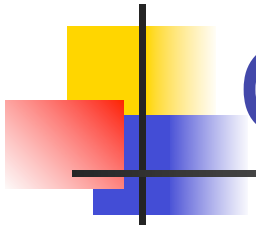
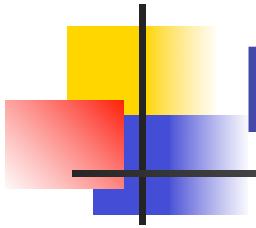


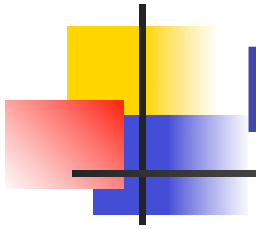
CS 11 Haskell track: lecture 6

- This week:
  - Modules
  - Arrays
  - More Monads
    - MonadPlus
  - Wrapping up



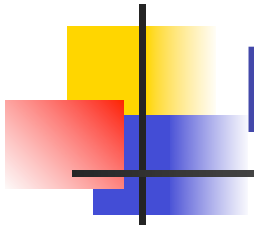
Modules

- Haskell modules much more conservative than ocaml's module system
- Much of the work of e.g. functors done by type classes
- Consequently, modules are rather simple



Module example

```
module Tree ( Tree (Leaf, Branch), fringe ) where

data Tree a = Leaf a | Branch (Tree a) (Tree a)

fringe :: Tree a -> [a]
fringe (Leaf x) = [x]
fringe (Branch left right) = fringe left ++ fringe right
```



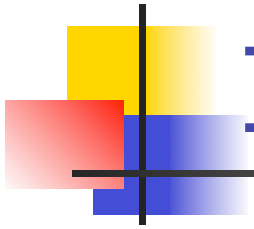
Module example

```
module Tree ( Tree(Leaf, Branch), fringe ) where
...
```

- This means that this module explicitly exports
  - the Tree datatype
  - the fringe function
  - nothing else
- If written as:

```
module Tree where ...
```

- then everything in module is exported



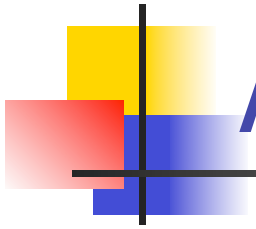
Importing into modules

```
module Main where
import Tree ( Tree(Leaf, Branch), fringe )
main = print (fringe (Branch (Leaf 1) (Leaf 2)))
```

- If the second line was just

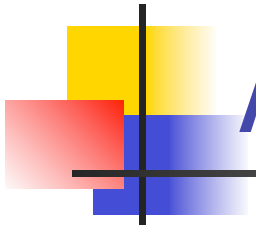
```
import Tree
```

- then everything exported from Tree module would be imported



Avoiding name clashes (1)

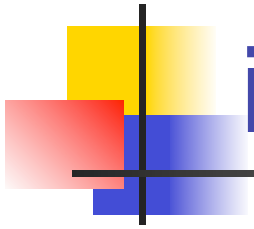
- By default, imported names dumped into local namespace
- What if two modules are used which share names?
- Can explicitly qualify names during import



Avoiding name clashes (2)

```
module Main where
  import Tree ( Tree(Leaf, Branch), fringe )
  import qualified Fringe ( fringe )
```

- Module Fringe contains a function fringe which has same name as Tree module's fringe function
- Qualifying means refer to second fringe as Fringe.fringe



import qualified ... as ...

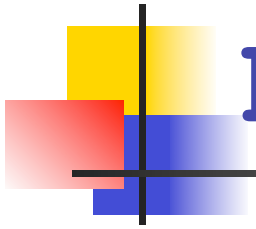
- Can rename the qualifier of a module by using the `as` syntax

```
import qualified VeryLongModuleName as V
```

- Watch out for this:

```
import Foobar as F
```

- Brings in all names from `Foobar` with and without qualification (why would you want this?)

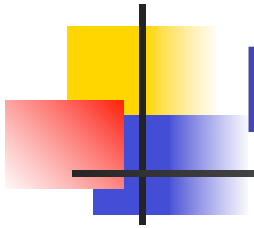


`hiding` declarations

- Can selectively hide some names upon import with a hiding declaration:

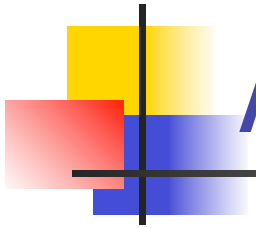
- Assume module A exports x and y

```
import A                 -- x and y imported
import A hiding y        -- x only
import qualified A hiding y -- A.x only
```



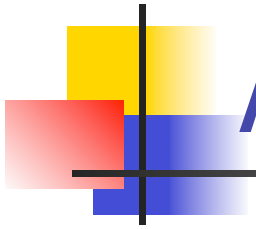
Modules and instances

- Instance declarations not explicitly imported/exported
  - modules export all instance declarations



Arrays

- Haskell arrays are functional
  - no in-place update in standard Arrays
  - though some mutable array types in ghc libraries (not covered here)
- Arrays require an `Ix` (indexing) type to represent indices (usually just `Int`)

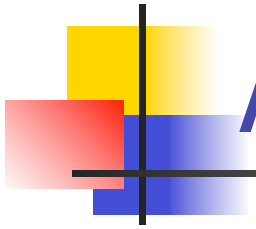


Array indices

```
class  (Ord a) => Ix a  where
        range     :: (a, a) -> [a]
        index     :: (a, a) -> a -> Int
        inRange   :: (a, a) -> a -> Bool
```

```
range (0,4) => [0,1,2,3,4]
```

```
range ((0,0), (1,2)) =>
  [(0,0), (0,1), (0,2), (1,0), (1,1), (1,2)]
```

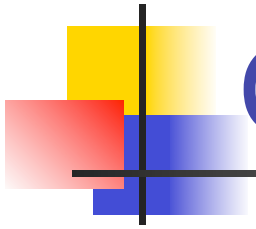


Array indices

```
class  (Ord a) => Ix a  where
        range      :: (a, a) -> [a]
        index      :: (a, a) -> a -> Int
        inRange    :: (a, a) -> a -> Bool
```

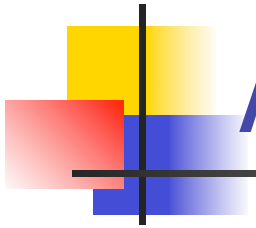
index (1,9) 2 => 1

index ((0,0), (1,2)) (1,1) => 4



Creating arrays

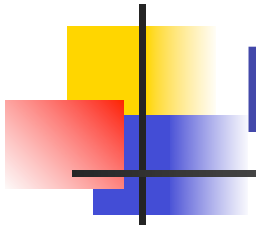
```
array :: (Ix a) => (a,a) -> [(a,b)] -> Array a b

squares = array (1,100) [(i, i*i) | i <- [1..100]]
```



Accessing array elements

squares ! 8 => 64

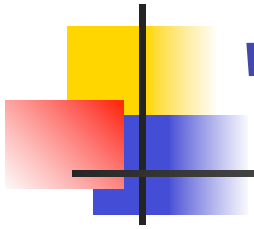
bounds squares => (1,100)



Example

```
fibs :: Int -> Array Int Int
fibs n  = a
    where a =
        array (0, n)
              ([(0, 1), (1, 1)] ++
               [(i, a!(i-2) + a!(i-1)) | i <- [2..n]])
```

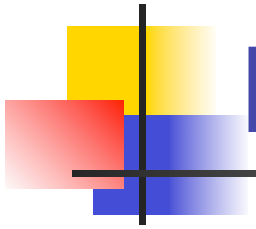
- Q: why do we need the where clause?



"Modifying" array elements

```
(//) :: (Ix a) => Array a b -> [(a,b)] -> Array a b

squares_bad = squares // [(8, 63)]
squares_bad ! 8 => 63
```

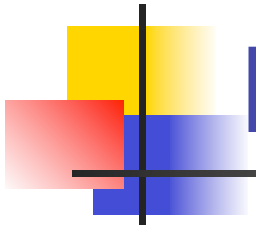
- Creates a new array, not modifying in place
- Other ways to actually modify in place
  - but need to be in e.g. `IO` monad



MonadPlus

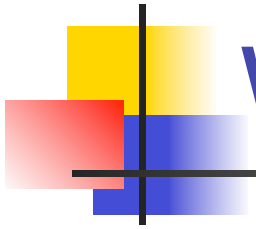
- Many Monads have a notion of
  - a "zero" element
  - some kind of "addition" of monadic objects
- This is captured in the MonadPlus class

```
class  Monad m => MonadPlus m  where
       mzero  :: m a
       mplus  :: m a -> m a -> m a
```



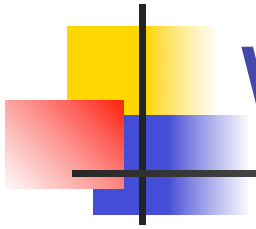
MonadPlus instances

```
instance  MonadPlus Maybe  where
   mzero                       = Nothing
   Nothing `mplus` ys          = ys
   xs      `mplus` ys          = xs

instance  MonadPlus []  where
   mzero = []
   mplus = (++)
```



Where to now? (1)

- Lots of information on the web
- `www.haskell.org`
- `www.haskell.org/ghc`
- Haskell mailing lists:
  - `www.haskell.org/haskellwiki/Mailing_Lists`
  - `haskell` mailing list
  - `haskell-cafe` mailing list



Where to now? (2)

- Lots of interesting paper collections
- I particularly recommend Phil Wadler's papers:
- `http://homepages.inf.ed.ac.uk/wadler/`
- Good examples:
  - "Imperative Functional Programming"
  - "Monads for Functional Programming"
  - "Comprehending monads"