To Ponder

Evaluate the ?'s

```
x = Array.new 3, 5 #=> [5, 5, 5]
x[0] += 1
x #=> ???

y = Array.new 3, [] #=> [[],[],[]]
y[0] << 'hi' # adds elt to array
y #=> ???
```

Ruby:
Useful Classes and Methods

Lecture 5

Ranges

- Instance of class (Range)

```
indices = Range.new(0, 5)
```

- But literal syntax is more common

```
nums = 1..10        # end inclusive
b = 'cab'...'cat'   # end exclusive
```

- Method `to_a` converts a range to an array

```
nums.to_a    #=> [1,2,3,4,5,6,7,8,9,10]
(0..5).to_a  #=> [0,1,2,3,4,5]
(5..0).to_a  #=> []
```

- Methods `begin`/`end`, `first`/`last`

```
b.last    #=> "cat", excluded from range!
b.last 2  #=> ["car", "cas"]
```

Range Inclusion

- Operator **===** (aka "case equality")

```
nums === 6 #=> true
b === 'cat' #=> false
```

- Two methods: **include? cover?**
  - **include?** (usually) iterates through range, looking for (object value) equality
  - **cover?** compares to end points
- Case statement (**case**/**when**) with ranges

```
case target
when 0...mid
  puts 'first half'
when mid...size
  puts 'second half'
end
```

Strings

- A rich class: 100+ methods!
  - See www.ruby-doc.org
- Note convention on method names
  - `?` suffix: polar result (*e.g.*, boolean)
  - `!` suffix: dangerous (*e.g.*, changes receiver)
- Examples
  - `empty? start_with? include? length`
  - `to_f, to_i, split  # convert string to…`
  - `upcase downcase capitalize  # +/- !`
  - `clear replace  # no ! (!!)`
  - `chomp chop slice  # +/- !`
  - `sub gsub  # +/- !`

Examples


```
s = 'hello world'
s.start_with? 'hi' #=> false
s.length #=> 11
'3.14'.to_f #=> 3.14
s.upcase #=> "HELLO WORLD", s unchanged
s.capitalize! #=> s is now "Hello world"
s.split #=> ["Hello", "world"]
s.split 'o' #=> ["Hell", " w", "rld"]
s.replace 'good bye' #=> s is "good bye"
s.slice 3, 4 #=> "d by" (start, length)
s[-2, 1] #=> "y" [start, length]
s.chomp! #=> remove trailing \n if there
```

Arrays

- Instance of class (Array)

```
a = Array.new 4 #=> [nil, nil, nil, nil]
a = Array.new 4, 0 #=> [0, 0, 0, 0]
```

- But literal notation is common

```
b = [6, 2, 3.14, 'pi', []]
t = %w{hi world} #=> ["hi", "world"]
```

- Methods for element access, modification

```
b.length   #=> 5
b[0]       #=> 6 (also b.first, b.last)
b[-2]      #=> "pi"
b[10] = 4  # assignment past end of array
b.length   #=> 11, size has changed!
b[2, 5]    #=> [3.14, "pi", [], nil, nil]
```

Mutators: Growing/Shrinking

- Add/remove from end: **push/pop** (<<)

```
n = [10, 20]
n.push 30, 40 #=> [10, 20, 30, 40]
n.pop         #=> 40, n now [10, 20, 30]
n << 50       #=> [10, 20, 30, 50]
```

- Add/remove from beginning: **unshift/shift**

```
n = [10, 20]
n.unshift 30, 40 #=> [30, 40, 10, 20]
n.shift          #=> 30
```

- Push/shift gives FIFO queue
- All modify the receiver (but no !)

Concatenation and Difference

- Concatenation: **+/concat**

```
n = [1]
n.concat [3, 4]     #=> [1, 3, 4]
[5, 1] + [5, 2, 3] #=> [5, 1, 5, 2, 3]
n.push [3, 4]      #=> [1, 3, 4, [3, 4]]
```

- Difference: **-**

```
n = [1, 1, 3, 3, 4, 5]
n - [1, 2, 4] #=> [3, 3, 5]
```

- Concat modifies receiver, +/- do not

And Many More

- Element order

```
[1, 2, 3, 4].reverse #=> [4, 3, 2, 1]
[1, 2, 3, 4].rotate  #=> [2, 3, 4, 1]
[1, 2, 3, 4].shuffle #=> [2, 1, 4, 3]
[3, 4, 2, 1].sort    #=> [1, 2, 3, 4]
```

- Search

```
[7, 3, 5, 7, 0].find_index 7 #=> 0
[7, 3, 5, 7, 0].rindex 7     #=> 3
[7, 3, 5, 7, 0].include? 0   #=> true
```

- Transformation

```
[1, 2, 2, 3, 1].uniq #=> [1, 2, 3]
[1, 2].fill 'a' #=> ["a", "a"], N.B. aliases!
['a', 'bbb', 'c'].join "_" #=> "a_bbb_c"
[1,2].product [3,4] #=> [[1,3],[1,4],[2,3],[2,4]]
[[1, 2], [3, 4], [5, 6]].transpose
                    #=> [[1, 3, 5], [2, 4, 6]]
```

To Ponder

Evaluate the ?'s

```
x = Array.new 3, 5 #=> [5, 5, 5]
x[0] += 1
x #=> ???

y = Array.new 3, [] #=> [[],[],[]]
y[0] << 'hi' # adds elt to array
y #=> ???
```

Example

- Generate a random sequence of 8 lower case letters, without repetition

- E.g., **`"minbevtj"`**

Example

- Write a program that reads in a list of names from stdin (keyboard), then prints out the list in alphabetical order in all-caps
- Hint:
  - Use **`gets`** to read input from stdin
  - Returns String up to and including newline (nil if ^d)

```
>> x = gets
Hello world
=> "Hello world\n"
```

Example: A Solution


```
index = 0
names = Array.new
while name = gets
   name.chomp!.upcase!
   names[index] = name
   index += 1
end

puts 'The sorted array:'
puts names.sort
```

Refactor: Array Literal


```
index = 0
names = []
while name = gets
   name.chomp!.upcase!
   names[index] = name
   index += 1
end

puts 'The sorted array:'
puts names.sort
```

Refactor: Extend Array


```
index = 0
names = []
while name = gets

   names[index] = name.chomp.upcase
   index += 1
end

puts 'The sorted array:'
puts names.sort
```

Refactor: Push


```
names = []
while name = gets

   names.push name.chomp.upcase

end

puts 'The sorted array:'
puts names.sort
```

Refactor: Push Operator


```
names = []
while name = gets

   names << name.chomp.upcase

end

puts 'The sorted array:'
puts names.sort
```

Refactor: Statement Modifier


```
names, name = [], ""


names << name.chomp.upcase
                    while name = gets


puts 'The sorted array:'
puts names.sort
```

Summary

- Naming convention for methods
  - Mutators marked with !, polar with ?
- Ranges
  - Inclusive, exclusive, operator ===
  - Case/when can use ranges
- Strings
  - Mutable (c.f. Java)
- Arrays
  - Can grow and shrink

Splat "Operator" *

- Split/gather arrays/elements
  - Not really an operator, must be outermost
- Parallel assignment splits/gathers a little

```
a, b = [1, 2]    #=> a, b == 1, 2
array = 1, 2, 3 #=> array == [1, 2, 3]
```

- On RHS, splats generalize split

```
a, b, c = 1, *[2, 3] #=> a,b,c == 1,2,3
```

- On LHS, splat generalizes gather

```
*r = 1 #=> [1]
a, b, *r = 1, 2, 3, 4    #=> r == [3, 4]
a, b, *r = [1, 2, 3, 4] #=> r == [3, 4]
a, b, *r = 1, 2, 3       #=> r == [3]
```

Splat in Function Definition/Use

- Ruby enforces: number of arguments equals number of parameters
- In function definitions, splat can gather up remaining arguments (*ie* var args)

```
def greet(msg, *names)
  names.each { |name|
      puts "#{msg} #{name}!" }
end
greet 'Ciao', 'Rafe', 'Sarah', 'Xi'
```

- In function calls, splat explodes arrays into multiple arguments

```
people = ['Rafe', 'Sarah', 'Xi']
greet 'Hi', *people
```

To Ponder

- Given an array of integers
- Produce the array that includes only the even elements, each squared
- Example:
  - Given

```
[1, 2, 3, 7, 7, 1, 4, 5, 6, 2]
```

  - Result

```
[4, 16, 36, 4]
```

Ruby:
Blocks, Hashes, and Symbols

Blocks

- A block is a *statement(s)* passed in as an *argument* to a function

```
5.times do
  puts 'hello world'
end
```

  - Equivalent, but more succinct:

```
5.times { puts 'hello world' }
```

- A block can, itself, have parameters!

```
5.times { |n| puts n**2 }
```

  - Method calls block, passing in arguments

Calling Blocks

- Within a function, the passed-in block is called with keyword "yield"

```
def fib_up_to(max)
  i1, i2 = 1, 1
  while i1 <= max
    yield i1 if block_given?
    i1, i2 = i2, i1 + i2
  end
end
fib_up_to(1000) { |f| print "#{f} " }
fib_up_to(1000) { |f| sum += f }
```

Idioms for Blocks

- Bracketed code (eg open, do stuff, close)

```
File.open('notes.txt', 'w') do |file|
  file << 'work on 3901 project'
end # file closed by open method
```

- Nested scope (eg for initialization code)

```
agent = Mechanize.new do |a|
  a.log = Logger.new ('log.txt')
  a.user_agent_alias = 'Mac Safari'
end # isolates init'n code and temp var a
```

- Iteration (very common)…

Simple Iteration

- While/until loop: Boolean condition

```
while boolean_condition
   …
end
```

- For-in loop: iterate over arrays (and other things like ranges)

```
for var in array
   …
end
```

  - Example

```
for str in 'hi'..'yo'
   puts str.upcase
end
```

  - Usually avoided (rubystyle.guide/#no-for-loops)

Iterating on Arrays Using Blocks

- Do something with every element

```
a.each { |str| puts str.upcase }
```

- Do something with every index

```
a.each_index { |i| print "#{i}--" }
```

- Fill array with computed values

```
a.fill { |i| i * i }
a.fill { |i| [] } # or omit i: { |_| [] }
```

- Search

```
a.index { |x| x > limit }
```

- Filter

```
a.select! { |v| v =~ /[aeiou]/ }
a.reject! { |v| v =~ /[aeiou]/ } # aka filter
```

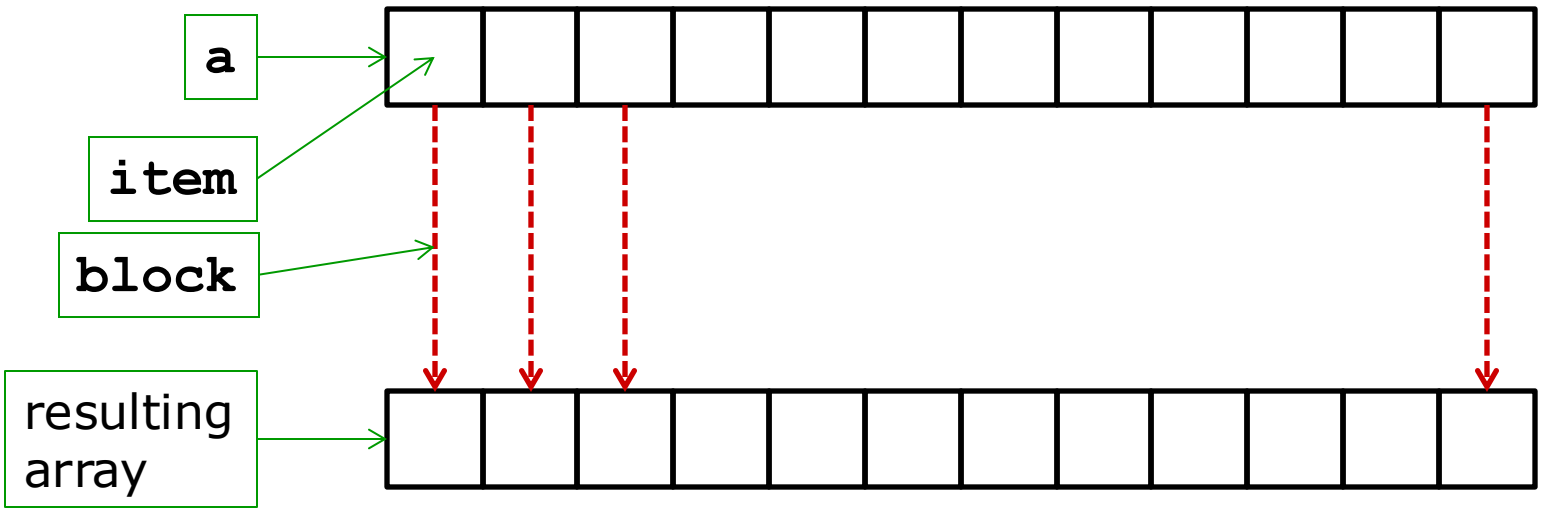
- Sort

```
a.sort! { |x, y| x.length <=> y.length }
```

Map

- Transform an array into a new array, *element by element*
- Uses *block* to calculate each new value

```
a.map { |item| block } # also !
```



Map: Examples

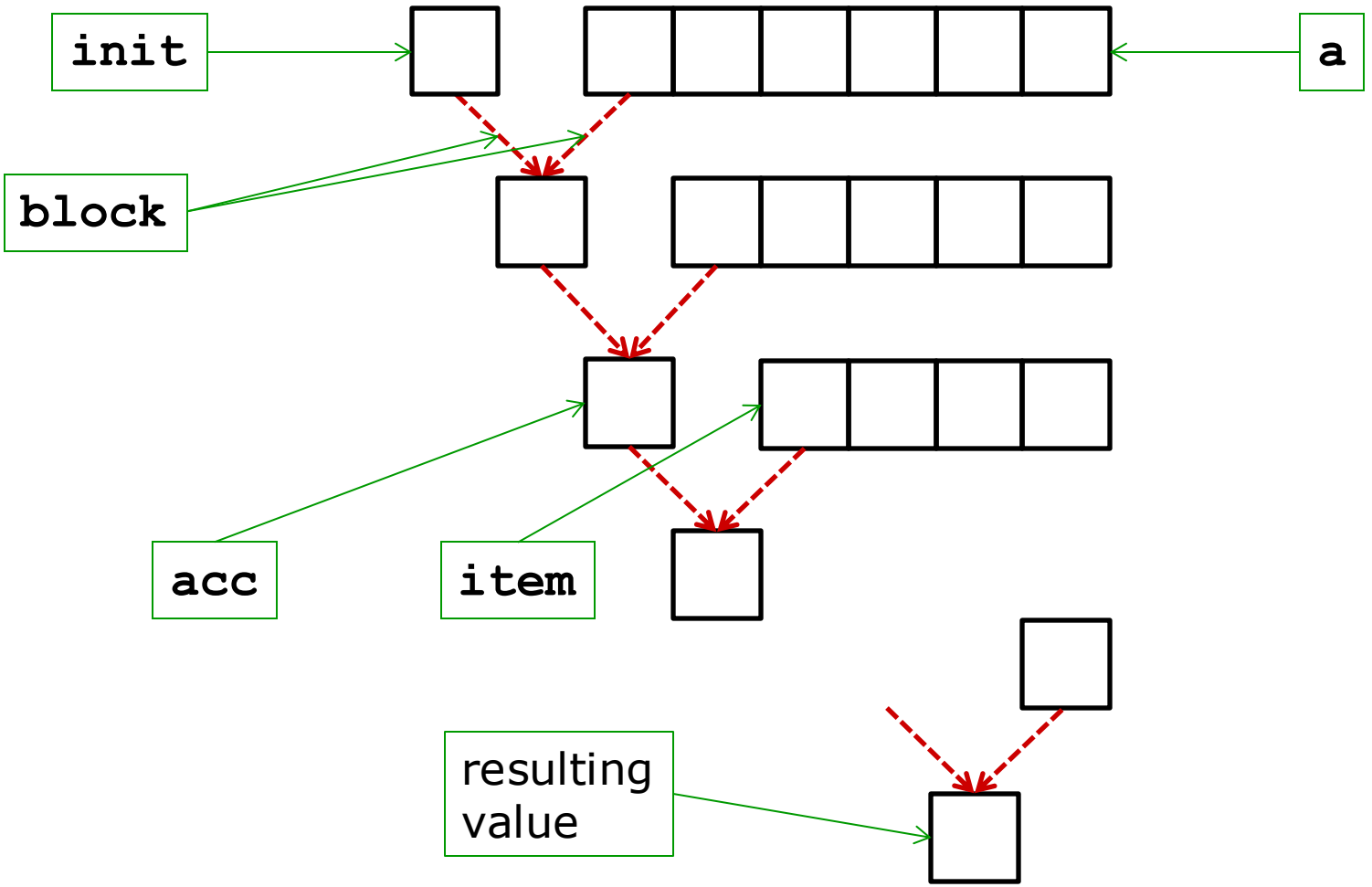

```
names = %w{ali noah marco xi}
  #=> ["ali", "noah", "marco", "xi"]
names.map { |name| name.capitalize }
  #=> ["Ali", "Noah", "Marco", "Xi"]
names.map { |name| name.length }
  #=> [3, 4, 5, 2]
[1, 2, 3, 4].map { |i| i**2 }
  #=> [1, 4, 9, 16]
[1, 2, 3, 4].map { |i| "x^#{i}" }
  #=> ["x^1", "x^2", "x^3", "x^4"]
```

Reduce

- Transform an array into a *single value*, by incorporating one element at a time
  - Also called "fold", or "inject"
- Uses block with 2 arguments: current accumulation and next array element

  `a.reduce(init) { |acc, item| block }`
  - Value *returned* by block is the next **`acc`**
  - **`a[0]`** is initial **`acc`**, if **`init`** not provided
- Example: Sum the values of an array
  - [15, 10, 8] → 0 + 15 + 10 + 8 → 33

Reduction Chain



Reduce: Examples


```
[3, 4, 5].reduce { |sum, i| sum + i }    #=> 12

[1, 2, 3, 4, 5].reduce '' do |str, i|
  str + i.to_s
end              #=> "12345"

words = %w{cat sheep bear}
words.reduce do |memo, word|
   memo.length > word.length ? memo : word
end              #=> "sheep"

[1, 2, 3].reduce [] do |acc, i|
  acc.unshift i
end              #=> ???
```

Module: Enumerable

- Quantify over elements

```
['hi', 'yo!'].all? { |w| w.length > 2 }
(0..100).any? { |x| x < 0 } #=> false
[1, 2, 3].none? { |x| x % 2 == 0 }
```

- Min/Max

```
words.max_by { |x| x.length }
```

- Search

```
(1..10).find_all { |i|  i % 3 == 0 }
   #=> [3, 6, 9]
```

- Map/reduce (only non-! version)

```
(5..8).map { 2 } #=> [2, 2, 2, 2]
(1..10).reduce(:+) #=> 55
book.reduce(0) { |sum, w| sum + w.length}
```

Your Turn

- Given a string
- Produce an array of indices where '#' occurs in the string
- Example:
  - Given

```
'a#asg#sdfg#d##'
```

  - Result

```
[1, 5, 10, 12, 13]
```

Your Turn

- Given an array of integers
- Produce the array that includes only the even elements, each squared
- Example:
  - Given

```
[1, 2, 3, 7, 7, 1, 4, 5, 6, 2]
```

  - Result

```
[4, 16, 36, 4]
```

Your Turn

- Given an array of (a mix of) integers and array of integers, where the (top level) integers are unique
- Remove from the contained arrays all occurrences of the top level integers
- Example:
  - Given

```
[3, 5, [4, 5, 9], 1, [1, 2, 3, 8, 9]]
```

  - Result

```
[3, 5, [4, 9], 1, [2, 8, 9]]
```

Example: What Does This Do?


```
words = File.open('tomsawyer.txt') { |f|
                        f.read }.split
freq, max = [], ''
words.each do |w|
  max = w if w.length > max.length
  freq[w.length] = 0 if !freq[w.length]
  freq[w.length] += 1
end
puts words.length
puts words.reduce(0) { |s, w| s + w.length }
freq.each_index do |i|
  puts "#{i}-letter words #{freq[i]}"
end
puts max
```

Hashes

- Partial map: keys → values
  - Keys must be unique
- Indexed with array syntax [ ]

```
h['hello'] = 5
```

- Literal syntax for initialization

```
h = {'red'   => 0xf00,
     'green' => 0x0f0,
     'blue'  => 0x00f  }
```

- Optional: Instantiate with a default value (or block)

```
h1 = Hash.new 0 #=> beware aliases
h2 = Hash.new { |h, k| h[k] = k + k }
```

Using Hashes


```
h = {'age' => 21}   # create new Hash
h['age'] += 1       # mutable values
h['id'] = 0x2a      # can grow
h.size              #=> 2
h['name'] = 'Luke'  # heterog. values
h[4.3] = [1, 3, 5]  # heterog. keys
h.delete 'id'       # can shrink

# h == {'age' => 22,
#       'name' => 'Luke',
#       4.3 => [1, 3, 5]}
```

Example


```
list = %w{cake bake cookie car apple}


# Group by string length:
groups = Hash.new{ |h, k| h[k] = [] }
list.each { |v|
  groups[v.length] << v
}
# groups == { 4 => ["cake", "bake"],
#       6 => ["cookie"],
#       3 => ["car"], 5 => ["apple"] }
```

Your Turn

- Write the Ruby code that, given an array of strings, computes frequency of occurrence of each word
- Example:
  - Given

    ```
    ["car", "van", "car", "car"]
    ```

  - Compute

    ```
    {"car" => 3, "van" => 1}
    ```

Example


```
list = %w{car van car car}

# Your code here


groups #=> {"car" => 3, "van" => 1}
```

Using Blocks with Hashes

- Do something with every key/value pair

```
h.each {|k, v| print "(#{k},#{v})"}
```

- Do something with every key or value

```
h.each_key { |k| print "#{k}--" }
h.each_value { |v| print "#{v}--" }
```

- Combine two hashes

```
h1.merge(h2) { |k, v1, v2| v2 - v1 }
```

- Filter

```
a.delete_if { |k, v| v =~ /[aeiou]/ }
a.keep_if { |k, v| v =~ /[aeiou]/ }
```

Immutability of Keys

- Rule: Once a key is in a hash, *never* change its value

```
grades[student] = 'C+'
student.wake_up! # danger
```

- Problem: Aliases
- "Solution": For strings, Ruby *copies* (and *freezes*) a string when added to a hash

```
a, b = String.new('fs'), String.new('sn')
h = {a => 34, b => 44}
puts a.object_id, b.object_id
h.each_key { |key| puts key.object_id }
```

Symbols

- Roughly: *unique* & *immutable* strings
- Syntax: prefix with ":"

```
:height
:'some symbol'
:"#{name}'s crazy idea"
```

- Easy (too easy?) to convert between symbols and strings

```
:name.to_s          #=> "name"
'name'.to_sym       #=> :name
```

- But symbols are *not* strings

```
:name == 'name' #=> false
```

Operational View

- A symbol is created once, and all uses refer to that same object (aliases)
- Symbols are immutable
- Example

```
[].object_id #=> 200
[].object_id #=> 220
[].equal? [] #=> false
:world.object_id #=> 459528
:world.object_id #=> 459528
:world.equal? :world #=> true
```

Symbols as Hash Keys

- Literal notation, but note colon location!

```
colors = {red: 0xf00,
          green: 0x0f0,
          blue: 0x00f}
```

- This is just syntactic sugar
  - `{name: value}` same as `{:name => value}`
  - The key is a *symbol* (eg `:red`)
- Pitfalls

```
colors.red      #=> NoMethodError
colors["red"]   #=> nil
colors[:red]    #=> 3840 (ie 0xf00)
```

Keyword Arguments

- Alternative to positional matching of arguments with formal parameters

```
def display(first:, last:)
  puts "Hello #{first} #{last}"
end
display first: 'Mork', last: 'Ork'
display last: 'Hawking', first: 'Steven'
```

- Providing a default value makes that argument optional

```
def greet(title: 'Dr.', name:)
  puts "Hello #{title} #{name}"
end
```

- Benefits: Client code is easier to read, and flexibility in optional arguments

Summary

- Blocks
  - Code passed as argument to a function
  - Elegant iteration over arrays
- Enumerable
  - Many useful iteration methods
- Hashes
  - Partial maps (aka associative arrays)
- Symbols
  - Unique, immutable strings
  - Often used as keys in hashes