JS Fundamentals

Core JavaScript

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Introductions

- Who am I?
- Who are you?
  - What do you do?
  - What do you hope to gain from this course?
  - What is your programming background?
    - Any JavaScript, HTML, CSS, jQuery, etc?
    - Are you coming in with love or hate for js?
- What is your current development environment and process?

Class Outline

Day 1

- Introductions/Setup
- JavaScript Syntax & Data types
- Hoisting, Scope and Context
- Prototype / OO

Mix of ES5/6
No OO
No modules

Day 2

- Refresher of HTML/CSS
- The DOM
- Event handling
- Ajax & Promises

Any specific topics you're interested in?

Expectations

- We're going to cover a **lot of ground**, quickly
  - *Don't expect to remember everything*
- I am a **guide**, not a deity
  - *I learn & re-learn things every day*
- Become an excellent **researcher**
  - *The documentation and google are our friends*
- There is **rarely "one way"** to do a thing
  - *Get used to opposing opinions and ambiguity*

Get the most out of the class

- Ask **questions**!
- Do the **labs** (pair up if needed)
- Be **punctual**
- **Avoid distractions**
- Master your **google-fu**
- **Play along**
- Don't be afraid to **break stuff**

Resources

- Documentation
  - http://devdocs.io
  - https://developer.mozilla.org/en-US/docs/Web
  - http://kapeli.com/dash (Mac only)
  - Google it.
- Compatibility checks
  - http://caniuse.com
- ES 5 compatibility table
  - http://kangax.github.io/compat-table/es5/

Set up for our labs

Don't have **NodeJS**?
Head here to download:
https://nodejs.org/

- *In your command line…*
- **Download** or clone this repository
  - https://github.com/rm-training/web-dev-bc
- **Initialize** the project
  - `npm install`
- **Start** the server
  - `npm start`
  - Visit http://localhost:3000/
- Let's **explore** our project files
  - Set up a new workspace in your IDE

everyone all set with the above?

module

JAVASCRIPT INTRO

History

- “Make webpages alive”
- 1995 - Netscape wanted interactivity like HyperCard w/ Java in the name
- Designed & built in 10 days by Brendan Eich
  - initially named "Mocha", released as “LiveScript"
  - Became “JavaScript” once name was licensed from *Sun*
  - Currently named **ECMAScript**
- Combines influences from:
  - Java, "Because people like it"
  - SmallTalk, prototypal

What is JavaScript?

- **Interpreted**
- Case-sensitive C-style syntax
- Dynamically typed (with weak typing)
- Fully **dynamic**
- **Single-threaded** event loop
- **Prototype**-based (vs. class-based)
- Safe (no CPU or memory access)
- Depends on the engine + environment running it
- *Kind of weird but enjoyable*

JavaScript Versions

- ES3/1.5
  - Released in 1999 – in all browsers by 2011
  - IE6-8
- **ES5/1.8**
  - Released in 2009
  - IE9+
  - http://kangax.github.io/compat-table/es5/
- **ES6 [ECMAScript 2015] mostly supported**
- ES7 [ECMAScript 2016] finalized, but weak support
- ES8 [ECMAScript 2017] finalized in June 2017
- ES9 — 2018
- ES.Next…

This is our sweet spot

Why JavaScript?

- Scrappy, flexible and powerful
- The language of the web
  - Integrates nicely w/ HTML/CSS
  - Supported across all browsers
- Beginning to dominate the entire stack
- *Easy to learn, hard to master*

Approaching JavaScript

- It's **not** Java or Class-based
- Very **dynamic** & **flexible**
- Supports **many paradigms**
  - imperative, functional and object-oriented

Approaching JavaScript

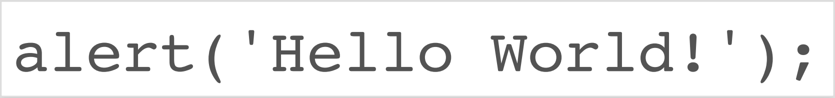
- Be aware of the **downsides**
  - Single-thread/Blocking
  - Evolved w/out ever cleaning the closet
  - Lot’s of parties involved in its evolution
  - Flexibility requires understanding

obligatory

HELLO WORLD

Alert hello

- In a browser, open the developer console and type:

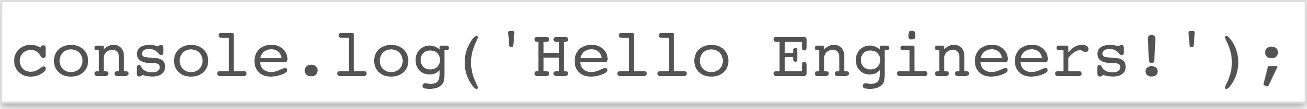


```
alert('Hello World!');
```

- Alternatively…
  - In a <script> tag
  - or… in a file linked from an HTML page
  - or… run by NodeJS

Log hello

- Now try



```
console.log('Hello Engineers!');
```

Debugging in the Browser

- Browser’s JavaScript Console
  - REPL to experiment and log output
  - Set breakpoints and monitor variables
  - Monitor events
  - View network requests
  - View memory usage
  - And of course inspect our HTML/CSS

Let’s check it out

The console object

- Console api

```
console.log(msg);    // echo/print/output
console.assert(data);// for testing
console.table(data); // output as table
debugger;            // triggers a breakpoint
```

- Tips while debugging through the console:
    - **Clear** your console of old errors
    - **Check** the error message line reference
    - **Disable caching**

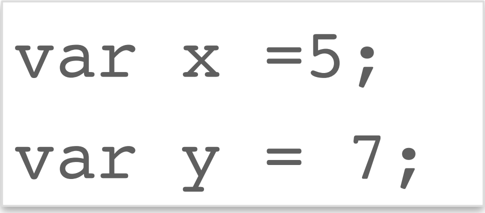
Everyone do this?

module

SYNTAX BASICS

C-family syntax

- Instructions are **statements** separated by **semi-colons**



```
var x =5;
var y = 7;
```

- Spaces, tabs and newlines are **whitespace**.
  - Whitespace and indentation generally don't matter
- Semi-colons are **automatically inserted**
  - *Don't rely on that!*

C-family syntax

- **Block statements** group related statements
- They are wrapped with **curly braces**

```
var x = 5;
if (x) {
  x++;
}
```

```
function test() {
  var x = 5;
  x++;
}
```

```
{
  x = 5;
  y = 7;
}
```

```
var z = {
  x: 5,
  y: 10
}
```

Not a block statement!

Automatic Semicolon Insertion

- Semicolons terminate statements

```
y = 5 + 1;
```

- They are *mostly* optional
  - Automatically inserted but not fail-safe
  - So, don’t rely on it…

```
var fn = function() {
  // do stuff
}
(function() {
  // do stuff
})();
```

Missing semi-colon here results in a `TypeError`

Comments

- Lines of text (or code) that are ignored
- Many lines

```
/*
 span multiple
 lines
*/
```

- Single line

```
// I can comment one line at a time
var x = 1; // wherever
// var x = 5;
```

Variables

- A name to help (or *reference*) a value

```
var MyName = “Ryan”;
var your_name;
var $; // like jQuery
var _myName;
var num10 = 5 + 5;
var 🍔 = 'burger';
```

- Var names can contain **letters**, **digits**, _, or **$**
  - Can’t begin with a digit
  - No reserved keywords
  - ***CaSE*** matters
  - **Unicode** characters are supported

Declaring variables

- With the keyword **var**
  - and **`let`** or **`const`** in ES6+
- One by one:

```
var foo;
var thing1;
```

- Or in sequence:

```
var a, b;
```

ES6:

```
let foo;
const thing1;
```

Assigning values

- Use = to assign values to variables

```
var x = 5;
var y = 1, z = 'rad';
```

- Can assign and re-assign at any time

```
var x;
x = 10;
x = 22; // ok!


var x; // redeclaring with var has no effect
x = 10 + x; // x is now 32!
```

Assigning values with let & const

- Cannot redeclare with let

```
let x = 5;
let x = 10; // error! can't redeclare
```

- Const values are immutable

```
const x; // error! must initialize consts
const x = 10;
x = 50; // error! can't modify
```

- However, object properties are still mutable

```
const z = {};
z.name = "John"; // ok!
```

Default Value

- Variables with no value set will default to a special value, `undefined`

```
var noValue;
console.log(noValue); // undefined

typeof noValue; // “undefined”
```

Don’t pollute the global scope

- Omitting the **`var`** keyword (or let, const) creates a ***globally scoped*** variable

```
myNumbers = [1,2,3];
myNumbers; // [1,2,3];


window.myNumbers; // [1,2,3];
```

- This is bad.

module

DATA TYPES

Primitives

- Five *primitive* data types:
  - null - *lack of value*
  - undefined – *no value set* (default)
  - strings
  - numbers
  - booleans
  - *ES6: Additional primitive, Symbol*
- Everything else is an *Object*
  - ie: `Object`, `Array`, `Function`, `Math`…
  - A function is a *callable* object
  - All *primitives* have *Object* counterparts

undefined & null

- Little difference between the two, in practice
- Variables declared without a value will start with `undefined`
- Can compare to `undefined` to see if a variable has a value

```
var a;
a === undefined; // true
typeof a; // undefined
```

boolean

- **`true`** or **`false`**

```
var isRyanTall = true;
var do_something = false;

if (isRyanTall) {
  // do something…
}
```

string

Warning about copy/ pasting quotation marks in presentations

- Enclosed by " or ' (just don't mix them)

```
var str = "My Name Is";
var name = 'Ryan';
```

- Combine strings with the **+** operator

```
"Hi, " + str + " " + name + "!";
```

- (ES6) Template Literals with ` (*backtick*)

```
var lastName = "Ryan";
var name = `Hello {x}`; // Hello Ryan
```

number

- 64bit floating point
- Numbers can be expressed in many ways:

```
var a = 1; // integer
var b = 1.5; // decimal
var c = -3; // negative
var d = 2.99e8; // scientific
var e = 0777; // octal
var f = 0xFF; // hexadecimal, 255
var g = 0b10000000000000000000000000000000;
```

Number oddities

- There is a max and min value of up to 15 digits
- Decimal arithmetic can be inaccurate

```
var x = 0.2 + 0.1; // 0.30000000000000004
```

- There is a special value for “*not a number*”

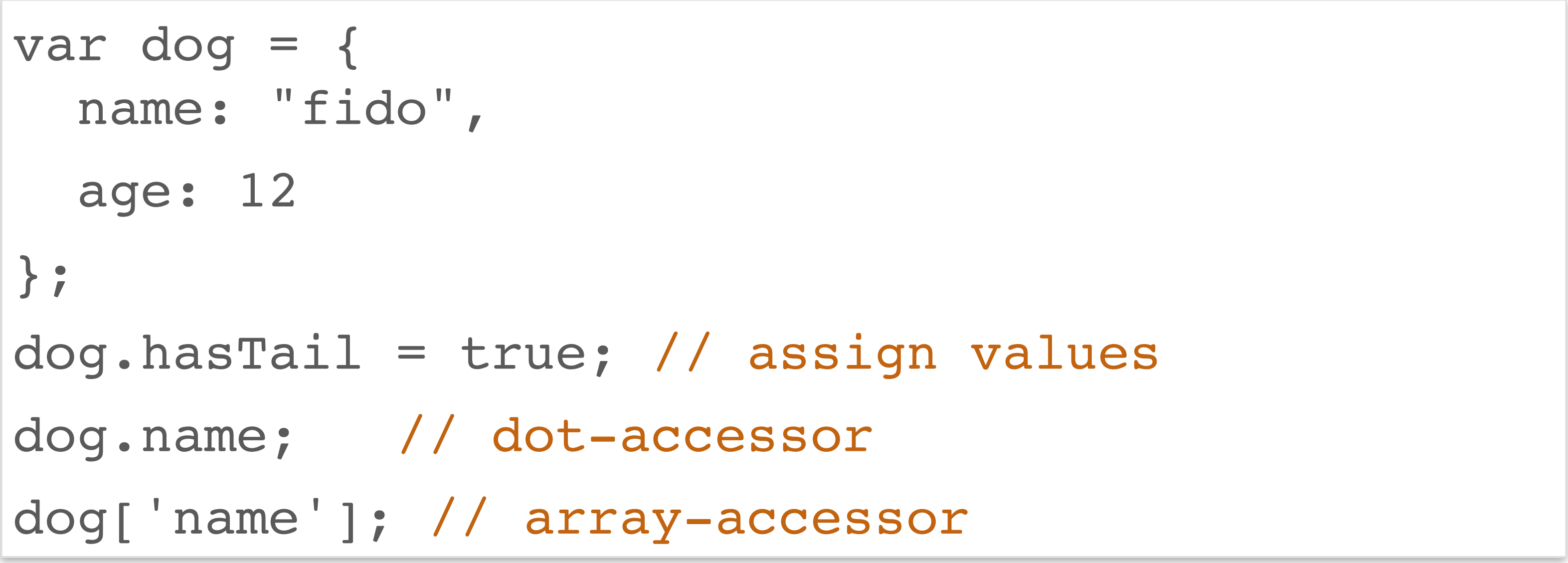
```
0/0; // NaN
NaN == NaN; // false??
```

- And a special value for *infinity*

```
5/0  // Infinity
5/-0 // -Infinity
```

Objects

- A list of **key:value** pairs, separated by **commas** and surrounded by **curly braces**



```
var dog = {
  name: "fido",
  age: 12
};
dog.hasTail = true; // assign values
dog.name;    // dot-accessor
dog['name']; // array-accessor
```

- Might be considered a *Dictionary*, *Hash* or *Map* in other languages

Objects, continued…

```
var person = {
  name: 'Ryan',
  isTall: true,
  speak: function() {
    console.log('Hi');
  }
}


person.name; // Ryan
person.speak(); // “Hi”
```

Keys are **unordered** strings
Quotes around key names are only required if they include special chars

Values can be **any type of data**, including **functions**

Functions

- Functions are **callable objects**

```
function addOne(x) {
  return x + 1;
}
addOne(10); // 11
```

- Functions are for storing some reusable functionality
  - When a function is called the flow of the script "*enters*" the function
  - Said to "*encapsulate*" a task

Functions

- They can be referenced by a **name** or **variable**

```
var hello = function hello() {
  console.log(“Hello!”);
}
```

- They can exist on objects as **methods**

```
var me = {}
me.hello = function() {
  console.log(“Hello!”);
}
```

- They can take **arguments**

Arrays

- Data stored *sequentially*

```
var emptyArray = [];
var myArray = [1,2,3,4];
```

- Can access and set values by their *index*

```
myArray[1]; // 2
myArray[1] = 20;
```

- They are zero-indexed

```
var favColors = ['red', 'blue', 'green'];
favColors[0]; // ‘red’
```

Arrays are strange

- In JavaScript, an **array is an object** that behaves *kinda* like an array (*array-like*)
- Strange behavior if you try to use string keys

```
var arr = [1,2,3];
arr.length; // 3 <— three items
arr['bar'] = 10;
arr.length; // 3 <- hmm i expected 4?
```

array methods

- Arrays are objects…
  - They have additional **properties**

```
myArray.length; // 4
```

  - And **methods**

```
// adds value to end
myArray.push('John');

// take value off end
myArray.pop(); // ‘John’
```

Everything* is an object

- In fact, ***everything*** can act like an object…
  - … and has additional properties and methods

```
var name= "John Smith";
name.length; // 10

"foo".toUpperCase(); // “FOO"

5..toString(); // 5
```

Exercise: Super Primitive

- Start the node server

```
$> npm start
```

- Open the following file:

```
public/exercises/primitives/primitives.js
```

- Complete the exercise
- Run the tests by visiting in your browser:

```
http://localhost:3000/exercises/primitives
```

Quick note on ESLint

Solution:
:https://github.com/rm-training/web-dev-bc/blob/master/public/solutions/primitives/primitives.js

module

OPERATORS

Unary

```
delete obj.x    // undefined
void 5 + 5      // undefined
typeof 5        // 'number'
+'5'            // 5
-x              // -5
~9              // -10 (bitwise flip bit)
!true           // false
++x             // 6
x++             // 5
--x             // 4
x--             // 5
```

Arithmetic

```
5 + 5       // 10
5 – 3       // 2
5 * 2       // 10
10 / 2      // 5
10 % 3      // 1
```

Bitwise

```
5 & 4     // 1
1 | 4     // 5
4 ^ 6     // 2
9 << 2    // 36
-9 >> 2   // -3
9 >>> 2   // 2
```

Assignment

```
x = 5       // 5
x += 1      // 6
x -= 2      // 4
x *= 3      // 12
x /= 4      // 3
x %= 2      // 1
```

Type checking

- **typeof** returns the type of the argument as a string

```
typeof undefined; // “undefined”
typeof 0;         // “number”
typeof "foo";     // “string”
typeof true;      // “boolean”
typeof null;      // “object” ???
typeof {};        // “object”


// can be used as a function
typeof(0);        // “number”
```

typeof objects

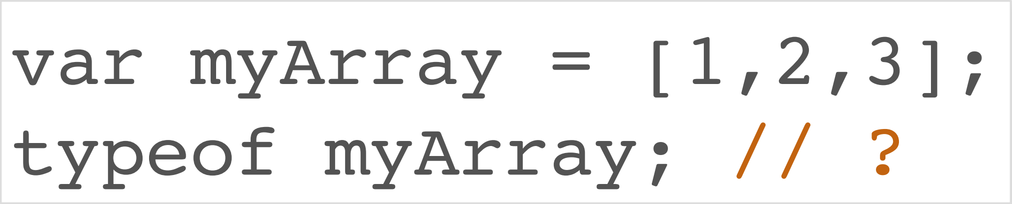
- **typeof** with any* object is **“object”**

```
typeof {};        // “object”
typeof [1,2,3];   // “object”
typeof Math;      // “object”
```

- *except **Functions**

```
typeof alert;      // “function”
```

Exercise - typeof an Array?



```
var myArray = [1,2,3];
typeof myArray; // ?
```

Everything* is an object

- Primitive literals all have Object counterparts
  - except null and undefined

```
5 === Number("5"); // true
"Hello" === String("Hello"); // true
true === Boolean(1); // true
```

- *most things, primitives are just ***coerced***

Primitive->Object Coercion

- This means we can access properties and methods of objects, including primitives

```
var str = "bla";
str.length; // 3
str.toUpperCase(); // BLA
"Hello".length; // 5
```

JS creates an object wrapper for the primitive, uses it, then throws it away

Literals

- Fixed values, not variables, that you *literally* provide in your script

```
5           // number literal
"a"         // string literal
true        // boolean literal

{}          // object literal
[]          // array literal
/^(.*)$/    // regexp literal
```

Don’t construct your literals

- Because they have object counterparts, one can ***construct*** them to create ***new instances***

```
new String("Hi"); // {0: "H", 1: “I"}
String("Hi"); // "Hi"
new Number(5); // 5
new Array(1,2,3); // [1,2,3]
new Boolean(1); // true
new Object(); // {}
```

- ***But:***
  - Uses additional memory/cpu
  - Some side-effects
  - Too class-based

Recap: basic data types

- There are 5 primitive types (string, number, boolean, null, undefined) and then Objects
  - Functions are a callable Object
  - Objects are property names referencing data
  - Arrays are for sequential data
- Declare variables with “var”
- Types are coerced
  - Including when a primitive is used like an object
- *Almost Everything* is an object, except the primitives
  - despite them having object counterparts

Exercise: Data Types

- Open the following file:

```
public/exercises/data-types/index.js
```

- Complete the exercise
- View your log output by visiting:

  http://localhost:3000/exercises/data-types

Solutions:
https://github.com/rm-training/web-dev-bc/blob/master/public/solutions/data-types/index.js

module

CONTROL STRUCTURES

Conditionals & Loops

Control Structures & Logic

- We'll use control structures & logical expressions to define the flow of our script
  - `if` and `if-else` statements
  - `switch` statements
- And to process data
  - `for` and `while` loops to repeat actions or loop over arrays
  - what about objects?

Conditional statements

- `if (expression) {…}`

-
  ```
  if (expression) {
      …
  } else {
      …
  }
  ```
- `if {} else if {} else {}`

Relational operators

```
'foo' in {foo: ‘bar'}   // true
[] instanceof Array     // true
5 < 4                   // false
5 > 4                   // true
4 <= 4                  // true
5 >= 10                 // false
```

Equality operators (strict vs loose)

```
5 == '5'              // true
5 != 'a'              // true
5 === '5'             // false
{} !== {}             // true
```

Logical operators

```
false && 'foo'   // false

false || 'foo'   // 'foo'
```

Conditional example

```
// generates a value between 0 and 1
const rand = Math.random();

if (rand > .1 && rand < .3) {
  // do something
} else if (rand === .4) {
  // do something
} else {
  // do something
}
```

Switch statements

```
switch (expression) {
     case val1:
          // statements
          break;

     default:
          // statements
          break;
}
```

Ternary

```
// condition ? then : else;
true ? 'foo' : 'bar' // 'foo'
```

looping - for

ES6:
var is scoped to this *block*
let is scoped to each *iteration*

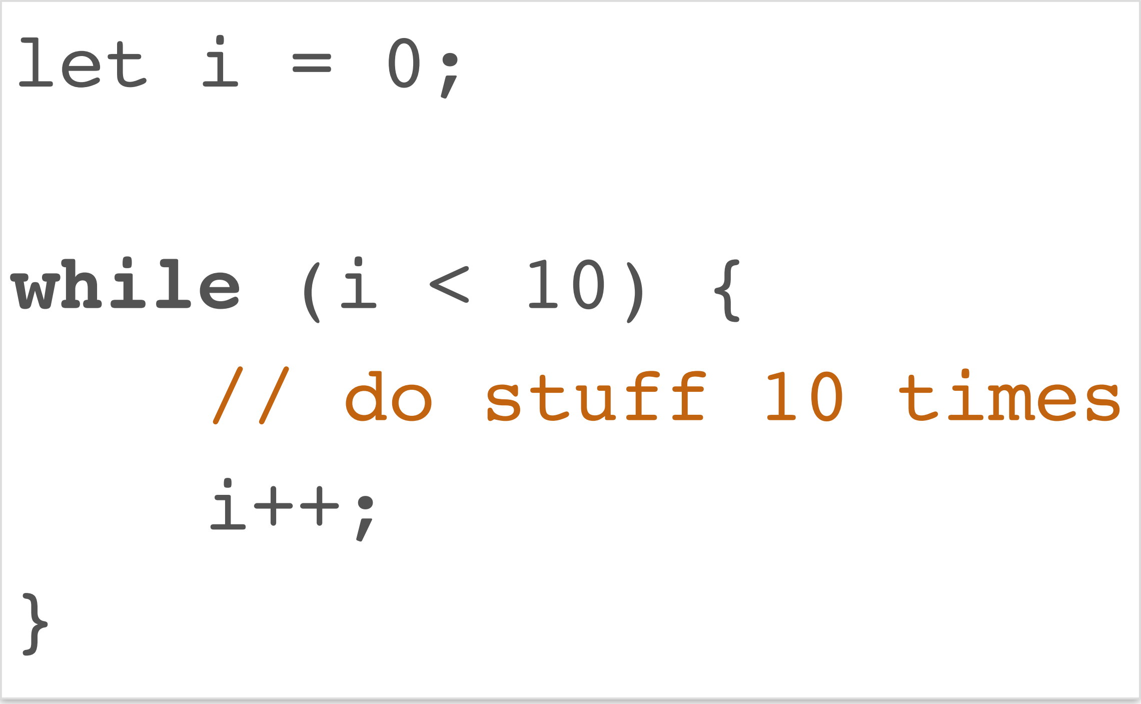
- Do something {x} times

```
for (var i=0; i<10; i++) {
    // executes 10 times…
}
```

- Great for something like… looping over an array

```
var arr = [1,2,3];
for (var i=0; i<arr.length; i++) {
  console.log(arr[i]); // 1, 2, 3
}
```

looping - while



```
let i = 0;

while (i < 10) {
    // do stuff 10 times
    i++;
}
```

Break and Continue

```
for (var i = 0; i < 10; i++) {
    if (i < 5) {
        continue; // skip iteration
    } else if (i === 8) {
        break;   // exit the loop
    }
    console.log(i);
}
```

Exercise: Boolean Operators

- What is the resulting value/output:

```
false && console.log("Yep"); // ?
```

```
true && console.log("Yep"); // ?
```

```
false || console.log("Yep"); // ?
```

```
true || console.log("Yep"); // ?
```

Logical short circuits

- **a && b** returns either a or b

```
if (a) {
      return b;
} else {
      return a;
}
```

- **a || b** returns either a otherwise b

```
if (a) {
      return a;
} else {
      return b;
}
```

Where short-circuits help

- Default function values

```
function name(x) {
  // set default value of x if undefined
  x = x || null;
}
```

- Gateways

```
return obj.name
  && obj.id
  && obj.doSomething();
```

Control Structures Recap

- Conditionals like if and if-else
- Switch statements
- Iterate (loop) with while and for
- Logical short circuits are a common pattern

Exercise: Control Flow (Level I)

- Open the following file:

  `public/exercises/control/index.js`

- Complete the exercise
- View test results by visiting:

  http://localhost:3000/exercises/control/

Solutions: https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/control

module

COERCION

Type Coercion

- If a variable type is not what JavaScript expects, it will convert it on the fly, based upon the context
  - Just like a primitive is coerced to an Object

```
"ryan".length; // coerced to a String()
```

  - In numeric expressions with the **+** operator, numbers may be coerced to strings (and vice versa)

```
+"42"; // 42
"Name: " + 42; // "Name: 42"
1 + "3"; // “13”;
```

Implicit Coercion

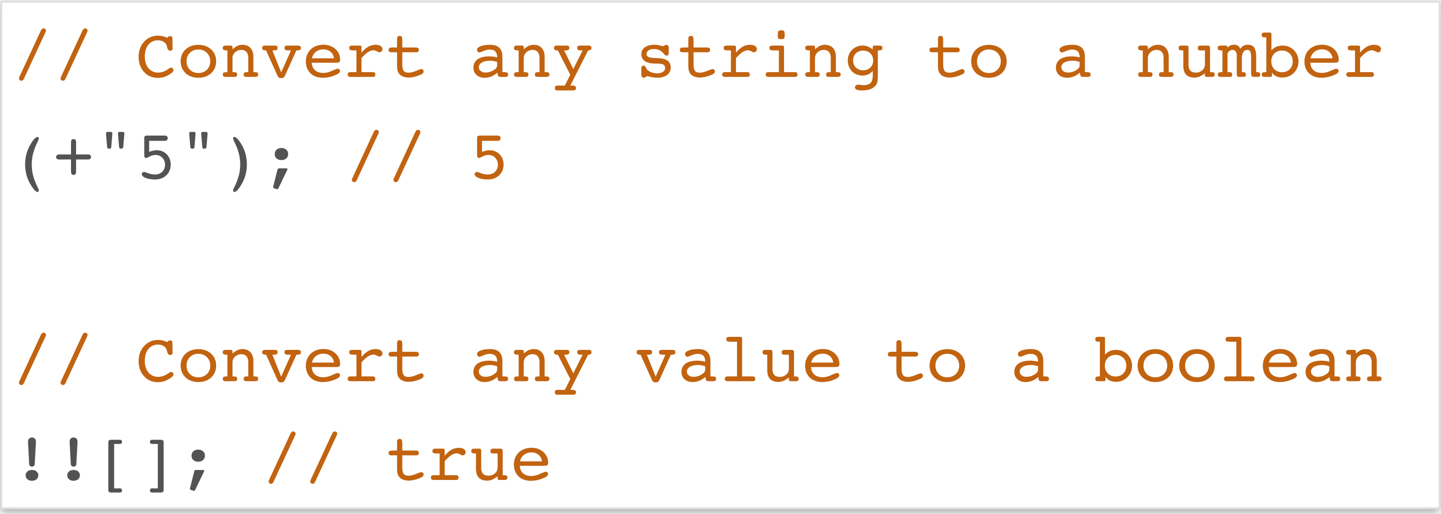
- It's not obvious how it will coerce…

```
8 * null; // 0
"5" – 1;  // 4
"5" + 1;  // “51”
```

- Much confusion ensues

```
[] + []; // ""
[] + {}; // [object Object]
{} + []; // 0
{} + {}; // NaN
```

Sometimes coercion is cool



```
// Convert any string to a number
(+"5"); // 5

// Convert any value to a boolean
!![]; // true
```

Coercing to boolean

- Most frequently we'll rely on it in logic checks

```
// x is a number
var x = 10;

// if x is true? … truthy
if (x) {
 // do something
}
```

Falsy / Truthy

- Really just *coercion*

These coerce to **false**

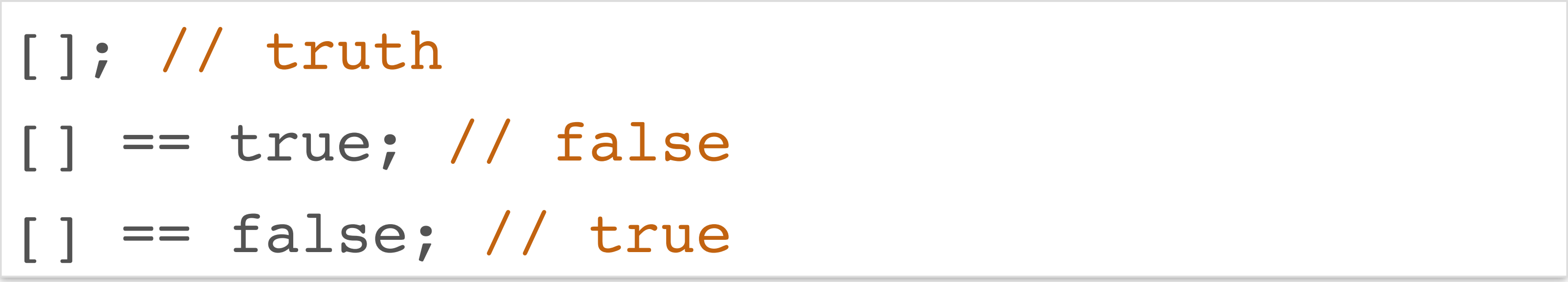
```
false
null
undefined
""
0
NaN
```

Everything else is **true**

```
{}
[]
"0"
"false"
```

Falsy / Truthy

- Checking falsy-truthy is not always the same as checking equivalency



```
[]; // truth
[] == true; // false
[] == false; // true
```

- Use === to avoid surprises

Exercise - Truthing and Falsing

- Consider ***two*** things:
  - Is the expression **truthy or falsy?**
  - What is the **actual result** of the expression?

1.`null`	1.falsy
2.`true`	2.truthy
3.`true && 5 && 10`	3.truthy
4.`1 && false && 2`	4.falsy
5.`false || 2`	5.truthy
6.`x = 2`	6.truthy
7.`10 >= 5`	7.truthy
8.`1 || 2 || 3`	8.truthy
9.`[]`	9.truthy

module

FUNCTION BASICS

Functions: "The best part of JS"

- Reusable, callable blocks of code
- Functions can be used as:
  - Object methods
  - Object constructors
  - Modules and namespaces
- They *are* ***First Class Objects***
  - *Can have their own properties and methods*
  - *Can be passed as function arguments (higher order!)*
  - *Can be referenced by variables*

Function Declaration

```
// declaration
function adder(a, b) {
      return a + b;
}


// invokation
adder(1, 2); // 3
```

- The function name is *mandatory*

Function Expressions

```
// function expression
var adder = function(a, b) {
        return a + b;
}


// invokation is identical
adder(1, 2); // 3
```

- When you assign a function to a variable
- Function name is optional — *making it anonymous*

Anonymous can be named

```
// an anonymous function
var someFunction = function() {};

// a named anonymous function
var someFunction = function me(a) {
  // name is available only in inner function
  me(a++);
}
```

Invokation

- Execute a function with **()**
  - Pass in any **arguments**
- Missing arguments are set as **`undefined`**

```
function mult(x, y) {
  return x * y;
}

mult; // ?
mult(); // ?
mult(1) // ?
mult(1,2); // ?
```

Default Values [ES6]

- ES6

```
function adder(first, second = 1) {
  // body
}
function addComment(comment = getComment()) {
  // body
}
```

- Pre-ES6

```
function adder(first, second) {
  second = second || 1;
}
```

Return statements

- Functions do not automatically return anything, i.e. they are *void**
- To return the result of the function invocation, to the invoker (caller) of the function:

```
return <expression>;
```

- Careful with your line breaks…

```
return
     x;
// Becomes
return;
     x;
```

Function **`arguments`**

- Functions have access to a special internal value when invoked, **`arguments`**
  - Contains all parameters passed to the function
  - It's an *array-like* object
    - Meaning we need to convert it to an array if we want to do "array stuff" on it.

```
function adder(first, second) {
  // won't work because not an array
  arguments.forEach(function(el) {
    console.log(el);
  });
}
adder(1,2); // ?
```

Function **arguments**

```
function sumAll() {
  // call an array method with
  // with arguments as the function context
  var args = Array.prototype.slice.call(arguments);

  // or in ES6
  var args = Array.from(arguments);

  return args.reduce(function(acc, curr) {
     return acc + curr;
  });
}
sumAll(1, 2, 3); // ?
```

Functions as First Class Objects

```
// function passed in to another function
setTimeout(function() {
  console.log("HI!");
}, 1000);


// check the docs; we define argument names
[1,2,3].forEach(function(curr, i, arr) {
  console.log(curr, i, arr);
});
```

- Functions can be passed around as arguments
- We can define argument names when we define per an api/interface

(Lots of) global functions

- **`alert(msg);`**
- **`confirm(msg)`**
- **`prompt(msg, msg);`**
- `isFinite()`
- ~~`isNaN()`~~ `// use Number.isNaN() [ES6]`
- **`parseInt()`**
- `parseFloat()`
- `encodeURI(), decodeURI()`
- **`setInterval, clearInterval`**
- **`setTimeout, clearTimeout`**
- `eval(); // dangerous`

Timer functions

- Establish **delay** for function invokation

```
// invoke func in 500 milliseconds
var timer = setTimeout(func, 500);
clearTimeout(timer); // cancel
```

- Establish an **interval** for periodic invokation

```
// invoke func every 1 second
var timer = setInterval(func, 1000)
clearInterval(timer); // cancel it
```

Exercise: Functional FizzBuzz

- Open the following file:

  `public/exercises/fizz-buzz/index.js`

- Complete the exercise
  - **The rules of FizzBuzz**
    - For numbers that are a multiple of 3, log "Fizz"
    - For numbers that are a multiple of 5, log "Buzz"
    - For numbers that are a multiple of both, log “FizzBuzz"
- View your log output by visiting:

  http://localhost:3000/exercises/fizz-buzz/

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/fizz-buzz

module

SCOPE

Scope

- Variable **access** and **visibility** in a piece of code at a given time
- **Scope is Lexical** (static)
  - as opposed to *dynamic*
  - Scope is defined at author-time
  - No need to execute; you can read code and determine scope
- Three scopes to consider in JavaScript
  - Function Scope
  - Global Scope
  - Block Scope [ES6+]

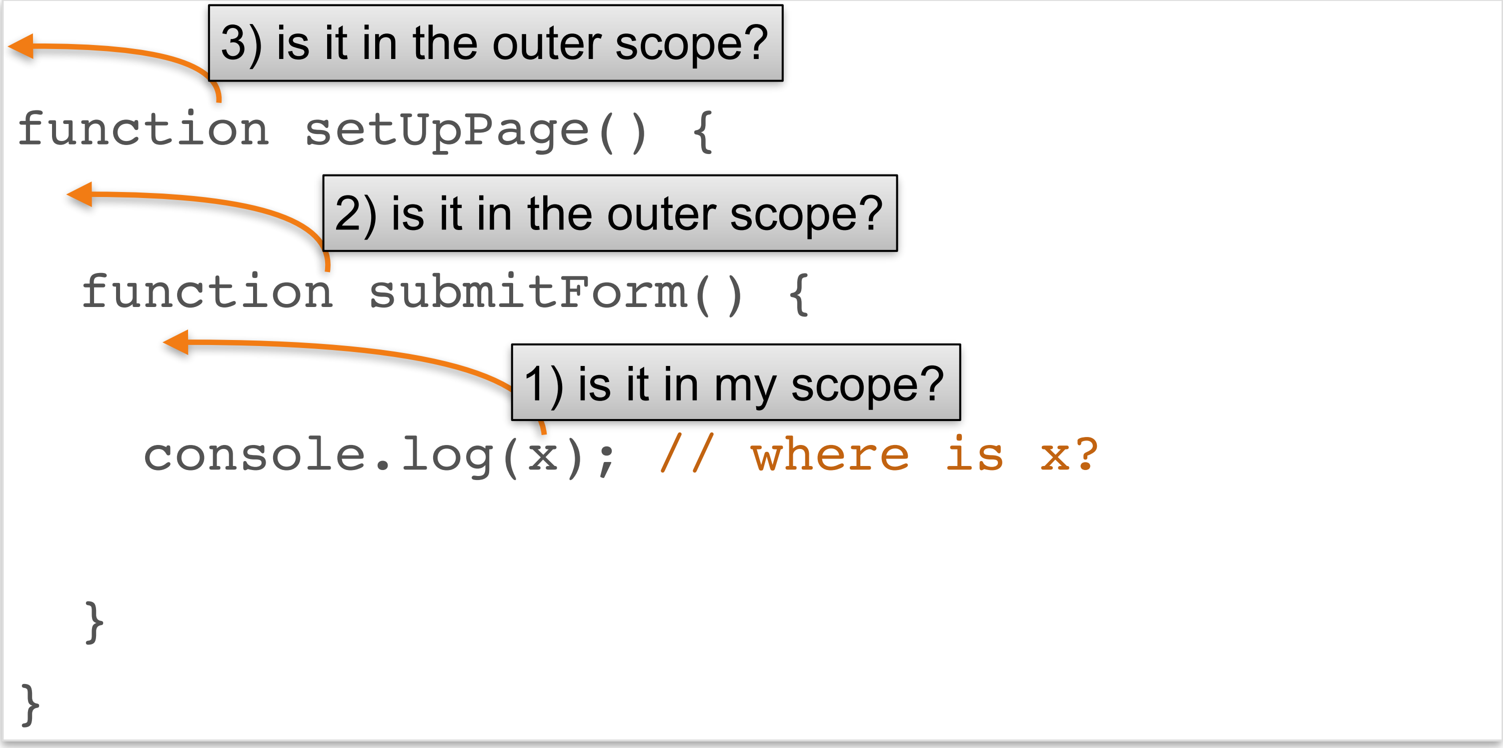
Function Scope

- JavaScript is originally **function-scoped**
  - **var** declares a variable in current function scope
  - variable is said to be “local” to the function

```
var x = 10; // what is the scope?

if (x > 1) {
  var y = 12; // scope?
}

function doMath(x) {
  var y = 10; // scope of x and y?
}
doMath(5);
```

Scope chain

- When a variable is not found in the current scope…
  - JavaScript will look into the outer scope
  - All the way up the scope chain until global



3) is it in the outer scope?

2) is it in the outer scope?

1) is it in my scope?

```
function setUpPage() {

  function submitForm() {

    console.log(x); // where is x?


  }
}
```

Scope visibility

- Outer scopes **can not** access inner scopes

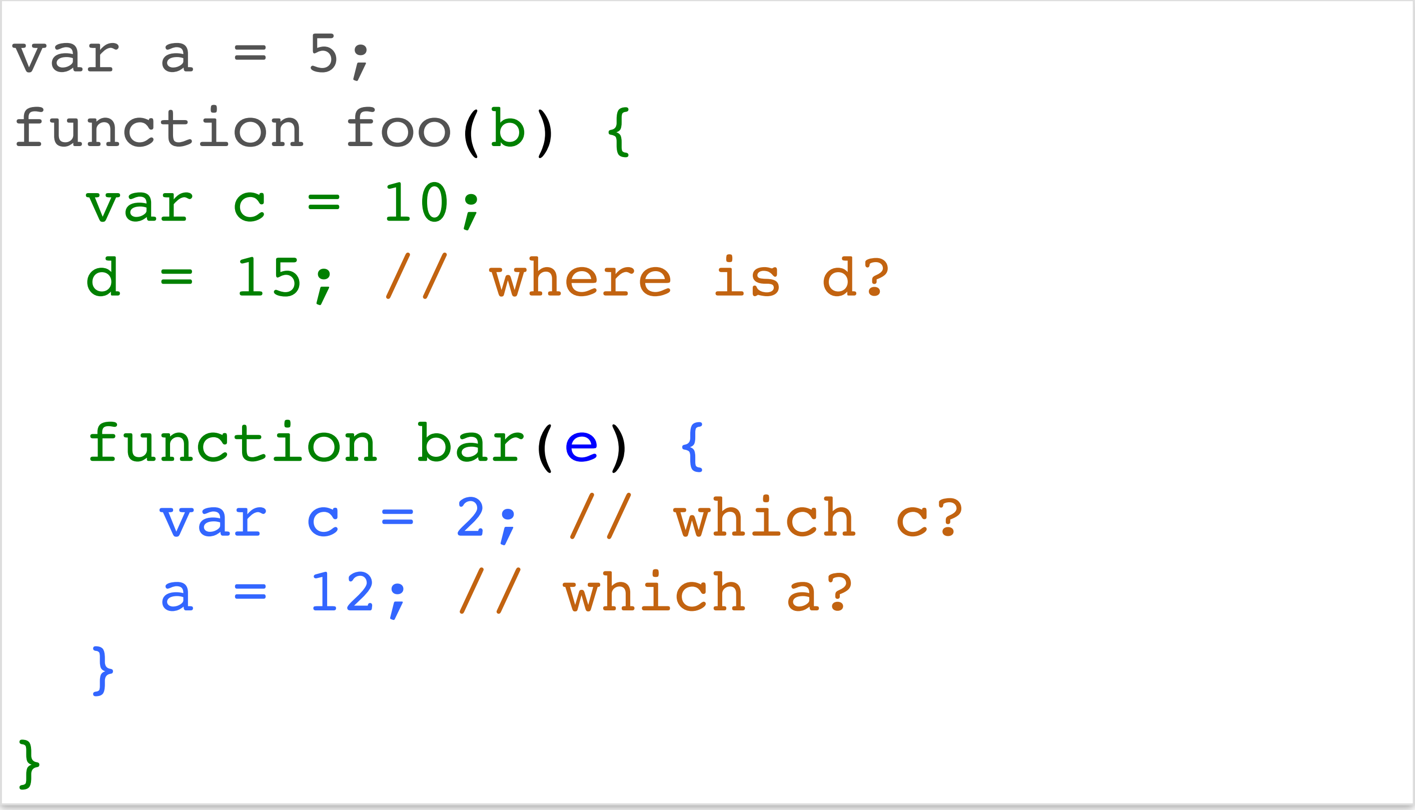
```
function doSomething() {
  var y = 10;
}


// can I access y?
```

- Inner scopes **can** access outer scopes

```
var x = 10;
function doSomething() {
  // can I access x?
}
```

What scope?

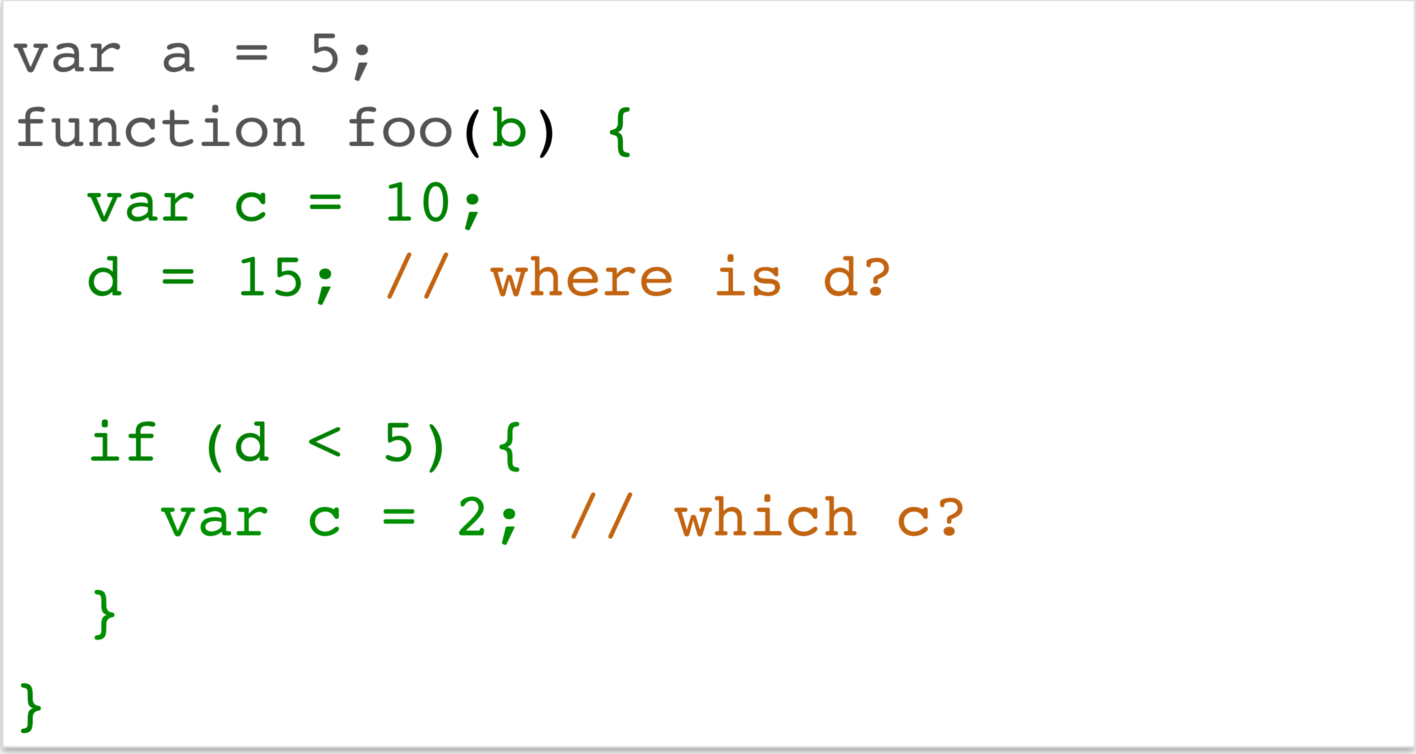
- What are the scopes here?



```
var a = 5;
function foo(b) {
   var c = 10;
   d = 15; // where is d?

   function bar(e) {
      var c = 2; // which c?
      a = 12; // which a?
   }
}
```

What scope, pt 2?

- What are the scopes here?



```
var a = 5;
function foo(b) {
   var c = 10;
   d = 15; // where is d?

   if (d < 5) {
      var c = 2; // which c?
   }
}
```

Block scope in ES6+

- **`let`** & **`const`** define variables in block scope
  - same visibility rules apply

Also:
* both can’t be redeclare
* `const` is immutable*
* aren't set on global object

```
let x = 5;
if (x > 1) {
  let x = 10; // This is OK, shadows outer x
  let y = 20;
}
console.log(x); // 5
console.log(y); // ReferenceError - not defined
console.log(window.x); // undefined
```

The Global Scope

- Refers to the outermost object
  - In a browser, this is `window`
- Variables are set in global when
  - Declared w/out “var”
  - Declared outside of any function or block
- Don’t muddy up your global scope
  - ‘use strict’;
  - let or const

```
x = 12;
var y = 1;
function setter () {
  z = 100;
}
```

```
const x = 12;
const y = 12;
function setter () {
  const z = 100;
}
```

Strict mode

- Opt in to a more **restrictive ES5**
  - It kills deprecated and unsafe features
  - It changes "silent errors" into thrown exceptions
  - Prevents global scope auto-setting
- Can be set **globally** or within **function** block
  - Careful when concatenating scripts

```
// entire script
'use strict';


// or just per function
function whatever() {
  'use strict';
}
```

Exercise: Sharing Scope

- Open the following file:

```
public/exercises/scope/index.js
```

- Complete the exercise
- Test in the console:

  http://localhost:3000/exercises/scope/

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/scope

module

HOISTING

Exercise: Hoisting (pt 1 of 3)

- What will the output be?

```
function foo() {
 x = 42;
 var x;

 console.log(x); // what will the output be?
 return x;
}


foo();
```

Exercise: Hoisting (pt 1 of 3)

This…

```
function foo() {
  x = 42;
  var x;

  console.log(x);
  return x;
}
foo();
```

Becomes…

```
function foo() {
  var x;
  x = 42;

  console.log(x); // 42
  return x;
}
foo();
```

Exercise: Hoisting (pt 2 of 3)

- And this?

```
function foo() {
 console.log(x); // ?
 var x = 42;
 return x;
}
foo();
```

Exercise: Hoisting (pt 2 of 3)

This…

```
function foo() {
 console.log(x);
 var x = 42;
 return x;
}
```

Becomes…

```
function foo() {
 var x;
 console.log(x);// undefined
 x = 42;
 return x;
}
```

Exercise: Hoisting (pt 3 of 3)

- And finally

```
foo(); // ?
bar(); // ?

function foo() {
 console.log("Foo!");
}

var bar = function(){
 console.log("Bar!");
}
```

Exercise: Hoisting (pt 3 of 3)

This…

```
foo();
bar();


function foo() {
 console.log(“Foo!”);
}


var bar = function(){
 console.log(“Bar!”);
}
```

Becomes…

```
var bar;
function foo() {
 console.log("Foo!");
}


foo(); // Foo!
bar(); // TypeError


bar = function(){
 console.log("Bar!");
}
```

Hoisting

- When a variable declaration is **lifted** to the top of its scope
  - … only the declaration, not the assignment
  - JS breaks a variable declaration into two statements
- **Best practice**
  - declare variables at the top of your scope

This…

```
var myVar = 0;
var myOtherVar;
```

Is interpreted by JS as…

```
var myVar = undefined
var myOtherVar = undefined;
myVar = 0;
```

Function hoisting

- Function *statements* are hoisted, too

```
hoo(); // ‘hoo’
bat();  // TypeError, function not defined

function hoo() {
   console.log("hoo");
}

var bat = function() {
   console.log("boy");
}
```

Hoisting with `let` & `const`

- Variables declarations with **`let`** and **`const`** are not hoisted
  - **Temporal Dead Zone** between declaration and having a value set results in ReferenceErrors
  - const variables ***must*** be declared with a value, however

```
console.log(x); // ReferenceError
let x = 5;

// when using an outer scoped y to set inner
let y = y + 5; // ReferenceError

const z; // SyntaxError
const z = 5; // OK
```

Exercise: Scope Cleanup

- Open the following file:

  `public/exercises/scope-clean/index.js`

- Complete the exercise
- View your log output by visiting:

  http://localhost:3000/exercises/scope-clean/

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/scope-clean

module

OBJECTS

Objects

- Remember that everything is an object except **`null`** and **`undefined`**
  - Even primitive literals (numbers, strings, etc) have object wrappers
- An object is a dynamic collection of properties

```
var dog = {
 name: 'Fido',
 age: 10
}
dog.speak = function() {
  console.log('Bark!');
}
dog.speak(); // Bark!
```

Why Objects

- Objects are structured data
- Objects as…
  - a collection
  - a map
  - a utility library
- Objects to represent things in our world or system (OOP)
  - They have **attributes** (properties)
  - And **behavior** (methods)
  - And can relate to other objects

Four ways to create an object

- Object **literal**

```
const cat = {};
```

- A **constructor** function with the `new` keyword

```
function Animal() {}
const cat = new Animal();
```

- **`Object.create()`**

```
const cat = Object.create(animal);
```

- The **`class`** keyword (and `new`) [ES6+]

```
class Animal {}
const cat = new Animal();
```

The Object Literal

- Create an object literal with {}:

```
const myObjLiteral = {
   name: "Mr Object",
   age: 99,
   toString: function() {
     return this.name; // what is this?
   }
};
```

Object properties

- Can get/set with dot or array-access syntax

```
myObj.key;
myObj.key = 5;

myObj["key"];
myObj["key"] = 5;

var propName = "key";
myObj[propName] = 5;
```

- Can delete a property with `delete`

```
delete myObj.key;
```

Object reflection

- Objects **inherit** properties from their prototype
  - ex: Array inherits from Object
  - “**Own**” means the property exists on the object itself, not from up the **prototype chain**
  - Use **`in`** and **`hasOwnProperty`** to determine where property resides

```
var myObj = { name: 'Jim' };
myObj.toString(); // [object Object]

'name' in myObj; // true!
'toString' in myObj; // true
myObj.hasOwnProperty('toString'); // false!
```

Object reflection, continued

- `Object.keys(obj)`
  - Returns array of all “**own**”, enumerable properties
- `Object.getOwnPropertyNames(obj)`
  - Returns array of all “**own**“ property names, including non-enumerable

Mutability

- All primitives in JavaScript are **immutable**
  - Using an assignment operator just creates a new instance of the primitive
  - “Pass by value” in functions

```
function addOne(x) {
  x = x + 10;
}

let y = 10;
addOne(y);
console.log(y); // 10
```

The primitive 10 is passed in as a value only. The original variable "y" is left untouched

Mutability

- Objects are **mutable**
  - Their values (properties) can change
  - “Pass by reference” in functions

The original object is modified by the function.

But.. obj = {} would NOT mutate

```
function addOne(obj) {
  obj.x = obj.x + 10;
}

const obj = {x: 5}; // event as a const!
addOne(obj);
console.log(obj); // {x: 15}
```

Exercise - Mutations

- What will the result of this be:

```
const rabbit = {name: 'Tim'};
let attack_count = 0;

function attack(obj, counter) {
  obj.is_injured = true;
  counter++;
}

attack(rabbit, attack_count);
console.log(rabbit, attack_count); // ???
```

Enumerating over objects

- `for…in`
  - Over object properties
- `for…of (ES6)`
  - Over *iterable* values
- ~~`for each…in`~~
  - deprecated
  - over object properties

for…in

- Loop over ***enumerable properties*** of an object
  - Will include inherited properties as well, including stuff you probably don't want
    - Use `obj.hasOwnProperty(propertyName)`
  - In order of insertion of the property

```
const obj = {foo: true, bar: false};


for (var prop in obj) {
  if (obj.hasOwnProperty(prop)){
    console.log(prop);
  }
  obj[prop];    // true
} // outputs: foo, bar
```

for...of [ES6]

- Loop over ***enumerable values*** of an **iterable**
  - Will include inherited properties as well, including stuff you probably don't want
  - **Not just objects** — *iterables* (including arrays)

```
const obj = {foo: true, bar: false};

for (let val of iterableThing) {
  console.log(val);
} // true, false

for (let x of [1,2,3]) {
  console.log(x);
} // 1, 2, 3
```

Properties descriptors

- Object properties have **descriptors**
- They modify property behavior

```
const myObj = {};
Object.defineProperty(myObj, "key", {
    value: 5,
    enumerable: true, // included in loop
    configurable: false, // re-configurable
    writable: false, // re-assignable
    // get: function() {return ‘hi’;}
}
myObj.key = 10; // silently fails
```

Exercise: Copying objects

- Open the following file:

  `public/exercises/index.js`

- Complete the exercise
- Run the tests by visiting in your browser:

  http://localhost:3000/exercises/copy/

- `Hint: for (var prop in obj) { /* */ }`
- `Hint: obj.hasOwnProperty(prop)`

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/copy

module

CONTEXT

Scope & Context

- We already discussed ***Scope***
  - Determines visibility of variables
  - Lexical scope (write-time)
- There is also ***Context***
  - *R*efers to the location a function/method was invoked *from*
  - Like a *dynamic scope*; it is defined at run-time
  - Context is referenced by a keyword in all functions: `this`

this?

- Anyone have an idea what **this** is?

```
function runMe() {
    console.log(this);
}

runMe(); // ?
```

`this` is context

- Reference to an object
  - The ***context*** where the function is running
  - *“The object of my invokation”* 🌹
- Dynamically bound
  - Determined on invokation
  - Not lexical
- Basis of
  - Inheritance
  - Multi-purpose functions
  - Method awareness of their objects

this example

```
const person = {
  name: "Carol Danvers",
  speak: function() {
    console.log("Hi, I am", this.name);
  }
}


person.speak(); // ?
const speak = person.speak;
speak(); // ?


// and if we put it on another object?
const otherPerson = {name: "Jim"}
otherPerson.speak = person.speak;
otherPerson.speak(); // ?
```

Binding Context

- We can control the context that a function is called in
- **Default** binding
  - Global
- **Implicit** binding
  - Object method
    - Warning: Inside an inner function of an object method it refers to the global object
- **Explicit** binding
  - Set with `.call()` or `.apply()`
- **Hard** binding
  - Set with `.bind()`
- Constructor binding with “`new`” keyword

“this” and global

- It’s possible to “leak” and access the global object when invoking functions that reference this from outside objects

```
const setName = function(name) {
  this.name = name;
}
setName("Tim");
name; // "Tim"
window.name === name; // true! oops.
```

- “use strict” prevents leaks like that by keeping global “this” undefined in this case

Explicit binding

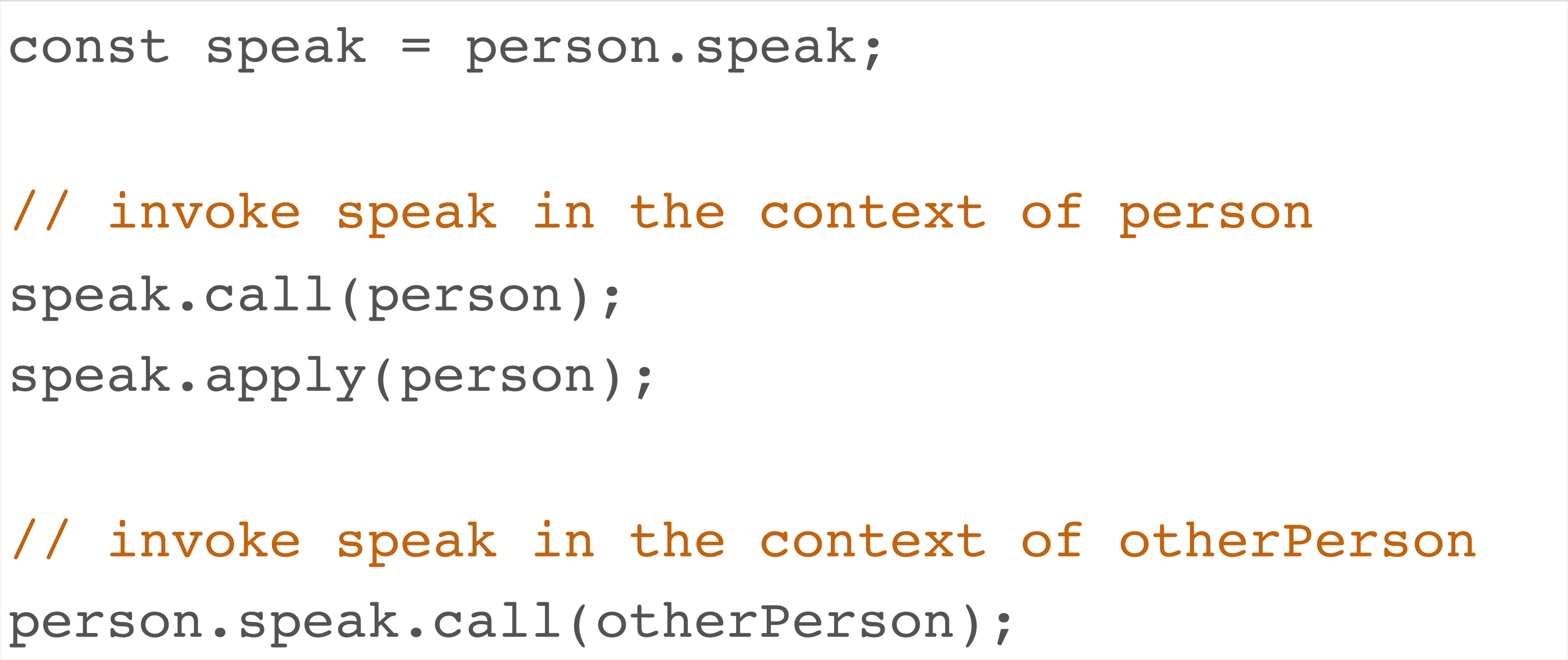
- Context can be changed via a Function's `call`, `apply` and `bind` methods

```
obj.foo(); // obj context
obj.foo.call(window); // window context
```

- "`bind`" returns a copy of the function with the context re-defined.

```
const getX = module.getX;
boundGetX = getX.bind(module);
```

Example: Explicit binding



```
const speak = person.speak;

// invoke speak in the context of person
speak.call(person);
speak.apply(person);

// invoke speak in the context of otherPerson
person.speak.call(otherPerson);
```

Example: Binding context

```
// permanently bound to person object
const speak = person.speak.bind(person);
speak();

// and if we put it on another object?
const otherPerson = {name: "Jim"};

otherPerson.jimSpeak = person.speak.bind(person);
otherPerson.jimSpeak(); // ?
```

Arrow Functions [ES6]

- **(Fat) Arrow** functions
  - Super short function syntax
  - Always anonymous
  - Lexical contextual binding
- Caveats
  - No **`arguments`** of its own (the *outer* function’s args)
  - No **`this`** of its own (uses the enclosing context)

```
const add = function (x) {
  return x + 1;
}


// ...can instead be written as...
const add = x => x + 1;
```

Arrow function syntax perks

```
const add = function (x, y) {
  return x + y;
}


// ...written as a fat arrow...
const add = (x, y) => x + y;


// ...also, written as a fat arrow...
const add = (x, y) => {
  return x + y; // what is this here?
}
```

Arrow function & a context gotcha

“The same this inside the function as outside the function”.

Bound on creation (not invokation)

```
me = {
  name: "Tim",
  talk: (x) => {
    console.log(this.name, x); // this is global :(
  },
  talkLater: function () {
    setTimeout(() => {
      console.log(this.name); // this is me :D
    }, 1000);
  }
}
```

Exercise: Objectify Yourself

- Open the following file:

```
public/exercises/object-you/index.js
```

- Complete the exercise
- View your log output by visiting:

  http://localhost:3000/exercises/object-you/

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/object-you

module

BUILT-IN OBJECTS

Built-in Objects

- String
- Number
- Boolean
- Function
- Array
- Date
- Math
- RegExp
- Error
- http://jsfiddle.net/mrmorris/rrb67ev0/

String

- Instance properties

```
new "foo".length; // 3
```

- Instance method examples

```
let str = "hello";


str.charAt(0);        // 'h'
str.concat('!');      // ‘hello!'
str.indexOf('w');     // 6
str.slice(0, 5);      // 'hello'
str.substr(6, 5);     // 'world'
str.toUpperCase();    // 'HELLO!'
```

Number

- Properties, such as

```
Number.MAX_VALUE;
Number.NaN;
```

- Generic methods

```
Number.isInteger()
Number.isFinite()
Number.parseFloat()
Number.parseInt()
```

- Instance methods

```
num.toString()
num.toFixed()
num.toExponential()
```

Math

- Singleton-ish
- Methods
  - `abs, log, max, min, pow, sqrt, sin, floor, ceil, random…`
- Properties
  - `E, LN2, LOG2E, PI, SQRT2…`

Array methods (accessors)

```
let arr = [1, 1];


arr.concat([2, 4]);    // [1, 1, 2, 4]
arr.join('-');         // "1-1"
arr.slice(1, 1);       // [1]
arr.toString();        // "1,1"
arr.indexOf(2);        // -1
arr.lastIndexOf(1);    // 1
```

Array methods (mutation)

```
let arr = [1, 2, 3];


arr.pop();             // 3
arr.push(3);           // 3
arr.reverse();         // [3, 2, 1]
arr.shift();           // 3
arr.sort();            // [1, 2]
arr.splice(1, 0, 1.5); // [1, 1.5, 2]
arr.unshift(0);       // [0, 1, 1.5, 2]
```

Array iteration methods

```
let arr = [1, 1, 2, 4];

// where fn is a function
arr.forEach(fn);// invoke fn for each
arr.every(fn);  // true if all matches
arr.some(fn);   // true if any matches

arr.filter(fn);// new, filtered array
arr.map(fn);   // new, transformed array
arr.reduce(fn);// value from an array
```

Enumerating over an Array

- Use “`for`”

```
for (let i=0; i < myArray.length; i++) {
   // do something for each element
}
```

- Or `.forEach(fn);` [ES5+]

```
myArray.forEach(function(val, index, arr) {
   // do something
});
```

- Don't use “`for…in`”, which doesn’t keep keys in order

Array filter, map

- `Array.prototype.filter()`
  - Iterate over your array of items passing them to a function. Returning `true` from the function indicates the item should be retained.

```
// ie: remove items that don’t equal 2
myArray.filter(function(item) {
  return item != 2;
});
```

Array map

- `Array.prototype.map()`
  - Iterates over array, invoking a function on each value. The return value is the modified value of the item.

```
// ie: increment each value by 1
myArray.map(function(item) {
  return item + 1;
});
```

Array reduce()

- `Array.prototype.reduce()`
  - Boils down a list of values into a single value.

```
// ie: sum up the array
[0,1,2,3,4].reduce(function(acc, item) {
  return acc + item;
}, 0); // initializer value
```

Date

- Represents a single moment in time based on the number of milliseconds since 1 January, 1970 UTC

```
new Date();
new Date(value);
new Date(dateString);
new Date(year, month[, day[, hour[, minutes[,
seconds[, milliseconds]]]]]);
```

Date Methods

- Generics

```
Date.now()
Date.parse('2015-01-01')
Date.UTC(2015, 0, 1)
```

- Instance method examples

```
var d = new Date();
d.getFullYear();                // 2015
d.getMonth();                   // 7
d.getDate();                    // 15
```

RegExp

- Creates a regular expression object for matching text with a pattern

```
let re = new RegExp("\w+", "g");
let re = /\w+/g;
```

- Generics

```
let re = new RegExp("\w+", "g");
re.global;          // true
re.ignoreCase;      // false
re.multiline;       // false
re.source;          // "\w+"
```

RegExp Methods

- Instance methods

```
re.exec(str)
re.test(str)
```

- String methods that accept RegExp params

```
str.match(regexp); // array of matches
str.replace(regexp, replacement);
str.search(regexp); // returns 1 at first match
str.split(regexp, limit); // returns array
```

Error

- Error objects are thrown when runtime errors occur

```
const err = new Error('Oh noes!');
```

- Implementation varies across vendors
- Instance properties

```
err.name;         // "Error"
err.message;      // "Oh noes!"
```

Error Handling

- JavaScript is very lenient when it comes to handling errors
- Internal errors are raised via the **throw** keyword, and are then considered "exceptions"
- Exceptions are handled via a **try/catch/finally** construct, where the thrown exception is passed to the **catch** block
  - Nesting allowed
  - Exceptions can be re-thrown
- *Anything* can be thrown, of any data type
- Uncaught exceptions halt the overall script

Error Throwing and Catching

```
function exceptionThrower() {
    throw {
        name: "ExceptionThrowerException",
        message: "Bad things afoot"
    };
    //throw new Error("Bad things afoot");
}

try {
    exceptionThrower();
} catch (e) {
    console.log(e);
} finally {
     console.log("Finally...");
}
```

Built-in Errors

- Error (Top level object)
- SyntaxError
- ReferenceError
- TypeError
- RangeError
- URIError
- EvalError

Exercise: Arrays

- Open the following file:

```
public/exercises/array/index.js
```

- Complete the exercise
- Run the tests by visiting in your browser:

```
http://localhost:3000/exercises/array/
```

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/array

Exercise: Strings

- Open the following file:

  `public/exercises/string/index.js`

- Complete the exercise
- Run the tests by visiting in your browser:

  `http://localhost:3000/exercises/string/`

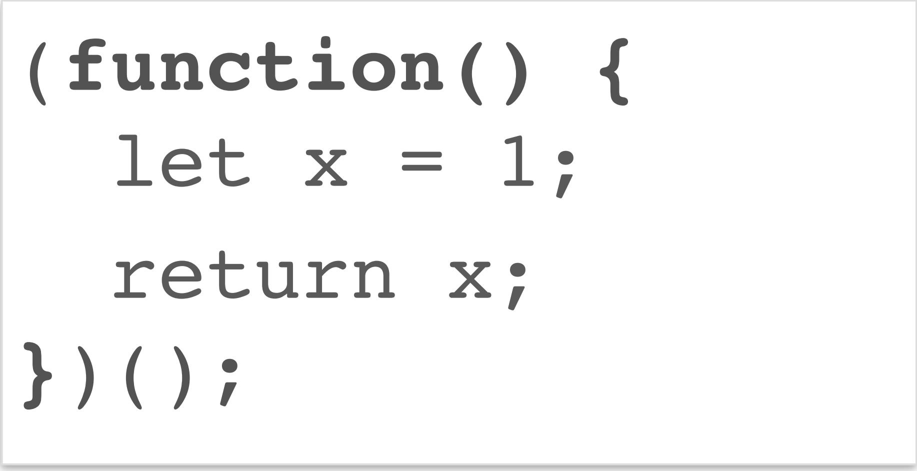
Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/string

module

FUNCTION PATTERNS

IIFEs

- **I**mmediately **I**nvoked **F**unction **E**xpression
- A function that is defined within a parenthesis, and immediately executed



```
(function() {
   let x = 1;
   return x;
})();
```

IIFE Uses

- Define namespaces/modules/packages
- Creates a scope for private variables/functions
- Extremely common in JS

Privacy and modules with IIFEs

```
var helper = (function() {
  let x = 1; // effectively private
  return {
    getX: function() {
      return x;
    },
    increment: function() {
      return x = x + 1;
    }
  }
})();


helper.getX();
helper.increment();
```

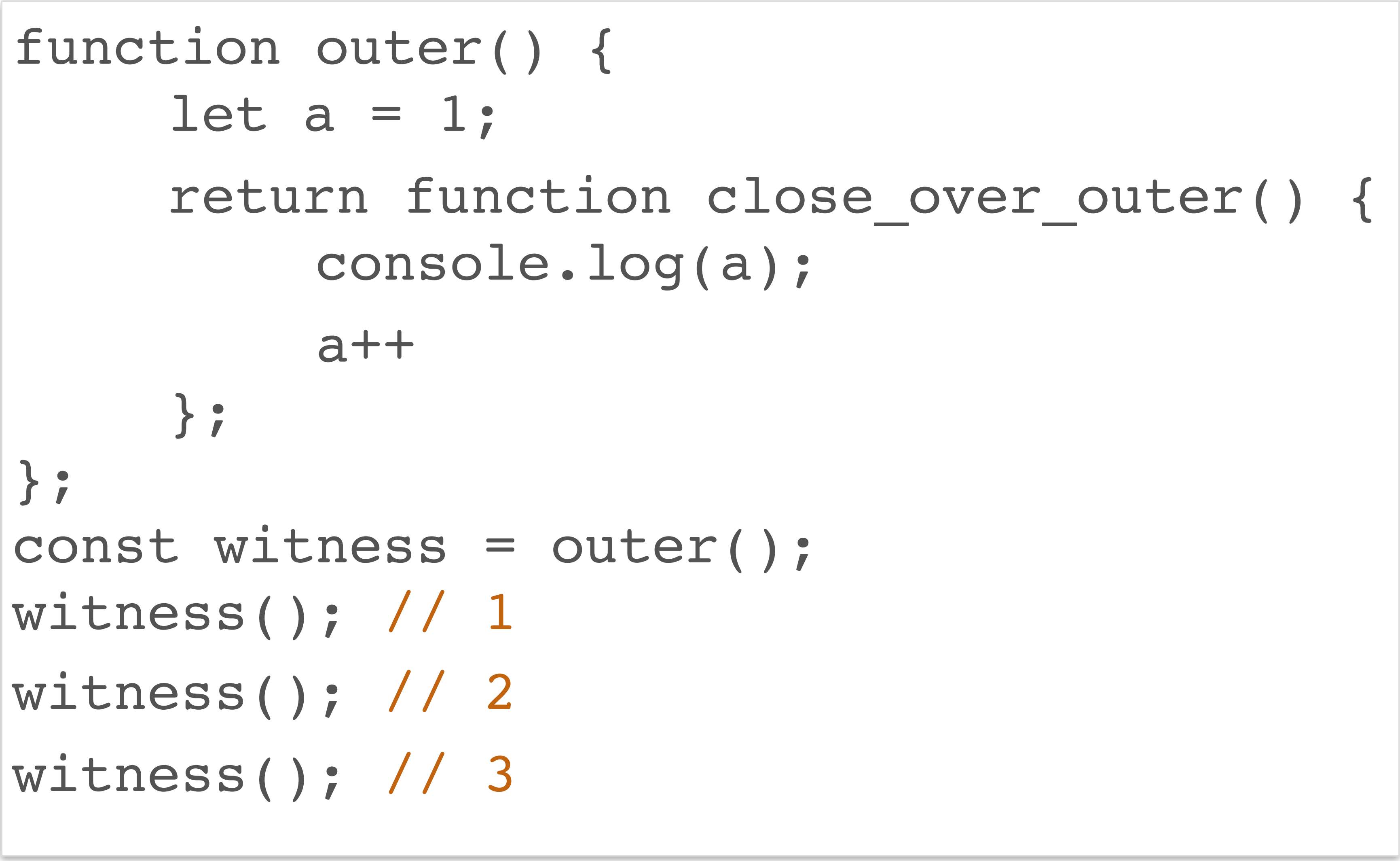
Privacy and modules with IIFEs

```
var helper = (function($) {
  const $button = $("button");
  return {
    getElement: function() {
      return $button;
    },
    clearElement: function() {
      $button.html("");
    }
  }
})(jQuery); // pass in globals
```

Closures

- A **closure** is created when an inner function has access to an outer (enclosing) function's variables
- A function that maintains state (it’s outer scope) after returning
- It has access three scopes:
  - Own – variables defined in its body
  - Outer – parameters and variables in the outer function
  - Global
- Pragmatically, *every* function in JavaScript is a closure!

Closure Example



```
function outer() {
    let a = 1;
    return function close_over_outer() {
        console.log(a);
        a++
    };
};
const witness = outer();
witness(); // 1
witness(); // 2
witness(); // 3
```

Closure Module Example

```
const helper = (function() {
  let secret = "I am special";

  return {
    secret: secret,
    tellYourSecret: function() {
      console.log(secret);
    }
  }
})();


helper.tellYourSecret(); // ?
helper.secret = "New secret";
helper.tellYourSecret(); // ?
```

Function Chaining

- Fluent style of writing a series of function calls on the same object
  - By returning context (**`this`**)

```
"this_is_a_long_string"
     .substr(8)
     .replace("_", " ")
     .toUpperCase(); // A LONG STRING
```

Support function chaining

```
const Cat = {
    color: null,
    hair: null,
    setColor: function(color) {
        this.color = color;
        return this;
    },
    setHair: function(hair) {
        this.hair = hair;
        return this;
    }
};

Cat.setColor('grey').setHair('short');
```

Exercise: What’s wrong here?

```
// given an integer representing a month
// return the month abbreviated name
const monthName = function(n) {

  const names = ["jan", "feb”, "mar", "apr", "may",
"jun", "jul", "aug", "sep", "oct", "nov", "dec"];

  return names[n] || "";

}
```

Lazy Function Definition

```
const monthName = function(n) {

  const names = ["jan", "feb", "mar", ...];

  // we are re-assigning the var to a new fn!
  // the new function will behave as a closure
  monthName = function(n) {
    return names[n] || "";
  }

  return monthName(n);

}
```

Functions Recap

- Are **Objects** with their own methods and properties
- Can be **anonymous**
- Can be bound to a particular **context**, or particular **arguments**
- Can be **chained** together, provided the return of each function has methods
- **Closures** can be used to maintain access to calling context's variables
- **IIFEs** can be used to maintain internal state
  - Both closures and IIFEs can be used to simulate "private" or hidden variables

Exercise: Closures - Temp Storage

- Open the following file:
  `public/exercises/closure/index.js`
- Complete the exercise
- Run the tests by visiting in your browser:
  `http://localhost:3000/exercises/closure/`

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/closure

Exercise: Closures - Guessing Machine

- Open the following file:

  `public/exercises/guessing-machine/index.js`

- Complete the exercise
- Run the tests by visiting in your browser:

  `http://localhost:3000/exercises/guessing-machine/`

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/guessing-mach

Exercise: Closures - Hosts Module

- Open the following file:

  `public/exercises/hosts/index.js`
- Complete the exercise
- Run the tests by visiting in your browser:

  `http://localhost:3000/exercises/hosts/`

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/hosts

module

OBJECT ORIENTED JAVASCRIPT

~~OO JS~~ - Object Creation in JavaScript

- There’s no “one” way in JavaScript
  - A rabbit hole of approaches
  - 4 competing JS engines, a lot of compromise in the definition of the language
- Lot’s of people trying to emulate classical styles
  - Your soul *may* want JS to be like other OO-approaches
- Resist the urge to say, “where’s my classes”…
  - Accept that there is “no right way”…
  - Learn about the many ways to create objects…
  - *Then decide which way to go with your team*

Object Creation in JavaScript

- **Object literal**
  - `var me = {name: "Tim"};`
- **`Object.create(personObj)`**
  - `var me = Object.create(null);`
- **Constructors w/ `new`**
  - `var me = new Person("Tim");`
- **Factory Functions**
  - `var me = makePerson({name: "Tim"});`
- **ES6 `class` keyword**
  - `var me = new Person("Tim");`

Let’s begin the OO Journey

- We create objects that represent the *things* of our system
  - They have methods for behavior
  - And properties for data
  - …
  - *What’s something we want to work with?*
    - Animals
    - Vehicles
    - Washing Machines?

The Object Literal

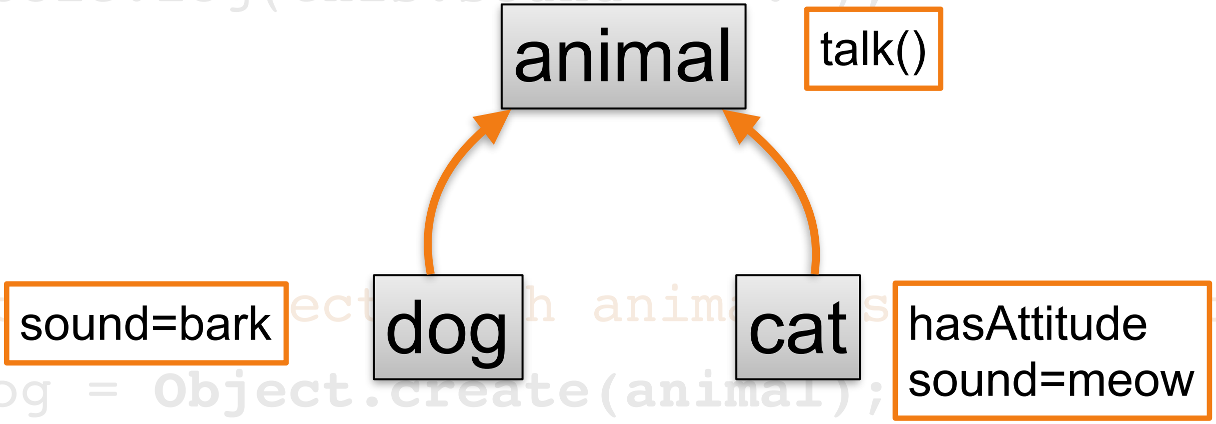
```
// We create Objects to represent Things in our
// system, each with methods and properties
const dog = {
  talk: function() {
    console.log("Bark!");
  }
}


const cat = {
 hasAttitude: true,
 talk: function() {
    console.log("Meow!");
  }
}
```

Prototypal Inheritance

```
// abstracting out shared behavior
const animal = {
  talk: function() {
    console.log(this.sound + "!");
  }
}

// create an object with animal as it’s prototype
const dog = Object.create(animal);
dog.sound = "bark";

const cat = Object.create(animal);
cat.hasAttitude = true;
cat.sound = "meow";
```

Prototypal Inheritance

```
// abstracting out shared behavior
const animal = {
  talk: function() {
    console.log(this.sound + "!");
  }
}

// create objects with animal as prototype
const dog = Object.create(animal);
dog.sound = "bark";

const cat = Object.create(animal);
cat.hasAttitude = true;
cat.sound = "meow";
```

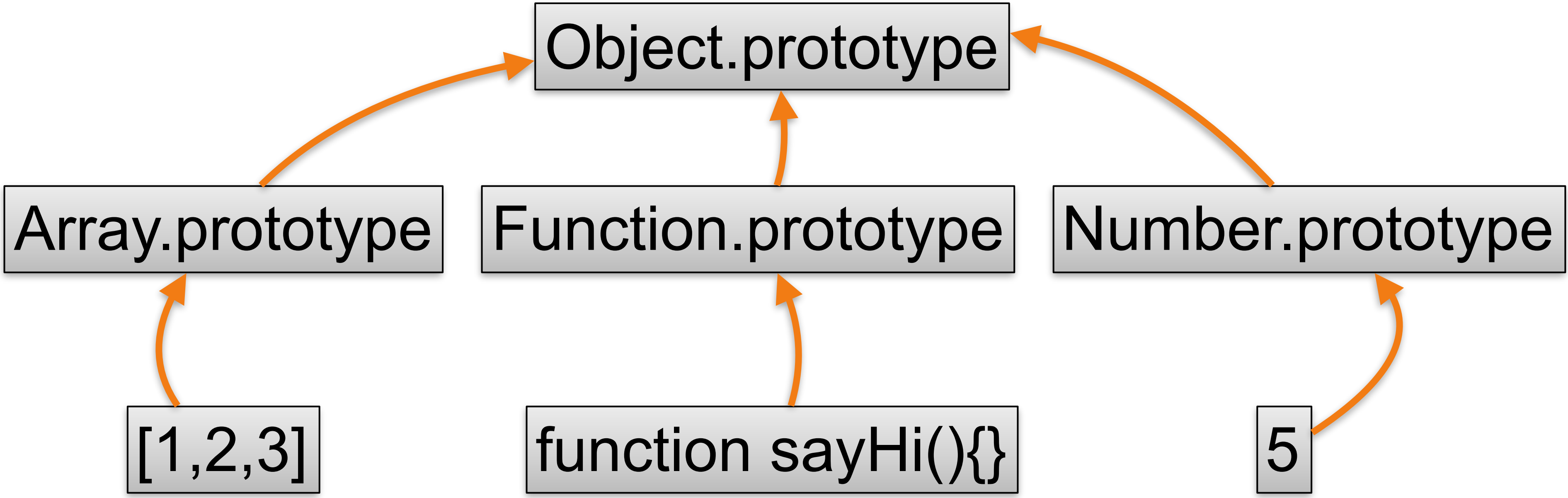


Prototype

- **Prototype** – "an original or first model of something from which other forms are copied or developed"
- Objects have an internal link to another object called its *prototype*
- Each prototype has its own prototype, and so on, up the ***prototype chain***
- Objects ***delegate*** to other objects through this prototype linkage
  - "For this object, use this other object as my delegate"

Built-in Objects

- Built-in JS objects use prototypal inheritance and prototype objects (__proto__ vs prototype)
- Array, Number, etc... store *generic* methods
- Array.prototype, etc, store *inherited* methods



.prototype vs. __proto__

- **`.prototype`** is a property of the Function object
  - Every Function object has one
  - When a function is used as a constructor, new objects will point to **`.prototype`** as their “prototype”
  - “*When I create an Array instance, it delegates to Array.prototype*”
- **`.__proto__`** is an instance property of an object
  - References its “prototype”
  - Prototype Chain
  - “*When I create an Array instance, use an internal property `__proto__` to point to Array.prototype*”
  - Not standard until ES6

Prototype Augmentation

- The linkage is live, you can extend at run-time and affect all copies

```
const animal = {};

const dog = Object.create(animal);

// setting a property on the prototype of dog
animal.hasTail = true;

console.log(dog.hasTail); // ?
```

Constructors and `new`

- A function that expects to be used with the ***new*** operator is said to be a constructor

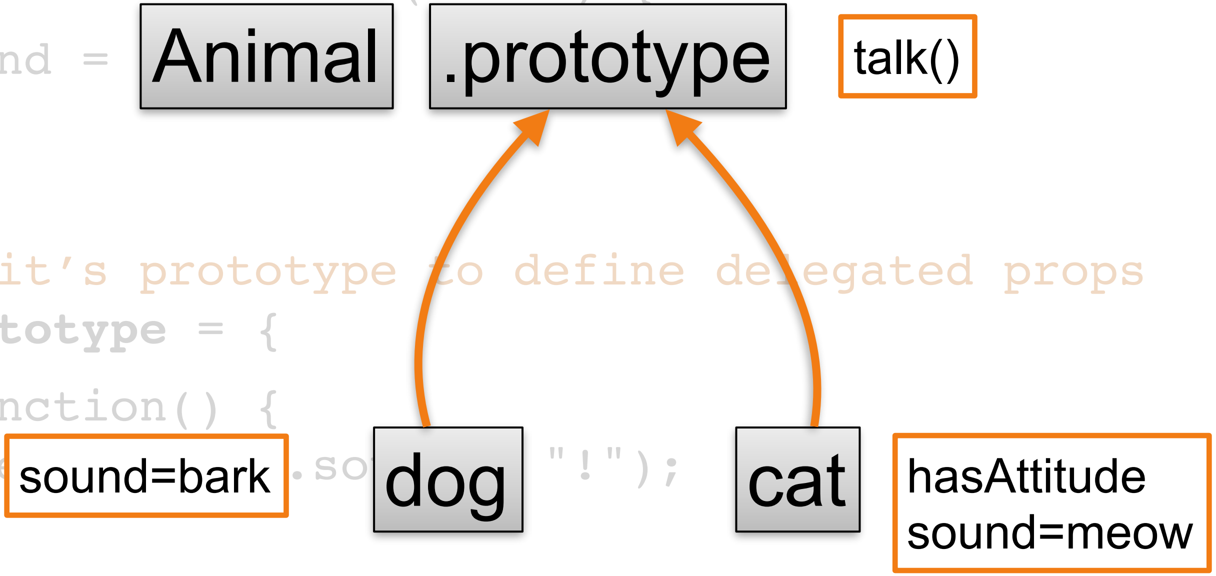
```
const MyConstructor = function(name) {
  // set instance-level properties
  this.name = name;
}

// set delegated methods and properties…
MyConstructor.prototype.sayHello = function() {};


const instance = new MyConstructor("DogCat");
```

Pseudo-Classical Inheritance

```
// We create a function to serve as our constructor
// which sets instance properties
const Animal = function (sound) {
  this.sound = sound;
}

// We use it’s prototype to define delegated props
Animal.prototype = {
  talk: function() {
    console.log(this.sound + "!");
  }
}


const dog = new Animal("bark");
const cat = new Animal("meow");
cat.hasAttitude = true;
```

Pseudo-Classical Inheritance

```
// We create a function to serve as our constructor
// which sets instance properties
const Animal = function (sound) {
  this.sound =
}

// We use it's prototype to define delegated props
Animal.prototype = {
  talk: function() {
    consol              .so              "!");
  }
}

const dog = new Animal("bark");
const cat = new Animal("meow");
cat.hasAttitude = true;
```



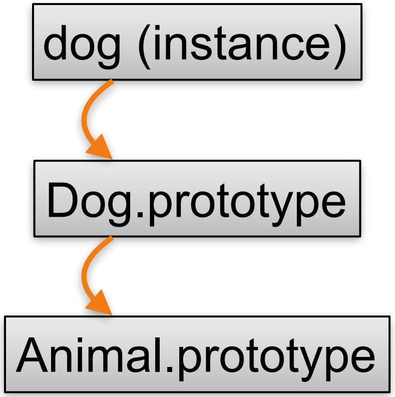
Constructors and Inheritance

- Depends on usage of **`new`** keyword, constructor functions and the prototype linkage
- Still… isn’t like classes
- Only supports single-inheritance
- Since inheritance is programmatic in JavaScript, we can create helpers to make things easier:
  - http://jsfiddle.net/jmcneese/p2ohmuw0

Pseudo Classical continued

```
const Animal = function (sound) {
  this.sound = sound;
}

Animal.prototype = {talk: function() {}}


const Dog = function(breed) {
  // apply the superclass constructor
  Animal.call(this, "bark");
  this.breed = breed;
}


// Dog extends Animal
Dog.prototype = Object.create(Animal.prototype);
Dog.prototype.wag = function() {};
Dog.prototype.constructor = Dog; // we overwrite this


const doggy = new Dog("Robot");
```

We want a prototype chain of:

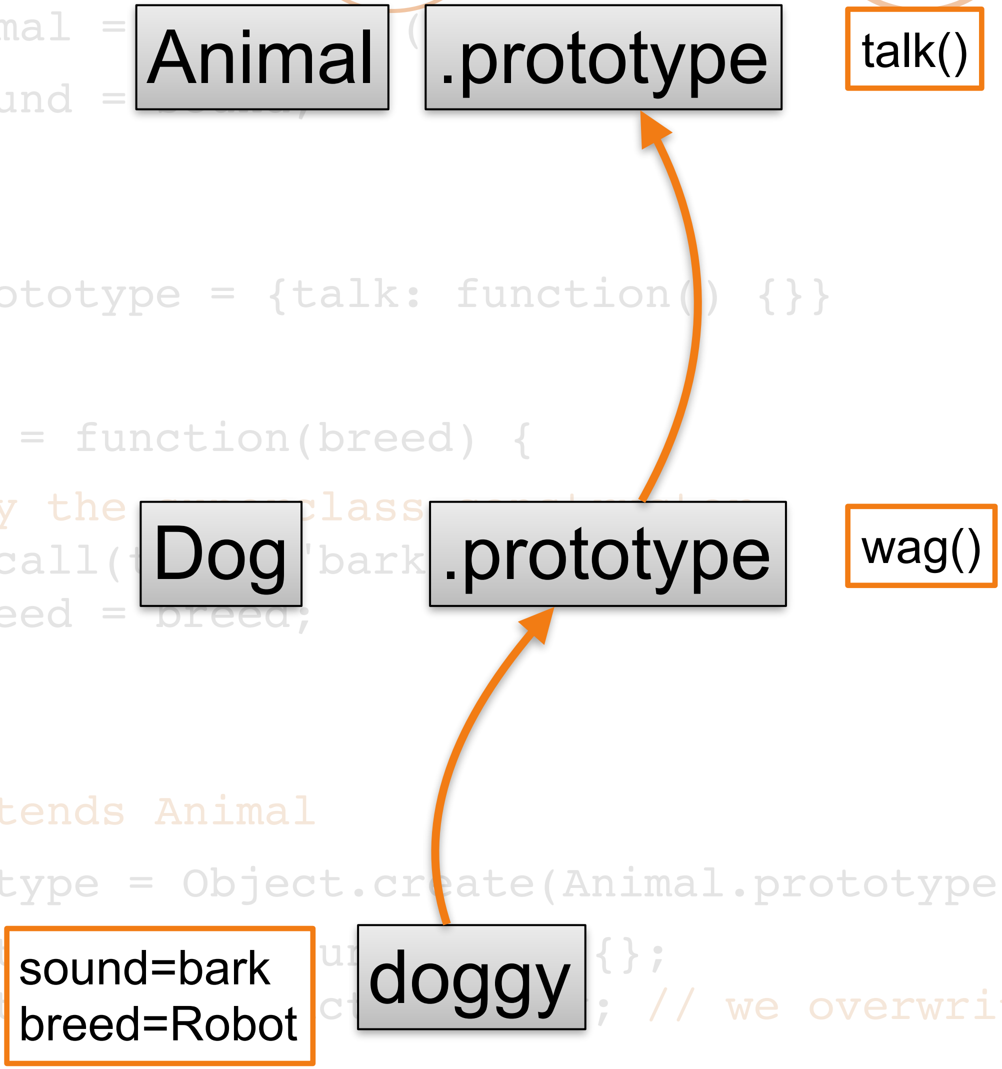

dog (instance)

Dog.prototype

Animal.prototype

Pseudo Classical continued

```
const Animal =                (
  this.sound =
}

Animal.prototype = {talk: function() {}}

const Dog = function(breed) {
  // apply the          class
  Animal.call(t    'bark
  this.breed = breed;
}

// Dog extends Animal
Dog.prototype = Object.create(Animal.prototype);
Dog.protot             u           {};
Dog.protot             c           ; // we overwrite this

const doggy = new Dog("Robot");
```



Setting the prototype

```
//slow
child.__proto__ = parent;


// class-like w/ constructors
MyFunction.prototype = parent;
let child = new MyFunction();


// slow, should be avoided
Object.setPrototypeOf(child, parent);


// fav
let child = Object.create(parent);
```

Reading the prototype

```
// check instance of
[1, 2, 3] instanceof Array;

// check prototype of
String.prototype.isPrototypeOf([1,2,3]);

// get prototype of
Object.getPrototypeOf(child);

// not widely supported
child.__proto__;
```

Prototype vs Class

- JavaScript leverages **prototypal inheritance** instead of **class-based** inheritance
- Classes…
  - Act as blueprints
  - You make copies
- Prototypes…
  - Act as delegates
  - Live representative, not a copy
- ES6 `class` keyword
  - Just a wrapper around prototype, so… ¯_(ツ)_/¯

Exercise - What’s wrong here?

```
function Animal(name) {
  this.name = name;
}

Animal.prototype.walk = function() {
  alert(this.name + ' walks');
};

function Rabbit(name) {
  this.name = name;
}

Rabbit.prototype = Animal.prototype;

Rabbit.prototype.walk = function() {
  alert(this.name + " bounces!");
};
```

Factory Function Pattern

- Functions that create and return objects
- Alternative to constructors
- Better encapsulation & privacy
- Retains context (through closures)

Factory Function Example

```
function dogMaker() {
  const sound = "woof";
  return {
    talk: function() {
      console.log(sound);
    }
  }
}


const dog = dogMaker();
dog.talk();


// real-world practical bonus here
// this retains context and works!
setTimeout(dog.talk, 1000);
```

Object Composition

- When objects are *composed* by *what it does*, not *what it is*
  - Animal
    -> Cat
    -> Dog

    vs
  - Animal
    -> Animal + Meower
    -> Animal + Barker
- Alternative to multiple inheritance
- Properties from multiple objects are copied onto the target object

Mixins Example

```
function CatDog() {
  Dog.call(this);
  Cat.call(this);
}

// inherit one class
CatDog.prototype = Object.create(Dog.prototype);

// mixin another
// Object.assign is ES6 object merging)
Object.assign(CatDog.prototype, Cat.prototype);
```

Functional Composition Example

```
const Animal = {legs: 4}

const meower = function (obj) {
  this.sound = "Meow";
  this.purr = function() {}
}
const barker = function () {
  this.sound = "Bark";
}


const cat = Meower(Animal);
const dog = Barker(Animal);
// And this is easier w/ Composition
const dogCat = Barker(cat);
```

`Class` keyword [ES6]

- Just syntactic sugar over prototypes
- Leaky abstraction; you’ll still deal with prototypes
- Not hoisted (like function declarations are)
- Uses `class` & `constructor` keywords

Pre-class keyword

Without class

```
const Human = function(name) {
  this.name = name;
}

Human.prototype.talk = function(str) {
  console.log(this.name, "says", str);
}

let tim = new Human("tim");
tim.talk("Hi!");
```

Class keyword [ES6]

With class

```
class Human {
  constructor (name) {
    this.name = name;
  }

  talk(str) {
    console.log(this.name, "says", str);
  }
}

let tim = new Human("tim");
tim.talk("Hi!");
```

class and **constructor** keywords

abbreviated method properties

But you are still using **new**, **this** and **prototype**

Extending Classes

```
const Rectangle = class {
  constructor(width, height) {
    this.width = width;
    this.height = height;
  }
  get area() {
    return this.width * this.height;
  }
}

class Square extends Rectangle {
  constructor (width, color) {
    super(width, width);
    this.color = color;
  }
  someMethod() {
    return "Hi";
  }
}
```

no literal properties allowed here :(

`Class` keyword extras

- You can **extend** traditional function-based "classes"
- Can define **static** methods
  - Won't be created on instances
- Can define **getters** and **setters** with get and set method keywords

OO – Recap

- No classes, only prototypes
  - Prototypes are full-fledged objects that new objects use to delegate behavior to
  - Everything derives from Object
- Fundamental concepts are fully supported
- Encapsulation/visibility can be implemented via closure/IIFE patterns
- Objects and their properties are runtime configurable
  - As are their mutability settings
  - Enough rope to hang yourself with, so be careful!

OO – Exercise

- **Create a hierarchy of objects**
  - Cats, Dogs, Animals
  - Me, People, Mammals
  - Car, Truck, Vehicles
- First using just Object.create()
- Then with constructors and/or the class keyword

the end is near

WRAPPING UP

Exercise: Stubs

- Write a function that keeps track of how many times it has been called, as well as the arguments it was called with in sequence

- Open the following file:

  `public/exercises/stub/index.js`
- Complete the exercise
- Run the tests by visiting in your browser:

  `http://localhost:3000/exercises/stub/`

Solutions:
https://github.com/rm-training/web-dev-bc/tree/master/public/solutions/stub