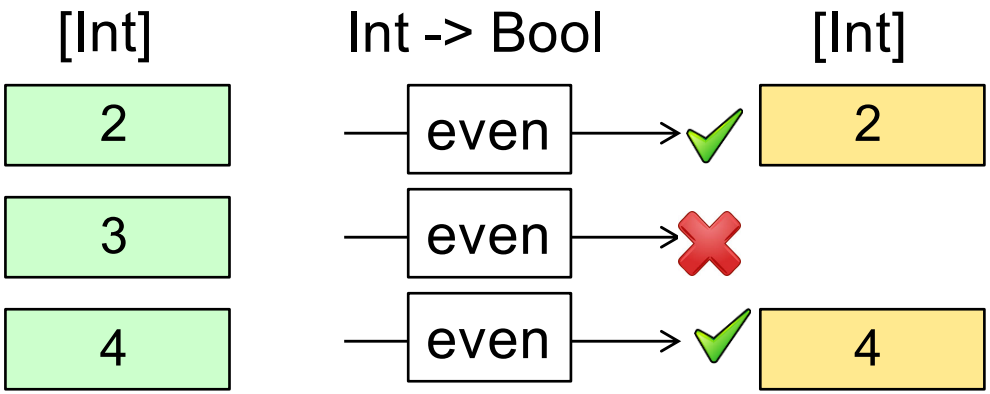
filter – Remove List Elements

- **Removes elements if they do not fulfill a condition**

```
filter :: (a -> Bool) -> [a] -> [a]
```

- **Illustration**

```
filter even [2, 3, 4] ~> [2,4]
```



- **Properties**
  - The type of the list does not change
  - The length of the list may change

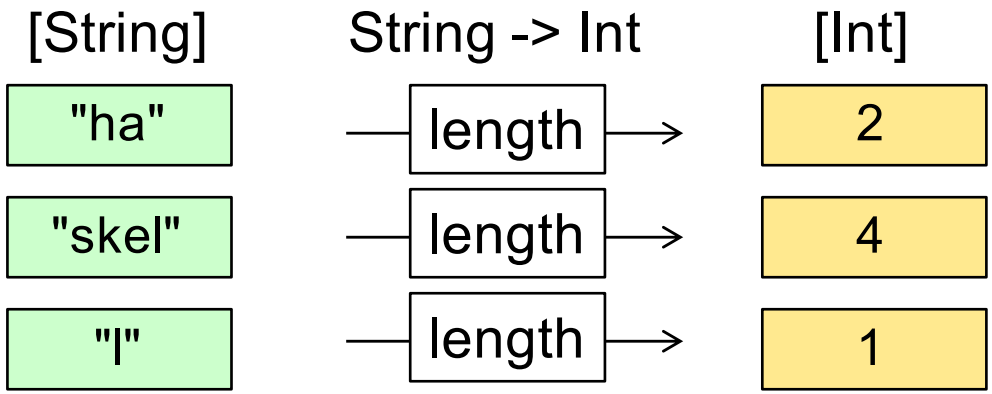
map – Transform List Elements

- **Transforms each element with the given function**

```
map :: (a -> b) -> [a] -> [b]
```

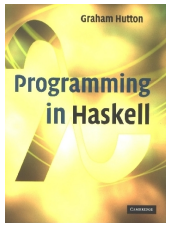
- **Illustration**

```
map length ["ha", "skel", "l" ] ~> [2,4,1]
```



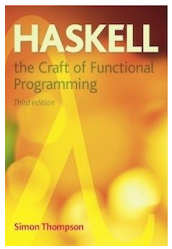
- **Properties**
  - The type of the list may change
  - The length of the list does not change

Further Reading



Chapter 2

Page 20



Chapter 5, 6

Pages 97 – 99, 109 – 111, 123 – 128

Chapter 1

Pages 7 – 12

http://www.haskell.org/haskellwiki/How_to_work_on_lists