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# III. Funktionale Programmierung

- 1. Prinzipien der funktionalen Programmierung
- 2. Deklarationen
- 3. Ausdrücke
- 4. Muster (Patterns)
- 5. Typen und Datenstrukturen
- 6. Funktionale Programmieretechniken: Funktionen höherer Ordnung

# Funktionen höherer Ordnung: comp

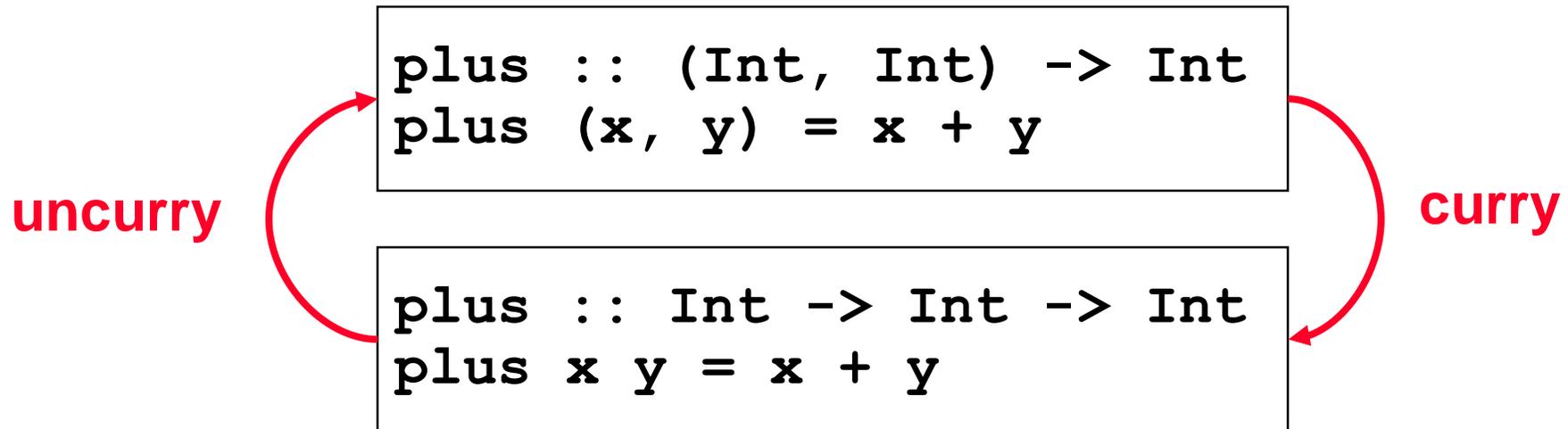
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$$\text{comp} :: (b \rightarrow c) \rightarrow (a \rightarrow b) \rightarrow (a \rightarrow c)$$
$$\text{comp } f \ g = \lambda x \rightarrow f (g \ x)$$

Argument vom Typ:  $(b \rightarrow c)$

Ergebnis vom Typ:  $(a \rightarrow b) \rightarrow (a \rightarrow c)$

# Funktionen höherer Ordnung: curry



```
curry :: ((a,b) -> c) -> a -> b -> c
curry f = g
      where g x y = f (x,y)
```

```
uncurry :: (a -> b -> c) -> (a,b) -> c
uncurry g = f
      where f (x,y) = g x y
```

# Funktionen höherer Ordnung: map

```
suclist :: [Int] -> [Int]
suclist [] = []
suclist (x:xs) = suc x : suclist xs
```

```
sqrtlist :: [Float] -> [Float]
sqrtlist [] = []
sqrtlist (x:xs) = sqrt x : sqrtlist xs
```

```
suclist [x1, ..., xn] = [suc x1, ..., suc xn]
sqrtlist [x1, ..., xn] = [sqrt x1, ..., sqrt xn]
map g [x1, ..., xn] = [g x1, ..., g xn]
```

```
f :: [a] -> [b]
f [] = []
f (x:xs) = g x : f xs
```

```
map :: (a -> b) -> [a] -> [b]
map g [] = []
map g (x:xs) = g x : map g xs
```

# Funktionen höherer Ordnung: map

```
suclist :: [Int] -> [Int]
suclist = map suc
```

```
sqrtnlist :: [Float] -> [Float]
sqrtnlist = map sqrt
```

```
suclist [x1, ..., xn] = [suc x1, ..., suc xn]
sqrtnlist [x1, ..., xn] = [sqrt x1, ..., sqrt xn]
map g [x1, ..., xn] = [g x1, ..., g xn]
```

```
f :: [a] -> [b]
f [] = []
f (x:xs) = g x : f xs
```

```
map :: (a -> b) -> [a] -> [b]
map g [] = []
map g (x:xs) = g x : map g xs
```

# Funktionen höherer Ordnung: filter

```
dropEven :: [ Int ] -> [ Int ]
dropEven [] = []
dropEven (x:xs) | odd x = x : dropEven xs
                | otherwise = dropEven xs
```

```
dropUpper :: [ Char ] -> [ Char ]
dropUpper [] = []
dropUpper (x:xs) | isLower x = x : dropUpper xs
                 | otherwise = dropUpper xs
```

```
f :: [ a ] -> [ a ]
f [] = []
f (x:xs) | g x = x : f xs
         | otherwise = f xs
```

vordefiniert im Modul  
Data.Char:

```
import Data.Char
```

```
filter :: (a -> Bool) -> [a] -> [a]
filter g [] = []
filter g (x:xs) | g x = x : filter g xs
                | otherwise = filter g xs
```

# Funktionen höherer Ordnung: filter

```
dropEven :: [ Int ] -> [ Int ]  
dropEven = filter odd
```

```
dropUpper :: [ Char ] -> [ Char ]  
dropUpper = filter isLower
```

```
f :: [ a ] -> [ a ]  
f [] = []  
f (x:xs) | g x = x : f xs  
          | otherwise = f xs
```

```
filter :: (a -> Bool) -> [a] -> [a]  
filter g [] = []  
filter g (x:xs) | g x = x : filter g xs  
                | otherwise = filter g xs
```

---

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# Unendliche Datenobjekte

```
from :: Int -> [Int]
from x = x : from (x+1)
```

```
take :: Int -> [a] -> [a]
take 0 _ = []
take n (x:xs) = x : take (n-1) xs
```

```
take 1 (from 5)
= take 1 (5 : from (5+1))
= 5 : take (1-1) (from (5+1))
= 5 : take 0 (from (5+1))
= 5 : []
```

Ergebnis: [5]

# Sieb des Eratosthenes

1. Erstelle Liste aller natürlichen Zahlen ab 2. *← from 2*
2. Markiere die erste unmarkierte Zahl in der Liste.
3. Streiche alle Vielfachen der letzten markierten Zahl.
4. Gehe zurück zu Schritt 2.

*löscht alle Vielfachen von x aus der Liste xs*

*Fkt von Int  $\rightarrow$  Bool, die y genau dann auf True abbildet, wenn y kein Vielfaches von x ist*

```
drop_mult :: Int -> [Int] -> [Int]  
drop_mult x xs = filter (\y -> mod y x /= 0) xs
```

```
dropall :: [Int] -> [Int]  
dropall (x:xs) = x : dropall (drop_mult x xs)
```

*löscht erst alle Vielfachen des 1. Elements ruft sich dann auf entstehender Liste ohne ihr 1. Element rekursiv auf*

```
primes :: [Int]  
primes = dropall (from 2)
```

# Sieb des Eratosthenes

---

```
primes = [2,3,5,7,11,13,17,19,23,29,31,...
```

```
take 5 primes = [2,3,5,7,11]
```

```
drop_mult :: Int -> [Int] -> [Int]
drop_mult x xs = filter (\y -> mod y x /= 0) xs
```

```
dropall :: [Int] -> [Int]
dropall (x:xs) = x : dropall (drop_mult x xs)
```

```
primes :: [Int]
primes = dropall (from 2)
```