Another way to use a map
at the School of Geography

Nicolas Payette

SCHOOL OF GEOGRAPHY
AND THE ENVIRONMENT

UNIVERSITY OF
OXFORD

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Overview

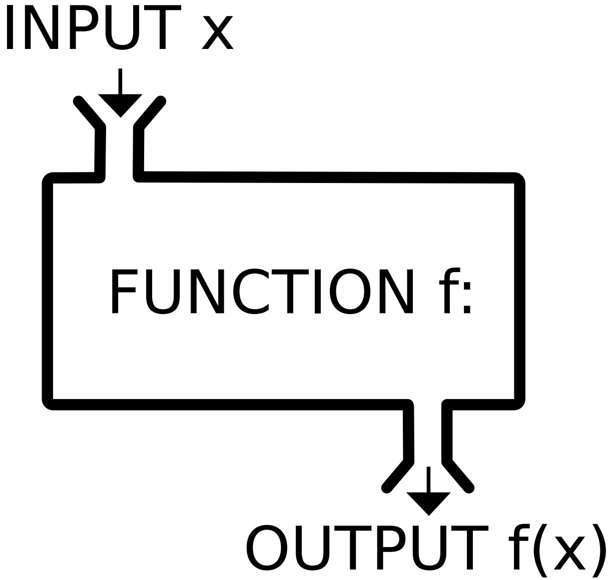
A word about functions

Mapping over a collection

A tiny practical example

Mapping over two collections

A word about functions



INPUT x

FUNCTION f:

OUTPUT f(x)

https://en.wikipedia.org/wiki/Function_(mathematics)

A **higher-order function**:

- takes one or more functions as inputs
- and/or outputs a function.

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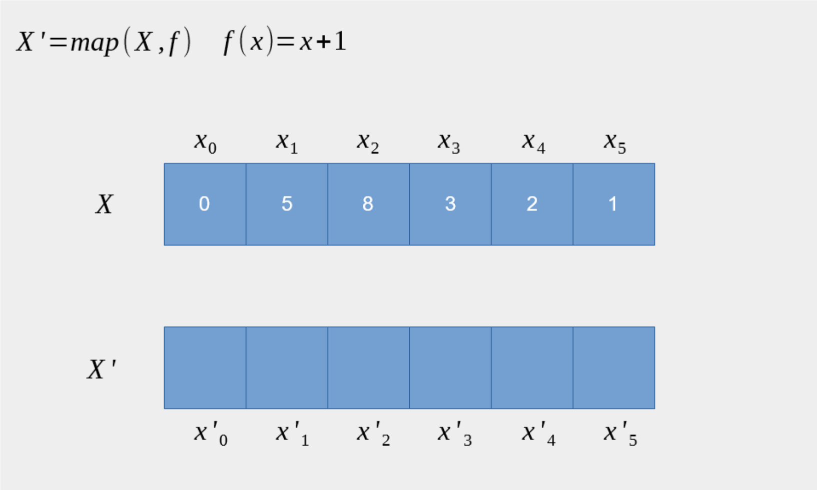
- takes one or more functions as inputs
- and/or outputs a function.

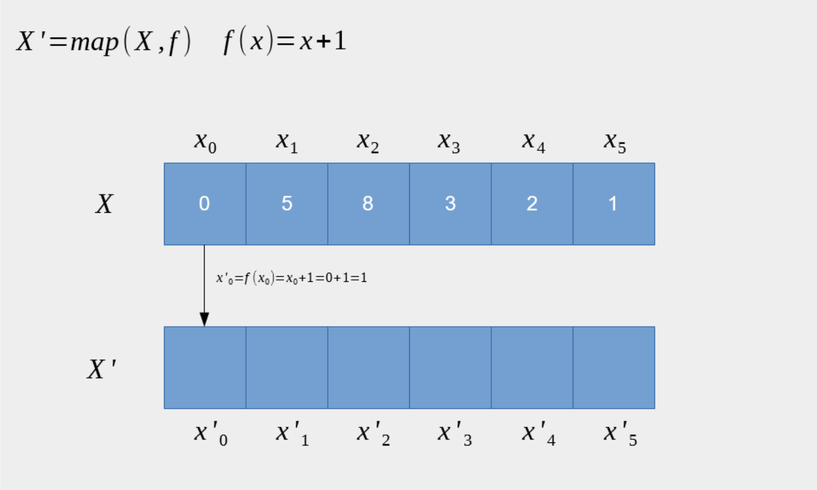
`map` is a higher-order function that:

- takes a function and a collection of things as inputs
- and outputs another collection of things.

Mapping over a collection



https://en.wikipedia.org/wiki/Map_(higher-order_function)



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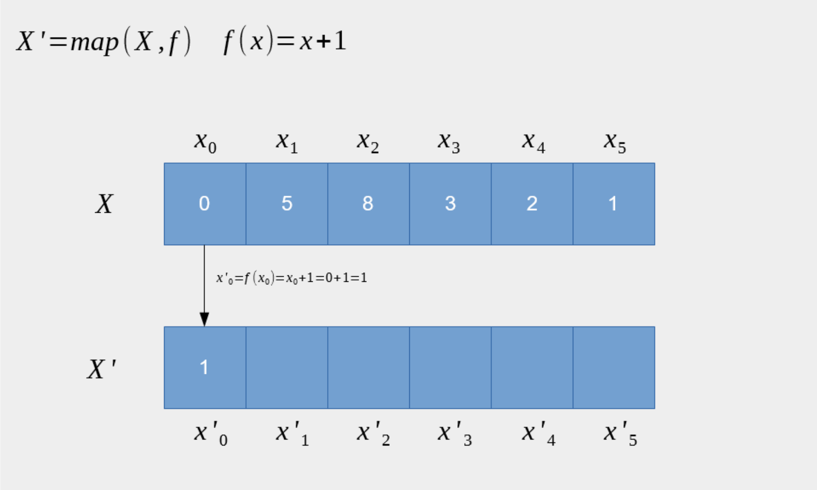

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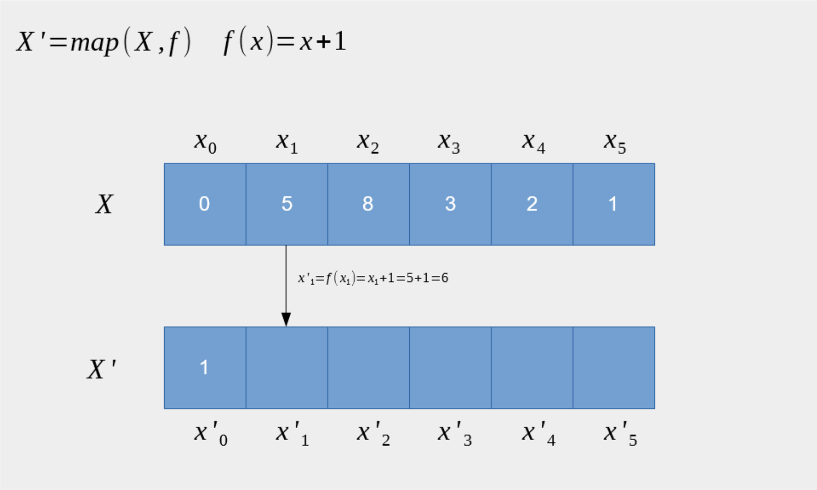
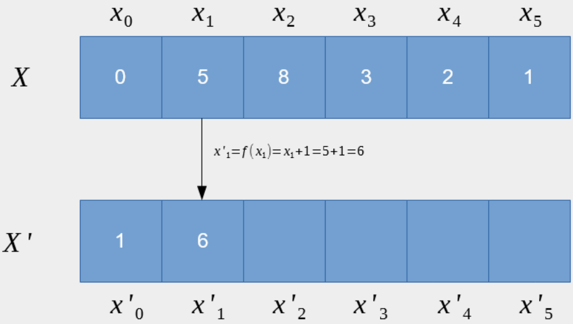


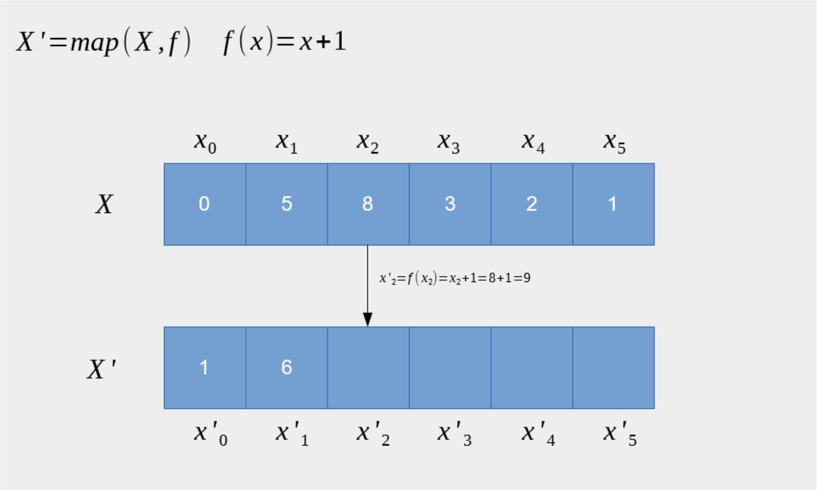
$X' = map(X, f) \quad f(x) = x + 1$
x_0 x_1 x_2 x_3 x_4 x_5
X
0 5 8 3 2 1
$x'_1 = f(x_1) = x_1 + 1 = 5 + 1 = 6$
X'
1
x'_0 x'_1 x'_2 x'_3 x'_4 x'_5

https://en.wikipedia.org/wiki/Map_(higher-order_function)

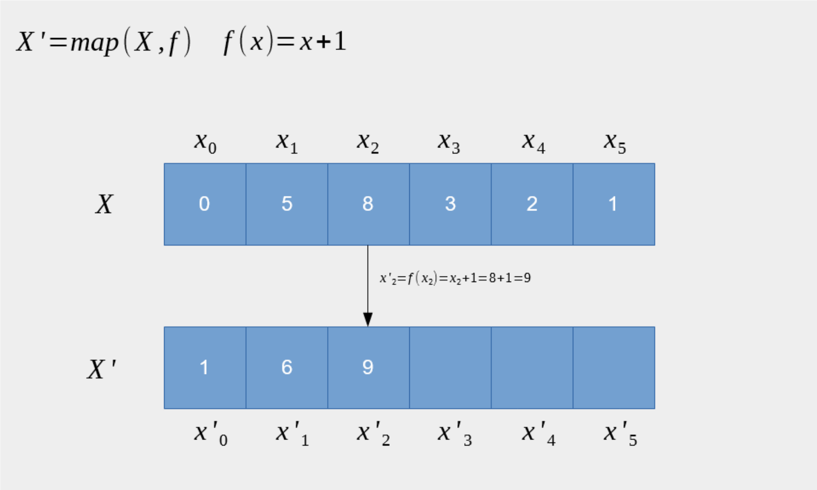
$$X' = map(X, f) \quad f(x) = x + 1$$


x_0 x_1 x_2 x_3 x_4 x_5
X
0 5 8 3 2 1
$x'_1 = f(x_1) = x_1 + 1 = 5 + 1 = 6$
X'
1 6
x'_0 x'_1 x'_2 x'_3 x'_4 x'_5

https://en.wikipedia.org/wiki/Map_(higher-order_function)


$X' = map(X, f) \quad f(x) = x + 1$
x_0 x_1 x_2 x_3 x_4 x_5
X
0 5 8 3 2 1
$x'_2 = f(x_2) = x_2 + 1 = 8 + 1 = 9$
X'
1 6
x'_0 x'_1 x'_2 x'_3 x'_4 x'_5

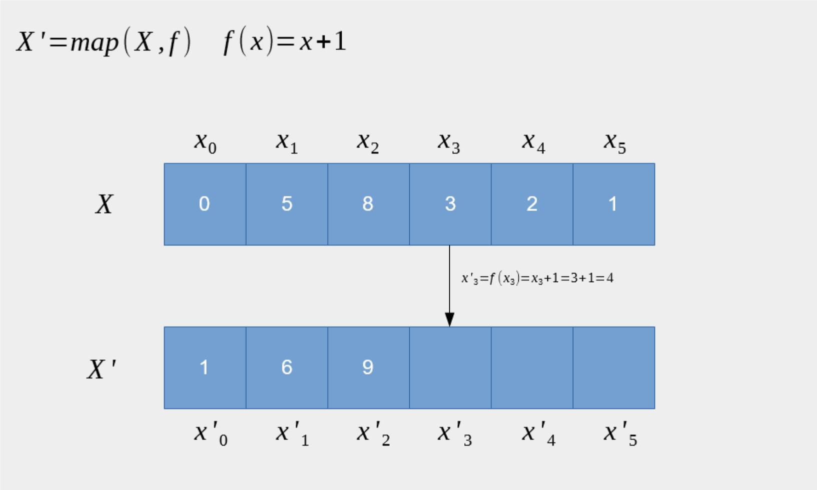
https://en.wikipedia.org/wiki/Map_(higher-order_function)



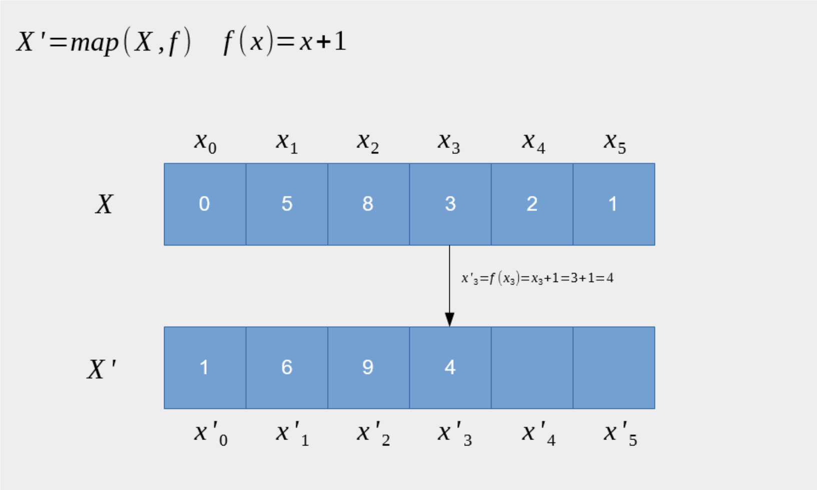
$X' = map(X, f) \quad f(x) = x + 1$

x_0 x_1 x_2 x_3 x_4 x_5
X
0 5 8 3 2 1
$x'_2 = f(x_2) = x_2 + 1 = 8 + 1 = 9$
X'
1 6 9
x'_0 x'_1 x'_2 x'_3 x'_4 x'_5

https://en.wikipedia.org/wiki/Map_(higher-order_function)


$X' = map(X, f) \quad f(x) = x + 1$
x_0 x_1 x_2 x_3 x_4 x_5
X
0 5 8 3 2 1
$x'_3 = f(x_3) = x_3 + 1 = 3 + 1 = 4$
X'
1 6 9
x'_0 x'_1 x'_2 x'_3 x'_4 x'_5

https://en.wikipedia.org/wiki/Map_(higher-order_function)

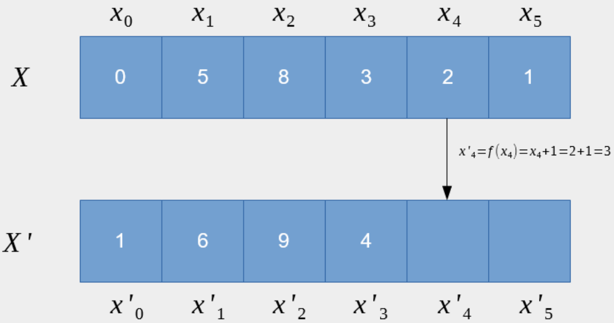


$X' = map(X, f) \quad f(x) = x + 1$

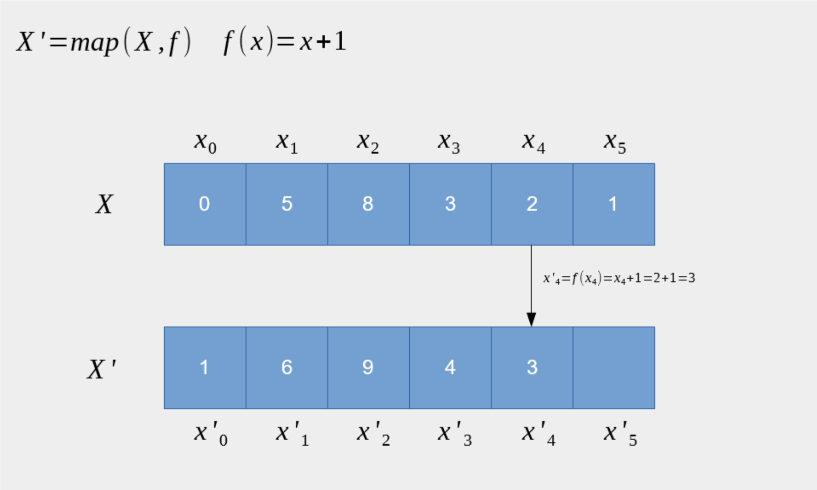
	x_0	x_1	x_2	x_3	x_4	x_5
X	0	5	8	3	2	1
X'	1	6	9	4		
	x'_0	x'_1	x'_2	x'_3	x'_4	x'_5

https://en.wikipedia.org/wiki/Map_(higher-order_function)

$$X' = map(X, f) \quad f(x) = x + 1$$

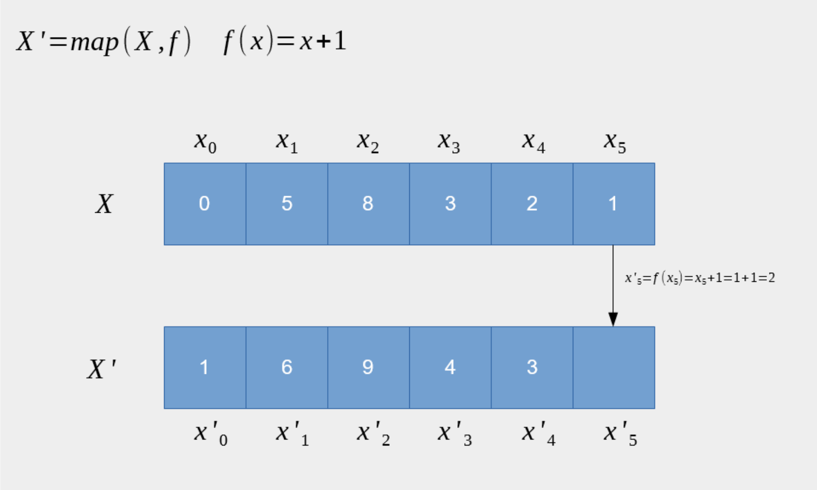

x_0 x_1 x_2 x_3 x_4 x_5
X
0 5 8 3 2 1
$x'_4 = f(x_4) = x_4 + 1 = 2 + 1 = 3$
X'
1 6 9 4
x'_0 x'_1 x'_2 x'_3 x'_4 x'_5

https://en.wikipedia.org/wiki/Map_(higher-order_function)



	x_0	x_1	x_2	x_3	x_4	x_5
X	0	5	8	3	2	1
X'	1	6	9	4	3	
	x'_0	x'_1	x'_2	x'_3	x'_4	x'_5

https://en.wikipedia.org/wiki/Map_(higher-order_function)



$$X' = map(X, f) \quad f(x) = x + 1$$

	x_0	x_1	x_2	x_3	x_4	x_5
X	0	5	8	3	2	1
X'	1	6	9	4	3	
	x'_0	x'_1	x'_2	x'_3	x'_4	x'_5

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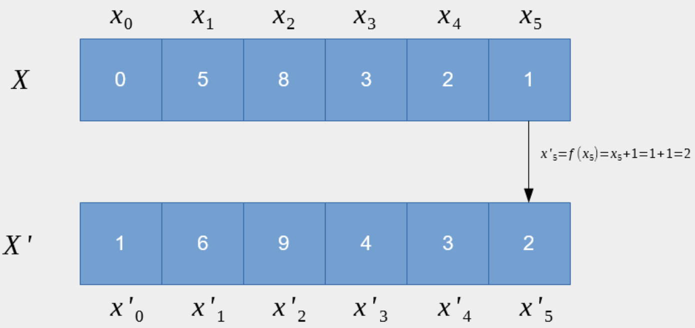
$$X' = map(X, f) \qquad f(x) = x + 1$$

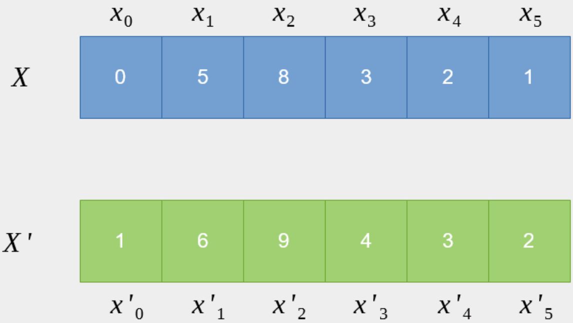


	x_0	x_1	x_2	x_3	x_4	x_5
X	0	5	8	3	2	1
X'	1	6	9	4	3	2
	x'_0	x'_1	x'_2	x'_3	x'_4	x'_5

$x'_5 = f(x_5) = x_5 + 1 = 1 + 1 = 2$

https://en.wikipedia.org/wiki/Map_(higher-order_function)

$$X' = map(X, f) \quad f(x) = x + 1$$



	x_0	x_1	x_2	x_3	x_4	x_5
X	0	5	8	3	2	1
X'	1	6	9	4	3	2
	x'_0	x'_1	x'_2	x'_3	x'_4	x'_5

https://en.wikipedia.org/wiki/Map_(higher-order_function)

Python

```python
def f(x):
    return x + 1
xs = [0, 5, 8, 3, 2, 1]

# For loop version
result = []
for x in xs:
    result.append(f(x))
print(result)

# List comprehension version
print([f(x) for x in xs])

# Map version
print(list(map(f, xs)))
```

Julia

```julia
f(x) = x + 1
xs = [0, 5, 8, 3, 2, 1]

# For loop version:
result = []
for x = xs
  push!(result, f(x))
end
println(result)

# List comprehension version:
[f(x) for x = xs] |> println

# Map version:
map(f, xs) |> println

# Broadcast version:
f.(xs) |> println
```

R

```r
f <- function(x) { x + 1 }
xs <- c(0, 5, 8, 3, 2, 1)

# For loop version
result <- c()
for (x in xs) {
  result <- c(result, f(x))
}
print(result)

# Base version, using sapply
print(sapply(xs, f))

# Using purrr::map
library(purrr)
xs %>% map_dbl(f) %>% print
```

NetLogo

```
to-report f [ x ]
  report x + 1
end

to demo-map

  let xs [0 5 8 3 2 1]

  ; for loop version:
  let result []
  foreach xs [ x -> set result lput f x result ]
  print result

  ; map version:
  print map f xs

  ; bonus `of` version
  create-turtles 10
  print [ f who ] of turtles

end
```

Agentsets		Lists
`of`	⟷	`map`
`with`	⟷	`filter`
`ask`	⟷	`foreach`

Java

```java
import java.util.Arrays;
import java.util.ArrayList;
import java.util.List;
import java.util.function.Function;
import java.util.stream.Collectors;

class DemoMap {
  public static void main(String[] args) {

    List<Integer> xs = Arrays.asList(0, 5, 8, 3, 2, 1);
    Function<Integer, Integer> f = x -> x + 1;

    // Using a for loop:
    List<Integer> result = new ArrayList<>();
    for (Integer x: xs) { result.add(f.apply(x)); }
    System.out.println(result);

    // Using map:
    System.out.println(
        xs.stream().map(f).collect(Collectors.toList()));
  }
}
```

Scala

```scala
import collection.mutable.ListBuffer

val xs = List(0, 5, 8, 3, 2, 1)
val f = (x: Int) => x + 1

// Using a for loop:
val result = new ListBuffer[Int]()
for (x <- xs) result += f(x)
println(result)

// Using map:
println(xs.map(f))

// Using for/yield
println(for (x <- xs) yield f(x))
```

A tiny practical example

Read all CSV files in a folder

R:

```r
library(tidyverse)
list.files(pattern = "*.csv$") %>% map(read_csv) %>% bind_rows()
```

Julia:

```julia
using DataFrames, CSV
vcat([CSV.read(f) for f = readdir() if endswith(f, ".csv")]...)
```

Mapping over two collections

Python

```python
xs = [0, 5, 8, 3, 2, 1]
ys = [9, 4, 1, 6, 7, 8]

# For loop version
result = []
for x, y in zip(xs, ys):
    result.append(x + y)
print(result)

# List comprehension version
print([x + y for x, y in zip(xs, ys)])

# Map version
import operator
print(list(map(operator.add, xs, ys)))
```

Julia

```julia
xs = [0, 5, 8, 3, 2, 1]
ys = [9, 4, 1, 6, 7, 8]

# For loop version:
result = []
for (x, y) = zip(xs, ys)
  push!(result, x + y)
end
println(result)

# List comprehension version:
[x + y for (x, y) = zip(xs, ys)] |> println

# Map version:
map(+, xs, ys) |> println

# Broadcast version:
xs .+ ys |> println
```

R

```r
xs <- c(0, 5, 8, 3, 2, 1)
ys <- c(9, 4, 1, 6, 7, 8)

# For loop version
result <- c()
for (i in seq_along(xs)) {
  result <- c(result, xs[i] + ys[i])
}
print(result)

# Base version, using mapply
print(mapply(`+`, xs, ys))

# Using purrr::map
library(purrr)
xs %>% map2_dbl(ys, `+`) %>% print

# Using dplyr:
library(dplyr)
tibble(x = xs, y = ys) %>% transmute(x + y) %>% .[[1]]
```

NetLogo

```
to demo-map2

  let xs [0 5 8 3 2 1]
  let ys [9 4 1 6 7 8]

  ; for loop version:
  let result []
  foreach range length xs [ i ->
    set result lput (item i xs + item i ys) result
  ]
  print result

  ; map version:
  print (map + xs ys)

end
```

Java

```java
import java.util.Arrays;
import java.util.ArrayList;
import java.util.List;
import java.util.stream.Collectors;
import java.util.stream.IntStream;

class DemoMap {
  public static void main(String[] args) {

    List<Integer> xs = Arrays.asList(0, 5, 8, 3, 2, 1);
    List<Integer> ys = Arrays.asList(9, 4, 1, 6, 7, 8);

    // Using a for loop:
    List<Integer> result = new ArrayList<>();
    for (int i = 0; i < xs.size(); i++) {
      result.add(xs.get(i) + ys.get(i));
    }
    System.out.println(result);

    // Using map:
    System.out.println(IntStream.range(0, xs.size())
      .mapToObj(i -> xs.get(i) + ys.get(i))
      .collect(Collectors.toList()));
  }
}
```

Scala

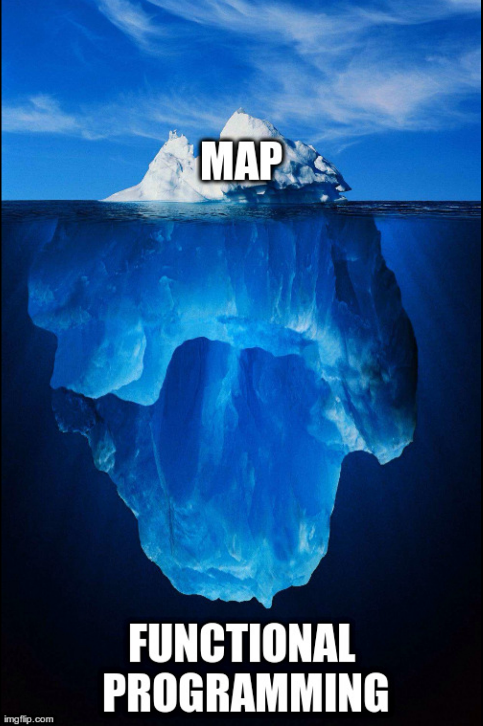
```scala
import collection.mutable.ListBuffer

val xs = List(0, 5, 8, 3, 2, 1)
val ys = List(9, 4, 1, 6, 7, 8)

// Using a for loop:
val result = new ListBuffer[Int]()
for ((x, y) <- xs.zip(ys)) result += x + y
println(result)

// Using map:
println(xs.zip(ys).map { case (x, y) => x + y })

// Using for/yield
println(for ((x, y) <- xs.zip(ys)) yield x + y)
```


MAP
FUNCTIONAL PROGRAMMING
imgflip.com