Haskell Introduction

Mihai Maruseac

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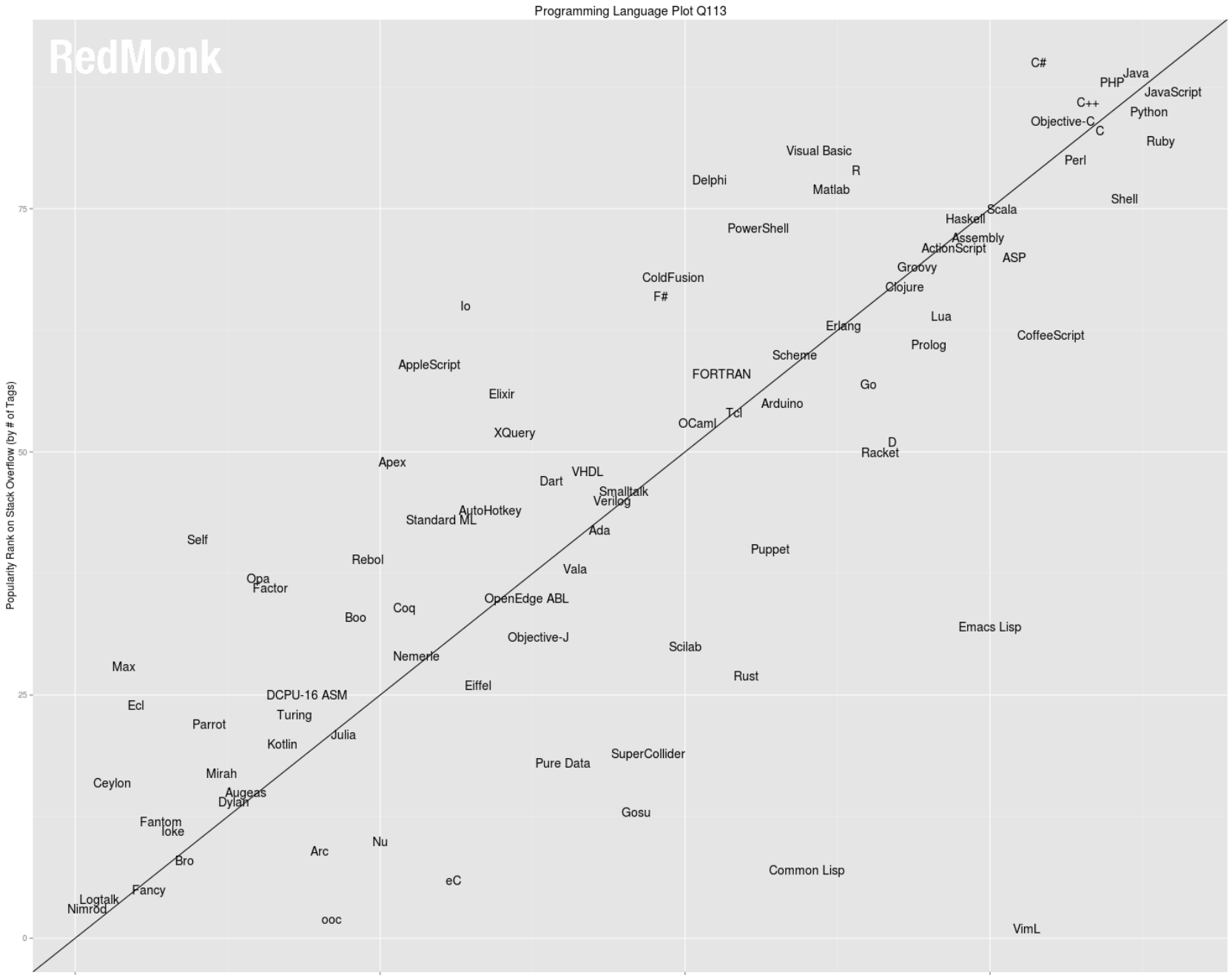
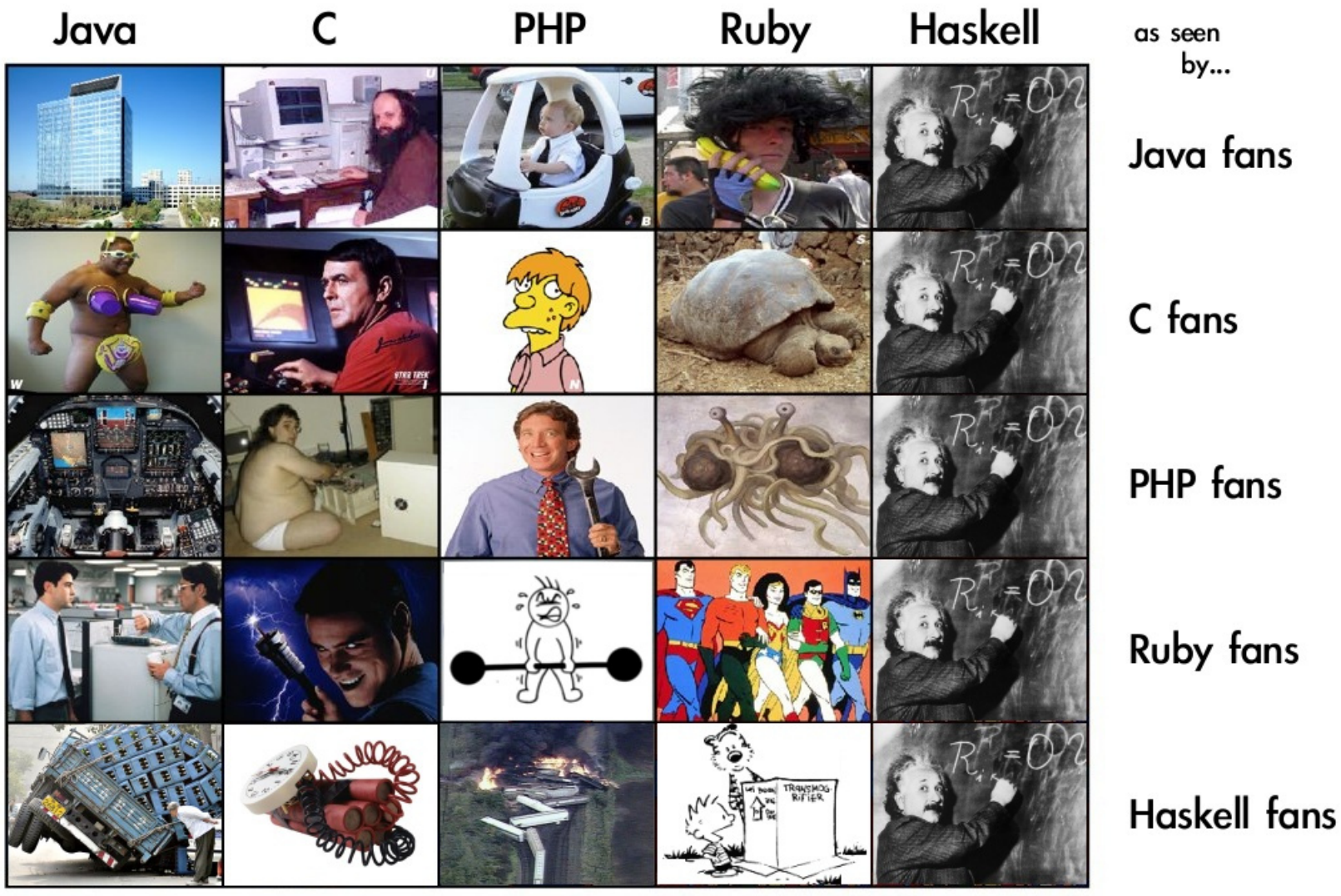
Layout

- 4 days of topics
  - moving from theoretical to practical
- 1 day of hackathon
  - you can propose your own subject

Language Popularity



Language Matrix



History

- 1930s, Alonzo Church, λ-calculus
- 1950s, John McCarthy, LISP
  - Scheme, Dylan, Scala, Racket
- 1960s, IPL, APL
- 1970s, FP, John Bachus
  - *Can Programming Be Liberated From the von Neumann Style? A Functional Style and its Algebra of Programs*
  - J
- 1970s, Robin Milner, ML
- 1970s, David Turner, Miranda
- 1990s, committee, Haskell
  - open standard for functional programming research

Haskell

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Users

- NASA
- Galois
- Jane Street
- Microsoft
- Facebook
- Google

Success Stories

- Perl6 interpreter
- Hermit Reasoner
- xmonad
- Pandoc
- detexify
- grammarly

Why

- declarative style

```
sort     [] = []
sort (x:xs) = lesser ++ x : greater
    where
        lesser  = sort [ a | a <- xs, a < x]
        greater = sort [ a | a <- xs, a >=x]
```

Why

- declarative style

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- correctness guarantee
  - if it compiles it should be right

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- lazy evaluation
- performance

Books

- Learn You A Haskell
- Real World Haskell
- and others

GHC

- *The Glorious Glasgow Haskell Compilation System, version 7.4.1*
- Haskell Platform (GHC, cabal, common libraries)
- ghc - compiler
  - ghc –make file.hs
- ghci - interpreter

ghci interpreter

- :load, :l, :reload
- :type
- :quit

Hands-On (1)

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- equality examples
- type errors examples
- calling functions (`not`, `min`)

Infix and Prefix Functions

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- functions made infix: `` `min` ``

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- operators - infix
- functions - prefix
- operators made prefix: `(+)`
- functions made infix: `` `min` ``
- sections: `(+ 3)`, `(3 -)`, `` (`min` 42) ``

Lists

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- constructors
- `[]`, `:`
- `[]` - the empty list
- `x:xs` - the list formed by appending an `x` to a list (of) `xs`
- all elements must have the same type

Functions (1)

- λ expressions

```
sum2 = \x y -> x + y
```

- explicit arguments

```
sum2' x y = x + y
```

- mixed style

```
sum2'' x = \y -> x + y
sum2''' = \x -> \y -> x + y
```

Functions (2)

- curry functions
- can call with fewer arguments
- returning function asking for more arguments

Functions (3)

- function composition

```
f x = 2 * x
g x = x + 4
h = f . g
```

- $ operator

```
f $ x = f x
```

```
(expression1) (expression2) === expression1 $ expression2
```

Functions (4)

- in Haskell, functions are *first order values*
  - list of functions
  - functions as arguments
  - functions as returned values

List Functions (1)

```
sum     []  = 0
sum (x:xs) = x + sum xs

sum     []  = 0
sum (x:xs) = (+) x (sum xs)

sum     []  = 0
sum (x:xs) = (+) x $ sum xs
```

List Functions (2)

```
product     []  = 1
product (x:xs)  = x * product xs

product     []  = 1
product (x:xs)  = ( * ) x $ product xs
```

List Functions (3)

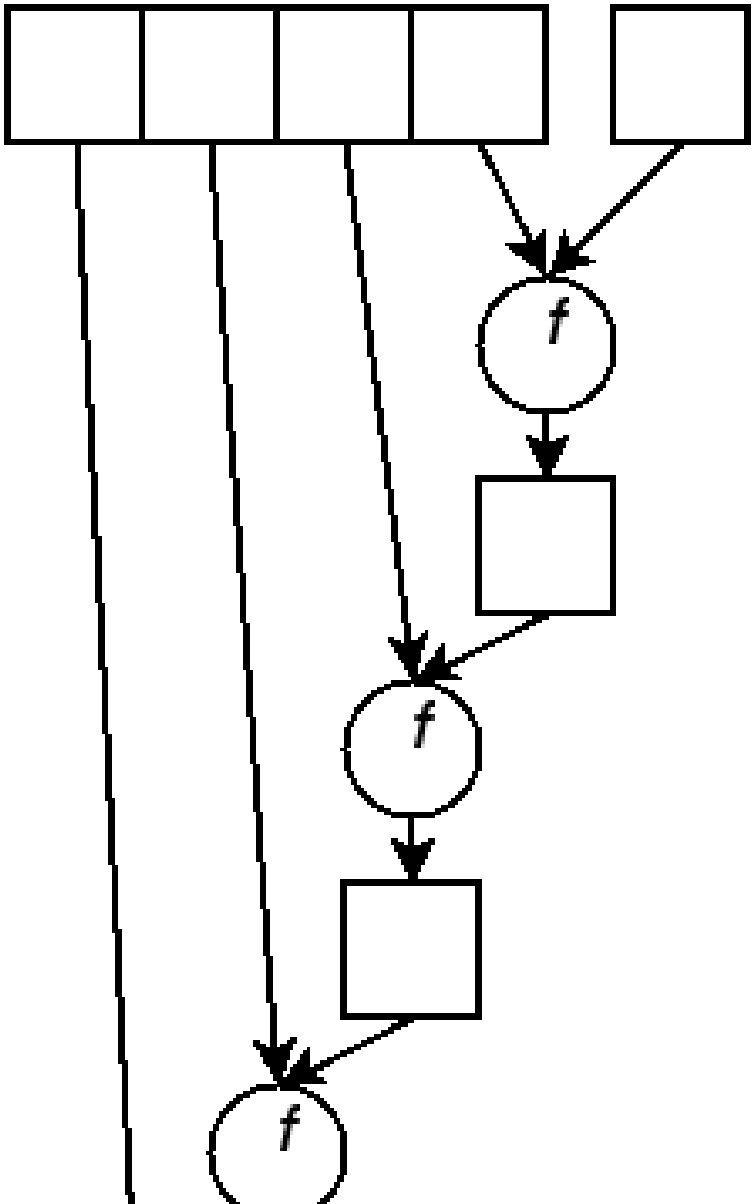
```
length     [] = 0
length (x:xs) = 1 + length xs

length     [] = 0
length (x:xs) = (+) 1 $ length xs
```

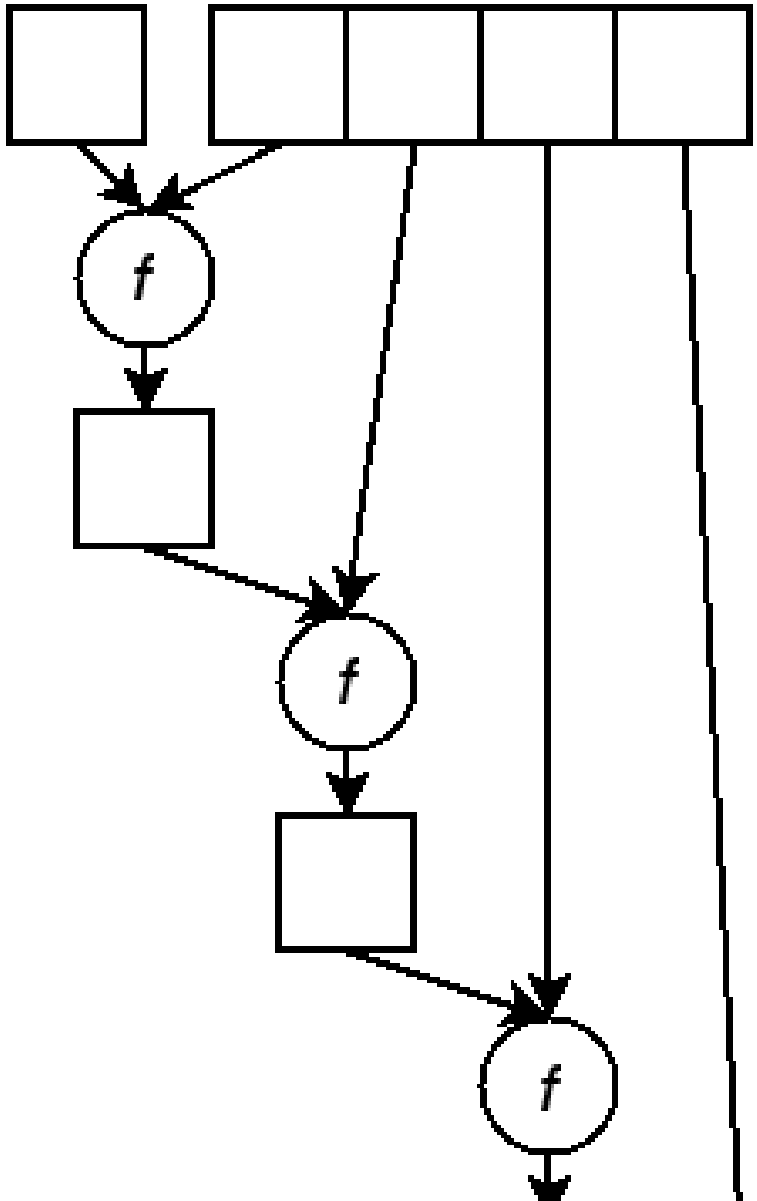
List Functions (4)

```
pattern     [] = initial_element
pattern (x:xs) = combining_function x $ pattern xs
```

List Functions (5)

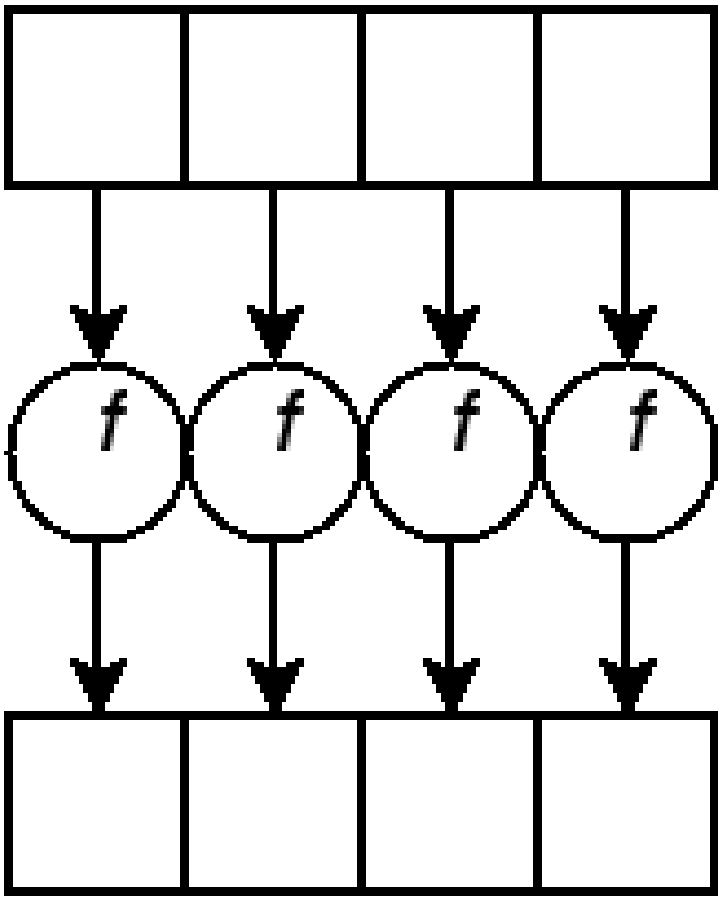
- `foldl`, `foldr`

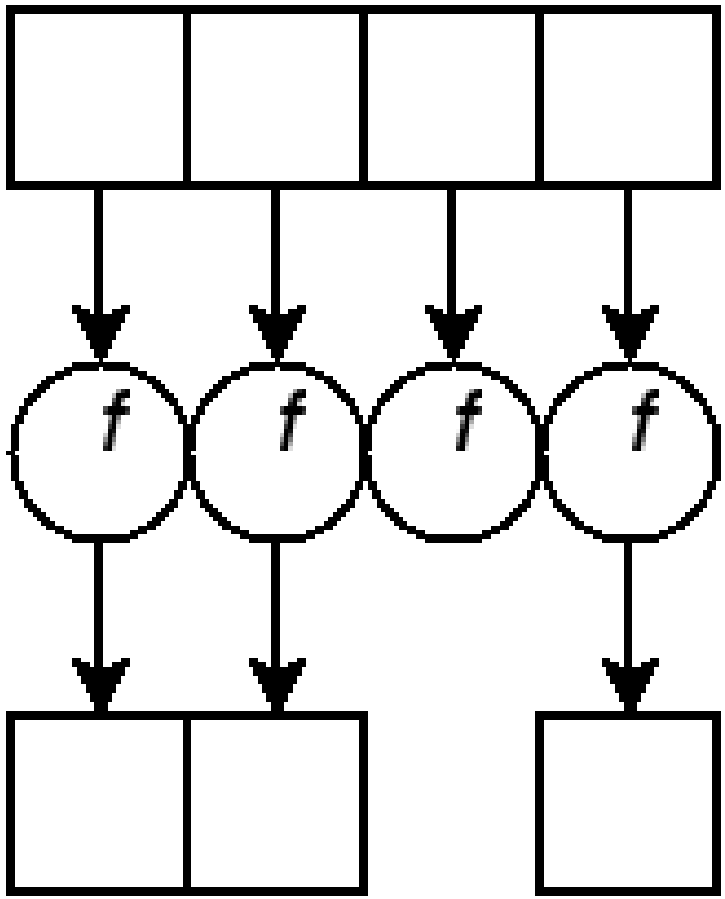




List Functions (6)

- `map`
- `filter`





List Functions (7)

- `take`
- `drop`
- `head`
- `tail`
- `takeWhile`
- `dropWhile`
- `zip`
- `unzip`

List Functions (8)

```
map (+ 1) [1, 2, 3, 4] === [2, 3, 4, 5]
filter (> 2) [1, 3, 1, 5, 2] === [3, 5]
foldl (+) 0 [1, 2, 3, 4, 5] === 15
take 5 $ map (+ 1) [1..] === [2, 3, 4, 5, 6]
takeWhile (< 10) $ map (2 * ) [1,3 .. 100] === [2, 6]
takeWhile (< 10) $ map (2 * ) $ [1,3 .. 100] === [2, 6]
takeWhile (< 10) . map (2 * ) $ [1,3 .. 100] === [2, 6]
```

Syntax in Functions (1)

```
factorial x = if x < 1 then 1 else x * factorial (x - 1)

factorial x = if x < 1
    then 1
    else x * factorial (x - 1)

factorial x =
    | x < 1 = 1
    | otherwise = x * factorial (x - 1)

factorial 1 = 1
factorial x = x * factorial (x - 1)
```

Syntax in Functions (2)

```
sum l = case l of
    [] -> 0
    (x:xs) -> x + sum xs

length l = case l of
    (_:xs) -> 1 + length xs
    _ -> 0
```

Local Bindings

```
f x = let double = 2 * x in double + 1

f x = double + 1
    where
        double = 2 * x
```

Printf Debugging

```haskell
import Debug.Trace

-- trace text value

f x = trace ("f called with " ++ show x) $ x + 1
```

Hands-On (2)

- square a list
- sum the odd numbers of a list (`odd`)
- find the first perfect palindrome
- ROT13 encryption (`Strings` are list of `Chars`, `ord`, `chr`)

Hands-On (3)

- square a list

```
square = map (^ 2)
```

- sum the odd numbers of a list

```
sumOdd = sum . filter odd
```

Hands-On (4)

- find the first perfect palindrome

```
isPerfect x = x == sumDiv x
  where
    sumDiv n = sum [ x | x <- [1..n `div` 2],
                         n `mod` x == 0]

isPalindrome x = x == (read . reverse . show $ x)

number = head $ filter both [1..]
  where
    both x = isPalindrome x && isPerfect x
```

Hands-On (5)

- ROT13 encryption

```
import Data.Char (ord, chr)

translate c = chr (newVal + ord 'a')
  where
    newVal = (oldVal + 13) `mod` 26
    oldVal = ord c - ord 'a'

rot13 msg = map translate msg
```